Preliminary Report

A Study of Workers in the Vermont Granite Industry: A Prospective Epidemiologic Investigation.

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Supported by NIOSH contract HHSM 99-72-66

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50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO.	2.	PB97-151740

4. Title and Subtitle A Study of Workers in the Vermont Granite Industry: A Prospective Epidemiologic Investigation

5. Report Date 1973/00/00

6.

7. Author(s) Peters, J. M., L. J. Fine, W. A. Burgess, G. P. Theriault, and L. DiBerardinis

8. Performing Organization Rept. No.

9. Performing Organization Name and Address Kresge Center for Environmental Health, Harvard School of Public Health, Boston, Massachusetts, Contract No. 35 pages, 16 references

10. Project/Task/Work Unit No.

11. Contract (C) or Grant(G) No.
(C) 99-72-66
(G)

12. Sponsoring Organization Name and Address

13. Type of Report & Period Covered

14.

15. Supplementary Notes

16. Abstract (Limit: 200 words) This study consisted of a prospective investigation of cohorts of granite shed workers, granite quarry workers, and marble workers studied in 1970 through 1972. There were 677 granite shed workers seen both in 1970 and in 1972. The granite quarry workers included 546 seen in 1970 and 532 seen in 1972. There were 107 marble workers seen in 1971 and 1972. A group of 344 workers from foundries and the talc industry was also studied to determine the effects of smoking on pulmonary function. The findings indicated that the prospective, follow up study confirms the results from an earlier cross sectional study. The annual decrement in pulmonary function appeared to be excessive in this population. There was a relationship between levels of dust exposure and rate of decline which cannot be accounted for by age, height or smoking. Smoking itself influenced the rate of decrement. Workers who have never smoked showed the least decrement, while current smokers showed the most. Heavy smokers had greater decrements than light smokers. No consistent relationship was found between X-ray opacities and rate of pulmonary function decrement.

17. Document Analysis a. Descriptors

b. Identifiers/Open-Ended Terms NIOSH-Publication, NIOSH-Contract, Contract-99-72-66, Mineral-dusts, Dust-exposure, Respiratory-system-disorders, Pulmonary-function-tests, Occupational-exposure, Cigarette-smoking, Humans, Quarry-workers

c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages 35
	22. Security Class (This Page)	22. Price

(See ANSI-Z39.18) See Instructions on Reverse OPTIONAL FORM 272(4-77) (Formerly NTIS-35) Department of Commerce

I. Introduction

The results of last year's cross sectional study of granite shed workers have been reported[1-4]. The important conclusions were that a dose-response relationship could be demonstrated between dust and exposure and pulmonary function abnormality, and dust and x-ray abnormality. Detectable effects on pulmonary function occurred several years before x-ray changes. The average granite shed respirable dust concentration ($523\mu/m^3$) was shown to produce effects on lung function at 32.5 years, and effects on x-rays at 46 years. On the basis of this we, recommended a standard of $300\mu g/m^3$ as a time weighted average for respirable dust in Vermont granite sheds.

This study consisted of a longitudinal or prospective investigation of cohorts of workers exposed to granite dust (sheds and quarries) and cohorts of workers exposed to marble dust.

The research was designed to answer the following questions:

1. Does the prospective-follow-up study confirm or refute our findings from the cross-sectional study conducted last year?
2. Is the annual decrement in pulmonary function excessive in this population?
   a. if yes, can this excess decrement be related to dust exposure?
   b. if yes, can this excess decrement be related to other factors, such as smoking habits?
   c. if yes, is there an age relationship to the rate of decrement?
   d. if yes, do specific x-ray patterns presage excessive decrement?
3. Are the air sampling data consistent with that obtained during last years survey?
4. Are exposure assessment techniques used in this study suitable for environmental survellance in the granite industry?

II. Methods

A. Health Effects

1. Populations - Several occupational groups have been studied during the past two years.

   a. granite shed workers - Available granite shed workers were studied in 1970, 1971 and 1972. Last year's report consisted of the cross-sectional study of 863 workers examined during 1971. This year's report consists primarily of workers seen both in 1970 and again in 1972. Cross-sectionally 961 workers were seen in 1970 and 798 in 1972. The cohort of workers seen on both occasions numbered 677 and will be the focus of this report.

   b. granite quarry workers - In 1970, 546 quarry workers were studied. The 1972 survey examined 532 workers. This cohort of quarry workers will also be analyzed in this report.

   c. marble workers - One hundred and seven workers from the marble industry were seen in 1971 and 1972.

   d. others - Workers from foundries and the talc industry were pooled to determine effects of smoking on decrement in pulmonary function. These miscellaneous industries had 344 workers who were seen in 1970 and again in 1972.

