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A Survey of Respiratory Disease Among New York City Postal and Transit Workers

2. Ventilatory Function Test Results[1]

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One-second forced expiratory volumes ($FEV_{1.0}$) were measured for 12,500 men in New York City who were included in a survey of respiratory disease symptoms among postmen and transit workers. The study design and data on prevalence of symptoms were given in an earlier report. Study of ventilatory function test results showed distinctive patterns with respect to age, smoking habits, and respiratory disease symptoms. One-second forced expiratory volumes decreased with age in all study groups; age-specific means were slightly higher for white than for non-white men; the lowest FEV_1 values were found among cigarette smokers, especially the heavy smokers, and the highest values were those of non-smokers or men without symptoms; variations in patterns of the decline with age, as well as differences in age-specific mean FEV_1 values, were evident among groups of men reporting different symptoms of respiratory disease.

This second report of the New York City survey of respiratory disease among postal and transit workers presents the findings on ventilatory function test measurements. The basic design of the survey and the findings with respect to prevalence of respiratory symptoms were presented by Densen *et al.* in 1967, and an earlier report (Densen *et al.*, 1962) described the preliminary organization for the study.

Interviews of survey participants representing 87.4% of available postmen and 81.3% of defined transit workers, were conducted over the period November 1961 through August 1963. The numbers of men interviewed in the two industry groups are shown in Table I which includes eligibility criteria. In the transit worker group, where payroll titles as of a particular date (Feb. 10, 1962) determined eligibility, 427 "additional interviews" were carried out with men who had acquired the specified job titles between the date of definition and the date of interview. For convenience, the total transit population thus obtained has been labeled the "interviewed" population, while the smaller total of men interviewed who were on the payroll Feb. 10, 1962, is called the "defined" population. Analysis of interview data showed that prevalence rates were very nearly the same for

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TABLE I
NUMBERS OF POSTAL AND TRANSIT WORKERS SURVEYED FOR PREVALENCE OF CHRONIC RESPIRATORY DISEASE, NEW YORK CITY, NOVEMBER 1961–AUGUST 1963

	Postal workers	Transit workers
Total in survey group[a]	6,077	8,440
Interviewed	5,313	6,864
Not interviewed	764	1,576
Additional interviews[b]	—	427
Total number interviewed	5,313	7,291

[a] Post office: Total defined as carriers and chauffeurs on the employment rosters of the respective stations and available for study on the survey dates in the respective stations, including men off sick or refusing interview, and those missed for other reasons; excludes men on annual or compensatory leave or on temporary assignment elsewhere. Transit: Total defined as all in payroll titles of motorman, surface lines operator, and surface lines dispatcher as of Feb. 10, 1962.

[b] Number (in transit group) represents men in specified occupational categories at time of interview but who were newly employed (or acquired the title) after Feb. 10, 1962.

these two total populations, and the first report included all men interviewed. It has not been practical, however, to repeat earlier tabulations of pulmonary function test data on the "defined" group in order to include the additional men; much of the material on transit workers in this report, therefore, is based on the defined population only. In all tables, small numbers of postal and transit workers, for whom information on specified parameters was incomplete, have been excluded.

METHODS AND PROCEDURES

The measurement of pulmonary function obtained with the McKesson Vitalor was the 1-second forced expiratory volume ($FEV_{1.0}$) defined as the volume of air which, after maximal inspiration, is forcibly expelled in 1 second. For each participant, an attempt was made to get two "successful" tests after one practice trial. Since low volumes could be the result of either insufficient effort on the part of the test subject or obstructive lung disease, the decision as to adequacy of performance was made by the technician at the time of the test, when he could assess by direct observation the participant's effort and adherence to proper technique. Visible lack of effort resulted in a request for additional expirations.

The test result recorded for study purposes was the maximum volume obtained, regardless of sequence of attempts. This procedure is at variance with procedures used by some other investigators. Ferris and Anderson (1962) used the average of the last three of five test values and Holland *et al.* (1965) consistently recorded the value read from the second test after one practice trial without the machine. Study of samples from this survey, however, showed very little difference in findings derived from these different methods of handling the data. The slight variation upward or downward which comes from use of maximum test results or averaged test results is not of an order of magnitude to affect the interpretation of findings. This is in line with Bates' (1962) conclusions.

Error in test results which could arise from failure of the participant to produce

maximum flow at the start of the expiration[3] was investigated in detail for the first 1,198 tests completed in the survey (Soland, 1962 mss.). Men in this group whose tests were tentatively classified as "unsatisfactory" (on the basis of curve readings) were found to be distributed on age and symptom prevalence similarly to those men whose tests were labeled "satisfactory." Since inclusion of these tests in the final survey results does not affect the distributions with respect to age and $FEV_{1.0}$, or symptom prevalence and $FEV_{1.0}$, delayed production of maximum flow was not used as a cause for rejection of Vitalor tracings.

RESULTS

Results of ventilatory function tests are presented for each industry group by race, age, smoking pattern and sitting height measurements. For the sake of brevity, detailed findings on $FEV_{1.0}$ values and symptom prevalence are given only for the transit worker population; in general, findings with regard to these relationships were similar for postal and transit workers.

Survey Group, Race and Age

Major findings of the analysis of $FEV_{1.0}$ values by survey group, race, and age are that mean volumes decrease with age among both white and non-white men in the postal and transit groups, that the age-race-specific mean volumes are similar for the two industry groups, but that volumes differ slightly for white and non-white men both as to absolute levels and as to rate of decrease with age (Table II and Fig. 1). The absolute values for white postmen range from

TABLE II
MEAN 1-SECOND FORCED EXPIRATORY VOLUMES ($FEV_{1.0}$)[a] FOR POSTAL AND TRANSIT WORKERS, BY RACE AND AGE

Age in years	Postal workers				Transit workers			
	White		Non-white		White		Non-white	
	Number tested	Mean $FEV_{1.0}$	Number tested	Mean $FEV_{1.0}$	Number tested	Mean $FEV_{1.0}$	Number tested	Mean $FEV_{1.0}$
All ages	4,089	3.27	1,198	3.06	5,271	3.10	1,942	3.12
<40, total	1,633	3.56	628	3.29	843	3.54	913	3.30
<35	915	3.68	424	3.38	307	3.70	488	3.39
35–39	718	3.42	204	3.11	536	3.46	425	3.19
40–49	1,687	3.20	334	2.93	1,888	3.26	734	3.04
50–59	696	2.86	190	2.68	2,004	2.91	268	2.81
≥60	73	2.51	46	2.46	536	2.57	27	2.53

[a] The amount of air (in liters) which, after a maximal inspiration, is forcibly expelled in 1 second. The test result recorded for each man tested was the maximum volume obtained on either of two (or more) expirations.

[3] If the maximum flow rate (volume/time) does not occur at the beginning of the expiration, an "S-shaped" curve is produced, leading to uncertainty as to starting point on the time axis. If time is calculated from the actual start of the expiration, the $FEV_{1.0}$ reading will be lower than it would be if time were calculated from a point obtained by projecting the maximum slope back to the horizontal axis.

