# Does current rather than cumulative dust exposure predict onset of asthma or chronic bronchitis among paper mill workers?

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## Introduction

Current dust exposure might be a more relevant metric than cumulative dust exposure when studying asthma and other respiratory conditions. In a previous retrospective cohort study of workers from a soft paper mill in Sweden, asthma was not associated with cumulative dust exposure, and the effect of current exposure was not addressed (1). Also, unpublished analyses of the same data revealed that chronic bronchitis was not associated with cumulative dust exposure. We re-analyzed these data to investigate whether current dust exposure predicted the onset of either asthma or chronic bronchitis. Based on a prior study of air samples from the mill, the dust contained no asbestos and less than 1% silica, and therefore fulfilled the criteria for a particle not otherwise regulated (PNOR) as defined by the USA Occupational Safety and Health Administration (OSHA). A final aim of this study was to investigate whether the OSHA PNOR standard of 15 mg/m$^3$ total dust was protective for workers in a soft paper mill.

## Methods

The subjects included 972 people who were alive in 1987 and had worked at least one year in the paper mill during 1960 to 1987 and 781 others living in the mill town in 1987. Subjects entered follow-up at either age 18 or 1960, whichever was later. Follow-up ended at illness onset for cases and 1987 for non-cases. Subjects completed a postal questionnaire that inquired about the occurrence of asthma since age 15 and respiratory symptoms characteristic of chronic bronchitis. Those who reported these conditions were asked to indicate year of onset. The questionnaire also inquired about work history, cigarette smoking, and childhood atopy. Proportional hazards regression was used with time-dependent outcome and paper-mill-exposure variables. Potential confounders that were considered included both time-dependent variables (e.g., cigarette smoking status) and variables that did not change during follow-up (e.g., childhood atopy).

Historical measurements of airborne dust in the paper mill were combined with self-reported work histories to get annual estimates of current and cumulative exposure for each subject. Based on the available dust measurements, each combination of job title and calendar year was assigned to one of five exposure ranges: 0, >0 to <1, $\geq$1 to <5, $\geq$5 to 10, and >10 mg/m$^3$. The person-years of current paper mill work were approximately equally split between the exposure ranges of >0 to <1 and $\geq$1 mg/m$^3$, and these two ranges were considered low and high current exposure, respectively. To estimate cumulative exposure, each year of follow-up for a subject was characterized by one of five exposure levels based on the approximate mid-points of the current-exposure ranges: 0, 0.5, 3.0, 7.0, and 15 mg/m$^3$. These annual values were then summed to determine an individual's cumulative exposure, expressed in units of mg/m$^3$-year. The person-years of current mill work were approximately equally split between the cumulative exposure ranges of >0 to 9.5 and $\geq$9.5 mg/m$^3$-year, and these two ranges were considered low

and high cumulative exposure, respectively, among current workers. The relatively small number of person-years in the category of previous mill employment discouraged further division based on cumulative exposure.

## Results

There were 44 people with onset of asthma and 119 with onset of chronic bronchitis during follow-up. The incidence of asthma varied little among the current exposure categories of unexposed (1.2 cases per $10^3$ person-years), low-exposed (0.6 cases/$10^3$), high-exposed (1.7 cases/$10^3$), and previously employed (2.1 cases/$10^3$), and regression analysis confirmed there was no statistically significant difference between unexposed subjects and each of the other three categories. In contrast, the incidence of chronic bronchitis varied by current exposure level: unexposed 2.2 cases/$10^3$, low-exposed 2.8 cases/$10^3$, high-exposed 6.4 cases/$10^3$, and previously employed 6.3 cases/$10^3$. The elevated incidence among those with high current exposure was not attributable to the experience of those with very high exposure. In fact, of the 37 cases in the high-current-exposure category ($\geq$1 mg/$m^3$), 35 were in the exposure range 1 to <5 mg/$m^3$ with an incidence of 8.5 cases/$10^3$. Incidence was also elevated relative to the unexposed for current mill workers when they were categorized by low and high cumulative dust exposure (4.6 and 5.3 cases/$10^3$, respectively). To clarify the relative contribution of current and cumulative dust exposure, the person-time experience of current workers was classified by both simultaneously. Based on regression, hazard ratios were consistently elevated for high current exposure but not high cumulative exposure (Table 1). Further analyses with chronic bronchitis revealed an elevated hazard ratio for current mill work (1.9, 95% CI 1.2, 2.9) independent of smoking status, while an elevated hazard ratio for previous mill work was limited to current smokers (3.8, 95% CI 2.0, 6.9).

**Table 1.** Proportional hazards regression model for chronic bronchitis[1]

| Current/Cumulative Exposure[2] | Hazard Ratio (95 % CI) | P-values |
|---|---|---|
| None/None | 1.0 | |
| Low/Low | 1.3 (0.7, 2.4) | 0.41 |
| Low/High | 0.9 (0.2, 3.9) | 0.93 |
| High/Low | 2.7 (1.3, 5.5) | 0.01 |
| High/High | 2.1 (1.2, 3.5) | 0.01 |
| Previously employed | 2.5 (1.5, 4.2) | <0.01 |

[1] Controlling for atopy as a child and current smoking.

[2] The cut points between low and high exposure were 1 mg/$m^3$ for current exposure and 9.5 mg/$m^3$-yrs for cumulative exposure.

## Discussion

We were able to use historical measurements of dust exposure to estimate job- and time-specific current exposures in a soft paper mill. Current dust exposure at $\geq$1 mg/$m^3$ predicted onset of chronic bronchitis but not asthma. The findings for chronic bronchitis suggest that the OSHA PNOR standard of 15 mg/$m^3$ total dust may not be protective for workers exposed to

paper dust.

## References

1. Torén K et al. Respiratory symptoms and asthma among workers exposed to paper dust: a cohort study. *Am J Ind Med* 1994;26:489-496.

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## Preface

This book contains the extended abstracts to the X2001 Conference on Exposure Assessment in Epidemiology and Practice in Göteborg, Sweden, June 10-13, 2001. The excellent work performed by the contributing scientists has made this book a first-class, up-to-date, state of the art review on what is known about exposure assessment today.

The outstanding scientific quality of the extended abstracts was secured through the work of five international programme committees. The chairmen for the committees were: Chemical, Patricia Stewart; Ergonomic, Alex Burdorf; Physical, Ulf Bergqvist; Psychosocial, Annika Härenstam and Biological, Jean-Francois Caillard.

Financial support to the conference and thereby to the publishing of this book was made possible by contributions from The National Institute for Working Life, Stockholm, Sweden; The Swedish Council for Working Life and Social Research, Stockholm and Volvo. Without the excellent skills of the organizing committee - Ulrika Agby (administration and layout), Ann-Sofie Liljenskog Hill (administration) and Christina Lindström Svensson (administration) - the production of this book would not have been possible.

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Göteborg in June 2001

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