U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
CENTERS FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
MORGANTOWN, WEST VIRGINIA

HEALTH HAZARD EVALUATION DETERMINATION REPORT

GTA 81-205-1060

MUNSINGWEAR INCORPORATED
MINNEAPOLIS, MINNESOTA

September 1981

I. SUMMARY

A health hazard evaluation was conducted by the National Institute for Occupational Safety and Health (NIOSH) at Munsingwear Incorporated, Minneapolis, Minnesota, in April 1980. The purpose of the investigation was to evaluate the pulmonary effects of cotton dust exposure in knitting department personnel. The evaluation consisted of a site visit, review of medical and environmental surveillance programs and limited vertical elutriator dust sampling.

Systematic vertical elutriator (VE) dust sampling by Munsingwear showed no knitting department work area exceeding a mean time weighted average (TWA) of 0.220 mg/m^3 since the program was initiated in Spring 1980. NIOSH VE sampling in the two dustiest knitting areas demonstrated mean TWA's of 0.110 mg/m^3 and 0.140 mg/m^3, confirming the generally low level of dust exposure.

Review of company medical surveillance data revealed 63% of shift pulmonary function tests unacceptable by American Thoracic Socieity (ATS) criteria (6) in either or both preshift and postshift spirometry. Among ATS acceptable spirograms, baseline lung function was normal in 92% and shift drops in FEV_1 10% occurred in 14% of smokers and 7% of non-smokers. Chest tightness, work-related cough, dyspnea and asthma were not found in the knitting department population. Chronic cough and chronic phlegm were present only in smokers with prevalence rates of 20.4% and 16.7% respectively. These findings are not interpretable owing to methodologic problems encountered (refer section Discussion & Recommendations) and the absence of a control population.

Based on these findings, it is difficult for NIOSH to assess accurately the prevalence of respiratory morbidity among workers at this knitting site. Diminished operation and imminent closure of the facility preclude additional NIOSH evaluation. Respiratory morbidity data for the knitting industry would require a controlled, medical and environmental study of a random sample from the industry. Recommendations for improving similar surveillance systems are contained in the section Discussion & Recommendations.

II. INTRODUCTION

In March 1981 the Division of Respiratory Disease Studies, National Institute of Occupational Safety and Health (NIOSH) received a request for a hazard evaluation from the Amalgamated Clothing and Textile Workers Union (ACTWU). The request specified concern for respiratory morbidity from exposure to cotton dust in knitting machine operators, mechanics and other personnel of the knitting department. Advance notice was provided to Mr. Bradley McMahon, regional personnel supervisor, Munsingwear Incorporated, Minneapolis, Minnesota, and a site visit was performed during the interval April 12-15, 1981.

III. BACKGROUND

Munsingwear manufactures primarily men's and boy's sportswear at the plant under study. The manufacturing process includes yarn knitting and the following fabric processing operations: dyeing, drying, chemical treatment, pattern cutting and embroidery. Cotton dust exposure occurs only in the knitting operation where cotton containing spools of yarn are utilized. Input yarns include 70% cotton containing yarns (100% cotton and 50% cotton plus 50% polyester) and 30% purely synthetic yarns (e.g. lycra, nylon). Dust exposure in knitting department work areas appears to depend on several factors:

-- ventilation

-- work practices: blow down, housekeeping, respirator use

-- engineering features: creel rack fans, humidification system

-- process factors: machine density, measuring distance from machines, yarn composition, number of yarn inputs per machine, needle action.

In an effort to comply with 29 CFR Part 1910.1043 governing cotton dust exposure in the hosiery industry, Munsingwear established a medical and environmental surveillance program in April 1980 for the knitting division. Medical testing has included shift spirometry and respiratory questionnaire data, and environmental surveillance has utilized semi-annual VE sampling of knitting work areas.

IV. EVALUATION CRITERIA

The criteria recommended for evaluation of pulmonary function in the Cotton Dust Standard were selected for purposes of routine and periodic screening or surveillance and not as criteria to generate a data base for epidemiologic research purposes. Since an objective of this review is to ascertain epidemiologic data, however, evaluation of pulmonary function

information collected under screening criteria is inappropriate. Application of epidemiologic or research criteria to the pulmonary function data is required in order to establish a set of information meeting certain quality standards. The quality standards to be employed are minimum standards for spirometry established by the American Thoracic Society (6) and criteria for interpretation of lung function studies to be employed are those of the Intermountain Thoracic Society (8).

