Byssinosis and Chronic Respiratory Disease in U.S. Cotton Gins

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A pilot study of cotton gin workers was undertaken in the ginning industry so as to determine if a definitive study could be undertaken and to make some first order estimates of byssinosis and chronic respiratory disease and to compare the findings to those reported in the African and European gins.

Baseline medical data were collected on 203 gin workers and 260 controls, consisting of a medical symptom questionnaire, a chest x-ray and the forced expiratory spirogram pulmonary test. Results revealed a prevalence of functional reactors equal to that found in the textile industry and other gin studies (44%) as determined by spirometric testing, without any association to smoking history. The major reaction group within the ginning population was those working in the baling press area. These same workers demonstrated evidence of chronic depressions in their spirometry data. No excess of chronic respiratory disease as determined by the questionnaire was detected within the gin worker population.

No one to date has attempted to measure the magnitude and severity of byssinosis among cotton gin workers in the United States.

Such a study in this country is important in light of some results of pertinent research abroad. Egyptian[1] and Sudanese[2] gin workers have demonstrated a comparable prevalence rate to textile mill employees in Great Britain and the United States. Although byssinosis was not detected in a limited study of 70 Greek gin workers, an increased prevalence of chronic respiratory disease (CRD) was noted. Gilson's[4] study of cotton gins in Kenya revealed that although functional reactions were present in workers exposed to dust, no symptomatology consistent with byssinosis was obtained. This finding was because of language difficulties experienced with native workers.

One would expect a gin worker to be as vulnerable to byssinosis as the textile worker, inasmuch as the causative agent is apparently present in the cotton bracts[5] (the plant leaves at the base of the cotton boll). Exposure to this waste product also would seem to be as great in the ginning process. This step separates the seeds and contaminants from the lint with a consequent production of strikingly high dust concentrations, as in any later procedures handled at the mills.

Three questions were addressed in developing this study: Would a byssinosis prevalence study of U.S. gin workers be feasible? If a study is undertaken in light of known serious limitations in employer-employee cooperation and available survey methodologies, what kinds of interpretations can one achieve? Are the prevalence inferences so obtained on acute and chronic symptoms and spirometry findings similar to that reported in African and European gins?

Feasibility of a Study

Of the several large cotton-producing areas in the United States, at least seven distinct regions were identified: California, Arizona, New Mexico, Texas High Plains, Lower Rio Grande Valley, Mississippi Valley, and the Southeastern States. Since the 1970 Occupational Safety and Health Act was not yet in effect, the choice of study locations was dictated by practical considerations such as initial contacts in the area, local cooperation, right of entry, and growing season. In light of these factors, gins located in the Lower Rio Grande Valley of Texas and the Las Cruces-El Paso areas of New Mexico were selected for possible study.

After numerous discussions and visits to the two regions, we concluded that the controlling factors which would limit the size of the gin worker sample were related directly to three factors: the short ginning season and its subsequent effect on the availability of workers; the erratic nature of the industry's hiring practices re-

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lated to the industry's unpredictable work schedules; and the large number of widely dispersed gins in the two regions.

Taking these factors into account, the proposed plan was to test about 200 male gin workers in each of the two regions to obtain baseline data and a retest at least six hours into the workshift, and to track respiratory data on each worker through the ginning season in order to obtain a measure of the incidence of reaction.

Several of the individual gin operations worked in groups or cooperatives. Most of these had a permanent body of workers who were employed year-round in other activities within the cooperative when ginning was not in season. It was only from these groups of gin workers that a definable preexposure group was accumulated. The study design called for a sample of gin workers to be obtained from both gin cooperatives and independent gins. But attempts to elicit participation were met with only limited success since several gins refused to participate in the survey. To avoid the possibility of a potential bias from using workers only from those gins which chose to participate in the study, six gins were selected randomly from the nonparticipating group, three being from each geographical area. An industrial hygiene survey was performed subsequently. We proposed that comparisons of dust concentrations between participating and nonparticipating gins would permit an assessment of the representativeness of the participating cotton gins.