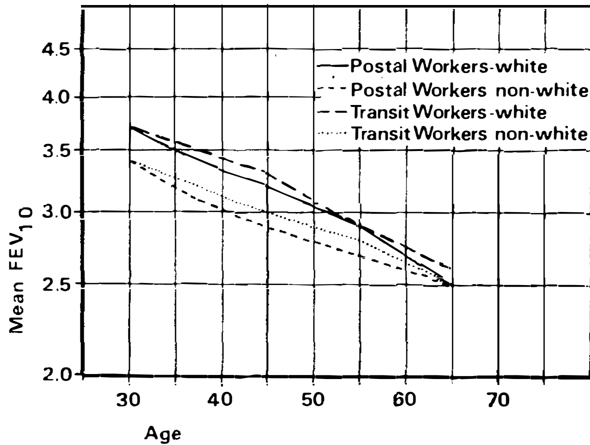

FIG. 1. Mean 1-second forced expiratory volumes ($FEV_{1.0}$) for postal and transit workers, by race and age.

3.68 liters for those under 35 years of age to 2.51 liters in the age group 60 and over; for white transit workers, the range is from 3.70 for those under 35 to 2.57 in the oldest age group. The comparable ranges for non-white men are 3.38 to 2.46 for postmen and 3.39 to 2.53 for transit workers.

The white vs. non-white differences are evident in Fig. 1, where the mean forced expiratory volumes are plotted on a logarithmic scale. Throughout the range of ages under 60 years, volumes are greater for white men than for non-white men. Age-specific means decrease at a greater rate for white men than for non-white men, however, so that race differences observed in the group under 35 years have almost disappeared in the oldest group, 60 years of age or more.

Smoking Patterns

Of the many variables with which ventilatory lung function may be associated, smoking exposures are of particular interest because of the effect of smoking habits on respiratory disease symptom prevalence. In the earlier report from this study (Densen *et al.*, 1967), excessive prevalence of symptoms was shown to be associated with increased numbers of cigarettes smoked per day. A relationship between amounts smoked and forced expiratory volumes appears to be clear-cut also, as shown in Table IV and Fig. 2. In Table IV average one-second $FEV_{1.0}$ values are shown for white and non-white men grouped by age and smoking category (the numbers of men tested in each category are given in Table III). Data are given only for nonsmokers (men who never smoked), those presently smoking cigarettes and no other form of tobacco, and those smoking pipes and/or cigars to the exclusion of cigarettes. The groups of smokers are again subdivided according to the usual quantities smoked per day. In both Post Office and Transit groups, and in both races, there is evidence of a consistent difference, in all age groups, between average $FEV_{1.0}$ values of nonsmokers and average $FEV_{1.0}$ values of heavy cigarette smokers, with the larger volumes obtained by nonsmokers. Test values for light cigarette smokers (fewer than 15 cigarettes per day) are very

TABLE III

NUMBER OF POSTAL AND TRANSIT WORKERS WITH MEASUREMENTS OF 1-SECOND FORCED EXPIRATORY VOLUMES ($FEV_{1.0}$) ACCORDING TO SMOKING CATEGORY AND AMOUNT SMOKED, BY RACE AND AGE

Race and age	Number of men													
	Postal workers							Transit workers						
		Cigarettes only[a] (gm)			Cigars and/or pipes only (gm)				Cigarettes only[a] (gm)			Cigars and/or pipes only (gm)		
	Nonsmokers	<15	15–24	25+	<15	15–24	25+	Nonsmokers	<15	15–24	25+	<15	15–24	25+
White														
All ages	696	305	861	847	221	116	173	656	434	1,393	840	260	178	165
<35	173	106	267	183	23	6	10	46	46	105	52	5	4	4
35–39	111	52	162	182	41	16	20	66	53	185	106	12	12	4
40–49	286	93	309	364	104	56	82	241	126	498	368	96	46	73
50–59	110	49	114	113	49	34	53	238	161	501	268	108	82	68
≥60	16	5	9	5	4	4	8	65	48	104	46	39	34	16
Non-white														
All ages	206	226	322	109	54	39	22	346	358	570	117	91	40	22
<35	90	112	116	36	8	5	1	102	114	152	22	8	2	—
35–39	26	35	62	25	7	6	2	82	82	130	29	17	6	3
40–49	42	52	99	32	14	12	9	116	119	223	51	43	17	10
50–59	33	21	41	15	19	15	8	39	41	62	15	19	13	9
≥60	15	6	4	1	6	1	2	7	2	3	—	4	2	

[a] Since 1 gm of tobacco is the same as 1 cigarette, these amounts refer to fewer than 15 cigarettes per day, 15–24 cigarettes per day, and 25 or more igarettes per day, respectively.

TABLE IV
MEAN 1-SECOND FORCED EXPIRATORY VOLUMES ($FEV_{1.0}$) FOR POSTAL AND TRANSIT WORKERS ACCORDING TO SMOKING CATEGORY AND AMOUNT SMOKED, BY RACE AND AGE

Race and age	Mean $FEV_{1.0}$													
	Postal workers							Transit workers						
		Cigarettes only[a] (gm)			Cigars and/or pipes only (gm)				Cigarettes only[a] (gm)			Cigars and/or pipes only (gm)		
	Nonsmokers	<15	15–24	25+	<15	15–24	25+	Nonsmokers	<15	15–24	25+	<15	15–24	25+
White														
Total number in group	*696*	*305*	*861*	*847*	*221*	*116*	*173*	*656*	*434*	*1,393*	*840*	*260*	*178*	*165*
All ages	3.4	3.4	3.3	3.2	3.3	3.1	3.2	3.3	3.2	3.0	2.9	3.2	3.0	3.1
<35	3.7	3.6	3.7	3.6	3.7	(3.3)	3.9	3.7	3.8	3.7	3.5	(3.8)	(4.1)	(3.5)
35–39	3.5	3.6	3.3	3.3	3.5	3.6	3.7	3.6	3.5	3.4	3.4	3.7	3.5	(3.9)
40–49	3.3	3.3	3.1	3.1	3.3	3.2	3.3	3.4	3.3	3.2	3.1	3.4	3.3	3.4
50–59	3.0	2.9	2.7	2.8	2.9	2.8	3.0	3.2	2.9	2.8	2.6	3.2	3.0	3.0
≥60	2.7	(2.3)	(2.4)	(2.2)	(2.4)	(2.8)	(2.6)	2.8	2.6	2.4	2.3	2.9	2.5	2.7
Non-white														
Total number in group	*206*	*226*	*322*	*109*	*54*	*39*	*22*	*346*	*358*	*570*	*117*	*91*	*40*	*22*
All ages	3.2	3.1	3.1	3.0	2.9	2.8	2.7	3.2	3.2	3.1	3.0	3.1	3.0	3.2
<35	3.4	3.4	3.4	3.2	(3.4)	(3.5)	(2.9)	3.5	3.4	3.4	3.2	(3.1)	(3.4)	—
35–39	3.2	3.1	3.1	3.1	(3.0)	(2.9)	(3.3)	3.2	3.2	3.2	3.1	3.3	(3.3)	(3.6)
40–49	3.0	2.9	2.9	3.0	2.9	2.7	(2.8)	3.1	3.1	2.9	3.0	3.2	3.1	3.1
50–59	2.8	2.7	2.6	2.4	3.0	2.6	(2.6)	2.8	2.8	2.7	2.7	3.0	2.7	(3.1)
≥60	2.5	(2.4)	(2.5)	(2.4)	(2.2)	(3.0)	(2.3)	(2.4)	(2.9)	(2.1)	—	(2.2)	(2.6)	—

Figures in parentheses represent average $FEV_{1.0}$ values based on fewer than 10 men tested in the specified categories.

