

# Chronic bronchitis in an elderly population

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## Abstract

**Background:** in order to describe the prevalence and prognostic implications of chronic bronchitis in individuals 65 years or older we analysed data from The Copenhagen City Heart Study.

**Methods:** the population was studied in 1976–1978 resurveyed in 1981–1983 and 1991–1994 and followed with regard to survival for up to 12 years. Approximately 3,700 elderly participants with a mean age of 76 years were available for analyses.

**Results:** the prevalence of chronic bronchitis was 13.0% in women and 18.6% in men. Multiple logistic regression yielded the following predictors for chronic bronchitis: male gender (odds ratio with 95% confidence interval = 1.1 (0.9–1.3)), previous smoking odds ratio = 1.7 (1.2–2.2), present smoking odds ratio = 2.1 (2.1–3.8), previous exposure to dusts and fumes (odds ratio = 2.2 (1.7–2.7)), chest infections in childhood (odds ratio = 2.1 (1.6–2.9)), more than 6 chest infections in previous 10 years (odds ratio = 6.2 (4.1–9.2)) and alcohol consumption of more than 3 drinks a day (odds ratio = 1.8 (1.3–2.3)). Chronic bronchitis was a significant predictor of both subsequent respiratory infections and survival. After adjustment for age, smoking and lung function, a Cox regression showed that chronic bronchitis was significantly related to mortality from all causes with a hazard ratio with 95% confidence interval = 1.3 (1.1–1.4), all benign respiratory diseases (hazard ratio = 2.0 (1.6–2.7)), obstructive lung disease (hazard ratio = 2.5 (1.7–3.6)) and lung cancer (hazard ratio = 2.0 (1.4–2.9)).

**Conclusions:** in an elderly population, chronic bronchitis is a prevalent condition with important prognostic implications.

**Keywords:** chronic bronchitis, elderly, epidemiology, prognosis, chronic obstructive lung disease, respiratory infections

## Introduction

Chronic bronchitis, defined as coughing and bringing up sputum for more than three months for at least two consecutive years is a common respiratory symptom in the elderly population [1]. Although this has been known for many years [2], the prognostic implications of this condition in the elderly population have not been investigated in detail. This is the case in spite of the fact that the proportion of individuals older than 65 years in high-income countries is ever increasing in both absolute numbers and in the proportion of total population. Previous studies of working adults have shown that chronic bronchitis is a significant predictor of chest infections [3, 4], absence from work [5] and in some, but not all, studies, a predictor of fast lung function decline [6, 7] and increased mortality [8, 9].

In the present paper, we focused on the prevalence, possible risk factors for and the prognostic importance of chronic bronchitis in a random sample of elderly population living in the city of Copenhagen. With regard to prognostic value of chronic bronchitis we focused on incidence of respiratory infections and survival. We used data from the 2nd and 3rd examination round of The Copenhagen City Heart Study comprising men and women 65 years or older.

## Material and methods

The original population sample was drawn in January 1976 from the Copenhagen Population Register among a population of approximately 90,000 inhabitants aged 20 years or more [10, 11]. The initial sample selected in 1976

was age-stratified with main emphasis on the age groups from 35 to 70 years. The cohort was investigated for the first time in 1976–1978, for the second time in 1981–1983, and for the third time in 1991–1994. In general, the response rates were approximately 65% in the participants older than 65 years, highest among subjects between 65 and 70 years of age (75%) and lowest among the subjects aged 80 years or more (approximately 32%).

A self-administered questionnaire concerning symptoms, somatic diseases, social status, smoking, and drinking habits was filled out and checked by one of the investigators. Chronic bronchitis was registered if the subjects reported phlegm for at least 3 months a year for at least two consecutive years [12]. At the 3rd examination, respiratory infections were registered if the participants in the questionnaire reported episodes of acute bronchitis or pneumonia in the past 10 years (time elapsing from the 2nd to 3rd examination). No attempts were made to validate these self-reported events. The classification of social status changed slightly between different examinations. At 2nd examination the participants reported the length of school education and were divided into 3 groups according to these variables, whereas at 3rd examination we obtained a more detailed information on their education and could subdivide them into 8 groups, with subjects with only basic school education in group 1 and subjects with academic education in group 8.