The questionnaire proposed for this study was a modified version of the Duke University textile mill questionnaire[6] with minor alterations made to reflect the change in target population (i.e., gin workers as opposed to textile workers). A Spanish translation also was used since we determined that many of the gin workers spoke only Spanish. The questionnaire was administered by an interviewer in either Spanish or English rather than self-administered, because we anticipated that many in the sample population would be illiterate. For related reasons, a motivational spirometry system was used, and a portable spirometer was included as a back-up if the electronic system would become inoperative. An Ohio 800 electronic spirometer was used for the collection and computation of the spirometry data. This automated spirometry system was modified to include a panel of motivational lights, and interfaced to a digital computer that assisted the technician with quality control decisions and calculated the spirometric measurements.[7] The system also permitted a permanent spirometric record of the analog flow and volume signal to be made as a back-up to the computer tape. A portable Jones Spirometer, cross-calibrated with the Ohio 800, also was carried as a back-up to the electronic systems. Because of the emerging logistics problems we encountered in the field, the portable spirometer was not used as a back-up, but to collect data remotely from the trailer unit as the need dictated. Eighteen percent of total data was collected in this way.

In addition to the questionnaire information and spirometry data, a posterior-anterior chest roentgenogram was taken on each examinee to rule out confounding chest pathology.

It was easier to obtain the cooperation of gin operators for environmental studies as compared with the medical tests described above. The environmental monitoring progressed without interrupting the workers' production, and the medical tests required that the workers leave their jobs for at least 15 to 20 minutes. Environmental sampling was done to determine the concentrations (by weight) of airborne particulates in the respirable range. It was anticipated that such concentrations could be correlated to the results of the medical portion of the study. Personal monitors were placed on those gin employees predominantly confined to the immediate gin environment, and these were operated for eight hours of the 12 hour working shift. The personal sampler consisted of a battery-powered pump, a Gelman Type VM-1 polyvinyl chloride membrane filter in a suitable holder, and an aluminum tube vertical elutriator, operating at a flow rate of 1.7 liters per minute, the particle cutoff being 30 μm. Battery operation limited the sampling time to no longer than eight hours. A maximum of five area samplers (large vertical elutriators) were operated at selected sites, such as areas of congregation, frequently used passages, operator stations, and areas along the gin stands and other equipment locations. The particle size cutoff of 15 μm for the area samplers was accomplished by using a Type VM-1 filter preceded by a vertical elutriator, running at a flow rate of seven liters per minute. To alleviate problems associated with varying relative humidity, filters were equilibrated in a dessicator for 24 hours prior to being weighed using Khan Gram Electrobalance. (A radioactive ionizing unit minimized electrostatic attraction.) In general, the environmental protocol proceeded as planned.

The field operations supervisor (FOS) provided the main interface between gin management and the examination team. Because cotton ginning is seasonal work, the FOS had to watch the ginning industry's schedule closely, and to inform the survey team when a gin within the sample was hiring and when it expected to begin ginning. This technic permitted the medical examination trailer to locate at the particular gin and obtain the necessary data. In order to obtain baseline studies on gin workers before exposure to cotton dust, initial testing was done prior to the beginning of the season on those gin workers already working around the gin (preparing the equipment for the ginning season). Typically, the ginning season begins with intermittent ginning, requiring only enough workers to man one 12 hour shift. Itinerant workers who routinely turn up at the gin daily are usually hired as the volume of ginning increased. By the third week of the 1970 season, ginning was at its peak, requiring around-the-clock operations (12 hour shifts, seven days a week). The peak in the Texas region preceded the New Mexico region by about six weeks. The only exception to this routine was when rain prevented the harvesting of cotton, thus reducing or precluding the supply of cotton to the gin. Followed closely, such rain breaks permitted a 24 to 36 hour "out-of-dust" measurement on those gin workers who had been hired on the spot after the season had begun and who consequently had no baseline data.

We found it very difficult to locate and to test gin workers in the traditional manner for a byssinosis study; that is, on a Monday following a weekend off work. Therefore, a modified testing routine was developed to permit byssinosis prevalence assessment in a manner as close as possible to that described in prevalence surveys conducted in the textile industry (i.e., measurement of the forced expiratory volume at one second (FEV_1), six hours into a workshift, following two or more days off). The revised model required a reliable baseline FEV_1 measurement whenever ginning circumstances permitted.

