Respiratory Symptoms and Lung Function in a Sample of Vermont Dairymen and Industrial Workers

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Abstract: This study reviews the respiratory status of a sample of Vermont male dairy farmers, and a comparison group from industry, matched for age, sex and smoking. Survey instruments included a standardized questionnaire and simple pulmonary function tests.

In general, past and present smokers had more respiratory symptoms than never-smokers; and farmers, in all smoking categories, reported symptoms with greater frequency than did their counterparts from industry. Forced vital capacity (FVC) tended to be lower among men with a history of smoking but, within each smoking category, dairymen and factory workers had very similar FVCs. Farmers who had never smoked or who were current cigarette users had lower FEV_1/FVC (forced expiratory volume at one second/forced vital capacity) ratios than their controls from industry. Sixteen dairymen demonstrated precipitins to either *Micropolyspora faeni* (13) or *Thermoactinomyces vulgaris*, (3), but only one reported a constellation of symptoms compatible with farmer's lung disease. The estimated prevalence of antibodies to thermophilic actinomyces in this farm population was approximately 10 per cent. Although sample sizes were limited, diarymen from small farms tended to be older, have more respiratory symptoms, less satisfactory pulmonary function, and more serologic evidence of exposure to farmer's lung antigens than their counterparts from large farms. (*Am J Public Health* 70:241-245, 1980.)

Introduction

Vermont is primarily a rural state, with a total population of less than one-half million. Even Chittenden County, the most densely settled area which includes Burlington, had only an estimated 106,000 inhabitants in 1975.[1] Nevertheless, respiratory disease represents a significant health problem in this northwest corner of New England. Vermont's age-adjusted respiratory disease death rate for the period 1968-1972 was appreciably higher than the comparable 1970 U.S. rate for the white population, (16.23/10,000 for Vermont vs. 13.38/10,000 for U.S. whites). Vermont males experienced excess respiratory deaths in all categories (malignant neoplasms, emphysema, pneumonia, influenza, bronchitis, asthma and "other" represented largely by chronic obstructive pulmonary disease). Vermont female respiratory death rates also exceed comparable national figures except for malignant neoplasms and emphysema.[2]

Because respiratory disease is an important cause of mortality and morbidity and because the size of the state makes it a good laboratory in which to investigate this problem, a pulmonary research program was begun in 1972 at the University of Vermont College of Medicine. Dairy farmers from Addison County in the western part of the state were one occupational group selected for study. Approximately 260 dairymen participated, and 198 were matched for age, sex and smoking status with a control population from industry similarly screened in 1976.

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Methods

Sample Selection

Two factors were considered in projecting the sample size of farmers to be investigated. First, numbers had to be large enough to provide a prevalence estimate of farmer's lung disease. Published literature from the United States and one Canadian province suggested rates up to approximately 15 per cent.[3-5] Secondly, time constraints, imposed by the coming of winter and the necessity of visiting each farm individually, placed an upper limit on the numbers which could be included.

A list of all dairy farms was provided by the Addison County Extension Service. Farms were classified as large if they had 80 or more milking cows and small if the herd consisted of 20-79 cows. Using a table of random numbers, a total of 100 farms were chosen, of which 96 agreed to participate. The stratified sample included 49 per cent of 126 large farms and 11 per cent of 300 small farms in the 15 towns surveyed. The response rate was 100 per cent for large farms and 89 per cent for small farms.

The sample was deliberately weighted with large farms in order to increase the number of people available for study. It was recognized that the chance of developing pulmonary conditions might vary with farm size.

A total of 263 people working on dairy farms was

TABLE 1—Average Age and Smoking Variables for 198 Dairymen and 516 Workers from Industry, Respiratory Disease Survey, Vermont

	Cigarette Smoking Category*					
	Never		Former		Present	
	Farm N = 78	Industry N = 156	Farm N = 51	Industry N = 153	Farm N = 69	Industry N = 207
Matching Variable						
Age	34.01	33.88	43.20	43.24	35.59	35.41
Years since quit	—	—	7.95	8.43	—	—
Pack-years	—	—	—	—	20.33	20.52

*Overall, 96 per cent of the matches were within three years for age; 93 per cent were within five years for years since quit among former smokers; and 90 per cent were within six pack-years for present smokers.

screened. However, 14 were under 18 years old and six were over 65. Both groups were eliminated from analysis because the control industrial population contained no one in these age categories. Also excluded were 28 adult women who comprised 11 per cent of the surveyed population, and whose numbers were too small to permit useful male-female comparisons. Finally, 17 dairymen were not included, because of uncertainty about their prior smoking history. Thus, the final farm sample consisted of 198 adult males, 42 (21 per cent) of whom came from small farms (an average of 1.4 per farm) and 156 (79 per cent) worked on large farms (an average of 2.8 per farm). Approximately 36 per cent of the farmers were ages 18–29, 44 per cent were ages 30–49, and 20 per cent were between 50 and 64 years of age.