At the first and second examination of the survey, FEV<sub>1</sub> and forced vital capacity (FVC) were measured with an electronic spirometer (Monaghan N 403, Littleton, CO, USA), which was calibrated daily with a 1 litre syringe and weekly against a water-sealed Godard spirometer. A dry wedge spirometer (Vitalograph, Maidenhaid, UK), which was calibrated weekly with a 1 litre syringe was used in the third round of examination. Unfortunately, at the time of the third survey the electronic spirometer used in the two previous examinations was no longer functioning, precluding a direct comparison between the two spirometers. After at least one trial blow, three values were obtained. As a criterion of a correct performance at least two measurements of FEV<sub>1</sub> and FVC differing less than 5% had to be produced. The best FEV<sub>1</sub> was used in the analyses. Lung function was included in the analyses as a percentage of predicted value (FEV<sub>1</sub>%p) using internally derived prediction equations [9].

The analytical strategy was the following. The prevalence of chronic bronchitis was assessed at the most recent investigation in 1991–1994. For exploratory comparison between prevalence of chronic bronchitis in different groups chi-square test was used. Multiple logistic regression was performed with chronic bronchitis at the 3rd examination as the dependent variable and age, sex, smoking (never-smokers, ex-smokers, present smokers), exposure to dusts and fumes at work (yes *versus* no), alcohol consumption (0–2 drinks a day *versus* 3 or more drinks a day), self-reported childhood respiratory infections (yes *versus* no) and social status (8 groups) as independent

covariates. The results are given as odds ratios (OR) with 95% confidence intervals (CI).

The prognostic significance of chronic bronchitis was investigated in two ways:

1. An analysis of chronic bronchitis as predictor of self reported respiratory infections, where we report the distribution of chest infections between the 2nd and 3rd examination (10 year period) in participants with and without chronic bronchitis at 2nd examination. In order to be eligible for this analysis the participants must have participated in both the 2nd and 3rd examination and be 65 years of age or older at the 2nd examination. There were 977 subjects who fulfilled these criteria.
2. The importance of chronic bronchitis as predictor of survival was investigated by constructing survival curves for participants with and without chronic bronchitis at the 2nd examination. A total of 3,145 individuals aged 65 years or more who attended the 2nd examination were eligible for analyses. A Cox regression model was developed with age as the underlying time scale [13]. Chronic bronchitis at the 2nd examination was the independent variable of interest and gender, smoking, FEV<sub>1</sub>%p, social status (3 categories) and alcohol consumption were covariates in the model. The average observation period for this analysis was the time from the second investigation until the end of 1993 for cause specific mortality and the end of 1995 for total mortality with an average observation period of 9.6 years and 11.6 years respectively. Notification of deaths and causes of deaths was obtained from The Danish Register of Causes of Deaths. This register includes dates and causes for all deaths in Denmark. Until the end of 1993 Denmark used the 8th revision of The International Classification of Diseases (ICD), which in the Danish version included no code describing chronic obstructive pulmonary disease without mention of asthma, bronchitis, or emphysema [14]. We analysed total mortality, deaths from obstructive pulmonary disease (ICD code 491–3: bronchitis and/or emphysema + asthma), all non-malignant respiratory diseases (ICD code 460–519), malignant diseases of trachea, bronchus and lung (ICD code 160–163). The results are given as hazard ratios (HR) and 95% CI. Possible interactions between variables were investigated and model control was performed.

## Results

### Predictors of chronic bronchitis

These analyses comprised 2,253 women and 1,483 men 65 years of age or older who attended the 3rd examination and had the complete data required for the analyses. This represents approximately 60% of the subjects invited

for the 3rd investigation. Mean age was 76 years and the overall prevalence of chronic bronchitis was 16.1%; 13.0% in women and 18.6% in men. As expected the prevalence of chronic bronchitis was significantly higher in elderly subjects with reduced lung function than in those with normal lung function, e.g. 44% in women with FEV<sub>1</sub>%p lower than 40%, whereas the similar figure in women with FEV<sub>1</sub>%p higher than 80% was only 10% (Chi-square = 106.4;  $P < 0.001$ ).