Three types of tests were accepted as baseline values. An "A" test represented data obtained on an examinee prior to the start of the ginning season (as indicated above this sample segment was generally located at gin cooperatives). This segment was relatively small since most workers were hired without advance notice from a labor pool daily, and in increasing numbers as the volume of ginning increased. A "B" test was obtained on a worker before he reported for work, after he had worked the previous day; consequently, he experienced only 12 hours of "out-of-dust" conditions. This "B" segment represented most of the sample data. A

"C" test was a preshift measurement obtained after a 24 to 36 hour break. The "C" tests were relatively scarce also, since they could only be obtained when inclement weather forced a temporary halt to the ginning schedule. All study group subjects in the sample had "in-dust" questionnaire and spirometry tests, usually obtained six hours after the beginning of the work shift in accordance with the protocol.

Observation of FEV_1 decrements to identify acute reactors entailed comparison of an "out-of-dust" measurement (A, B, or C test) with an "in-dust" measurement. To assure further comparability, a pair of "out-of-dust"/"in-dust" tests were used only if both measurements were made on the same spirometer. Survey logistics problems compromised our objective of obtaining a sample of 400 study subjects. Only 286 gin workers had "out-of-dust" and "in-dust" tests. After about three weeks of testing, all attempts to track gin workers through the season were abandoned since the worker turnover was astoundingly high.

Chronic respiratory disease (CRD) was defined by selected responses on the symptoms questionnaire and baseline spirometry results compared with predicted values. To determine the prevalence of CRD as exhibited by spirometric abnormalities, baseline FVC and FEV_1 from several baseline tests (A, B, or C) were averaged for those several examinees who had undergone multiple "out-of-dust" measurements. This averaging was done to reduce temporal fluctuation of the data and learning effects caused by repetitive testing.

In spite of considerable effort to explain the test and motivate the subject, about 30% of the workers (83/286) did not provide a reliable baseline spirometry test. "Reliability" of the test was deemed to have been met in a given test sequence of five trials when the best trial, as chosen by a ten parameter Best Trial Score,[7] satisfied both the following criteria: (1) The forced vital capacity (FVC) was within 5% of at least one other FVC in that sequence, and (2) The FEV_1 values of the best and second best trials, as selected by the above criterion, were within 5% of each other. For the byssinosis prevalence analyses, two reliable test pairs of spirometry data were required, one "out-of-dust" and the other "in-dust." Only about 50% (138/286) of the gin workers met that criteria.

To facilitate a meaningful analysis of the data, gin workers were categorized according to the area in which they worked. Gin stand workers were those who looked after the ginning machines and their helpers (i.e., ginners and ginner helpers). Pressmen were those who managed the baling presses and loaded the bales (i.e., pressmen and balemen). The "other" classification contained a variety of job categories, such as scalemen, yardmen, suctionmen, seedmen, trackmen, and lint fly men. Each of these people frequently moved in and out of these job categories and consequently their long-term exposure to cotton dust was not measurable. Control subjects were drawn from the same two regions concurrent to the testing of gin workers.

Approximately two controls (442) for each gin worker were examined to permit the gin population to be matched on race, age, and smoking histories. Unfortunately, no match could be obtained for the socioeconomic variable (poor and relatively uneducated). Investigations into various occupational groups revealed that workers of like socioeconomic status to gin workers usually worked in the dirtier plant processes of other industries where significant environmental exposures prevailed. Controls were obtained from high schools, national guardsmen (those whose civilian jobs were confined to dust-free industries), and civil service personnel. Data from these tests were used to compare the ambient level of CRD prevalence and chronic FEV_1 and FVC changes with that of gin employees, as well as to examine if values predicted for Caucasians were valid for this population.

Of the 442 controls tested, only about 80% (346/442) demonstrated reliable pulmonary function tests. These data were stratified by age, race and smoking history, and excess examinees were removed randomly from appropriate strata until parity had been obtained to that of the equivalent strata of gin workers. The resulting control population of 260 is compared to gin workers in Table 1. Both groups are similar with respect to percent of whites (14% versus 12%), percent of smokers (52.3% versus 49.3%), percent of previous smokers (19.2% versus 18.7%), and mean age (36.1 years versus 36.3 years), respectively. Pack-years* experienced by the smokers and previous smokers are also similar for the two groups. The one main variable that is different between the groups is the gin stand workers average of 8.8 years of exposure to cotton dust.

