THE RELATIONSHIP BETWEEN PULMONARY FUNCTION AND MORTALITY IN MEN SEEKING COMPENSATION FOR ASBESTOSIS

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INTRODUCTION

Exposure to asbestos dust may carry a risk of shortened life expectancy associated with increased mortality rates from respiratory diseases and cancer. A variety of epidemiologic studies have demonstrated dose-response relationships between estimates of personal exposure to asbestos dust, expressed either as cumulative exposures or as time-weighted exposures, and mortality risk.

It may sometimes be desirable to be able to assess the asbestos-associated risk for individuals or groups. Dose-response relationships in the literature may be used to make predictions when it is feasible to calculate estimates of personal or group exposures. For most individuals exposed to asbestos, however, personal exposure records or records of airborne asbestos levels will not exist, and such a calculation will not be possible. In these circumstances, it would be useful if one could find a surrogate for the exposure record for the purpose of prognosis.

It has been demonstrated that the results from two commonly used clinical tests, namely the chest radiograph and pulmonary function tests, are associated with measures of exposure to asbestos dust, with the test result worsening in response to increasing exposure.[1,2] It would thus be expected that these clinical test results might serve as surrogates for missing exposure histories in a mortality dose-response relationship. It has indeed been shown that mortality risk is associated with radiographic scores.[1] It is the purpose of this paper to demonstrate that the results of pulmonary function testing are also predictive of the risk of death from asbestos-associated diseases.

MATERIALS AND METHODS

Subjects in this study were 161 men who had been examined by the physicians of an Advisory Panel to the Ontario Workers' Compensation Board in the years 1962 through 1978, in connection with claims for compensation for asbestosis. Workers were examined in the Laboratory of the Occupational Chest Disease Service of the Ontario Ministry of Labour and underwent medical, radiographic, and pulmonary function examinations. Occupational, medical, and smoking histories were obtained by the examining physician. Any man known to have a malignancy at the time of the index examination was excluded from the present analysis.

Eighty-eight (55%) of the applicants were awarded a disability pension for asbestosis at the time of the index examination, 33 (20%) were awarded a pension at subsequent examinations, and 40 (25%) have not been awarded a disability pension to this date. The results of lung function testing at the time of the initial disability examination provide the data for this analysis.

The claimants were given a standard spirometric examination and the Morris reference equations were used to standardize the results of FVC and FEV_1 for age and height.[3] Workers were followed-up for mortality through the end of 1986. For examination of the association between test results and mortality rates, subjects were divided into 4 groups according to the quartile of the study population in which the test result fell.

Person-years at risk, from the time of the entry examination until death or the end of follow-up, were calculated with the Person-Years computer program.[4] An examination of the age distribution of the person-years at risk indicated that they were similar across pulmonary function quartiles, indicating that a direct comparison of Standardized Mortality Ratios (SMR) was valid. The Person-Years program was thus used to compute SMRs using the general male population of Ontario as the reference population. Poisson regression analysis was used to model the relationships between pulmonary function percentiles and SMRs.[5]

RESULTS

Ninety-nine (61%) of the 161 claimants had worked in the asbestos-cement industry, 38 (24%) had worked as insulators, and the remainder (15%) had worked in a variety of other asbestos-exposed occupations.

The mean age at examination was 54.2 years, with a range from 35 to 75 years. Fifty-eight of the claimants had died by the end of 1986, while 27.9 deaths would have been expected in the general population (SMR = 194).

Table I gives the SMRs for various causes for the 4 quartiles of FVC (Percent Predicted) in the study population. The age distributions are similar in the 4 groups so that the SMRs may be legitimately compared. Most of the subjects were smokers, with only 7% claiming never to have smoked, and the distribution of smokers was similar across the quartiles. There is a monotonic increase in the All Causes SMR across

Table I
The Relationship Between FVC (Percent Predicted) and Mortality Ratios

	GROUP 1 (N=41)			GROUP 2 (N=40)			GROUP 3 (N=40)			GROUP 4 (N=40)		
Mean Age (Standard Deviation)	52.4 (8.6)			54.7 (9.1)			55.8 (8.2)			53.9 (9.5)		
Range of FVC Percent Predicted	84.3 - 125			74.6 - 83.9			64.1 - 74.5			28.5 - 63.9		
Mean FVC% (Standard Deviation)	94.1 (8.9)			78.9 (3.1)			69.5 (3.5)			53.0 (9.4)		
	OBS	EXP	SMR	OBS	EXP	SMR	OBS	EXP	SMR	OBS	EXP	SMR
ALL CAUSES OF DEATH	4	6.45	62	10	9.44	106	19	6.38	298	25	5.68	440
ALL MALIGNANCIES	1	1.84	54	6	2.46	244	9	1.75	514	8	1.49	537
CHEST MALIGNANCIES+	0	0.68	0	3	0.85	353	5	0.64	781	4	0.53	755
ABDOMINAL MALIGNANCIES+	0	0.55	0	3	0.76	396	3	0.54	559	2	0.47	429
RESPIRATORY DISEASES	0	0.35	0	1	0.69	145	4	0.39	1030	10	0.43	2350
CIRCULATORY DISEASES	3	3.13	96	0	4.84	0	4	3.21	125	3	3.27	92