The OSHA standard for occupational exposure to cotton dust is contained in 29 CFR 1910.1043. It states that no employee should be exposed to airborne concentrations of lint-free, respirable cotton dust greater than 0.5 mg/m^3 averaged over an 8 hour period as measured by vertical elutriator (2). The NIOSH recommended standard is 0.2 mg/m^3 lint-free cotton dust and is based on data collected from primary cotton processing operations (1).

V. METHODS

Company derived medical surveillance information was collected by NIOSH investigators and consisted of pre- and postshift spirometry (FEV_1,FVC) and respiratory questionnaire data modeled on the cotton dust standard, pulmonary symptom prototype. To assess the technical quality of the pulmonary function data, Ohio 822 volume-time spirograms were reviewed for compliance with ATS standards.

Tracings were classified into ATS acceptable and ATS unacceptable categories with violated criteria enumerated for the latter. Misclassification of pulmonary function status among ATS acceptable cases resulting from company errors in spirometric calculations was evaluated by comparing company and NIOSH computations.

Description of baseline and shift changes in FEV_1 and FVC was only possible for individuals with ATS acceptable tracings. In this group the findings are stratified by smoking status -- dust exposure years and smoking status alone. The low level of dust exposure obviates any attempt to derive meaningful dose-response relationships other than by utilization of knitting division tenure as a measure of cumulative dust exposure. Predicted values for FEV_1 and FVC are those of Knudson (9) and are adjusted for age, sex, race and height.

Respiratory symptom data are presented for all individuals having a completed questionnaire. These data are also reviewed according to smoking status and cumulative dust exposure.

Dust sampling by NIOSH was limited to the two areas identified as posing highest exposures according to Munsingwear environmental compliance data, i.e., rib machine and positive feed areas. Small NIOSH VE's were placed in these locations over first and second shifts for a three day period yielding six samples from each site. Mean TWA's resulting from the sampling are reported and compared to compliance data for these areas.

VI. RESULTS

A. Demographic Characteristics of Knitting Department Personnel

Munsingwear's Knitting department employs 103 persons. Workers are predominantly female (75%) and caucasian (78%). The mean age of this population is 37.4 years and mean tenure is 6.7 years. The distribution of workers by smoking status is 53% current smokers, 39% never smokers and 8% ex-smokers.

B. Epidemiologic Quality of Medical Surveillance Data

Of 103 cases reported by Munsingwear 63% were judged unacceptable by ATS criteria in either or both preshift and postshift spirometry (Table 1 Appendix). This rejection rate results in only 52 suitable persons for assessment of baseline lung function and 38 for assessment of shift-related changes in FEV_1.

ATS criteria violations per case were frequent and often multiple. The more common problems noted included: improper back extrapolation to time zero (32%), early termination of expiration (29%), excessive variability of FVC among acceptable curves (23%) and submission of incomplete curve(s) for analysis (17%) (Table 2 Appendix). While evaluation of misclassification among unacceptable cases was not possible, misclassification of pulmonary function status in the ATS acceptable group occurred in only two cases. Both individuals were notified as having abnormal pulmonary function due to miscalculations from spirogram tracings.

C. Criteria for Interpretation of Spirometry: Company Surveillance vs Intermountain Thoracic Society

Table 3 illustrates differences in criteria used to interpret simple spirometry in company surveillance and NIOSH research. Criteria for abnormality of FEV_1/FVC ratio and shift changes in FEV_1 are more sensitive and less specific in the surveillance program than in that utilized by NIOSH in its field investigations. This results in a greater proportion of individuals being initially classified as abnormal by the surveillance criteria. For example, among the 52 ATS acceptable preshift tracings, 40% are abnormal by surveillance criteria whereas only 8% are judged abnormal by NIOSH research criteria (Table 4 Appendix).