Of primary concern was the possibility that the spirometric prediction equations used in this study were not applicable to a Mexican-American population, or that Mexican-Americans might react differently to cotton dust than whites. To resolve these questions, nonsmoking white controls were compared with nonsmoking nonwhite controls. The whites had a mean FVC of 93.0% of predicted values, whereas nonwhites had 96.3%. For FEV_1, whites had a mean of 92.5% of predicted versus 94.3% for the nonwhites; both had a mean FEV_1/FVC ratio of 0.83. None of these differences were significant statistically at the 0.05 level. This was taken as evidence that the predicted FEV_1 and FVC equations used were not inappropriate for either race, even though they were based on an all-white nonsmoking population.

A review of the smoking history by race revealed that 44% of the white gin workers were smokers as opposed to 50% of the nonwhites, yet the white exhibited three times the mean pack-year value of the nonwhites (34.4/11.4). This indicates that although a larger number of nonwhites smoke, their intensity of smoking was significantly less than their white counterparts. Because of these confounding differences, along with the small number of white ginners (12%), and the fact that the prediction equations seemed to be independent of race, no further analysis by race was attempted; consequently, data from both races were merged. The merge was justified further after examination of the prevalence of ΔFEV_1 reactors, which showed there were no significant differences between the two races ($p > 0.05$).

Byssinosis Estimates Based Upon Feasibility Study Data

We concluded from this experience that: a definitive byssinosis prevalence study in the U.S. gin industry would be feasible; a better cooperation of gin operators and workers is achievable now; a logistics plan deploying many portable spirometers would be an improvement in the testing methodology; and a certain segment of gin workers are so mobile so as to preclude all reasonable efforts to track them through a significant portion of the season. We also concluded that the baseline data we obtained on 203 gin workers, the acute reactor data obtained on 138 gin workers, and the comparison data on 346 controls from the same two regions constituted a data set suitable for a first order estimate of byssinosis prevalence, including the extent of CRD resulting from chronic exposure.

Classically, byssinosis is defined in a worker when he gives positive responses to questions on chest tightness and

*A pack-year is equal to one pack smoked per day for one year.

Table 1. — Distribution of Gin Worker and Control Groups.

	Gin Stand	Baling Press	Others	Total Gin Workers	Controls
Total persons in group	47.0	42.0	112.0	203.0	260.0
Mean age (years)	39.7	33.8	35.4	36.3	36.1
Mean number of years ginned	13.1	7.2	7.9	8.8	—

breathlessness that occur several hours into a workshift after he has not worked for one or more shifts.[8]

Negative responses to the byssinosis questions consistently were given by every gin worker in the sample, resulting in a clinical prevalence rate of zero. The data gathered during the aborted tracking effort also yielded no positive responses on questionnaires. However, as shown in Table 2, when the functional grading system recommended by Bouhuys[8] for classification and management of exposed workers was used to grade the forced expiratory spirogram measurement data, it appears to show that both acute and chronic reactions are occurring in a significant number of workers not reporting typical symptoms.

A prevalence of 18.7% was found using the Bouhuys cutoff based upon "out-of-dust" to "in-dust" decrements in FEV_1, where the latter was measured within 48 hours of the former. (The "in-dust" measurement for each worker was usually taken four to six hours into the 12 hour shift.)

Table 3 presents the distribution of reactor prevalence rates by smoking category and degree of reaction using the data on the 80 gin workers retested within 48 hours. An overall prevalence of 34% was demonstrated, with moderate reactors ($\Delta FEV_1 > -5\%$ to -10%) contributing 25%, and severe reactors ($\Delta FEV_1 > -10\%$), 9%. When stratified by smoking history, exsmokers and nonsmokers demonstrated the lowest prevalence of reaction (28% and 20%). Light smokers (<10 pack-years) show a prevalence of 52%, whereas heavy smokers (>10 pack-years) have a prevalence of 34%. Differences between smoking groups were not significant at the 0.05 level.

If one does not restrict the time interval between the two FEV_1 measurements, a total reactor prevalence of 44% is obtained as given in Table 4. When the prevalence rate was examined by severity of reaction, it was observed that moderate reactors made up 27%, and severe reactors, 17%. The table also demonstrates a trend of greater severity of reaction and smoking history ($p < .001$).

Table 2. — Functional Grade Classification (F) of 48-Hour Reactors.