2. Techniques

   a. Questionnaire

   Each year information was obtained from each worker with regard to smoking habits and whether the worker had shortness of breath. The complete lifetime smoking habits included: age at which smoking began, years smoked, current daily consumption, type of smoking (pipes, cigars or cigaretts) and average amount smoked over this time. From this, total lifetime packs were computed. Shortness of breath was ascertained simply by asking the worker whether he was short of breath

b. Chest x-rays

Posterior-anterior (PA) and lateral chest x-rays were taken in full expansion. Total lung capacity (TLC) was estimated planimetrically by the method of Barnhard *et al*.[5] The x-rays were read according to the UICC-Cincinnati classification by one of us (GPT).

The x-rays were taken on a mobile unit which contained a modern 200 ma 125 KVP photo-timed x-ray machine which takes 14 x 17-inch x-rays at a standard distance of 6 feet.

c. Pulmonary Function Tests

At least three satisfactory forced expirations after a maximal inspiration were performed by each worker on a Stead-Wells (Collins) 13.5 liter spirometer with a fast Kymograph speed of 3.2 cm per second. From these tracings the forced vital capacity (FVC) and forced expiratory volume in one second ($FEV_{1,0}$) were derived by standard methods. The mean of these three satisfactory trials was corrected to BTPS and then served as the "true" value for each individual.

FVC was subtracted from TLC (derived from x-rays) to derive the residual volume (RV).

3. Analyses - The data were transferred from code sheets to IBM cards which were punched and verified. The data were then subjected to several analyses using programs from "Data Text" and "SPSS". The analyses were carried out at the Harvard Computing Center. These programs were used to generate basic statistics, cross tabulations and multiple regression analyses. A significant amount of time and

effort went into collating data from all the years and various sources.

B. Dust Exposure

1. Air Sampling Methods

The major air sampling effort during the second year of the contract was conducted from November, 1972 to February, 1973. During this period 255 full shift personal air samples and 41 general air samples were taken in 17 sheds in Barre, Vermont using mass respirable sampling techniques. Quartz analysis was conducted on a portion of the personal air samples.

The sampling method for respirable dust was identical to that used in the first year. Personal air sampling was conducted using a MSA Portable Pump Assembly Model G modified with the addition of a flow dampener [15]. The first stage of the mass respirable sampler was a 10 mm Nylon cyclone (MSA Part No. 456228) and the second stage was a 35 mm PVC filter (MSA Part No. 625413) with a 5μM pore size used in a plastic filter holder (MSA Part No. 625412) with a stainless steel backing plate (MSA Part No. 456224). Samples were collected over 6 to 7 hour work periods by a technician supported by the contract under the direction of the Vermont Dept. of Occupational Hygiene. The sampling rate was maintained at 1.7 lpm during the sampling period.

The filters were tared and final weights obtained at the Vermont Division of Industrial Hygiene using a Cahn Electrobalance weighing to the nearest ten micrograms. In the previous sampling year the initial sampling weights were obtained at the Harvard School of Public Health and the assembled filters were shipped to Barre for sampling. After sampling they were returned to Harvard for reweighing.

It was intended that the Vermont Division of Industrial Hygiene would also carry out the quartz analysis using recently acquired IR instrumentation to verify the value of this technique for the field laboratory. However, a reliable procedure could not be introduced in Vermont in the available time period so the analyses were conducted at Harvard using the method described by Cares et al.[16]

2. Sampling Sites

The second year sampling included 17 different sheds compared to 51 for the first year. All of the sheds in the second year sampling period except one were visited during the first year. There were 20 different job occupations in the first year in addition to a general air classification. In the second year, 12 of these occupations were sampled and the general air samples were divided into five "specific" area categories. The cutter, which was the major occupation sampled in the first year, was split into cutter with and without pneumatic hand tool. Two categories from the first year, sculptor and carver, were combined into one category. The other job occupations which were not sampled in the second year are of little importance with the exception of the finisher which had 40 samples taken last year and none this year.