[a] Since 1 gm of tobacco is the same as 1 cigarette, these amounts refer to fewer than 15 cigarettes per day, 15–24 cigarettes per day, and 25 or more cigarettes per day, respectively.

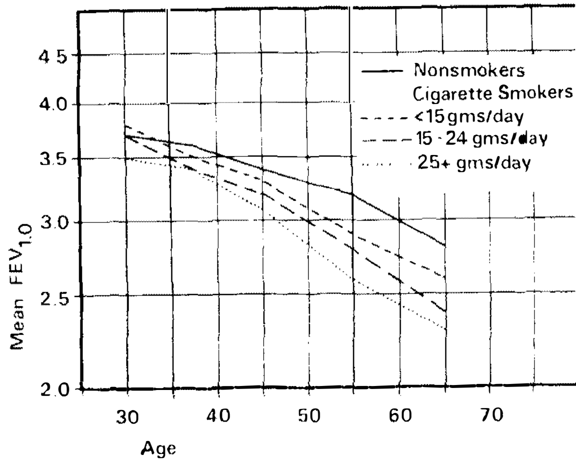

FIG. 2. Mean 1-second forced expiratory volumes ($FEV_{1.0}$) by age, for nonsmokers, and for cigarette smokers, according to amount smoked per day: white transit workers.

similar to those for nonsmokers; values for moderate cigarette smokers (15–24 per day) in 12 out of 20 age-race-industry-specific categories under comparison are slightly lower than those for light smokers; and heavy cigarette smokers (25 or more per day) have lower values than light smokers in 15 of the 20 age-race-industry-specific groups.

$FEV_{1.0}$ values for cigar and pipe smokers appear to have no consistent relationship with amounts smoked, and are similar to the values for nonsmokers and light cigarette smokers.

It is particularly interesting to note that the decline of $FEV_{1.0}$ values with age, and the slight difference in averages for white and non-white men, noted in Table II and Fig. 1, are still apparent regardless of smoking category and amount smoked. Within each of the specified smoking categories, the decrease in test volumes with age is evident; and within almost all of the age-smoking category-specific groups, the average volume for white men is greater than that for non-white.

The rate of decrease in $FEV_{1.0}$ values over the age span is slightly greater for smokers than for nonsmokers in both industrial groups and appears to be somewhat greater for heavy smokers than for nonsmokers and light smokers. Among white transit workers the decrease in mean volume between the youngest (under 35 years) and the oldest (60 years and over) age groups was 0.9 liters, or 24%, for nonsmokers, 1.3 liters, or 35%, for moderately heavy smokers (15–24 gm per day) and 1.2 liters, or 34%, for heavy (25 gm or more per day) cigarette smokers. Age-specific mean test volumes for these groups of white transit workers are shown in Fig. 2.

Sitting Height and Age

Since the 1-second forced expiratory volume is dependent to some extent on the total lung capacity, some measurement related to chest size has been considered important for comparison of $FEV_{1.0}$ values among population groups. In this, as in several other field studies, the measurement of sitting height has been

TABLE V

Regression Equations of $FEV_{1.0}$ on Age and Sitting Height, and Mean Values of the Parameters, for Specified Groups of Postal and Transit Workers, by Race

Population group	Number of men	Mean age (yr.)	Mean sitt. ht. (in.)	Mean $FEV_{1.0}$ (L)	Regression equation A = age in years H = sitting height in inches
TOTAL					
White					
Postal	4,088	41.3	34.8	3.27	$FEV_{1.0}$ = 1.0345 − .0297(A) + .0995(H)
Transit	5,016	49.0	35.2	3.09	$FEV_{1.0}$ = 1.9953 − .0338(A) + .0781(H)
Nonwhite					
Postal	1,194	39.5	34.6	3.06	$FEV_{1.0}$ = −.4411 − .0262(A) + .1314(H)
Transit	1,690	41.7	34.7	3.09	$FEV_{1.0}$ = .0083 − .0245(A) + .1185(H)
ASYMPTOMATIC[a]					
White					
Postal	1,063	41.4	34.8	3.34	$FEV_{1.0}$ = 1.2092 − .0269(A) + .0934(H)
Transit	1,549	50.3	35.1	3.17	$FEV_{1.0}$ = 2.6443 − .0333(A) + .0628(H)
Non-white					
Postal	311	40.1	34.5	3.08	$FEV_{1.0}$ = 2.0000 − .0239(A) + .1230(H)
Transit	500	41.0	34.7	3.18	$FEV_{1.0}$ = .1719 − .0218(A) + .1124(H)
NON-SMOKERS					
White					
Postal	685	41.0	34.7	3.37	$FEV_{1.0}$ = 1.1861 − .0249(A) + .0922(H)
Transit	620	48.7	35.1	3.29	$FEV_{1.0}$ = 1.5770 − .0281(A) + .0879(H)
Non-white					
Postal	204	38.6	34.6	3.16	$FEV_{1.0}$ = .2647 − .0235(A) + .1098(H)
Transit	298	40.8	34.7	3.18	$FEV_{1.0}$ = 1.1320 − .0255(A) + .1531(H)
CIGARETTE SMOKERS[b]					
White					
Postal	2,340	40.0	34.9	3.26	$FEV_{1.0}$ = .8196 − .0325(A) + .1071(H)
Transit	2,941	48.0	35.2	3.01	$FEV_{1.0}$ = 1.4087 − .0373(A) + .0965(H)
Non-white					
Postal	768	38.3	34.6	3.08	$FEV_{1.0}$ = −.5760 − .0288(A) + .1376(H)
Transit	1,041	41.0	34.6	3.07	$FEV_{1.0}$ = .3841 − .0288(A) + .1116(H)
<25 gm/day					
White					
Postal	1,292	39.3	34.8	3.30	$FEV_{1.0}$ = .9610 − .0309(A) + .1021(H)
Transit	1,929	48.2	35.1	3.05	$FEV_{1.0}$ = 1.2428 − .0377(A) + .1030(H)
Non-white					
Postal	599	37.9	34.5	3.09	$FEV_{1.0}$ = −1.1208 − .0296(A) + .1545(H)
Transit	891	40.9	34.6	3.08	$FEV_{1.0}$ = .4035 − .0296(A) + .1122(H)
≥25 gm/day					
White					
Postal	1,038	40.8	35.0	3.21	$FEV_{1.0}$ = .5508 − .0342(A) + .1158(H)
Transit	1,011	47.6	35.2	2.94	$FEV_{1.0}$ = 1.6636 − .0373(A) + .0868(H)
Non-white					
Postal	161	40.0	34.8	3.03	$FEV_{1.0}$ = .8770 − .0239(A) + .0895(H)
Transit	149	41.8	34.8	3.00	$FEV_{1.0}$ = .0217 − .0224(A) + .1126(H)

[a] Asymptomatic men are those men who replied negatively to all questions about respiratory symptoms and recent history of chest illness (questionnaire items 1–21).