Grade	Predicted	48-Hour ΔFEV_1%	No. of Persons
F0	>80	4 to 0	45
		-9 to -5	15
		>-10	7*
F1	60-79	-4 to 0	5
		>-5	4*
F2	<60		4*
Total			80

*18.7% (7 + 4 + 4/80) of the population fell into categories recommended by Bouhuys as needing further medical surveillance and transfer to a lower risk area.

Table 3. — Prevalence of 48-Hour ΔFEV_1 Reaction by Number and Percent (N = 80).

	Smoking Category				
	Non-smokers	Ex-smokers	Light Smokers	Heavy Smokers*	Total
Nonreactors	20	10	11	12	53
Moderate reactors	5	3	9	3	20
Severe reactors	0	1	3	3	7
Percent reactors	20%	28%	52%	34%	34%

* Greater than 10 pack-years

$p > .05$

Table 5 shows that when the data are stratified by job areas, the highest prevalence occurs in pressmen, with 52% being reactors (moderate 39%, and severe 13%); the second highest occurs in ginners with 44% (moderate 28%, and severe 15%); and the least prevalence occurs in the "other" group with 42% (moderate 21%, and severe 21%). These differences between job areas, although indicating a strong trend, were not significant statistically.

The distribution of the degree and prevalence of reactors by gin was examined in comparison to dust levels. No statistical correlation was found to exist between dust levels and prevalence of reactors. Table 6 shows the dust concentrations by work area for Texas and New Mexico gins. The respirable dust samples by work area (obtained with the large vertical elutriator sampler) showed the overall mean to be 0.93 mg/m³. In New Mexico, the samples obtained at the gin stand consistently had dust concentrations at least twice as high as those obtained in the baling press areas and other locations. However, in Texas, the concentrations were very similar throughout the gin. This same result was also demonstrated by the small vertical elutriator and personal samples.

Although only saw gins were used in Texas, substantial numbers of saw and roller gins were used in New Mexico. But comparisons of dust concentrations between the two types of gins did not reveal any noticeable differences. Because spindle pickers were used almost exclusively in both states, predominantly long-fiber cotton was used, that is, Stoneville and Acala. A significant proportion of New Mexico cotton was extra-long-fiber Pima. A major factor that could account for differences in dust levels was the prevailing weather in each area, since the barn-like structures of gins are essentially open to the elements. (Texas had a very high humidity with little wind, whereas New Mexico was very dry and windy.)

Because of the generally uncooperative attitudes of gin industry management, several cotton gins in Texas barred the medical testing of their employees. To check for any possible bias in the nonresponsive gins, arrangements were made to at least obtain

Table 4. — Total* Prevalence of ΔFEV_1 Reaction by Number and Percent (N = 136).

	Smoking Category			
	Non-smokers	Ex-smokers	Smokers	Total
Nonreactors	27	15	35	77
Moderate reactors	10	7	20	37
Severe reactors	5	4	15	24
Percent reactors	36%	42%	50%	44%

*Includes pairs tested more than and less than 48 hours

$p < .001$

Table 5. — Distribution of Pulmonary Reactors and Dust Levels by Job Area.

	No. of Nonreactors (ΔFEV1 > -5%)	No. of Moderate Reactors (ΔFEV1 > -5% to > -10%)	No. of Severe Reactors (ΔFEV1 > -10%)	Total	% of Population Reacting	Dust Levels (LVE, mg/m³)
Ginners	22	11	6	39	44	1.25
Pressmen	15	12	4	31	52	0.71
All others	38	14	14	66	42	0.76
Unclassified	2	0	0	2	0	—
Total	77	37	24	138	44 (avg)	0.93 (avg)

$p = > .05$.

dust samples from them and findings were compared to those obtained from participating gins. No significant difference was found.

Estimated Prevalence of CRD Based Upon Feasibility Data

The prevalence of chronic respiratory disease (CRD) is a major interest in this study because its relationship to byssinosis was about 5% for both the study group and controls, based upon the more restrictive cutoffs on spirometry (> -2.326 standard deviation) and questionnaire (abnormal). Radiographic readings showed no unusual small opacity profusions or other pathology in either the gin workers or controls.