III. Results and Discussion

A. Health Effects

1. Basic Statistics - The basic statistics for the 1972 cohort of granite shed workers are presented in Table 1. The main variables of interest in this tabulation are means and ranges. It should be noted that the mean and range for total lung capacity (TLC) are derived from 755 of the 798 workers. We were unable to derive reliable TLC measurements from the x-rays of 43 workers. In table

2 are shown the same basic statistics for the cohort of 961 workers seen during 1970 the ranges were similar. No measurements for TLC were made in 1970. It is interesting to note that the 1970 cohort shows approximately the same results as the one from 1972 for the listed parameters. This suggests that older people (older than the average - ± 43) are leaving at a faster rate than the younger workers. It also supports the commonly stated difficulty of dealing with cross-sectional data, that is, selection factors may be involved that are difficult to quantify. We will deal in more detail with this important question later. The variable, duration of exposure, is the years worked in granite sheds. It is not the cumulative life time of dust exposure referred to as dust-years.[2]

2. Multiple Regression -Table 3 contains the multiple regression equations for the 3 principal dependent variables for 1972. This analysis reveals which factors account for a significant amount of the variability of the dependent variable in order of importance and computes a co-efficient for each factor. For example in table 3 for $FEV_{1.0}$ as the dependent variable, each year of age accounts for a loss of 27 ml, each year smoked causes a loss of 12 ml and each year in the granite shed a 1+ ml loss. The height factor is positive and means that for each cm of height you have 41 ml of $FEV_{1.0}$. The multiple R^2 represents the variability of the dependent variable explained by the listed independent variables. For example, in table 3, these factors account for 55.8% of the variability in $FEV_{1.0}$. If the rest of table 3 is inspected it will be noted that the same factors affect FVC in the same order and in about the same degree (R^2=0.540 or 54.0%). For TLC the factors appear in a different order and have much less significant impact, that is, they only account for about

18.7% of the variability. This is consistent with general knowledge of the natural history of the TLC, it is relatively more stable in value than FVC and $FEV_{1.0}$ in the face of aging, smoking, etc.

In Table 4 are presented similar data for the 1970 cohort of 961 granite shed workers. It is most interesting to note the similarity of results for the two cohorts (compare table 3 to 4). The ordering of the independent variables is the same, the coefficients attached to each is approximately the same and the multiple R^2 are almost the same. Note that the coefficient for years smoked is greater for $FEV_{1.0}$ than FVC, a finding consistent with obstructive lung disease with decreased ratio of $FEV_{1.0}$/FVC resulting from smoking. It is also instructive to add up the 3 factors which have a negative effect on the FVC and $FEV_{1.0}$. In both cohorts (1970 & 1972), for both $FEV_{1.0}$ and FVC, they total about 40 ml/year. As will be discussed later, this is larger than expected.

3. Two Year Decrement - The 677 workers seen both during 1970 and 1972 are the focus of this report. This 2 year follow-up allows us to begin to quantify the usefulness of prospective versus cross-sectional studies. Because 44 workers of our matched sample changed jobs within the granite industry during our two years of study, we will analyze for dust effect only 633 who did not.

The change in pulmonary function between 1970 and 1972 is displayed in table 5. It can be seen that the FVC fell 134 ml and $FEV_{1.0}$ 109 ml in the 2 years of study. In both cross-sectional[6,7,8] and longitudinal studies [9-14] the usual annual decrement is much lower usually in the range of 20-30 ml for a normal population. Our shed population is therefore falling at a rate approximately double that which is expected.

If we look at the two year decrement broken down by age (see table 2,6 and 7) we see no consistent pattern. Although the number of workers less than 25 is small (n-19), it does appear that no decrement occurs during this period. It is easy to conceive that growth is still occurring which would effect the lung in a positive way. With the decrement for FVC exceeding that for $FEV_{1.0}$, one would expect an increase in the $FEV_{1.0}/FVC$ ratio or a tendency toward restrictive disease, known to occur with prolonged silica exposure. It would appear that the rates of decrement are excessive and that FVC exceeds $FEV_{1.0}$.

4. Dust Effect - To determine whether the level of dust exposure during the 2 years had an effect on the rate of decrement, the 633 workers were broken down into high (600-700$\mu g/m^3$) medium (500-600$\mu g/m^3$) and low (<500$\mu g/m^3$) exposure categories based on the first year air sampling data. It was not felt that we could further subdivide the level of exposure more finely than this. The results are presented in table 8. It is clear that there is an effect of dust level on the rate of decrement. Our report of last year[1] strongly suggested a dust effect in the granite sheds. These findings confirm what was concluded from last year's study. For FVC (as with the cross-sectional study) the finding is most convincing. For $FEV_{1.0}$ there is not significant difference between the decrement for medium and for low exposure. It is important to note that ages, heights, years smoked and durations of exposure do not vary widely between exposure groups. This reduces greatly the liklihood of a confounding variable accounting for the different decrements by dust level.

A special regression equation was computed by giving exposure categories numerical equivalents. This analysis is presented in table 9. While the results do not quite achieve statistical significance, they are very close and suggest a credible coefficient of loss of ventilatory capacity with increased dust exposure.