[b] Includes men smoking cigarettes plus other forms of tobacco. Included in the totals of these smokers are men for whom amounts were not reported.

used as an index of lung size, as recommended for conduct of respiratory disease prevalence studies by the British Medical Research Council (1960). Accordingly, each study participant was seated on a flat-topped stool against a wall and his length from seat to top of head measured against a standard mounted on the wall. Measurements were recorded to the next lowest quarter inch.

From the regression equation of 1-second forced expiratory volumes on sitting height and age (Table V), the average increase in $FEV_{1.0}$ with increasing sitting height and the average decrease in $FEV_{1.0}$ with age can be seen as similar for postal and transit workers. For example, in the white postal group, the decrease in $FEV_{1.0}$ values was about 30 cc per year of age, or 150 cc (0.15 liters) for 5 years of age. Among white transit workers, the decrease was about 34 cc per year, or 170 cc (0.17 liters) for every 5 years of age. In comparing the coefficients of the regression equation, it should be remembered that the age distributions of postal and transit workers differed, so that the transit age span on which the regression was calculated covers an older range than does the postal age span. This difference is reflected in the mean ages, which are also shown in Table V.

The increase in $FEV_{1.0}$ values with each inch of sitting height was about 100 cc (0.10 liters) for white postal employees and about 78 cc (0.08 liters) for white transit workers. For non-white men in both industries, the slope of the regression of $FEV_{1.0}$ on stem length was steeper; $FEV_{1.0}$ values increased by 131 cc with each inch of sitting height of non-white postmen, and by 119 cc for each inch of sitting height of non-white transit workers.

Within each of the four race-industry subgroups, mean sitting heights, and also mean ages, were very similar throughout the subcategories shown in Table V for these groups; comparing race-industry subgroups with each other, white transit workers were consistently older, and with slightly longer sitting heights, than the other three groups of men.

In Table VI, the regression equations of Table V are used for calculating

TABLE VI
STANDARDIZED 1-SECOND FORCED EXPIRATORY VOLUMES ($FEV_{1.0}$) FOR SPECIFIED POSTAL AND TRANSIT WORKERS AT AGE 45 AND SITTING HEIGHT OF 35 INCHES

	Standardized $FEV_{1.0}$[a]			
	Postal workers		Transit workers	
Population group	White	Non-white	White	Non-white
Total	3.18	2.98	3.21	3.05
Asymptomatics[b]	3.27	3.03	3.34	3.12
Nonsmokers	3.29	3.05	3.39	3.08
Cigarette smokers, total[c]	3.11	2.94	3.11	2.99
<25 gm/day	3.14	2.95	3.15	3.00
≥25 gm/day	3.06	2.93	3.02	2.95

[a] Calculated from the regression equations in Table V.

[b] Asymptomatic men are those men who replied negatively to all questions about respiratory symptoms and recent history of chest illness (MRC questionnaire items 1–21).

[c] Includes men smoking cigarettes plus other forms of tobacco; included in the totals of these smokers are men for whom amounts of tobacco were not specified.

expected $FEV_{1.0}$ values for specified subgroups of the study population at a standard age and sitting height (45 years and 35 inches). Although differences in these means are not great, the numerical advantage (of relatively high test values) is with the asymptomatics and nonsmokers, as compared with the cigarette smokers, particularly those smoking more than two packages of cigarettes per day. Another feature of this summary table is the consistency with which $FEV_{1.0}$ values for non-white men, in both postal and transit groups, remain slightly below those for white men.

Symptom Prevalence, Ventilatory Function and Age

The relationship between ventilatory function and symptoms of respiratory disease, in the transit worker study population, has been explored further in three ways. First, in Tables VII and VIII, average 1-second forced expiratory

TABLE VII
MEAN 1-SECOND FORCED EXPIRATORY VOLUMES ($FEV_{1.0}$) FOR WHITE TRANSIT WORKERS ACCORDING TO SPECIFIED SYMPTOMS AND AGE

Symptom[a]	Age group						
	All ages	<40	40–44	45–49	50–54	55–59	≥60
Total number in group	*5,016*	*706*	*793*	*1,039*	*994*	*962*	*522*
Average $FEV_{1.0}$ of group	*3.1*	*3.5*	*3.4*	*3.2*	*3.0*	*2.8*	*2.6*
Cough, AM (1)	2.8	3.4	3.2	2.9	2.7	2.5	2.3
Cough, day/night (3)	2.9	3.4	3.2	3.0	2.8	2.6	2.4
Persistent cough (5)	2.9	3.4	3.2	3.0	2.8	2.6	2.3
Phlegm, AM (6)	2.9	3.4	3.2	3.0	2.8	2.6	2.4
Phlegm, day/night (8)	3.0	3.5	3.3	3.1	2.9	2.6	2.4
Persistent phlegm (10)	3.0	3.4	3.2	3.0	2.9	2.6	2.4
Exacerbations (12b, c)	2.9	3.4	3.2	3.1	2.7	2.6	2.4
Dyspnea 2+ (14a)	2.9	3.4	3.2	2.9	2.8	2.6	2.3
Wheezing (15)	2.9	3.4	3.2	3.0	2.8	2.6	2.3
Wheezing with colds (15a)	2.9	3.4	3.2	3.0	2.8	2.5	2.3
Wheezing apart from colds (15b)	2.8	3.4	3.1	2.9	2.7	2.5	2.2
Persistent wheezing (15c)	2.6	3.2	2.8	2.8	2.6	2.3	2.1
Weather affects chest (17)	2.8	3.5	3.1	2.9	2.7	2.5	2.2
Weather causes dyspnea (17f)	2.6	3.4	3.0	2.7	2.4	2.4	2.1
Nasal catarrh (18)	3.0	3.4	3.3	3.1	2.9	2.7	2.5
Persistent nasal catarrh (20)	3.0	3.5	3.3	3.1	3.0	2.7	2.4
Chest illnesses past 3 years (21)	3.0	3.4	3.3	3.1	2.9	2.7	2.4
Asthma (22)	2.6	3.0	3.0	2.9	2.6	2.3	1.8
Hay fever (23)	3.1	3.5	3.4	3.3	3.1	2.9	2.5
Persistent cough and phlegm (5, 10)	2.8	3.3	3.1	2.9	2.7	2.5	2.2
Persistent cough and phlegm, exacerbations (5, 10, 12b,c)	2.7	3.4	3.0	2.9	2.5	2.3	2.2
Persistent cough and phlegm, dyspnea 2+ (5, 10, 14a)	2.7	3.4	3.0	2.7	2.6	2.3	2.1
Asymptomatic	3.2	3.7	3.5	3.3	3.1	3.0	2.7

[a] Numbers following symptoms are questionnaire item numbers.