Consistent with the distribution of FEV_1 reactors being aggregated among pressmen, the prevalence of CRD appeared to be higher in this job category also. The amount of CRD indicated by questionnaire or spirometric test is given in Table 7. Spirometry data (FEV_1) indicated that "pressmen" had more borderline findings than gin stand workers ($p < 0.05$), as shown in Table 8. Pressmen also demonstrated twice as many combined borderline-abnormal spirograms as the other two groups, but this strong trend was not significant statistically. As described by cigarette pack-years, the smoking intensity of pressmen was only half of that experienced by other gin workers, as shown in Table 9.

Table 10 shows a comparison of mean $FEV_1\%$ values by smoking category for those with short-term, medium-term, and long-term dust exposure. Smokers exhibited an almost linear drop in $FEV_1\%$ predicted values between the zero to one year, two to five year, and six year exposure groups. A similar effect was found when all gin workers, regardless of smoking history, were combined. Nonsmokers, on the other hand, exhibited a drop only in the six year (or greater) exposure group.

This relationship was investigated further by generating separate correlation matrices for smokers and nonsmokers using four variables, i.e., pack-years, $FEV_1\%$, FEV_1/FVC, and years worked. For the nonsmokers, the years worked variable had negligible correlation coefficients with all other variables, whereas for smokers, years worked had a correlation coefficient of +0.41 with pack-years, -0.37 with $FEV_1\%$, and -0.43 with FEV_1/FVC. Pack-years demonstrated a correlation coefficient of -0.26 with $FEV_1\%$ and -0.45 with FEV_1/FVC. To differentiate between the cotton dust exposure as reflected by the years worked and by smoking effects on pulmonary function, a stepwide linear regression was performed. The resulting regression equation was: $FEV_1\% = 100 - 0.131$ (pack-years) - 0.564 (years worked). The years worked coefficient was significant statistically at less than 0.01.

In summary, the pressmen were younger, had smaller mean pack-years of exposure, shorter job tenure and more CRD. For all gin workers job tenure was correlated indirectly with FEV%, controlling for smoking history. Gin workers in press areas did not show unusually high exposures as given in Table 6. Assuming the exposure data is valid, one might hypothesize that pressmen were more susceptible to byssinosis dust exposures and both their acute and chronic effects. More work would be needed to test this hypothesis.

Discussion

Perhaps the most serious, confounding circumstance of this study was the high percentage of Mexican-Americans (82%), many of whom were illegal aliens from Mexico and thereby extremely reluctant to participate in a federal survey. When persuaded to participate, these gin workers demonstrated much anxiety about

Table 6. — Dust Concentrations by Work Area.

Gin Locations	No. of Gins	Area	Samples	LVE* (mg/m³) Mean	High	Low	Median
Texas gins	13	Gin stand	16	0.83	2.09	0.12	0.40
		Baling press	23	0.90	2.70	0.08	0.64
		Other	7	0.79	1.99	0.29	0.48
		Overall	46	0.86	2.70	0.08	0.48
New Mexico gins	16	Gin stand	28	1.52	4.98	0.19	1.23
		Baling press	29	0.63	1.67	0.14	0.46
		Other	7	0.72	1.08	0.51	0.71
		Overall	64	1.03	4.98	0.14	0.73
Combined Texas and New Mexico gins	29	Gin stand	44	1.25	4.98	0.12	1.08
		Baling press	52	0.71	2.70	0.08	0.48
		Other	14	0.76	1.99	0.29	0.59
		Overall	110	0.93	4.98	0.08	0.67

*USPHS Cotton Dust Vertical Elutriator; particle size cutoff approximately 15 μm.

Table 7. — Spirometry and Questionnaire Classification by Group and Smoking History.

Test Group	Spirometry Class (%) Normal	Borderline	Abnormal	Questionnaire Class (%) Normal	Borderline	Abnormal	Prescreened*
Gin workers (203)							
Nonsmokers	84	11	5	77	12	3	8
Smokers	88	7	5	58	28	10	4
Exsmokers	89	8	3	55	32	3	10
Average	87	8	5	63	24	6	7
Controls (260)							
Nonsmokers	87	9	4	72	23	1	4
Smokers	88	7	5	40	40	12	8
Exsmokers	84	12	4	70	22	4	4
Average	87	8	5	55	32	7	6

*Preexisting chest disease, physician diagnosed.

their job security because the general antipathy of the industry toward the survey tended to discourage participation.