In both sexes the prevalence was significantly related to smoking. In never-smoking men the prevalence was 6.7%, whereas in heavy smoking men it was 23.4% (Chi-square = 17.6;  $P < 0.001$ ). Passive smoking, defined as being a non-smoker and living with a smoking spouse was significantly associated with a higher prevalence of chronic bronchitis in women (12.6% *versus* 8.8%, Chi-square = 3.6;  $P = 0.05$ ), but not in men (11.4% *versus* 14.6%, Chi-square = 1.3;  $P = 0.25$ ).

The participants were subdivided into 8 groups according to social status, based on type of their education and type of work. In elderly women, there was no relationship between social status and prevalence of chronic bronchitis (Chi-square = 2.54;  $P = 0.92$ ), whereas elderly men with low social status had a higher prevalence of chronic bronchitis (26.3%) than men with high social status (14.2%) (Chi-square = 17.1;  $P < 0.05$ ). Also previous exposure to dusts and fumes was significantly related to higher chronic bronchitis prevalence: 11.6% in women without exposure *versus* 28.4% in women with exposure (Chi-square = 48.3;  $P < 0.001$ ) and similarly in men 15% *versus* 27.7% (Chi-square = 32.8;  $P < 0.001$ ).

There was also a significant association between self-reported chest infections during childhood and chronic bronchitis in old age: 12.1% *versus* 25% in women (Chi-square = 21.7;  $P < 0.001$ ) and 17.1% *versus* 40.6% in men (Chi-square = 32.9;  $P < 0.001$ ). In addition, in both sexes chronic bronchitis was significantly more prevalent in individuals who reported repeated respiratory infections during the last 10 years: for example 67% of men with more than 10 respiratory infections during the previous 10 years reported chronic bronchitis in contrast to only 14% of men without chest infections (Chi-square = 113.5;  $P < 0.001$ ).

Finally, we performed a multiple logistic regression with chronic bronchitis as dependent variable and gender, active and passive smoking, childhood and recent respiratory infections, industrial dusts and fumes exposure, alcohol consumption, and social status as independent variables (Table 1). The regression showed that smoking, chest infections in childhood, recent chest infections, exposure to dusts and fumes, and alcohol consumption of more than 3 drinks a day were all significant and independent predictors of chronic bronchitis (Table 1).

### Prognostic importance of chronic bronchitis

A total of 977 participants who participated in both the 2nd and the 3rd examination were available for analyses

**Table 1.** Risk factors for chronic bronchitis in the elderly participants at the 3rd examination of The Copenhagen City Heart Study. The OR and 95% CI are derived from multiple logistic regression model

Variable	OR	95% CI
Male gender	1.1	(0.9–1.3)
Smoking		
Never-smokers	1	
Previous smokers	1.7	(1.2–2.2)
Present smokers	2.8	(2.1–3.8)
Respiratory infections		
Less than 6 in past 10 years	1	
6 or more in past 10 years	6.2	(4.1–9.2)
Exposure to dust and fumes at work	2.2	(1.7–2.7)
Frequent chest infections in childhood	2.1	(1.6–2.9)
Alcohol consumption of more than 3 drinks a day	1.8	(1.3–2.3)

