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Chronic obstructive pulmonary disease in Denmark: Age-period-cohort analysis of first-time hospitalisations and deaths 1994–2012

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ABSTRACT

Background: During the 80s and 90s the mortality and number of hospitalisations due to chronic obstructive pulmonary disease (COPD) in the country of Denmark almost doubled. Since then there has been a plateau.
Objective: To analyse age, period, and cohort effects on rates of deaths and first-time hospitalisations with COPD in Denmark during the period from 1994 to 2012 and to make a forecast of these parameters.
Methods: By use of national registers, two separate age-period-cohort analyses were made, one on COPD-specific mortality rates and the other on incidence rates of first-time hospitalisations with COPD.
Results: Both analyses found that high risk of developing severe COPD is associated with being born for women around year 1930 and for men around year 1925. The model has solid predictive ability and projections of future death- and hospitalisation rates due to COPD were made.
Conclusion: Long-term cohort effects rather than present exposure and treatment explain the recent rise and fall in the epidemic of COPD in Denmark. In the near future ageing of birth cohorts with lower COPD-specific mortality and hospitalisation rates will most likely lead to a substantial decrease in severe COPD in Denmark. However, rising trends for cohorts born after year 1948 calls for concern.

1. Introduction

Chronic obstructive pulmonary disease (COPD) is a world leading cause of deaths and hospitalisations. In low-income countries the burden of the disease rapidly increases making the worldwide prognosis sinister. However, in most high-income countries the COPD-specific mortality and the incidence of hospitalisations with COPD has recently levelled and even decreased [1]. In the same period more resources were used on treatment and prevention of the disease [2]. Thus, it may intuitively be concluded that in high-income countries such as Denmark the recent improvements in treatment and prevention have succeeded in slowing down the COPD epidemic. However, such optimism about the effect of recent initiatives is in conflict with the conception of COPD as a chronically progressive disease that takes about 40–50 years before it causes death or need for hospitalisation [3].

Age-period-cohort analyses are used to answer the question whether a trend is caused by factors that occur in the same period as the trend or by ageing of birth cohorts exposed to factors many decades before. Such an analysis including Denmark and six other European countries suggested that time trends in COPD-specific mortality could be explained by long-term birth cohort effects of cumulated tobacco exposure rather than contemporary events such as changes in treatment [4]. However, the study ended before the sharp turning point of the Danish COPD epidemic [5,6], before the first GOLD report, and before the initiation of major national Danish actions aimed at slowing down the epidemic [7,8]. Thus the important distinction between long-term cohort effects and effects of recent initiatives remain unclear, which may cause decision- and policymakers to draw wrong conclusions about the effects of their actions.

This study aims to analyse age-, period-, and cohort effects on deaths and first-time hospitalisations with COPD in Denmark during the period from 1994 to 2012 and to make a forecast of these parameters.

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2. Methods

The study conducted separate age-period-cohort analyses on COPD-specific mortality rates and rates of first-time hospitalisations with COPD in Denmark 1994–2012.

2.1. Setting and data

In 2011 the country of Denmark had 5.6 million citizens. Since year 1994, all diagnoses of admissions to hospital and causes of death have been recorded in the Danish National Patient Register and the Danish Register of Causes of Death classified according to the International Classification of Diseases 10th revision (ICD-10) [9]. All data are registered with the patient's unique civil registration number, which allows data linkage on an individual level between all registers.

For each of the years from 1994 to 2012, the Danish Health and Medicines Authority and Statistics Denmark provided the total age- and gender-specific numbers of COPD-specific and all-cause deaths and of persons in the total Danish population. According to the approach of Danish causes of death statistics a death was considered as COPD-specific if the cause was coded with one of ICD-10 codes J41–44 (chronic bronchitis, emphysema, or COPD) or J47 (bronchiectasis). COPD-specific deaths in the period from year 1994–2012 were retrieved in five-year age strata from age 45–49 to 85+ years, corresponding to birth cohorts from year 1907–1967.

According to the only validation study [10] and in line with prior studies [6,11,12], hospitalisation with COPD was defined as any hospitalisation with either ICD-10 codes J41-44 as primary diagnosis or with J13–18 (pneumonia) or J96 (respiratory failure) as primary diagnosis combined with J41-44 as a secondary diagnosis. The individual health administrative data were linked with data from the Demographic Register regarding the patients' dates of birth, death, and migrations to or from Denmark. First-time COPD hospitalisation was defined as any COPD hospitalisation of a subject who had not been hospitalised with COPD during a period of 8 years before the hospitalisation in question. The 8-year retrospective review period was according to prior Danish COPD time trend studies [11]. Since data were available from year 1994–2011, subtraction of the 8-year period gave 10 years observation period of first-time hospitalisations (period 2002–2011). Rates of first-time COPD hospitalisation were calculated in one-year age strata from age 43–90 years, corresponding to birth cohorts from year 1912–1968. Thus, the hospitalisation data were more detailed than the mortality data, but covered a shorter period.