D. Prevalence Rates for Normal & Abnormal Preshift Pulmonary Function

Exact prevalence rates cannot be generated from these data owing to the frequency of uninterpretable spirograms. The distribution of lung function can be described, however, for those cases with ATS acceptable preshift spirometry, i.e. 52 persons. In this population baseline lung function is normal in 92% and abnormal in 8% using epidemiologic criteria (Table 4 Appendix).

E. Pulmonary Function for ATS Acceptable Spirometry

ATS acceptable preshift spirometry was available for 52 persons, including 24 smokers, 24 non-smokers and 4 ex-smokers. Baseline lung function by smoking category is illustrated in Figure 1 Appendix and shows decreased mean % predicted FEV_1 and FVC for smokers compared to non-smokers. Figure 2 Appendix stratifies this group by both smoking status and total years of dust exposure. It demonstrates reduced baseline lung function for both FEV_1 and FVC with greater exposure tenure in each smoking category. Student's t-test for these differences, however, shows them not to be statistically significant.

Table 5 illustrates shift changes in FEV_1 and FVC among persons with ATS acceptable pre- and postshift spirometry by smoking status. While smokers tend to exhibit greater changes in FEV_1 and FVC over a shift, the changes are not statistically significant. Further stratification of this group by exposure tenure was not performed because numbers per cell were correspondingly smaller, variances larger and interpretation therefore of little value. Table 6 describes the four cases showing greater than 10% drops in FEV_1 over a shift. While their number is quite small no discernible pattern for exposure tenure or smoking status is evident.

F. Respiratory Symptoms Among Knitting Department Personnel

Table 7 Appendix describes the distribution of respiratory symptoms among knitting employees. A 0% prevalence rate was found for chest tightness after greater than 40 hours away from the work area as well as for work-related breathlessness, cough and asthma. Prevalence rates (%) for chronic cough and chronic phlegm were 20.4% and 16.7% for smokers and 2.5% and 0% for non-smokers. Differences in prevalence rates for chronic cough and chronic phlegm among smokers by exposure category were examined (Table 8 Appendix) and found not to be statistically significant.

G. Environmental Surveillance Data

Munsingwear's environmental surveillance program for dust exposure consists of semi-annual VE sampling of knitting department work areas. The instrument used is a General Metal Works Company VE with a 7.41 L/min. critical orifice. Filters employed are millipore SM mixed cellulose ester filters which are <u>not</u> recommended for gravimetric analysis due to their tendency to accumulate water. Nevertheless, results of this surveillance program show no area exceeding a mean TWA of 0.220 mg/m^3 (Table 9 Appendix).

NIOSH sampling of the two highest dust exposure areas confirmed the generally low level of dust in the knitting department. NIOSH small VE's employing polyvinyl chloride filters revealed mean TWA's below 0.140 mg/m^3 (Table 10 Appendix).

VII. DISCUSSION & RECOMMENDATIONS

Medical Surveillance

Munsingwear's medical surveillance program is compliant with all aspects of the mandates of 29 CFR Part 1910.1043. Testing is diligent and routine including pre-employment, shift and re-test scheduling. Pulmonary function test administration, however, is shown to be technically deficient. This is manifested by a significant proportion of unacceptable tracings by the ATS minimum set of quality standards.(6) The result is inappropriate interpretation of poor tracings and a cost factor that includes for abnormals in this group individual anxiety regarding health status and larger numbers for retesting and follow-up than is necessary. Since most technical errors noted tend to underestimate an individual's true lung function, this is quite likely to be the case.

The best estimates of the true distribution of pulmonary function in knitting department employees are those provided by ATS acceptable spirograms. Application of Intermountain Thoracic criteria to this population (Table 4) shows 92% with normal and 8% with abnormal baseline pulmonary function. Shift drops in FEV_1 greater than 10% for ATS acceptable spirograms occurred in 14% (3/21) of smokers and 7% (1/15) of non-smokers (Table 5). The significance of these findings is unclear in the absence of a suitable control population, even if it could be assumed that ATS acceptable spirograms were a random, unbiased sample of the entire population.

In contrast to the pulmonary function data, respiratory symptom data was available on the entire population. Analysis of this information reveals the absence of dyspnea, chest tightness and work-related cough, dyspnea and asthma. Symptoms of chronic cough and chronic phlegm were present only in smokers with prevalence rates of 20.4% and 16.7% respectively. Among smokers the presence of symptoms appeared to be independent of total years of dust exposure. Interviewer bias and consistency in questionnaire administration are important considerations in the assessment of symptom data and could not be evaluated after the fact.