TABLE VIII
MEAN 1-SECOND FORCED EXPIRATORY VOLUMES ($FEV_{1.0}$) FOR NONWHITE TRANSIT WORKERS ACCORDING TO SPECIFIED SYMPTOMS AND AGE

Symptom[a]	Age group						
	All ages	<40	40–44	45–49	50–54	55–59	≥60
Total number in group	*1,690*	*698*	*405*	*297*	*186*	*78*	*26*
Average $FEV_{1.0}$ in group	*3.1*	*3.3*	*3.1*	*3.0*	*2.8*	*2.8*	*2.5*
Cough, AM (1)	2.9	3.2	3.0	2.7	(2.6)	(2.6)	(2.0)
Cough, day/night (3)	3.0	3.2	3.0	2.9	2.7	2.6	(2.4)
Persistent cough (5)	3.0	3.1	3.0	2.9	2.6	2.6	(2.2)
Phlegm, AM (6)	3.0	3.3	3.0	2.9	2.7	2.6	(2.2)
Phlegm, day/night (8)	3.1	3.3	3.0	3.1	2.7	2.5	(2.3)
Persistent phlegm (10)	3.1	3.3	3.1	3.0	2.7	2.5	(2.5)
Exacerbations (12b,c)	3.0	3.2	2.9	3.0	2.8	2.8	(1.1)
Dyspnea 2+ (14a)	3.0	3.2	2.9	2.9	2.7	2.8	(2.2)
Wheezing (15)	3.0	3.2	2.9	2.9	2.7	2.6	2.4
Wheezing with colds (15a)	3.0	3.1	3.0	2.9	2.7	2.7	(2.3)
Wheezing apart from colds (15b)	2.7	3.2	2.8	2.7	2.8	(2.5)	(2.5)
Persistent wheezing (15c)	2.9	3.1	2.6	2.9	2.8	(2.5)	(2.0)
Weather affects chest (17)	2.8	3.1	2.7	2.8	2.7	(2.5)	(2.2)
Weather causes dyspnea (17f)	2.8	3.1	2.8	2.8	2.9	(2.7)	(2.1)
Nasal catarrh (18)	3.1	3.3	3.0	3.0	2.8	(2.6)	(2.3)
Persistent nasal catarrh (20)	3.1	3.3	3.1	3.1	2.8	(2.7)	(2.2)
Chest illnesses past 3 years (21)	3.0	3.2	2.9	3.0	2.8	(2.9)	(2.2)
Asthma (22)	2.8	3.2	2.7	2.2	2.3	(2.6)	(2.3)
Hay fever (23)	3.1	3.3	2.9	3.0	2.8	(2.9)	(2.4)
Persistent cough and phlegm (5, 10)	3.0	3.2	3.0	3.0	2.6	(2.5)	(2.2)
Persistent cough and phlegm, exacerbations (5, 10, 12b,c)	3.0	3.3	2.9	3.2	2.8	(2.6)	(1.1)
Persistent cough and phlegm, dyspnea 2+ (5, 10, 14a)	2.9	3.1	2.9	2.9	2.6	(2.4)	(1.1)
Asymptomatic	3.2	3.3	3.2	3.1	2.9	2.9	2.7

[a] Numbers following symptoms are questionnaire item numbers. Figures in parentheses represent mean $FEV_{1.0}$ values based on fewer than 10 men.

volumes are shown according to age-group for men who reported having specified symptoms. Second, in Tables IX and X, the prevalence of symptoms is shown for men in specified $FEV_{1.0}$ categories; and third, in Tables XI and XII, symptom prevalence data are given for men with $FEV_{1.0}$ values described in terms of deviations from group means. Each of these ways of looking at the data has pertinence for identification of individuals at risk of chronic respiratory disability, since they relate to the sensitivity and specificity of the measures employed.

Looking first at the data for white transit workers (in Table VII), the group of men with the lowest expiratory volumes, in almost all of the age categories shown, are those who reported having asthma. Low volumes are also seen for groups reporting wheezing, dyspnea caused by weather conditions, and persistent cough and phlegm in combination with other symptoms. In fact, age-specific $FEV_{1.0}$ values are below the averages for this study population for groups of men

TABLE IX
PREVALENCE OF RESPIRATORY SYMPTOMS AMONG TRANSIT WORKERS AGES 40–49
BY RACE AND $FEV_{1.0}$ GROUP

	$FEV_{1.0}$							
	White				Non-white			
Symptom[a]	<2.5	2.5–2.9	3.0–3.4	≥3.5	<2.5	2.5–2.9	3.0–3.4	≥3.5
Total number in group	*129*	*366*	*683*	*654*	*80*	*223*	*251*	*148*
Cough, AM (1)	37.2	23.5	18.0	11.2	17.5	14.3	11.6	9.5
Cough, day/night (3)	37.2	24.3	20.9	14.5	27.5	27.8	24.3	20.9
Persistent cough (5)	35.7	23.2	19.3	11.9	21.3	13.9	16.3	14.2
Phlegm, AM (6)	41.1	28.1	22.8	16.2	23.8	27.4	21.5	19.6
Phlegm, day/night (8)	38.0	27.6	25.6	21.3	28.8	26.5	30.3	26.4
Persistent phlegm, (10)	37.2	23.8	20.5	15.1	20.0	18.4	20.7	20.3
Exacerbations (12b,c)	9.3	8.5	8.6	5.0	10.0	11.2	9.2	5.4
Dyspnea 2+ (14a)	39.5	25.4	20.6	13.3	26.3	19.3	17.5	11.5
Wheezing (15)	40.3	32.5	26.6	17.9	48.8	36.3	29.5	19.6
Wheezing whit colds (15a)	34.1	27.3	23.1	15.7	43.8	32.7	28.3	18.9
Wheezing apart from colds (15b)	20.2	14.2	9.1	5.5	15.0	11.2	7.6	1.4
Persistent wheezing (15c)	14.7	4.4	2.8	1.8	5.0	4.9	1.2	1.4
Weather affects chest (17)	20.9	10.9	6.6	4.4	13.8	7.6	4.0	3.4
Weather causes dyspnea (17f)	13.2	4.4	2.0	1.2	5.0	1.3	2.8	0.7
Nasal catarrh (18)	34.9	23.8	28.1	24.9	30.0	25.1	25.1	22.3
Persistent nasal catarrh (20)	24.0	13.7	15.8	14.2	11.3	11.2	15.5	11.5
Chest illnesses past 3 years (21)	24.0	20.8	18.0	15.0	26.3	17.0	19.5	13.5
Asthma (22)	7.0	2.7	2.3	1.1	11.3	4.0	1.2	1.4
Hay fever (23)	0.8	6.8	5.9	7.0	10.0	8.1	5.6	5.4
Persistent cough and phlegm (5, 10)	30.2	15.6	12.0	6.4	15.0	9.0	10.8	10.1
Persistent cough and phlegm, and exacerbations (5, 10, 12b,c)	6.2	2.7	3.7	0.6	2.5	3.1	2.0	2.7
Persistent cough and phlegm, and dyspnea 2+ (5, 10, 14a)	18.6	7.4	5.0	1.7	7.5	2.7	4.8	1.4

[a] Numbers following symptoms are questionnaire item numbers.

reporting any of the specified symptoms with a single exception: men who said they had hay fever have $FEV_{1.0}$ values which are similar to the total group averages and, at ages 45–54 years, are the same as the $FEV_{1.0}$ values of men who reported none of the listed symptoms. For this last group of asymptomatic men. every age-specific $FEV_{1.0}$ value is higher than the corresponding mean for the whole group.