In addition, a language-culture barrier frequently was encountered, which was manifest by common words having different meanings, and questions not being fully understood by the examinees. This situation was the result of subtle language differences between Mexican nationals and Mexican-Americans. This problem, coupled with widespread illiteracy, often defied resolution in spite of Spanish-speaking interviewers, technicians, and a Spanish-translated questionnaire. The summary result of the communication, culture, and attitude problems was a negative prevalence of byssinosis symptoms. A similar problem was experienced by Gilson et al,[4] in their study of cotton gins and mills in Kenya. In this study, the total absence of byssinosis symptoms was because of either a reluctance to admit to symptoms because of fear of job loss and subsequent deportation, or a total misunderstanding of the questions. It was observed in some cases that symptoms of wheezing often were present, but questions pertinent to this condition were answered negatively. For these reasons, the byssinosis portion of the questionnaire data was not considered reliable.

On the other hand, the CRD-bronchitis section of the questionnaire showed a prevalence of CRD similar to that found in other industries having high dust levels, thereby indicating that these data were fairly reliable. Speculation about the difference between the two parts of the questionnaire led us to assume that the byssinosis questions were more threatening, since each referred directly to the workers' jobs in the gin. A sample question was: What time of the day does your chest feel tight or does your breathing seem difficult? Possible answers were: (1) Before entering the gin; (2) After entering the gin; (3) After leaving the gin.

The total prevalence of FEV_1 decrements found in gin workers (44%) was higher than that found in workers in the cotton textile industry. Thus, although there were no controls for this acute part of the study, nor any reliable questionnaire findings to corroborate with, it would seem that the same response pattern to cotton dust found in textile workers is also occurring in gin workers. The finding that FEV_1 decrement reactions were independent of smoking history, but further exacerbated in smoking concurs with findings by other workers.[6, 9, 10]

The inability to obtain spirometry data in the accepted manner, namely, six hours into the shift after two days off work, would tend to reduce the magnitude of the observed FEV_1 decrements. Since the opportunity to recover from the dust exposure is limited, because of the short "out-of-dust" intervals that had to be contended with in this population, it can be hypothesized that the number of severe reactions identified in this study probably is underestimated. A comparison of the prevalence of reactors by gin workers showed that the pressmen group had nearly twice as many moderate reactions as either of the other two groups. Although this finding was not significant statistically, this very strong trend would appear to support the hypothesis that workers experiencing repeated acute pulmonary decrements ultimately will develop chronic functional changes, as was demonstrated in this study, which may progress into a chronic obstructive lung disease. No associations were apparent between prevalence of reaction and dust level or years of seniority.

The analysis of reactor prevalence reveals the existence of a possible selection process at work and points to the fact that gin stand workers are a hardier group of workers. The gin stand operator is considered a skilled worker, and the position is attained through experience and seniority. This accounts for the six year difference in exposure between gin stand operators and other job categories. If this worker remains in the industry over a prolonged period of time, it would suggest that he is less sensitive to the environmental irritant than his peers. Indeed, a review of the data reveals that gin workers, in spite of their increased exposure, do not report any more respiratory symptoms than the

Table 8. — Distribution of FEV_1 Classification by Job Category.

Category	Gin Stand Workers (N=47)	Pressmen (N=42)	Other (N=112)
Normal	93.6%	81.0%	86.6%
Borderline*	2.1	11.9	9.8
Abnormal	4.3	7.1	3.6
Borderline/ Abnormal	6.4	19.0	13.4
Total number	47	42	112

*$p < .05$

Two out of 203 gin workers could not be classified into a job category.

Table 9. — Smoking Distribution by Job Category.

	Ginners	Pressmen	Others	Controls
Smokers	51.1%	57.1%	45.5%	52.3%
Previous smokers	25.5%	19.1%	15.1%	19.2%
Nonsmokers	23.4%	23.8%	39.4%	28.5%
Smoker, mean pack-years*	16.0	7.3	15.3	11.4
Previous smoker, mean pack-years	9.6	4.1	8.0	9.1

*Pack-year = 1 pack/day/year.

Table 10. — Mean FEV1% as a Function of Years Worked, by Smoking Category.