5. Quarry Workers - Since it was thought that outdoor quarry workers had minor exposure to dust, we could use them as a suitable control or comparison group. In table 10 and 11 are tabulated the basic data on the 1972 and 1970 quarry workers seen during that time. Quarry workers are slightly younger, have smoked less time and have been at their jobs less time than shed workers. Pulmonary function results are very similar. Likewise multiple regression equations for the quarry workers (see table 12 and 13) look similar to shed workers except that in 1972 coefficients for duration of exposure are higher. Years smoked continues to effect $FEV_{1.0}$ more than FVC and the multiple R^2s are about the same magnitude. The coefficient for age is consistently between 25 and 30 ml for all groups. Three hundred and sixty-five quarry workers were seen both in 1970 and 1972. Their mean fall in FVC was 133 ml and for $FEV_{1.0}$ was 110 ml. This is essentially the same result seen in the shed workers. We believe that quarry workers are falling at an excessive rate. We plan to do comprehensive sampling in the quarries to quantify exposure to dust and to test whether they show the same response to different dust levels.

6. Smoking Effect - As noted already from the multiple regression equations, smoking would appear to effect the rate of decrement in pulmonary function. To determine whether this effect can be seen in a 2 year prospective study, we looked at workers by current smoking status and by amount consumed. In order to generate the largest

number of workers for our breakdowns we combined shed workers, quarry workers, talc workers, foundry workers and other miscellaneous workers. In table 14, 1464 workers who were seen in both 1970 and 1972 are broken down by current smoking status. The 219 workers who had never smoked showed 2 year decrements of 81 ml for FVC and 78 ml for $FEV_{1.0}$. This is slightly more than expected from a "normal" population. For the 346 ex-smokers the figures were 117 ml for FVC and 74 ml for $FEV_{1.0}$. Current smokers showed the greatest 2 year declines - 154 ml for FVC and 126 ml for $FEV_{1.0}$. Note that ages, heights and duration of exposure and level of exposure are similar. This suggests that the different occupational groups are distributed reasonably randomly so.

The 677 granite shed workers seen in 1970 and 1972 show the same general pattern by smoking status. Clear differences appeared between never smokers and current smokers with ex-smokers falling in an intermediate position. Again age and height factors seemed unimportant.

In table 15, 1346 workers are arranged by current smoking category. The main interest centers around whether heavy smokers have a greater decrement than light smokers. Heavy smokers are defined as workers who smoke a pack or more per day. For both FVC and $FEV_{1.0}$ the rate of decrement was greater for heavy cigarette smokers than light cigarette smokers. A surprise finding was that pipe and cigar smokers show high rates of decrement, this finding deserves further evaluation.

7. X-ray Patterns were plotted from the 1971 assessment by the UICC - Cincinnati classification according to size of rounded opacities (p,q,r) and profusion (0-3). For $FEV_{1.0}$ the rate of decrement

appears to show no relationship to either size or profusion. For FVC there appears to be a slightly greater decrement for category q rounded opacitics than for p. With increasing profusion the rate of decrement gets smaller for FVC. None of the differences noted in table 17 appear to be very important. As expected, profusion increases with advancing age.

B. Air Sampling Results

The results of the second year air sampling program appear in tables 17 through 22. Respirable dust and quartz concentrations are presented by occupation and plant. A statistical summary of the data for individual years and with both years combined is shown in table 21. Although the present quartz in the respirable dust remained essentially the same as in the previous years samples, the respirable dust and quartz concentrations increase significantly in a number of the shed.

Samples were taken during the first year from August to November and November to February; the sampling period during the second year was November to February. A review of the sampling data shows that the increase in respirable dust and quartz concentrations during the second year can be explained in part by seasonal differences. The major seasonal differences were noted in plants 6, 19 and 43.

A comparison of the two years data by occupation and plant is presented in tables 22 and 23. A review of the occupations shows that the respirable dust and quartz concentrations increased by 50% to 60% in most occupations while the percent quartz remained the same in 80% of the samples compared. However, a closer examination of the data by plant in table 23 reveals that the increase in concentrations is centered in 5 of the 13 plants. These 5 plants (6, 19, 35, 40, 43) represent 60% of the second year sampling data and 21% of the first year sampling data. It should be remembered that no attempt was made to match plant or occupation from year 1 to year 2.