Even in the asymptomatic group, where absolute mean values are high, the expiratory volumes decline with age. The decrease with age occurs in all symptom categories, but is more marked in some than in others. The greatest change pinpoints again the group with asthma, among which the average volume for men 60 years of age and over (1.8 liters) is 40% lower than the average volume (3.0 liters) for men under 40. The other symptom groups in which age-specific mean values were low are also characterized by greater decrease with age than is

TABLE X
PREVALENCE OF RESPIRATORY SYMPTOMS AMONG TRANSIT WORKERS AGES 50–59 BY RACE AND $FEV_{1.0}$ GROUP

	$FEV_{1.0}$							
	White				Non-white			
Symptom[a]	<2.5	2.5–2.9	3.0–3.4	≥3.5	<2.5	2.5–2.9	3.0–3.4	≥3.5
Total number in group	*392*	*597*	*625*	*342*	*62*	*100*	*81*	*21*
Cough, AM	34.9	16.4	14.9	9.1	19.4	11.0	11.1	0.0
Cough, day/night (3)	30.9	17.4	15.7	12.0	33.9	27.0	22.2	23.8
Persistent cough (5)	31.4	15.9	15.5	8.5	22.6	16.0	12.3	0.0
Phlegm, AM (6)	32.4	21.9	17.9	12.3	29.0	12.0	19.8	9.5
Phlegm, day/night (8)	29.8	17.4	17.8	14.3	38.7	25.0	22.2	19.0
Persistent phlegm (10)	27.3	15.6	17.9	10.8	29.0	15.0	13.6	14.3
Exacerbations (12b,c)	12.0	7.9	4.2	5.8	8.1	10.0	13.6	0.0
Dyspnea 2+ (14a)	32.1	20.4	18.2	11.1	14.5	14.0	11.1	14.3
Wheezing (15)	33.7	21.8	17.9	11.4	41.9	27.0	23.5	23.8
Wheezing with colds (15a)	29.1	18.4	15.0	9.9	41.9	26.0	21.0	23.8
Wheezing apart from colds (15b)	16.8	8.7	6.1	3.5	8.1	10.0	4.9	4.8
Persistent wheezing (15c)	9.7	3.4	3.0	2.3	3.2	6.0	3.7	4.8
Weather affects chest (17)	13.3	6.9	6.1	2.9	9.7	10.0	3.7	4.8
Weather causes dyspnea (17f)	8.2	2.8	1.9	0.9	3.2	3.0	2.5	4.8
Nasal catarrh (18)	27.8	23.8	20.8	18.4	25.8	26.0	22.2	19.0
Persistent nasal catarrh (20)	13.3	11.4	12.2	9.4	12.9	12.0	9.9	14.3
Chest illnesses past 3 years (21)	17.3	13.2	11.5	13.2	16.1	12.0	19.8	14.3
Asthma (22)	4.8	2.3	1.6	1.2	8.1	3.0	1.2	0.0
Hay fever (23)	6.1	8.4	8.8	9.6	8.1	8.0	7.4	9.5
Persistent cough and phlegm (5, 10)	21.2	10.4	9.0	4.4	16.1	9.0	8.6	0.0
Persistent cough and phlegm, and exacerbations (5, 10, 12b,c)	5.1	3.2	1.1	1.2	4.8	4.0	3.7	0.0
Persistent cough and phlegm, and dyspnea 2+ (5, 10, 14a)	12.2	4.5	2.9	2.0	6.5	3.0	2.5	0.0

[a] Numbers following symptoms are questionnaire item numbers.

shown by the whole study group; namely, the groups reporting wheezing, dyspnea caused by adverse weather, and persistent cough and phlegm in combination with dyspnea. Generally speaking, the men with chest-related symptoms appear to have lower $FEV_{1.0}$ values, and to exhibit a greater change in expired volumes with increasing age, than do the groups reporting symptoms primarily related to the nasal passages. These differences are evident in Fig. 3, where age-specific means are shown for symptom categories which demonstrate the variation in patterns.

The relationships and patterns described above are less clearly marked for non-white transit workers (Table VIII) than they are for the white. It is interesting to see that the non-white men in this industry group have $FEV_{1.0}$ values which, again, are lower than those for the white workers, that show less variation across the age range, and that also vary less within specific ages for men with

TABLE XI

PREVALENCE OF RESPIRATORY SYMPTOMS AMONG WHITE TRANSIT WORKERS WITH SPECIFIED DEVIATIONS BETWEEN OBSERVED AND EXPECTED $FEV_{1.0}$ VALUES

	Deviation: observed $FEV_{1.0}$ minus expected $FEV_{1.0}$ (liters)								
	Observed values less than expected values				Minimal difference	Observed values greater than expected values			
Symptom[a]	< −1.0	−.8, −.9, −1.0	−.5, −.6, −.7	−.2, −.3, −.4	−.1, 0, +.1	.2, .3, .4	.5, .6, .7	.8, .9, 1.0	>1.0
Number in each group	*222*	*290*	*603*	*1,013*	*1,134*	*925*	*527*	*219*	*83*
Cough, AM (1)	43.7	30.7	25.4	20.3	16.4	13.3	9.3	7.3	6.0
Cough, day/night (3)	40.1	33.4	22.6	20.9	19.1	15.6	13.5	12.3	8.4
Persistent cough (5)	38.3	31.7	24.7	19.2	16.7	14.6	10.4	8.2	7.2
Phlegm, AM (6)	45.0	32.8	29.7	24.8	20.0	18.3	14.4	14.2	12.0
Phlegm, day/night (8)	38.3	30.7	28.2	23.1	21.0	21.0	16.1	18.3	18.1
Persistent phlegm (10)	36.9	25.9	25.9	21.0	16.2	18.1	13.1	12.8	15.7
Exacerbations (12b,c)	17.1	10.7	9.8	9.4	7.3	5.6	4.4	5.9	6.0
Dyspnea 2+ (14a)	46.4	29.7	28.2	19.8	18.2	16.4	12.1	13.7	9.6
Wheezing (15)	45.9	36.6	30.8	26.1	21.4	19.2	15.6	11.4	9.6
Wheezing with colds (15a)	41.4	29.7	26.5	22.1	17.8	16.5	14.0	10.5	7.2
Wheezing apart from colds (15b)	26.6	17.9	13.8	9.3	7.8	6.3	5.1	3.2	2.4
Persistent wheezing (15c)	18.5	11.0	5.0	3.7	2.6	2.5	2.3	0.9	1.2
Weather affects chest (17)	23.9	13.4	11.4	6.2	6.1	6.2	4.6	3.2	3.6
Weather causes dyspnea (17f)	16.2	6.9	5.5	2.4	2.1	2.1	1.5	1.4	0.0
Nasal catarrh (18)	36.5	28.3	27.7	25.6	23.6	25.0	19.2	19.2	18.1
Persistent nasal catarrh (20)	20.7	16.2	14.8	13.8	13.5	14.9	9.9	9.6	9.6
Chest illnesses past 3 years (21)	24.3	21.0	18.6	16.8	15.4	12.4	15.0	12.8	15.7
Asthma (22)	11.7	5.5	3.5	1.3	2.0	1.3	0.6	1.8	0.0
Hay fever (23)	4.1	7.6	8.1	6.6	7.8	6.9	6.5	11.0	8.4
Persistent cough and phlegm (5, 10)	30.6	20.7	16.4	13.6	9.0	8.3	5.3	4.1	6.0
Persistent cough and phlegm, exacerbations (5, 10, 12b,c)	10.8	3.8	4.1	3.5	2.4	1.2	0.9	1.8	1.2
Persistent cough and phlegm, dyspnea (5, 10, 14a)	19.8	11.0	7.6	5.6	3.8	1.9	1.9	2.7	1.2

[a] Numbers following symptoms are questionnaire item numbers.