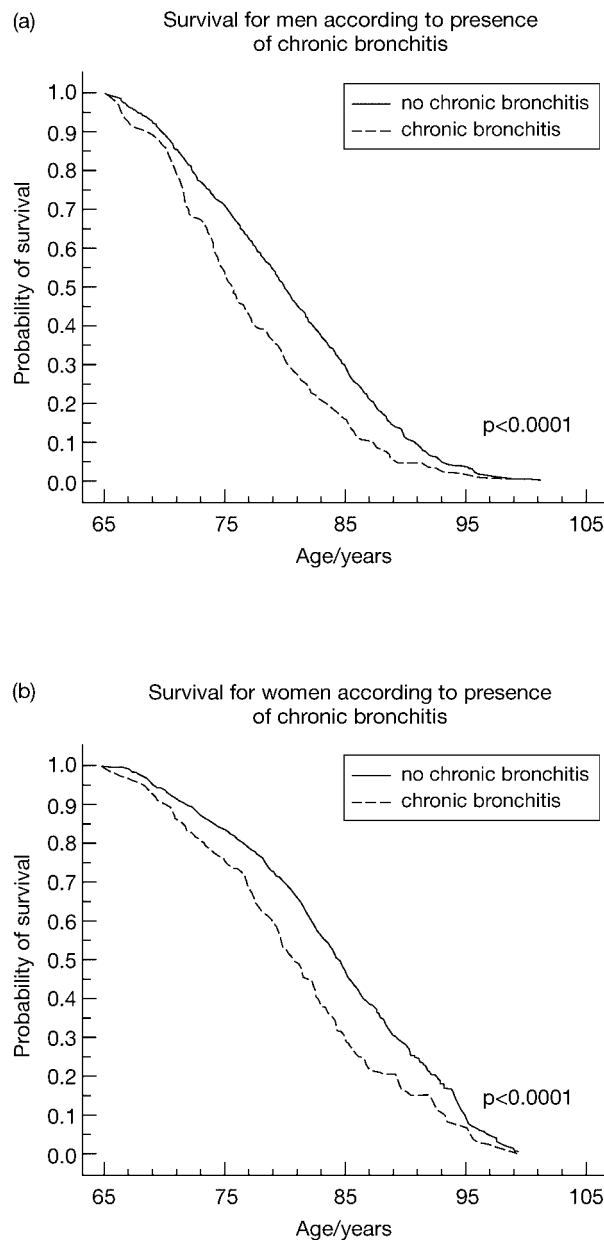
of chronic bronchitis as predictor of subsequent respiratory infections. The distribution of subjects according to presence of chronic bronchitis and number of self-reported chest infections during the 10-year follow-up is shown in Table 2. It shows a strong relationship between chronic bronchitis and subsequent chest infections (gamma test for trend,  $P < 0.01$ ).

Mortality analyses were performed on 3,145 individuals. During follow-up, 1,817 subjects died. The crude mortality in those reporting chronic bronchitis was higher (71%) than in subjects without chronic bronchitis (54%). The importance of chronic bronchitis as predictor of survival in women and men is shown in the survival curves in Figure 1a and 1b. In the Cox regression analysis including gender, smoking, and FEV<sub>1</sub>%p, length of school education and alcohol consumption as covariates the HR of death associated with CMH was 1.3 (1.1–1.4).

As chronic bronchitis is a marker of airway disease we specifically investigated mortality from obstructive pulmonary disease (COPD + asthma), from lung cancer, and from all non-malignant respiratory diseases. Using Cox regression models and adjusting for similar variables as in the analysis of total mortality, we found that chronic bronchitis was a significant predictor of death from obstructive lung disease HR = 2.5 (1.8–3.6), lung cancer RR = 2.0 (1.4–2.9) and non-malignant lung disease HR = 2.1 (1.6–2.7).

**Table 2.** Prognostic importance of chronic bronchitis with regard to the frequency of respiratory infections during a 10-year follow-up for the elderly participants in both 2nd and 3rd examination

	No chronic bronchitis at the start of follow-up ( <i>n</i> = 876)	Chronic bronchitis at the start of follow-up ( <i>n</i> = 101)
No. of infections		
None	83.2 %	59.4%
1–5	14.6%	31.7%
6 or more	2.2 %	8.9%



**Figure 1a and b.** Survival for men and women according to presence of chronic bronchitis.

(Table 3). There was no significant interaction between gender and chronic bronchitis with regard to total mortality, obstructive lung disease mortality and mortality from non-malignant lung disease, but with regard to lung cancer mortality the test for interaction was significant ( $P = 0.006$ ) and resulted in the following HR with women without chronic bronchitis as reference group (HR = 1): women with chronic bronchitis: HR = 4.4 (2.2–8.5); men without chronic bronchitis: HR = 4.3 (2.6–7.1) and finally men with chronic bronchitis: HR = 6.1 (3.4–11.0).

## Discussion

This study shows that in addition to being very common in the elderly population, chronic bronchitis also has strong prognostic implications in this age group.

Previous investigations of this cohort have shown a prevalence of chronic bronchitis around 10% [15]. In the present analyses of elderly subjects, this prevalence was even higher, which is comparable to earlier studies of different elderly populations as summarised by Enright and coworkers [1]. These figures are likely to underestimate the actual prevalence of chronic bronchitis due to the non-responder bias, as chronic bronchitis, at least in our study, was slightly more common in the non-responders than in the responders [15].