The dairymen were compared with 516 males surveyed in 1976, and employed by nine non-mineral Vermont industries.* For every non-smoking farmer, two non-smoking factory workers were identified on the basis of age. Three counterparts from industry were chosen for each former and present-smoking dairyman. The matching variables for former smokers were age and number of years since cessation of cigarette use, whereas present smokers were matched on the basis of age and pack-years. As Table 1 indicates, the two samples were quite similar with respect to these characteristics.

Survey Procedures

While the farm sample was being selected, the Addison County Extension Service publicized the forthcoming survey on its radio programs and at meetings with dairymen. Fortuitously, a farm journal with wide circulation carried an article describing farmer's lung disease just a few months before screening began, so many people were alert to the importance of this occupational respiratory hazard.[6]

Letters were sent to each farm in the sample, describing the purpose and procedures of the study. A few days later, these households were contacted by telephone, invited to take part, and a date was set for a visit by the survey van. Because of distance between farms, delays in locating workers and time needed to conduct the procedures, each farm required about one hour to complete. It proved impractical to schedule studies until after barn chores were finished about 9 a.m., nor could the dairymen be expected to participate later than 4 p.m. when evening milking began.

Screening was carried out in an 18-foot camper-type rented van. One team member interviewed participants while the other drew a blood sample and conducted pulmonary function tests. Narrow, snowy back roads posed an occasional problem but, in most other respects, the van proved very satisfactory for these farm visits.

Screening instruments for this survey included: 1) a two-part questionnaire, 2) simple pulmonary function determinations (forced vital capacity (FVC), forced expiratory volume at one second (FEV_1) and FEV_1/FVC ratios), and 3) a serologic test for farmer's lung antibodies.

The first part of the questionnaire was that prescribed by the Specialized Center of Research (SCOR) Program of the National Heart and Lung Institute. It was used for both the farm and industrial surveys, and was based on the bronchitis questionnaire developed by the British National Research Council.[7] Respiratory symptoms were emphasized, as was a detailed smoking history. For purposes of this study, a person was considered to wheeze if he stated that his breathing sounded wheezing or whistling, or if he had shortness of breath with wheezing. Dyspnea was defined as shortness of breath when hurrying on level ground or walking up a slight hill, or shortness of breath when walking with someone of the same age on level ground. The definition of chronic sputum production was: sputum most days, persisting for at least three months a year. The second part of the questionnaire, given only to dairymen, dealt with symptoms of farmer's lung disease and certain farming practices. The questionnaires were administered by trained interviewers.

At the beginning of the farm study, a lung function analyzer (Vertek 5000/Lung Function Analyzer 47401A, Hewlett-Packard, Waltham, Massachusetts) was used to test 26 male dairymen (13 per cent of the sample). This instrument, which was also employed in the industrial surveys, provided numerical print-outs of FVC and FEV_1, and was connected to an X-Y recorder that drew a time/volume curve for each trial. Because of a mechanical problem with the lung function analyzer, the remaining diarymen (87 per cent) were screened with a bellows spirometer (Vitalograph, Vitalograph Ltd., Lenexa, Kansas). Prior to field studies, volume determinations of each instrument were verified, using measured amounts of air in a calibrated five liter syringe. Both the Vertek 5000 and the Vitalograph reproduced readings within acceptable limits (plus or minus three per cent of known volumes). Similar volume tests were conducted daily during the surveys.

The age, sex, and self-reported height of each participant were recorded before testing, and the proper method of blowing into the machine was explained. A minimum of three breaths was measured, and additional tracings were made if the individual did not appear to be forcibly exhaling

*Three printing firms, two engaged in wood-working, one in metal fabrication, a company moulding plastic products, a plant that manufactured small batteries, and a construction firm.

TABLE 2—Per Cent Positive for Respiratory Symptoms and Reduced Pulmonary Function among Dairymen and Workers from Industry, Matched by Age and Cigarette Smoking, Respiratory Disease Survey, Vermont

	Cigarette Smoking Category							
	Never		Former		Present		Total	
	Farm N = 78	Industry N = 156	Farm N = 51	Industry N = 153	Farm N = 69	Industry N = 207	Farm N = 198	Industry* N = 516
Symptoms	%	%	%	%	%	%	%	%
Wheezing	31	22	41	29	47	45	39	32
Dyspnea	27	19	51	34	45	36	40†	29
Chronic sputum production	16	10	19	9	39	30	25†	17
Pulmonary Function								
FVC below 80% predicted	6	7	14	12	13	10	11	9
FEV_1/FVC ratio below 70%	14	7	16	19	23	17	18	14

*Total industry rate directly adjusted to the smoking distribution of the farm sample.
†Significantly different from the industry rate using a one-sided 5 per cent simultaneous statistical test.

and/or completely emptying his lungs. BTPS** corrected volumes were recorded and the highest FVC and FEV_1 were compared to the expected values for a person of the same age, sex, and height. Expected values were derived from Morris, et al,[8] and were tabulated as a per cent predicted for the FVC and FEV_1, and as the observed FEV_1/FVC ratio for that individual.