2.2. The model

An age-period-cohort model was fitted in the same way to each dataset. The approach has been described and discussed elsewhere by Kristensen [13–15]. It assumes that birth cohort effects are constant over lifetime and multiplicatively connected to age and period. Each birth cohort was included as a dummy variable with one cohort as a reference.

The best model for the COPD-specific mortality rate became:

$$\begin{aligned}\mathrm{Log}(\mathrm{MR_{COPD}})\text{*Age} = {} & \alpha_1 + \alpha_2\mathrm{Age}^2 + \alpha_3\mathrm{Age}^3 + \alpha_4\mathrm{Age/T} \\ & + \alpha_5\mathrm{Age}^2/\mathrm{T}^2 + \alpha_6\mathrm{Age}^3/\mathrm{T}^3 \\ & + \beta_1\mathrm{Coh1909}\text{*Age} + \beta_2\mathrm{Coh1910}\text{*Age} \\ & + \ldots + \beta_{59}\mathrm{Coh1967}\text{*Age}\end{aligned}$$

$\mathrm{MR_{COPD}}$ is the number of COPD-specific deaths in 100,000 persons observed in a given year, T is the period (year 1994 = 1), Coh indicates birth cohort (followed by a birth year), and β is the coefficient that expresses a protective or detrimental effect of the specific birth year.

Based on the modelling of the hospitalisation data, period (calendar year) was not associated with the rate of first-time COPD-specific hospitalisations. Thus, the Age-Period-Cohort model was reduced to an Age-Cohort model.

$$\begin{aligned}\mathrm{Log}(\mathrm{HR_{COPD}})\text{*Age} = {} & \alpha_1 + \alpha_2\mathrm{Age}^2 + \alpha_3\mathrm{Age}^3 + \beta_2\mathrm{Coh1913}\text{*Age} \\ & + \ldots + \beta_{57}\mathrm{Coh1968}\text{*Age}\end{aligned}$$

Assuming that age-, period- and cohort effects are stable, the estimated α- and β-coefficients were used for ex-post and ex-ante forecasts in to the near future. See details of the full approach in the supplementary file.

3. Results

The analyses found substantial birth cohort effects on both COPD-specific death- and hospitalisation rates. Birth year around 1930 for women and 1925 for men were associated with the highest risk of both hospitalisation and death from COPD. The risks are lower for earlier birth cohorts. After the high-risk birth cohorts the risks decrease. However, after the 1948 birth cohort the risks

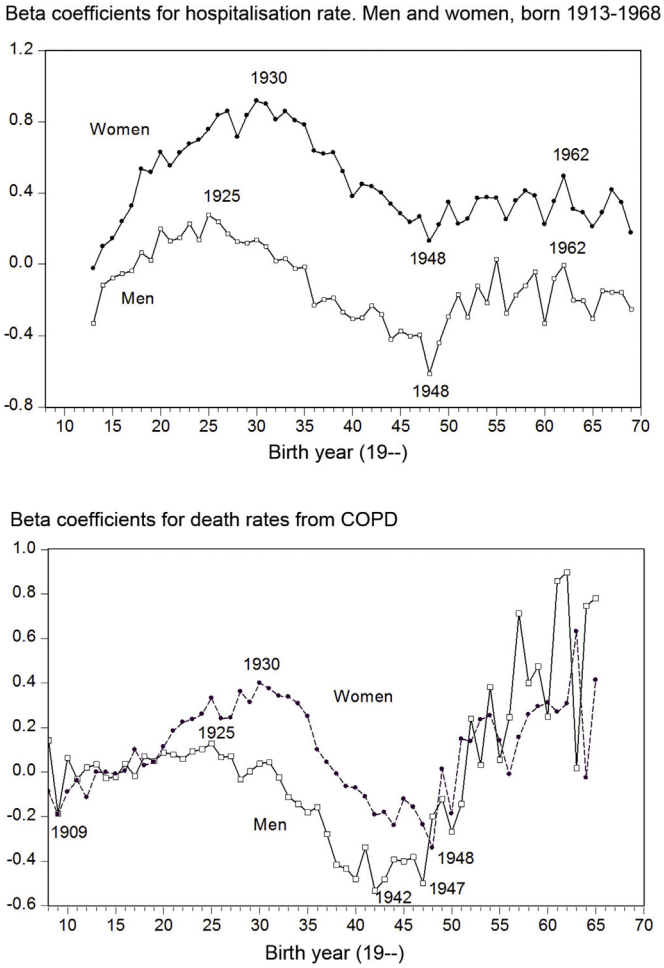

Fig. 1. Estimated birth-year-specific β-coefficients for men and women, above regarding first-time COPD hospitalisation rates and below regarding COPD-specific mortality rates.