Self-reported chronic bronchitis assessed by means of a questionnaire correlates well with the actual sputum volume and is widely used in epidemiological studies [16]. In our study, chronic bronchitis was related to both irritative exposures like smoking, dusts and fumes at work and independent of this also to episodes of self reported repeated chest infections in the past. Chronic bronchitis should therefore be regarded both as a marker of airway inflammation, most often triggered by exogenous stimuli and also as a marker of recurrent airway infection, perhaps related to bacterial colonisation of the airways [17]. In addition the variable prevalence of chronic bronchitis across subgroups with similar exposures suggests dependency on endogenous factors. In this context, it is interesting that the present retrospective analysis based on self-reported data also could demonstrate a connection

**Table 3.** Hazard ratios for death from specific causes in participants with chronic bronchitis in comparison with participants without chronic bronchitis. The HR and the 95% CI are derived from Cox regression models with age, gender, smoking, FEV<sub>1</sub>%p, school education and alcohol consumption as covariates. Only significant variables are shown

	All deaths <i>n</i> = 1817	Obstructive pulmonary disease <i>n</i> = 123	Lung cancer <i>n</i> = 129	All non-malignant pulmonary deaths <i>n</i> = 277
Chronic bronchitis	1.3 (1.1–1.7)	2.5 (1.8–3.6)	2.0 (1.4–2.9)*	2.1 (1.6–2.7)
Smoking	1.3 (1.2–1.4)	1.8 (1.2–2.6)	2.7 (1.8–4.0)	1.4 (1.1–1.8)
Male sex	1.6 (1.5–1.8)	2.1 (1.4–3.1)	2.9 (2.0–4.3)	2.1 (1.7–2.7)
FEV <sub>1</sub> % pred (per 10% pred)	0.89 (0.87–0.91)	0.59 (0.55–0.64)	0.84 (0.78–0.89)	0.76 (0.72–0.79)
School education < 7 years	1.1 (1.0–1.2)			
Alcohol consumption > 21 drinks/week	1.3 (1.1–1.5)			

There was a significant interaction between gender and chronic bronchitis with regard to lung cancer mortality (see text).



between childhood respiratory infections and chronic bronchitis in the old age. We fully acknowledge the weakness of the present approach with regard to assessment of both childhood and recent respiratory infections by means of retrospective self-reporting. Unfortunately we have no data to confirm these self-reports nor data on the severity or the exact type of these events, which were perceived as chest infections by the participants. Yet, our findings are in keeping with the findings from prospective studies linking childhood respiratory disease with lung disease in the middle-aged and elderly [18].

The relatively low impact of social status on chronic bronchitis in this elderly population is in contrast with findings in younger subjects [15]. This discrepancy could reflect cohort differences in smoking habits: in the younger age groups smoking is more prevalent in low social classes, whereas no social gradient regarding smoking was observed in this elderly cohort. Another explanation could be that factors correlated with low social status mainly operate in childhood and early adulthood and that their influence is more difficult to detect in an elderly population. In addition, there are probably also age-related cohort differences with regard to occupation conditions. As all our subjects lived within the same geographical area, the study was not designed to study the effects of airways pollution, which for decades has been a well-known risk factor for chronic bronchitis [2].

In the present study, we chose to regard respiratory infections both as *a predictor* of subsequent chronic bronchitis, but also as *an outcome* in the analyses focusing on chronic bronchitis as predictor of subsequent infections. Due to the retrospective assessment of respiratory infections, our study cannot elucidate whether any of the observed relations between chronic bronchitis and respiratory infections reflect causality, but our study shows that these two conditions are very closely interrelated. Until the middle of the 1970s chronic bronchitis was considered as the major respiratory symptom. It was anticipated that the presence of mucus in the airways was the link between recurrent respiratory infections and *development* of permanent lung function impairment, the so-called 'British Hypothesis'. Although this is still believed to be the case for diseases like bronchiectasis and cystic fibrosis, it does not seem to be valid with regard to the development of COPD, as shown by Fletcher *et al.* [3] in their seminal publication more than 25 years ago. However, most recent longitudinal studies suggest that frequent exacerbations, which are mainly caused by respiratory infections, are associated with a faster decline of lung function in smokers with COPD [19]. So even if the 'British Hypothesis' is not relevant for the development of COPD, it may well be of importance for the later phases of the disease. This is in line with previous studies suggesting that presence of chronic bronchitis may be an important modifier of prognosis in subjects with already established pulmonary disease influencing both mortality and subsequent decline of lung