This difference between years is further detailed in table 24 where a breakdown by plant of cutters (both with and without pneumatic hand tools) can be seen for the two years. The "cutters" category was chosen because it represents 72% of the comparison population of air samples for respirable dust and had a 50% increase in concentration from the first year to the second year. Plants 6, 19, 27 and 40, which show an average increase in mass respirable dust concentrations of 60 to 70%, include 50% of the cutter samples compared to 25% in the first year. It appears that the dust concentrations have increased by a substantial amount in several plants and has affected the mean values for the total sample population as shown in table 23.

Summary

Several populations of Vermont workers were studied between 1970 and 1972. The group of primary interest was 677 granite shed workers. Of these 677,633 had not changed jobs. Our conclusions are that the prospective, follow-up study confirms the results from our cross-sectioned study. Our estimates for safe exposure from the cross-sectional study receive support from this prospective study. The prospective study, at this point, does not refine our estimate of safe exposure.

The annual decrement in pulmonary function appears to be excessive in this population. Further, there is a relationship between level of dust exposure and rate of decline which cannot be accounted for by age, height or smoking. Smoking itself influences the rate of decrement. Workers who have never smoked show the least decrement while current smokers show the most. Amongst current cigarette smokers, heavy smokers have greater decrements than light smokers.

There appears to be no consistent relationship between x-ray opacities (either size or profusion) and rate of pulmonary function decrement.

Our intent to involve the Vermont Division of Industrial Hygiene in the mass respirable dust sampling was completely successful with all field samples taken by a technician supported by the contract under the supervision of the Division. The Vermont group was not, however, able to confirm our infrared technique for quartz and these samples were run at the Harvard School of Public Health. We will continue to co-operate with Vermont in developing their procedure for quartz. We are also co-operating with other laboratories in analytical comparisons for quartz other methods.

Of the thirteen plants surveyed during the second year five showed a substantial increase in respirable mass concentrations. These five plants (6, 19, 35, 40 and 43) include 60% of the second year samples and showed increases of 57, 89, 231, 92 and 101 percent in mass respirable concentrations. In three of these plants sound differences play a part. The balance of the plants showed only slight increases in dust conentrations.

The mean quartz percentage in respirable dust in the second year was similar to the first year.

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Table 1

Cohort of Granite Shed Workers - 1972
Basic Statistics - 823 Workers

	Mean	Range
Age (yrs)	43.32	18-75
Height (cm)	173.55	150-194
Years smoked	20.09	0-54
Duration in Shed	13.96	0-54
FVC-ℓ	4.042	1.360-7.010
$FEV_{1.0}$-ℓ	3.339	0.770-5.470
TLC-ℓ	5.970 (n=755)	3.38-8.84

Table 2

Cohort of Granite Shed Workers - 1970
Basic Statistics - 961 Workers

	Mean
Age (yrs)	43.10
Height (cm)	173.44
Years Smoked	20.48
Duration in Shed	13.48
FVC -ℓ	4.089
$FEV_{1.0}$ -ℓ	3.358

Table 3

Multiple Regression Equations -
Granite Shed 1972 - 823 Workers

Dependent Variable $FEV_{1.0}$

	Coeff.	DF	Signif.
Age (yr)	-27.07ml	818	< 0.001
Hgt.(cm)	40.80	818	< 0.001
Yrs. Smoked	-12.04	818	< 0.001
Duration Exposure (yr)	- 1.23	818	> 0.500

Multiple $R^2 = 0.558$

Dependent Variable FVC

	Coeff.	DF	Signif.
Age (yr)	-29.72ml	818	< 0.001
Hgt. (cm)	56.02	818	< 0.001
Yrs. Smoked	- 9.00	818	< 0.001
Dur. Exp.(yr)	- 0.92	818	> 0.500

Multiple $R^2 = 0.540$

Dependent Variable TLC

	Coeff.	DF	Signif.
Hgt. (cm)	53.68ml	752	< 0.001
Yrs. Smoked	- 6.54	752	0.011
Age (yr)	- 5.06	752	0.079

Multiple $R^2 = 0.187$

Table 4

Multiple Regression Equations

Granite Shed 1970 - 961 Workers

Dependent Variable $FEV_{1.0}$

	Coeff.	DF	Significance
Age (yr)	-28.18ml	956	< 0.001
Height (cm)	42.10	956	< 0.001
Yrs. Smoked	-10.97	956	< 0.001
Dur. Exp. (yr)	- 2.30	956	0.270

Multiple $R^2 = 0.531$

Dependent Variable FVC

	Coeff.	DF	Sig.
Age (yr)	-28.94ml	956	< 0.001
Height (cm)	58.13	956	< 0.001
Yrs. Smoked	- 8.49	956	< 0.001
Dur. Exp. (yr)	- 1.75	956	0.411