Environmental Surveillance Program

Munsingwear's environmental program was technically satisfactory and consistent with the requirements of the Cotton Dust Standard. Although filters utilized in the gravimetric analysis are not recommended, both company and NIOSH measurements demonstrate a low level of dust exposure, considerably below the 0.500 mg/m^3 TWA ceiling established in 29 CFR 1910.1043.

VIII. RECOMMENDATIONS

Methodologic problems in pulmonary function testing prevent a meaningful interpretation of the findings from this cotton dust surveillance program. The absence of a control population further limits the utility of the data. Irrespective of these considerations, the data cannot be used to derive inferences about the knitting industry in general since the population is neither a random sample of all knitting industry workers nor representative of exposures throughout all work sites. With further technical training and adherence to accepted standards of pulmonary function testing, the medical surveillance program can be both less costly and significantly improved as a screening program and epidemiologic tool.

The current phase out of operations at this plant prevents further NIOSH evaluation. To generate the epidemiologic data necessary for an assessment of respiratory morbidity in the knitting industry, the following is recommended:

1. Assessment of an industrywide random sample by environmental sampling and medical testing in accordance with standards utilized by NIOSH in its epidemiologic investigations, including appropriate control groups. Environmental characterization might include VE time motion studies, particle sizing, high volume sampling and dust component analysis, and endotoxin assessment in study and control areas.

Other recommendations for industry surveillance are:

3. Further training for nurses or technicians administering pulmonary function tests in ATS standards for spirometry and spirogram interpretation, such as would be provided by attending a NIOSH approved course.

4. Use of screening criteria recommended in the Cotton Dust Standard (4) in particular FEV_1 greater than 80% of predicted.

5. Use of polyvinyl chloride filters in VE sampling measurements.

6. Development of a follow-up protocol for workers referred for clinical evaluation based on company screening.

IX. REFERENCES

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X. AUTHORSHIPS AND ACKNOWLEDGEMENTS

Report prepared by:

Martin-Jose Sepulveda, M.D., MPH
Clinical Investigations Branch
DRDS, NIOSH
Morgantown, WV

Laurie Piacitelli, IH
Environmental Investigations Branch
DRDS, NIOSH
Morgantown, WV

Originating Office:

Alan L. Engelberg, M.D., M.P.H.
Coordinator, Mining Hazard Evaluation and Technical Assistance Program
DRDS, NIOSH
Morgantown, WV

Acknowledgements:

Bradley McMahon
Regional Personal Director
Munsingwear Incorporated
Minneapolis, MI

James Mangan
Amalgamated Clothing & Textile Workers Union
Minneapolis, MI

John L. Hankinson, Chief
Clinical Investigations Branch
DRDS, NIOSH
Morgantown, WV

Connie Boyles, Pulmonary Investigator
Clinical Investigations Branch
DRDS, NIOSH
Morgantown, WV

Aremeta Watson Statistican
Epidemiogical Investigations Branch
DRDS, NIOSH
Morgantown, WV

Kay Basile, Secretary
Clinical Investigations Branch
DRDS, NIOSH
Morgantown, WV

TABLE 1

EVALUATION OF KNITTING DEPARTMENT MEDICAL SURVEILLANCE PROGRAM: APPLICATION OF ATS MINIMUM SPIROMETRIC STANDARDS*

ATS ACCEPTABLE SPIROGRAM SETS	NUMBER	% TOTAL
1. Pre- and post-shift	38	37%
2. Pre-shift only	14	14%
3. Post-shift only	17	16%
4. Neither	34	33%
TOTAL	103	100%

* American Thoracic Society, Amer Rev Resp Dis, 119(5):2-11, 1979

MISCLASSIFICATION OF PULMONARY STATUS AMONG ATS ACCEPTABLE CASES

STATUS	COMPANY (Number)	NIOSH # Correctly Classified	Correct Status of Misclassfied		
			A	B	C
A	15	15	—	—	—
B	21	19	2	—	—
C	2	2	—	—	—
TOTAL	38	38			