All people surveyed were notified about the outcome of their pulmonary function studies. With the subject's permission, his personal physician was sent the test and questionnaire results, if the FVC was below 80 per cent of predicted and/or the FEV_1/FVC ratio was below 70 per cent.

In checking for farmer's lung antibodies, a 10 ml sample of venous blood was drawn, and permitted to clot. After removal of serum at the laboratory, each sample was stored at −20 C until tested in immuno-diffusion plates against *Micropolyspora faeni* and *Thermoactinomyces vulgaris* extracts produced by the double dialysis method[9] and kindly supplied by Dr. John H. Edwards of the MRC Pneumoconiosis Unit, Cardiff, Wales. A more detailed report of the immunological aspects of this study has subsequently been published.[10]

Results

Respiratory Survey:

Table 2 summarizes the results of the farm and industry survey. Because never-smoking dairymen were matched with two rather than three controls from industry, the total prevalence rates for industry appearing in the right-hand column were directly adjusted to the smoking distribution of the farm sample. Using a one-sided five per cent simultaneous statistical test, total farm prevalence rates for dyspnea and chronic sputum production were significantly higher than the corresponding levels from industry.[11, 12] The difference between the two occupational groups with regard to wheezing was of borderline significance. As Table 2 indicates, farmers from every smoking category reported each symptom more often than did their industrial counterparts. Present-smokers from both farms and factories had a higher frequency of symptoms than did never-smokers of the same approximate age.

Reduced pulmonary function was likewise associated with a history of smoking, but within each smoking category, dairymen and factory workers had very similar FVCs. However, occupation seemed to influence FEV_1/FVC ratios, because more never-smoked and present-smoking farmers had low ratios than did their matched controls from industry.

Farmer's Lung Survey

During visits to each farm, blood samples were drawn for farmer's lung antibodies. Among 221 male dairymen, age 18 and over, who were tested, 16 (7 per cent) demonstrated precipitins to either *M. faeni* (13 persons) or *T. vulgaris* (3 persons). Eleven of those with precipitins were weakly positive, five were positive, and none were strongly positive. Antibodies were found more often in dairymen from small farms, compared with those tested on larger farms (11 per cent vs. 6 per cent), giving an estimated prevalence in this Vermont farm population of 10 per cent. In addition to these 16 males, one of the adult women sampled was also positive for *M. faeni*. Thirty-one precipitin-negative household members resided on the same farms as those who showed serologic evidence of farmer's lung antibodies. Interestingly, if rates were calculated for farms rather than persons at risk, 15 per cent of both large and small farms yielded evidence of precipitins to *M. faeni* or *T. vulgaris*. Contributing to these identical rates was one large farm containing three people with positive serologies.

For purposes of this report, clinical farmer's lung disease was defined as dyspnea, cough and fever (with or without chills) beginning two to 12 hours after exposure to moldy

**Body temperature and pressure, saturated with water vapor.

hay. Although 16 dairymen were precipitin positive, only one (a known asthmatic) gave a clinical history compatible with the disease. Three additional farmers recalled the appropriate constellation of symptoms on at least one occasion, two to 12 hours after exposure to moldy hay, and two of the three had a history of asthma, but none were positive for farmer's lung antibodies.

The timing of the survey may have influenced the number of positive responses to the farmer's lung questionnaire. Contact with moldy hay and subsequent illness would have been most likely during the winter and early spring, when hay is fed indoors. However, the Vermont farms were visited during the autumn, and perhaps episodes of illness had been forgotten.

Table 3 compares the 16 precipitin-positive farmers and the 205 who were precipitin-negative. Small numbers, as well as slight age differences between the two populations, limit usefulness of the data. Nevertheless, the following observations may be worth noting: the two groups were very similar with regard to wheezing, chronic sputum production and pulmonary function. However, dairymen with serologic evidence of past exposure to *M. faeni* or *T. vulgaris* appeared to come more frequently from small farms, report less dyspnea and use cigarettes less often than the precipitin-negative cohort. This latter observation regarding smoking is consistent with the findings of Morgan, et al, in Great Britain.[13, 14]

Sporadic use of moldy hay was reported by 62 per cent of both precipitin-positive and negative dairymen, indicating quite widespread potential contact with thermophilic actinomyces. However, serologic evidence of farmer's lung antibodies was relatively rare (7 per cent found and 10 per cent estimated). These observations, taken together, reinforce the concept that individual host susceptibility is more important than environmental exposure in determining who develops clinical or serological evidence of this condition.