	Short (0-1 Year)	Medium (2-5 Years)	Long (6+ Years)
All gin workers	99.6%	96.4%	93.0%
Nonsmokers	99.9%	100.4%	94.8%
Smokers	98.2%	94.7%	90.1%

other groups. They demonstrated better pulmonary function values, have less FEV1 reactors, and have a higher smoking pack-year history. Moreover, gin stand workers have more exsmokers than any other group, indicating that the person who is sensitive to the combination of cigarette smoke and dust prefers to give up smoking and keep the job. This observation is demonstrated in Table 5.

A group of people exists in this gin working population (18.7%) who, according to Bouhuy's F-Grade classification scheme, need to be moved to a lower risk area and given semiannual pulmonary function tests. However, possibly because of the irregular exposure to cotton each year, gin workers as a group did not develop an excess prevalence of CRD as determined by questionnaire or pulmonary function testing.

The findings of this study generally agree with those of other studies of byssinosis in cotton gin workers. Batawi's study[1] of Egyptian gin workers also showed the highest prevalence of byssinosis to be in the baling press workers (53%) with the ginners having the second highest rate (38.4%). His finding of an overall prevalence of 38.5% is similar to the total prevalence shown in this study of 44%. Likewise, the highest dust concentrations were found in the gin stand areas, yet no excess of chronic bronchitis was demonstrated when this group was compared to a control group (26%/21%). Kondakis,[3] in his study of Greek cotton gins, did not find evidence of any byssinosis, but he did find a 19% prevalence of chronic bronchitis, and a 20% prevalence of abnormal pulmonary function. In this study, 30% of the ginners demonstrated symptoms of respiratory disease, of which only 6.4% could be classified as having chronic bronchitis using the BMRC questionnaire criteria. Also, the pressmen showed a 19% prevalence rate of depressed pulmonary function.

Summary and Recommendations

Although this feasibility study revealed an absence of any byssinosis symptomatology as defined by the classical questions, the overwhelming evidence of functional reactors would indicate that there is an acute respiratory problem being experienced by gin workers, particularly those working in the gin press areas. These data, and findings from other gin studies, would indicate that there is a need to undertake a complete prevalence survey on a probability sample of gin workers, controlling for such variables as job description, age, seniority, smoking, type of gin (roller or saw), and type of cotton being ginned. Such a study could be completed successfully, given the new climate of cooperation with the ginning industry and that the lessons learned from this study are observed. Specifically, these lessons are:

1. To identify a sample of permanent gin workers as opposed to the itinerant, Spanish-speaking, seasonal help. The latter are much too mobile to be included in a medical survey and the resulting severe language difficulties could thus be avoided. Considerable sensitivity could also be added by including a group of retired or ex-gin workers so as to obviate the "healthy worker effect" or "survivor population," which prevents the true assessment of disease to be made in a cross-sectional survey. Acute testing should also be undertaken on a control group matched by such variables as socioeconomic class, age, smoking, and no history of having worked in a dusty trade. Data from this comparison would then permit a measure of "background noise" to be made enabling a truer estimate of reaction to be made.

2. To avoid the use of large survey trailers as used during this survey. This cumbersome approach does not give the field team sufficient flexibility to move quickly, nor to move in several directions at any one time. A better method would be to use a series of "flying squads," consisting of two or three technicians equipped with portable electronic spirometry systems. These systems should be accurate, precise, and cross-calibrated to all other systems being used. Testing methodology should also be standardized employing rigorous reliability and quality control procedures.

3. Although the use of a questionnaire to elicit byssinotic symptoms is of doubtful value, better success may be obtained by use of medically trained interviewers conversant with the local slang and customs of the target group. The use of objective tests of pulmonary function, such as the flow-volume curve, and measures of terminal airflow parameters may prove to be more useful methods for identifying and quantifying the byssinotic reactor, particularly in light of Batawi's findings of a high correlation between symptomatic byssinosis and a reduction in lung function.

4. To spend more time sensitizing the target population through group meetings, printed material, and health education, so as to allay unnecessary fears and elicit higher response rates.

The authors thank David P. Discher, M.D., Chairman, Department of Occupational Health, San Jose Medical Clinic, for his constructive criticisms and review of the manuscript.

This study was supported by funds from the Division of Field Studies and Clinical Investigations, NIOSH.

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