TABLE 2

DISTRIBUTION OF UNACCEPTABLE SPIROGRAM SETS ACCORDING TO UNMET CRITERIA

A. Criteria Invalidating Trial Set

Criteria	% of Cases*
i. Early termination of expiration	29%
ii. Excessive variability of FVC among acceptable curves	23%
iii. Incomplete curve(s) submitted	17%
iv. Recorder turned off during expiration	7%
v. Excessive variability of effort during a single trial	6%

B. Criteria Not Invalidating Trial

i. Absent/improper back extrapolation	32%

* % cases = $\frac{\text{number of cases in which observed}}{\text{total number cases tested}} \times 100$

TABLE 3

INTERPRETATION OF PULMONARY FUNCTION TESTS:
COMPANY COTTON SURVEILLANCE versus NIOSH EPIDEMIOLOGIC CRITERIA

Test	Company	NIOSH
FEV_1/FVC %	Greater than 80%*** equal to	Greater than 69% *
% Pred FVC	None	Greater than 81% * equal to
Shift Change: FEV_1	Greater than 5%	Greater than 10% **

*: Intermountain Thoracic Society, 1975

**: Organizing Committee Nat'l Conference Cotton Dust & Health, Arch Env Hlth 23, 1971

***: The Cotton Dust Standard does not use FEV_1/FVC % as a parameter for surveillance. Rather, it suggests the use of % Predicted FEV_1 80%

DISTRIBUTION OF PRE-SHIFT LUNG FUNCTION AMONG KNITTING PERSONNEL: COMPANY COTTON SURVEILLANCE vs. NIOSH CRITERIA

Lung Function Status	Company Criteria		NIOSH Criteria	
	ATS	TOTAL*	ATS	TOTAL*
Normal	17	36 (35%)	30	64 (62%)
Abnormal	21	21 (20%)	8	8 (8%)
Undetermined	65	46 (45%)	65	31 (30%)
	103	103 (100%)	103	103 (100%)

*: Population includes:

i. ATS acceptable spirometry

ii. ATS unacceptable spirometry with errors underestimating true lung function yet yielding normal % pred FVC and FEV_1/FVC ratio

DISTRIBUTION OF PARTICIPANTS BY COMPANY NOTIFICATION STATUS* AND % IN EACH STATUS MEETING ATS CRITERIA

	COMPANY	ACCEPTABLE BY ATS CRITERIA	
Status	Number	Number	% of Given Status
Total	103	38	37%
A	58	15	26%
B	43	21	49%
C	2	2	100%

* Company Notification Criteria:

A: Normal test: preshift

shift change in FEV_1

B: Abnormal test: preshift 60%

shift change in FEV_1

C. Chest consult suggested:

FEV_1/FVC %

TABLE 4

Pre-Shift Lung Function Among Knitting Personnel With ATS Acceptable Spirometry: Company Cotton Surveillance Criteria vs. NIOSH Epidemiologic Criteria

Lung Function Status	Surveillance Criteria	Epidemiologic Criteria
	Number (% total)	Number (% total)
Normal	35 (67%)	48 (92%)
Abnormal	17(33%)	4 (8%)
TOTAL	52 (100%)	52 (100%)

TABLE 5

MEAN SHIFT CHANGES IN FEV_1, FVC AMONG ATS ACCEPTABLE SPIROGRAMS BY SMOKING STATUS

Parameter	Smokers	Non-Smokers
Number	21	15
Mean % Change FEV_1*	-0.87	2.19
±SE	8.57	9.49
Mean % Change FVC*	-1.63	-0.94
±SE	4.36	5.69
Change FEV_1, Greater Than 10%, No. (%)	1.0 (7%)	3.0 (14%)

* Mean % Change FEV_1 or FVC = MEAN POSTSHIFT FEV_1 - MEAN PRESHIFT FEV_1

TABLE 6

Characteristics of Cases Demonstrating Greater Than 10% Decrements in FEV_1 Over a Shift Among ATS Acceptable Spirometry

Case Number	Tenure (Yrs)	Smoking Status*	% FEV_1	%Pred FVC	FEVR**
1	11.3	SM	-13%	81%	85%
2	3.5	NS	-14%	98%	86%
3	1.1	SM	-11%	109%	82%
4	1.6	SM	-15%	110%	78%