TABLE 3—Comparison of 16 Dairymen Positive and 205 Negative for *M. faeni* or *T. vulgaris*, Respiratory Disease Survey, Vermont

	Precipitin Positive Group (N = 16)		Precipitin Negative Group (N = 205)	
	No.	Per Cent	No.	Per Cent
Age (years)				
18–29	5	31	71	35
30–49	7	44	88	43
50+	4	25	46	22
TOTALS	16		205	
Resident of small farm	5	31	41	20
Current cigarette smoking	3	19	70	34
Wheezing	6	38	76	37
Dyspnea	3	19	82	40
Chronic sputum production	4	25	49	24
FVC below 80% predicted	2	13	25	12
FEV_1/FVC ratio below 70%	3	19	41	20

Discussion

This study substantiates the body of evidence linking smoking and respiratory symptoms.[15] Present-smokers from industry reported approximately twice as frequent wheezing and dyspnea and three times as frequent chronic sputum production as did their non-smoking colleagues, even though the mean age difference between the two groups was only 1.5 years. However, for farmers the difference in symptom prevalence between never- and present-smokers was less striking, because even never-smoking farmers had appreciable levels of wheezing (31 per cent), dyspnea (27 per cent) and chronic sputum production (16 per cent).

As mentioned earlier, present smokers demonstrated reduced FVCs. However, men from both farms and industry had very comparable forced vital capacities within each smoking category. FEV_1/FVC ratios, likewise, tended to be lower in persons with a history of smoking; but never-smoking farmers showed low ratios appreciably more often than did the never-smoking industrial cohort.

Besides documenting a link between smoking and early pulmonary disease, this study also suggests that dairy farming may be associated with an increased prevalence of respiratory symptoms and reduced FEV_1/FVC ratios. The apparent effect of farming shows up in all symptom/smoking categories and in two of the three ratio/smoking categories. But perhaps the respiratory implications of dairy farming are most evident when age-matched never-smokers from farms and factories are examined, because the confounding variable of past or present cigarette usage is eliminated. Table 2 indicates that dairy farmers who never smoked had about 30 per cent more wheezing and dyspnea, 37 per cent more chronic sputum production and twice the prevalence of low ratios when compared with the never-smoking cohort from industry.

Although the physiologic effects of smoking have been well studied, less is known about the effects of farming on early respiratory disease. Because farming involves much outdoor work, the question of ambient air pollution might be raised. Vermont is subject to periodic bouts of air pollution, most of it coming on prevailing southerly winds from industrial centers in adjacent states. However, the burden of impurities does not approach concentrations common in many metropolitan areas, so air pollution is an unlikely explanation for the excess respiratory symptoms reported by dairymen.

With regard to the work environment itself, farming is a diverse occupation and persons so employed may be exposed to a variety of potentially allergenic and irritant inhalants. These include organic and inorganic dusts such as pollens, molds, fungi, animal dander, fertilizers, soil particles, fumes from diesel and gasoline exhausts, potentially toxic herbicides and insecticides, and occasionally such lethal gases as nitrogen dioxide which can accumulate in silos. Physiologic responses to these and other job-associated agents probably contribute to the higher respiratory symptom rates experienced by dairymen, as well as their lower FEV_1/FVC ratios. In addition, farming is a strenuous occupation which taxes the cardio-respiratory system. Con-

sequently, dairymen may recognize and report symptoms more readily than workers on an assembly line. Symptom recognition, however, would not explain the early signs of obstructive disease manifest by low FEV_1/FVC ratios.

In summary, smokers regardless of occupation, showed more evidence of pulmonary problems than did their nonsmoking counterparts; and dairymen, regardless of smoking status, demonstrated an excess frequency of respiratory symptoms and low FEV_1/FVC ratios, compared with age-matched controls from industry. Speculation is advanced that the differences observed between these two occupational groups arise from factors in the farm environment which remain to be precisely identified.

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Announcement of Conference on Citizen CPR

The National Heart Center at Baylor College of Medicine will host the Conference on Citizen CPR, to be held at the Shamrock Hilton Hotel, Houston, Texas, April 30-May 2, 1980. The conference will focus on training, testing, retention, and implementation of community based citizen cardiopulmonary resuscitation (CPR) training programs. Concerned researchers, paramedics, and individuals interested in CPR will be invited to attend the conference and will have the opportunity to review current and practical experiences in CPR.

The presentation of papers reporting original research or practical experience on innovative techniques for implementing CPR training programs will be a vital component of the conference. The presentations will contribute to the development of specific recommendations and guidelines to aid community organizations in developing local CPR training programs.

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