Multiple $R^2 = 0.560$

Table 5

Change in Ventilatory Capacity in Liters 1970-1972 633 Granite shed workers

	1970	1972	diff.
FVC 1.	4.129	3.996	0.1338
$FEV_{1.0}$ 1	3.404	3.295	0.1091

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Table 6

2 Year Decrement in Ventilatory Capacity ($FEV_{1.0}$)
By Age Catagory Granite Shed -1970-72 Cohort

Age	Mean 2 yr decrease $FEV_{1.0}$	SD	N
< 25 years	+ 5 ml	181ml	19
25-34	-131	274	127
35-44	-118	235	156
45-54	-121	213	190
55-64	- 72	243	130
65+	-155	255	11
Average	109	239	633 = Total

Table 7

2 Year Decrement in Ventilatory Capacity (FVC)
By Age Category Granite Shed - 1970-72 Cohort

Age	Mean 2 yr decrease in FVC	SD	N
< 25 years	+50ml	271ml	19
25-34	-148	256	127
35-44	-139	267	156
45-54	-150	259	190
55-64	-114	272	130
65+	-154	194	11
Average	134	265	633 = Total

Table 8

DECREMENT IN VENTILATORY CAPACITY 1970-72
BY DUST EXPOSURE - GRANITE SHED

	Dust Exposure Category			
	High	Medium	Low	Avg
n (633)*	190	75	368	
Δ FVC(ml)	159	130	121	134
Δ $FEV_{1.0}$(ml)	140	88	97	109
Age (yr)	41.96	44.40	46.17	44.70
Height(cm)	172.98	172.96	173.87	173.50
Yrs. Smoked	19.42	21.68	21.95	21.16
Duration (yr)	13.74	17.30	16.28	15.64

* The number is less than cohort of 677 because only those with same job in 1970 and 1972 were used to determine effect of dust exposure.

Table 9

Special Regression Equation Computed for Dust Level
low = 1, medium = 2, high = 3

	Coefficient	T test	DF	Significance
$FEV_{1.0}$ decrement	* -20.2ml	1.90	631	0.058
FVC decrement	-18.5	1.57	631	0.117

* A rise of one dust level accounts for 20.2ml loss per 2 yrs.

Table 10

Cohorts of Quarry Workers - 1972
Basic Statistics - n = 532

Age (yr)	42.69	18-81
Hgt. (cm)	173.68	152-196
Years Smoked	18.47	0-67
Dur. Exp. (yr)	8.9	0-48
FVC -ℓ	4.119	1.68-6.74
$FEV_{1.0}$ -ℓ	3.355	0.65-5.63
TLC -ℓ	6.11 (234)	2.13-9.75

Table 11

Cohorts of Quarry Workers - 1970
Basic Statistics - n = 546

Age (yr)	41.67	18-73
Hgt. (cm)	173.12	154-190
Years Smoked	17.24	0-50
Dur. Exp.(yr)	10.23	1-46
FVC -ℓ	4.187	1.55-7.07
$FEV_{1.0}$ -ℓ	3.393	0.57-5.75

Table 12

Multiple Regression Equations - Quarry 1972

Dependent Variable $FEV_{1.0}$

	Coeff.	DF	Signif.
Age	-26.56	554	< 0.001
Hgt. (cm)	46.16	554	< 0.001
Yrs. Smk.	- 9.9	554	< 0.001
Duration of Exposure	- 4.5	554	0.103

Multiple R^2 = 0.524

Dependent Variable FVC

	Coeff.	DF	Signif.
Hgt. (cm)	61.73ml	554	< 0.001
Age	-27.05	554	< 0.001
Yrs. Smk	- 7.60	554	< 0.001
Duration of Exposure	- 4.87	554	0.100

Multiple R^2 = 0.552

Dependent Variable TLC

	Coeff.	DF	Signif.
Height (cm)	91.24ml	230	< 0.001
Age	-20.94	230	< 0.001
Duration of Exposure	- 6.71	230	0.337

Table 13

Multiple Regression Equations - Quarry 1970

Dependent Variable $FEV_{1.0}$

	Coeff.	DF	Sig.
Age	-26.86	541	< 0.001
Height (cm)	40.09	541	< 0.001
Yrs. Smk	-13.34	541	< 0.001
Yrs. Dur.	- 1.18	541	> 0.500

Multiple R^2 - 0.513

Dependent Variable FVC

	Coeff.	DF	Sig.
Age	-25.00	541	< 0.001
Hgt. (cm)	58.29	541	< 0.001
Yrs. Smk	-10.85	541	< 0.001
Yrs. Dur.	- 0.63	541	> 0.500

Multiple R^2 = 0.524

Table 14

Effect of Smoking on Decrement in Ventilatory Capacity
1970-72. All Workers* - Vermont

	Never	Ex-smokers	Current	Avg.
# (1464)	219	346	899	
Δ FVC (ml)	81	117	154	134
Δ $FEV_{1.0}$ (ml)	78	74	126	106
Age	44.52	47.72	43.89	44.89
Height (cm)	174.52	173.35	173.00	173.31
Yrs. Smoked	0	21.41	25.72	20.87
Duration	12.96	14.59	11.44	12.41

* Includes Granite Shed and Quarry Workers, Foundry Workers and Talc Workers.

