Use of an existing exposure database to evaluate lung cancer risk and silica exposure in Vermont granite workers

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Introduction

Vermont granite workers are known to have experienced high past exposures to silica dust. Since most have had little other occupational exposure, they are, therefore, a very suitable group for study of lung cancer and silica exposure. Previous studies have provided evidence of excess lung cancer mortality among the higher and longer exposed granite workers, particularly longer-tenured workers in the sheds. These studies have been handicapped, however, through restriction of the analysis to job and tenure surrogates, with the resulting potential for misclassification and inability to evaluate quantitative exposure-response. The omission was not through lack of environmental exposure data. From 1924 to 1977 six environmental surveys were undertaken in Vermont granite sheds and quarries, resulting in an extensive database of industrial hygiene information, which has also already been summarized (2). To remedy this omission, therefore, the mortality follow-up data for the Vermont cohort has been analyzed in conjunction with dust concentration data from these sources, incorporating job histories available in the cohort to provide cumulative respirable silica exposures.

Methods

Details of the cohort and methods of mortality follow-up are presented elsewhere (1,3). The job-time exposure matrix published as Table I of Davis et al. (1983) formed the basis of the cumulative exposure derivation. This matrix was derived from six environmental surveys undertaken between 1924 - 77. As noted by Davis and colleagues, this time period corresponds closely with the years the cohort was employed in the granite industry. Adjustment was made for the period of transition when control measures were being introduced in the 1940s.

Work history information available for each cohort member was matched with the job titles available from the job-time exposure matrix; exposures for jobs not included in the exposure matrix were estimated by substituting data from other jobs. Cumulative exposures were then calculated by summing the products of years in job and dust concentration. Finally, conversion from mppcf-yr to mg-yr/m^3 was made employing a conversion factor of 10 mppcf = 0.07 mg/m^3 respirable free silica.

In the current analysis, the exposure data were divided into groups having approximately equal numbers of deaths in each category, but with the cut-points rounded to increments of 0.25 mg-yr m^{-3} for ease of description; SMRs were derived for each group. Model fitting was undertaken using Poisson regression incorporating both internal and external adjustment for age and time period, and log and untransformed exposures. In addition, the same models were fitted after allowing for a 15 year lag in cumulative exposures.

Results

After jobs with similar or equivalent titles had been reconciled, twelve accounted for 75% of the 7,428 work history record entries. Each of the summarized job titles was matched with the job titles in the job-exposure matrix (2). Ten of the 12 most frequently reported job groups could be linked directly with specific jobs in the exposure matrix. Table 1gives the summary statistics of dust exposures and other indices for the cohort. The mean cumulative exposure was 2.1 mg-yr/m^3 with an s.d. of 3.8 mg-yr/m^3. The average intensity of exposure (i.e., the free silica dust concentration) was 0.08 mg/m^3, with 10% being greater than 0.21 mg/m^3.

Mortality from malignancy of the trachea, bronchus and lung is shown in Table 2 and rises almost consistently with exposure level from an SMR of 0.77 in the lowest exposure group to 1.70 in the penultimate exposure group (3.0 - 6.0 mg-yr/$m^{3)}$. The elevations in the SMR for the penultimate two exposure groups are statistically significant ($p<0.05$ and $p<0.01$). Poisson models eliminating the highest exposure group all had highly significant coefficients in comparison ($p<0.005$ for all). Within this group there was little difference between models based on the log transformed versus untransformed exposure, and between those using internal versus external adjustment for age and decade. However, the log transformed models had marginally greater statistical significance.

Discusssion

The results show a clear relationship between extent of silica exposure and lung cancer mortality. Although it was not possible to adjust for smoking in the analysis, there was little evidence of confounding from this factor, since causes of death typically associated with smoking (e.g., NMRD and emphysema) tended to be elevated in the lower rather than higher silica exposed groups. The workers had little or no exposure to any other carcinogens, such as asbestos, radon, or arsenic.

Conclusion

This study has provided confirmation that exposure to silica dust can lead to lung cancer.

References

1. Costello J, Graham GB. Vermont granite workers' mortality study. *American Journal of Industrial Medicine* 1988; 13:483-497.
2. Davis LK, Wegman DH, Louis TA. *Mortality experience of Vermont granite workers*. 1983; 4:705-723.
3. Graham GB, Costello J. Vermont granite mortality study: An update with an emphasis on lung cancer. 2001 (Under review).

Table 1 Summary statistics on respirable free silica exposure variables

	Cumulative exposure ($mg\text{-}yr/m^3$)	Tenure (yr)	Dust concentration (mg/m^3)
Mean	2.1	20.2	0.08
Standard deviation	3.8	15.3	0.10
Median	0.72	18	0.045
Lower decile	0.02	1	0.01
Upper decile	6.4	43	0.21

Table 2 Mortality statistics for malignancy of trachea, bronchus, and lung by respirable free silica exposure groups. Time since first exposure = 15 years or more

Cumulative exposure group ($mg\text{-}yr/m^3$)	SMR	SRR
0-	0.77	1.00
0.25-	0.98	0.91
0.5-	1.26	1.28
1.0-	1.25	1.32
1.5-	1.33	1.32
2.0-	1.47*	1.38*
3.0-	1.70**	1.76**
6.0-	1.16	0.86
All	1.17*	1.30**

* one-sided $p<0.05$, ** one-sided $p<0.01$

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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.

We want to express our gratitude to the contributing authors, session chairmen and to the participants who presented papers and contributed in the discussions, for making X2001 an outstanding meeting.

Göteborg in June 2001

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