TABLE XII

PREVALENCE OF RESPIRATORY SYMPTOMS AMONG NONWHITE TRANSIT WORKERS WITH SPECIFIED DEVIATIONS BETWEEN OBSERVED AND EXPECTED $FEV_{1.0}$ VALUES

Symptom[a]	Deviation: observed $FEV_{1.0}$ minus expected $FEV_{1.0}$ (liters)								
	Observed values less than expected values				Minimal Difference	Observed values greater than expected values			
	< −1.0	−.8, −.9, −1.0	−.5, −.6, −.7	−.2, −.3, −.4	−.1, 0, +.1	.2, .3, .4	.5, .6, .7	.8, .9, 1.0	>1.0
Number in each group	*42*	*58*	*199*	*354*	*436*	*340*	*177*	*54*	*30*
Cough, AM (1)	38.1	12.1	13.6	12.1	10.8	9.1	9.0	9.3	6.7
Cough, day/night (3)	35.7	29.3	30.7	26.6	21.3	21.5	24.3	11.1	20.0
Persistent cough (5)	28.6	22.4	17.1	15.0	12.2	13.5	14.1	7.4	3.3
Phlegm, AM (6)	33.3	24.1	19.1	21.8	19.3	17.4	20.3	14.8	20.0
Phlegm, day/night (8)	42.9	31.0	25.1	23.7	23.9	26.2	24.3	20.4	36.7
Persistent phlegm (10)	26.2	22.4	15.6	19.5	15.8	16.5	18.6	14.8	16.7
Exacerbations (12b,c)	14.3	8.6	11.6	8.5	9.2	9.4	6.8	7.4	3.3
Dyspnea 2+ (14a)	33.3	24.1	18.1	14.4	14.9	15.3	12.4	7.4	6.7
Wheezing (15)	45.2	43.1	42.7	31.9	27.3	24.7	19.2	13.0	20.0
Wheezing with colds (15a)	42.9	37.9	39.7	30.2	25.2	23.2	18.6	11.1	16.7
Wheezing apart from colds (15b)	14.3	12.1	9.0	8.8	7.3	4.7	2.3	1.9	3.3
Persistent wheezing (15c)	14.3	3.4	3.5	4.0	3.2	2.4	2.3	1.9	3.3
Weather affects chest (17)	14.3	12.1	8.5	6.2	4.1	3.5	4.5	0.0	3.3
Weather causes dyspnea (17f)	7.1	1.7	2.0	2.3	2.1	1.2	1.7	0.0	0.0
Nasal catarrh (18)	38.1	24.1	27.1	23.2	25.2	22.1	23.2	31.5	33.3
Persistent nasal catarrh (20)	11.9	12.1	13.6	13.3	13.3	12.1	10.7	11.1	20.0
Chest illnesses past 3 years (21)	21.4	15.5	21.1	16.7	15.4	15.0	13.0	14.8	20.0
Asthma (22)	19.0	12.1	3.5	4.5	3.0	1.8	2.3	7.4	0.0
Hay fever (23)	14.3	8.6	5.5	8.8	7.1	6.5	6.2	11.1	13.3
Persistent cough and phlegm (5, 10)	16.7	19.0	9.5	9.0	7.8	8.5	9.6	7.4	3.3
Persistent cough and phlegm, exacerbations (5, 10, 12b,c)	2.4	3.4	3.0	2.5	2.5	2.4	2.8	3.7	0.0
Persistent cough and phlegm, dypsnea 2+ (5, 10, 14a)	7.1	8.6	4.0	2.5	2.3	2.9	1.7	1.9	0.0

[a] Numbers following symptoms are questionnaire item numbers.

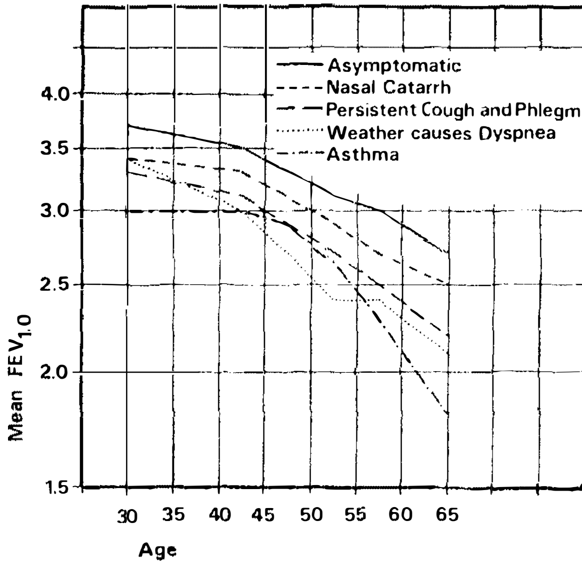

FIG. 3. Mean 1-second forced expiratory volumes ($FEV_{1.0}$) for white transit workers in specified symptom categories, by age.

specified symptoms, even those most directly related to the chest. In some of the subgroups shown, however, the numbers of non-white men tested are small.

In Tables IX and X, the axes have been reversed in order to show symptom-prevalence rates for men with specified forced expiratory volumes. Because of the strong correlation between age and lung-function test measurements, the data are given separately for two age-groups, 40–49 years, and 50–59 years. Among both white and non-white men in the younger age group, and among white men in the older group, the association between high prevalence of symptoms and low expiratory volumes, and, conversely, low symptom prevalence and relatively high expiratory volumes, is evident. The most marked gradients in symptom prevalence between men with $FEV_{1.0}$ values under 2.5 liters and those with values of 3.5 liters or more occur in all three study groups among men reporting wheezing, asthma, adverse effects of weather, and persistent cough and phlegm, in combination with other symptoms. In general also, prevalence rates of other chest-related symptoms are two or three times as great among men with $FEV_{1.0}$ values under 2.5 liters as they are among men with values of 3.5 or more. For example, prevalence of cough reported by these men, whether in the morning, or during the day or night, or persistent at any time for three months of the year, is strongly associated with $FEV_{1.0}$ level. Moreover, among the white men, the difference between prevalence of phlegm or shortness of breath for "low" and "high" FEV groups, is only slightly less than that observed for persistent cough.