NOTES: +Chest Malignancies includes Lung Cancer and Pleural Mesothelioma

+Abdominal Malignancies includes ICD 150.0 to ICD 159.9

quartiles, with the most spectacular changes occurring in the SMRs for Respiratory diseases. No respiratory deaths were observed in the group with the best FVC while there was a 23-fold excess of respiratory deaths in the group with FVC averaging 53% of predicted.

The relationship between the All Cause SMRs and Mean FVC (Percent Predicted) was modelled with Poisson Regression analysis. There was a strongly significant linear association (Chi-Squared = 24.2; df = 1; P <0.001) and the best fitting equation was:

$$SMR = 834 - 8.36 * FVC\%.$$

There were also strong associations between the Mean FVCs and the SMRs for malignant diseases and respiratory diseases.

The test results for FVC and FEV_1 were highly correlated (r = 0.86), so it is not surprising that the findings for the relationships between quartiles of FEV_1 and SMRs had a similar structure (Table II). There was again a highly significant linear association between Mean FEV_1 (Percent Predicted) and All Cause SMRs (Chi-Squared = 25.2; df = 1; P <0.001) and the best fitting equation was:

$$SMR = 787 - 7.27 * FEV_1\%.$$

Various authors have proposed criteria, which combine information from several tests, for grading impairment of pulmonary function. One such proposal appears in the text by Morgan and Seaton.[6] Table III compares the SMRs of those without impairment (Group 1: FVC and FEV_1 *both* at least 80% of predicted) with the SMRs of those with varying degrees of impairment. Group 2 consists of all those not in Group 1. Group 3 consists of those with FVC and FEV_1 *both* 70% or less of predicted and group 4 of those with FVC and FEV_1 *both* no more than 60% of predicted. Groups 2, 3, and 4 are not mutually exclusive and contain overlap in membership. Those without impairment had a favorable mortality experience in comparison with the general population (possibly an example of the "healthy worker effect") while the most severely impaired had a marked increase in mortality rates.

DISCUSSION

This analysis has demonstrated that the results of pulmonary function testing were predictive of mortality risk in a group of 161 men examined because of workers' compensation claims for asbestosis. About half of the claimants were awarded compensation at the time of the index examination while a quarter have not yet been classified as having a disability due to asbestosis. Mortality risk was found to be strongly associated with reductions in FVC and FEV_1 and regression equations were fitted to the data. The risk coefficients are derived from relatively small numbers of men and need to be replicated in other groups of asbestos-exposed workers before the quantitative result can be generalized.

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Table II
The Relationships Between FEV_1 (Percent Predicted) and Mortality Ratios

	GROUP 1 (N=42)			GROUP 2 (N=39)			GROUP 3 (N=40)			GROUP 4 (N=40)		
Mean Age (Standard Deviation)	53.9 (9.3)			54.2 (9.0)			54.2 (8.7)			54.5 (8.8)		
Range of FEV1 Percent Predicted	93.7 - 130			79.8 - 93.5			65.0 - 79.2			26.6 - 64.0		
Mean FEV1 (Standard Deviation)	101.3 (7.5)			86.1 (4.2)			71.1 (4.2)			50.4 (9.2)		
	OBS	EXP	SMR	OBS	EXP	SMR	OBS	EXP	SMR	OBS	EXP	SMR
ALL CAUSES OF DEATH	4	8.90	45	14	6.06	231	15	7.35	204	25	5.64	444
ALL MALIGNANCIES	2	2.42	83	8	1.67	479	7	1.95	359	7	1.50	467
CHEST MALIGNANCIES+	1	0.86	116	5	0.61	820	3	0.69	437	2	0.54	373
ABDOMINAL MALIGNANCIES+	1	0.74	135	1	0.51	196	4	0.60	666	2	0.47	429
RESPIRATORY DISEASES	0	0.58	0	1	0.37	270	4	0.49	816	10	0.35	2864
CIRCULATORY DISEASES	1	4.46	22	2	3.01	67	3	3.73	80	4	2.88	139

NOTES: +Chest Malignancies includes Lung Cancer and Pleural Mesothelioma

+Abdominal Malignancies includes ICD 150.0 to ICD 159.9

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