Table 15

2 Year Decrement in Pulmonary Function By current Smoking Habits.

FVC	Mean change	SD	N	Age	Yrs. Smoked
*non-smoker	103	265	565	46.7	14.1
pipe and cigar	155 ml	314	147	48.1	28.4
light cigarette	117	220	103	43.4	24.0
heavy cigarette	167	290	531	42.8	25.4
			1346		

FEV	Mean change	SD	N	Age	Yrs. Smoked
*non-smoker	75ml	221	565	46.7	14.1
pipe and cigar	133	289	147	48.1	28.4
light cigarette	107	205	103	43.4	24.0
heavy cigarette	122	264	531	42.8	25.4
			1346		

*combines ex and never

Table 16

The Relationship of Rounded Opacitics on x-rays to Decrement in $FEV_{1.0}$ - 1970-72

For $FEV_{1.0}$-ℓ	Profusion			
	0	1	2	3
p	0.150 (51)*	0.112 (76)	0.042 (11)	0.335 (2)
q	0.118 (33)	0.117 (98)	0.096 (12)	-
r	-	0.068 (7)	0.170 (1)	0.110 (5)
For FVC-ℓ				
p	0.168 (51)	0.130 (76)	0.073 (11)	0.580 (2)
q	0.212 (33)	0.165 (98)	0.098 (12)	-
r	-	0.085 (7)	0.630 (1)	0.062 (5)
For Age (yrs)				
p	45.6	48.0	50.1	55.5
q	41.4	44.4	48.6	-
r	-	43.7	56.0	60.6
For years smoked				
p	22	25.2	28.0	29.5
q	17.5	23.1	21.9	-
r	-	18.2	17.0	41.0

* n in parentheses

TABLE 17

Summary of Respirable Dust Concentration by Occupation
(November, 1972-February, 1973)

Occupation	Number of Samples	Avg. Conc. (μg/m^3)	Conc. Range (μg/m^3)
Cutter-no pneumatic hand tool	125	963	77-3719
Sculptor(carver)	20	1123	111-3124
Polisher	7	674	275-1922
Sandblast area	11	616	15-2357
Contour, planer	7	660	266-1713
Wire Saw	21	913	191-2488
Guillotine(hydrosplitter)	6	1049	529-1451
Crane Operator	4	702	296-1473
Lumper	1	309	-
Dry polishing-buzzer	1	454	-
General air -stencil cutting	6	1026	690-1749
General air-grinding	1	1402	-
General air-polishing	5	1057	645-1571
General air-lathe	3	310	225-434
General air-cutting	21	818	347-1829
Sawing(boxing)	1	1283	-
Bull setting	2	495	376-614
Cutter with pneumatic hand tool	56	762	93-2957
Total cutter - with and without pneumatic hand tools	181	762	77-3719

TABLE 18

Summary of Respirable Quartz Concentration by Occupation
(November, 1972-February, 1973)

Occupation*	# Number of Samples	Avg. Conc. (μg/m^3)	Average % Quartz	Conc. Range (μg/m^3)
Cutter-no pneumatic hand tool	27	109	9.4	7-620
Sculptor(carver)	8	196	15.0	10-468
Polisher	6	17	8.0	9-34
Sandblast area	4	43	7.2	15-73
Contour,planer	3	46	6.3	13-98
Wire Saw	-	-	-	-
Guillotine(hydrosplitter)	-	-	-	-
Crane operator	3	30.	4.0	13-64
Lumper	-	-	-	-
Dry polishing-buzzer	-	-	-	-
General air-stencil cutting	2	115	12.4	55-175
General air-grinding	-	-	-	-
General air-polishing	1	38	2.0	-
General air-lathe	1	49	18.0	-
General air-cutting	9	30	3.4	10-84
Sawing(boxing)	-	-	-	-
Bull setting	-	-	-	-
Cutter with pneumatic hand tool	17	131	13	7-475
Total cutter with and without pneumatic hand tool	46	117	10.7	7-475

*Arranged according to code for year (1)