function (4, 9, 20, 21). We can speculate that the mechanism connecting chronic bronchitis with mortality in the present cohort could be both an accelerated FEV<sub>1</sub> decline and exacerbations, which in subjects with low FEV<sub>1</sub> may result in hospitalisation and death.

Since in particular COPD, and to a certain degree also asthma affects the elderly subjects more severely, the elderly population may be especially vulnerable to the detrimental consequences of chronic bronchitis. This is the main reason for focusing on subjects 65 years or older, where outcomes like episodes of chest infections and survival are more relevant to study than is the decline of FEV<sub>1</sub>. In addition, the elderly population merit attention due to the fact that both the absolute numbers and the proportion of subjects older than 65 years is ever increasing. It is estimated that within a few decades this group will account for approximately 20% of the population in high-income countries [22].

As in the study of Fletcher *et al.* [3], our elderly subjects with chronic bronchitis were at higher risk of developing lung infections. This is likely to reflect the fact that persistence of mucus in the airways leads to bacterial colonisation, which in connection with viral infection of upper airways may lead to lower airway infections. Previous studies have shown that chronic bronchitis in working-men is associated with increased absence from work [5]. Although this may not be relevant in elderly subjects, repeated infections may result in hospitalisations [6] and in fatal respiratory infections especially if there is a concomitant lung function impairment [4]. This is probably the most likely explanation for the observed association between chronic bronchitis and mortality from non-malignant respiratory disease, which in addition to obstructive lung disease mainly represents pneumonia and other pulmonary infections (Table 2). One could speculate that the mechanism behind the association between chronic bronchitis and increased risk of lung cancer could be poor mucociliary clearance in individuals with chronic bronchitis resulting in a longer contact between inhaled carcinogens and bronchial mucosa. In addition to respiratory disease, chronic bronchitis was significantly related to survival as such. This association, although much weaker than between chronic bronchitis and death from respiratory disease, indicates a 30% excess mortality in subjects with chronic bronchitis. This could be explained by chronic bronchitis acting as an effective biomarker of deleterious effects of smoking, but could also be caused by the fact that COPD, lung cancer and respiratory infections are implicated in a substantial part of all deaths in the elderly population. Previous mortality studies of male workers showed that chronic bronchitis was of little relevance as a prognostic marker of mortality from COPD after taking FEV<sub>1</sub> level into account (23–25), although it has been significantly related to overall mortality [8, 9]. Due to an age-related waning of the immune system, age is an important variable for the outcome of respiratory infections including community-acquired pneumonia [26]. It is therefore plausible that in an elderly cohort like ours, where the risk of death is much higher than in the

cohorts of younger active workers, the impact of chronic bronchitis on mortality is relatively greater.

Although our findings are derived from a cohort of subjects living in a defined geographical area, we think that they are generalisable to other elderly populations. The City of Copenhagen has a low degree of air pollution and we recruited subjects at random. This resulted in a study sample representative to social background of the inhabitants of Copenhagen. Although our response rate was not very high and around 60–65% our follow up with regard to mortality is very accurate because of very low mobility in this cohort and the fact that we could trace every single individual due to an unique personal number, that is allocated to every Danish inhabitant.

Our findings advocate an active policy in this age group in order to minimise both the prevalence and the negative effects of chronic bronchitis. These measures should both include primary preventive actions against smoking and air pollution in general community and at work places and also secondary prevention including early antibiotic treatment for lower airways infection and an active immunisation policy against influenza and pneumonia in elderly subjects with chronic bronchitis.

We conclude that in the elderly population, chronic bronchitis is a very common condition with important prognostic implications. It is consistently associated with poor prognosis including increased risk of chest infections and increased mortality.

## Key points

- Chronic bronchitis has a prevalence of around 15% in an elderly population.
- Chronic bronchitis is a significant predictor of both respiratory and total morbidity and mortality.

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