*: SM = Smoker
NS = Never Smoker

**: $FEVR = \frac{FEV_1}{FVC}$ %

TABLE 7

Prevalence Rate (%) of Symptoms by Smoking Status Among Knitting Employees

Symptom*	Smoker	Non-Smoker
Number	54	40
Chronic Cough	20.4%	2.5%
Chronic Phlegm	16.7%	0%
Chest Tightness	0%	0%
Breathlessness	0%	0%
Work-Related	0%	0%
Breathlessness	0%	0%
Cough	0%	0%
Asthma	0%	0%

*Symptoms defined by positive answers to the following questions in the Munsingwear respiratory questionnaire:

Chronic cough	Q #33
Chronic phlegm	Q #38
Chest tightness	Q #47
Breathlessness	Q #54
Work-related:	
Breathlessness	Q #59
Cough	Q #34
Asthma	Q #64 (negative answer)

TABLE 8

Prevalence Rates of Chronic Cough, Chronic Phlegm
for Smokers by Dust Exposure-Years

	EXPOSURE-YEARS		
Symptom	0-4	4	All
Number	36	18	54
Mean Pk-Yrs	18.2	20.6	18.9
Mean Age (Yrs)	29.5	42.4	33.8
Chronic Cough* (%)	17%	28%	20.4
Chronic Phlegm* (%)	14%	22%	16.7

*: Differences among exposure categories are NOT statistically significant by analysis.

TABLE 9

MUNSINGWEAR ENVIRONMENTAL SURVEILLANCE PROGRAM: 1980, 1981

DATE	AREA	NO. SAMPLES*	MEAN TWA (Mg/m^3)	RANGE (Mg/m^3)
4/80-5/80	Bldg. 6 Dubbies	9	0.048	0.011-0.078
	Stripers	3	0.074	0.053-0.097
	Bentleys	3	0.071	0.047-0.106
	Bldg. 7 Positive Feeds	21	0.220	0.115-0.331
	Brintons	7	0.175	0.142-0.205
	Bldg. 1 Ribbers	7	0.123	0.091-0.128
	Interlocks	3	0.138	0.101-0.177
	Tubers	2	0.107	0.075-0.138
2/81	Bldg. 7 Brintons	7	0.160	0.109-0.201
	Positive Feeds	18	0.206	0.144-0.330
	Bldg. 1 Ribbers	6	0.182	0.127-0.262
	Interlocks	3	0.212	0.098-0.155
	Tubers	3	0.102	0.076-0.146

*: Number of samples obtained per area are directly related to the number of workers employed in a given area.

TABLE 10

Environmental Surveillance Data:
Company Compliance vs. NIOSH Sampling

DATE	AREA	COMPANY* NO. SAMPLES	COMPANY* MEAN TWA (mg/m^3)	NIOSH** NO. SAMPLES	NIOSH** MEAN TWA (mg/m^3)
4/80-5/80	Bldg. 1 Ribbers	7	0.123	___	___
	Bldg. 7 Positive Feeds	21	0.220	___	___
2/81-3/81	Bldg. 1 Ribbers	6	0.182	6	0.110
	Bldg. 7 Positive Feeds	18	0.206	6	0.140

*: Large Vertical Elutriator, 6 or 8 hr. TWA, Millipore SM Mixed Cellulose Ester Filters

**: Small Vertical Elutriator, 6 hr. TWA, Polyvinyl Chloride Filters

Demographic Characteristics of Knitting Department Personnel

Feature		Number/%
Population		103
Mean Age (Yrs)		37.4 Yrs
Sex	M	26%
	F	75%
Race	C	78%
	B	17%
	O	6%
Smoking:	Smokers	54%
	Never-Sm	39%
	Ex-Sm	8%
Mean Tenure		6.7 Yrs

Prof. s of ATS Acceptable and
ATS Unacceptable Groups

	Acceptable	Unacceptable
Number	52	51
Age (Yrs)	37.8 Yrs	38.8
Tenure (Yrs)	7.48 Yrs	6.53 Yrs
Sex: % F	74%	76
Race: % C	83%	78%
Smoking:		
% Smokers	53%	58%
% Non-Smokers	43%	28%