TABLE 19

Summary of Respirable Dust Concentration by Plant
(November, 1972-February, 1973)

Plant#	Number of Samples	Average Conc. (μg/m3)	Range(μg/m3)
3	8	545	337-823
6	55	1191	398-2488
7	1	1035	-
13	10	632	347-1210
16	9	653	306-1429
19	8	443	191-721
20	1	431	-
23	8	490	198-861
25	22	413	193-811
27	43	1106	279-3124
28	6	543	267-887
34	8	730	62-1254
35	8	814	15-1940
40	71	1024	376-3719
43	28	737	93-2957
44	1	1035	-
55	9	406	77-1056
TOTAL	296	898	15-3719

TABLE 20

Summary of Respirable Quartz Concentration by Plant
(November, 1972-February, 1973)

Plant #	# Samples	Average Conc. (μg/m3)	Conc. Range (μg/m3)	Average % Quartz
3	4	67	37-98	11.0
6	5	46	14-105	3.4
7	-	-	-	-
13	2	51	17-85	9.8
16	2	54	45-63	8.0
19	-	-	-	-
20	-	-	-	-
23	-	97	-	11.3
25	11	37	9-87	13.7
27	22	140	13-468	14.0
28	3	36	13-77	7.0
34	2	123	116-130	11.5
35	-	-	-	-
40	11	136	10-620	8.6
43	14	132	7-447	12.3
44	-	-	-	-
55	4	88	10-208	16.0
TOTAL	80	85	7-620	10.0

TABLE 21

Summary of First and Second Year Air Sampling Data

	Respirable Dust Concentrations				Respirable Quartz Concentrations			
	Number of Samples	Arith. Mean	Geometric Mean	Geometric Standard Deviation	Number of Samples	Arith. Mean	Geometric Mean	Geometric Standard Deviation
Total Samples Second year	296	900	770	2.3	83	97	53	2.6
Total samples First year	805	523	400	2.0	493	50	33	2.5
Total samples First and second year	1101	624	450	2.2	576	6.7	35	2.3

TABLE 22

Comparison of Two Years Sampling Data by Occupation

Occupation	Number of Samples (Dust)		% of Total Samples(Dust)		Dust Conc. Ratio $(\frac{\text{Year II}}{\text{Year I}})$	Quartz Conc. Ratio $(\frac{\text{Year II}}{\text{Year I}})$
	Year I	Year II	Year I	Year II		
Cutter	258	125	30	42	1.60	1.77
Sculptor	32	20	4	7	1.80	1.80
Polisher	98	7	11	2	1.20	0.38
Sandblast area	52	11	6	3	1.44	2.10
Contour,planer	48	7	6	2	1.38	2.7
Wire saw	97	21	11	7	1.90	-
Guillotine	17	6	2	2	3.54	-
Crane operator	4	4	<1	1	1.47	1.25
Lumper	10	1	1	<1	0.50	-
Dry polishing-buzzer	6	1	< 1	<1	0.75	-
* Cutter and pneumatic hand tool	-	181	-	61	1.50	1.90

TABLE 23

Comparison of Two Years Sampling Data by Plant

Plant	Number of Samples (Dust) Year I	Year II	% of Total Samples(dust) Year I	Year II	Dust Conc. Ratio (Year II / Year I)	Quartz Conc. Ratio (YearII/YearI)
3	21	8	2.5	3	1.14	1.86
6	21	55	2.5	19	1.57	0.55
13	20	10	2.5	3.5	0.75	0.56
16	3	9	1	3	0.93	0.57
19	34	8	4	3	1.89	-
23	9	8	1	3	1.12	2.85
25	56	22	7	7.5	1.31	1.80
27	17	43	2	14.5	1.27	1.93
28	15	6	2	2.5	1.38	0.81
34	15	8	2	3	1.45	2.46
35	20	8	25	3	3.31	-
40	80	71	10	24	1.92	2.42
43	21	28	2.5	10	2.08	2.36

Note: Plants #7 and 20 were omitted because they contained only one sample.

TABLE 24

Comparison of Cutters and Pneumatic Hand Tool Operators by Plant for Two Years Sampling Data

Plant	YEAR I No. of Samples	%	YEAR II No. of Samples	%
TOTAL	258	100	181	100
3	7		5	
6	12	4.7	21	11.6
7	2		1	
13	4		7	
16	2		2	
19	15	5.8	5	2.8
20	6		-	
23	5		2	
25	13		5	
27	5	1.9	20	11.5
28	6		2	
34	5		1	
35	3		2	
40	37	14.3	43	23.8
43	5		3	
44	3		1	