The relationship between symptom prevalence and forced expiratory volumes has been considered thus far with respect to race and age only. This is a practical and perhaps adequate way of characterizing large groups of people, since the effect on $FEV_{1.0}$ of variations in sitting height is small compared with that of age. Even with the relatively large numbers of men in the industrial groups of this

study it was not practical to subdivide the study populations further into subgroups of sitting heights. Some other technique was needed to summarize the data for each race-industry study group on the four criteria, ventilatory function, symptom prevalence, age, and sitting height. The method chosen was basically that of comparing each man's observed $FEV_{1.0}$ value with a standard, or "expected" value for "normal" men of his own race, age, and sitting height class, and noting the size and the direction of the difference. Thus, deviations from normal $FEV_{1.0}$ values, preadjusted for age and sitting height, provide another index for examining relationships between symptom prevalence and ventilatory function within each race subgroup. For Tables XI and XII, "expected" values were obtained by inserting the specified ages and sitting heights in the regression equations for asymptomatic men of the appropriate race and industry group. Final classification of differences between "observed" and "expected" volumes was based on absolute differences between the two values. Differences could have been related to expected values in terms of percentages (or multiples of standard error, etc.). This would bring about a slight intergroup rearrangement of men, since any given deviation is of less importance, percentagewise, for large volumes than it is for small. Since no more authority exists for equating percentage deviations with clinical significance than for equating absolute differences with it, this is a moot point.

In the tables referred to, observed volumes less than expected are separated from those greater than expected by a group varying from the expected by no more than one-tenth of a liter and which is described as a minimal difference. This characterization is based on experience with the instrumentation and with observer variation in reading values from the graphs.

In general, the picture presented by the data in Tables XI and XII is similar to that in the previous set; as the observed $FEV_{1.0}$ values drop away more and more from the expected, prevalence of symptoms increases. In fact, this tendency appears to begin with the group of values with maximal differences *above* the expected and to continue across the range of deviations. These findings are of interest from the epidemiologic standpoint. The difference in prevalence percentages is not a clear-cut distinction between "sick" and "well" adults, but one which becomes increasingly evident with decreasing volume measurements. Along the scale of decreasing $FEV_{1.0}$ values, there would be a critical point, specific for each age (and size) group, below which significant numbers of men would be found to have clinical symptoms of obstructive lung disease. Whether those with relatively high $FEV_{1.0}$ values who nevertheless have clinical symptoms are a group in the early stages of the disease, also whether those with low values and no symptoms are a group with some other type of disease, would be interesting questions to pursue.

DISCUSSION

Lung function tests, performed as one of the procedures in this survey of New York City postal and transit workers, provided basic descriptive data of the men as a total population and also revealed distinctive patterns with respect to smoking and to respiratory disease symptoms. To summarize these findings: 1-second

forced expiratory volumes decreased with age in all study groups; age-specific mean $FEV_{1.0}$ values were slightly higher for white than for non-white men, and these differences were maintained within comparable smoking categories and when the study groups were standardized for sitting height measurements; the lowest values were found among cigarette smokers, especially the heavy smokers, and the highest volumes were those of nonsmokers or men without symptoms; and variations in patterns of the decline with age, as well as differences in age-specific mean $FEV_{1.0}$ values, were evident among groups of men reporting specified symptoms of respiratory disease.

The decrease with age in forced expiratory volumes among all subcategories of the study groups is consistent with findings in other studies. In the New York City groups, however, the rate of decline appeared to be different for the white and non-white men. Although average volumes in the age group under 35 years were 300 cc greater for white than for the non-white, this race difference was diminished to only 50 cc in the age group 60 years of age and over.

The data associating impaired ventilatory function with heavy cigarette consumption point again to the role of cigarette smoking in respiratory disease which was commented upon in the previous report of this survey dealing with respiratory disease symptoms (Densen *et al.*, 1967). The possible role of other agents is less clear. This is partly because of the marked association between indices of disease and cigarette use and the fact that so many individuals in the study population were cigarette users; even with the large populations included in this study, the numbers of nonsmokers in specific categories became very small when two or more additional variables were considered.

In comparisons of lung-function tests and symptom prevalence, percentages of men with symptoms were greater for those with lowest $FEV_{1.0}$ values than for those with high values. It was not surprising to find strong associations between low $FEV_{1.0}$ values and such symptoms as wheezing, shortness of breath, and effects of weather on chest symptoms since these symptoms, as the test itself, relate directly to impaired pulmonary ventilation.

It is in the symptom categories of cough and phlegm that a curious phenomenon appears. In the previously reported analysis of symptom prevalence of these men (Densen *et al.*, 1967), prevalence of cough and phlegm was found to increase with increasing numbers of cigarettes smoked daily but there was no marked age effect on prevalence of these symptoms. On the other hand, $FEV_{1.0}$ values, also associated with both cigarette smoking and with these symptoms, are themselves affected by age. The fact that age as a variable appears to operate differently on symptom-prevalence data and on ventilatory-function-test measurements may be one of the reasons that respiratory symptoms are reported in the absence of impaired function and, conversely, impaired function appears in the absence of symptoms. Other important factors in the relationship between function and occurrence of symptoms are the effects of smoking, per se, and the precision of the instruments of measurement. For interpreting data on pulmonary function tests and for determining standards it would be important to know if smoking (and, if so, at what level of consumption) lowers forced expiratory

volumes without producing symptoms. Olsen and Gilson (1960) have observed low $FEV_{1.0}$ values among smokers without evidence of chronic respiratory disease.

Despite the multiplicity of factors which bear on all of the parameters studied, it was nevertheless true that men in the New York City study with $FEV_{1.0}$ values under 2.5 liters reported greater prevalence of symptoms of chronic respiratory disease than did men with values above that volume, and the differences in prevalence were particularly marked among white men with $FEV_{1.0}$ values under 2.5 and those with values of 3.5 or more. Furthermore, when observed values were compared with "expected" values (based on regression equations) for each race-industry group, men with observed values exceeding expected by more than 1 liter appeared to be particularly symptom-free. Consistent with these findings was the fact that average age-specific $FEV_{1.0}$ values for men with cough and phlegm were lower than corresponding values for men without the symptom. Pinpointing the exact relationship between progression of respiratory symptoms and deterioration of ventilatory function, and the role of age, race, smoking habits, and other environmental factors, may depend on development of more sensitive testing mechanisms, but will certainly depend on observations of large numbers of individuals with known characteristics over a period of years.

To summarize the contrasting findings for white and nonwhite men in these study populations of postal workers and transit workers, symptom prevalence in general appeared to be higher among white men and forced expiratory volumes were also slightly higher for white men than for non-white men. Since it is the prevalence of symptoms and low test results which are taken to be indicative of chronic respiratory disease, this apparent contradiction in findings suggests the possibility that the data from these two sources may not have the same significance for the two racial groups. Consistent with the findings on symptoms are the mortality statistics which show that death rates from chronic bronchitis and emphysema in New York City are considerably higher for white males than they are for other males. The possibility that differences in ventilatory function measurements are associated with anatomic differences in the two races, or that the differential in presence of symptoms is related to differences in susceptibility, ought to be examined further. Discovery of real differences between the two groups could provide clues to the pathogenesis of chronic respiratory disease.

REFERENCES

BATES, D. V., WOOLF, C. R., AND PAUL, G. I. (1962). Chronic Bronchitis. A report on the first two stages of the coordinated study of chronic bronchitis in the Department of Veteran's Affairs, Canada. *Med. Serv. J. Can.*, 18, 211–303.

British Medical Research Council. Committee on the Aetiology of Chronic Bronchitis (1960). Instructions for the Use of the Questionnaire on Respiratory Symptoms. Pamphlet published by the British Medical Research Council.

DENSEN, P. M., BREUER, J., BASS, H. E., AND JONES, E. W. (1962). Organizational problems in the New York City survey for chronic respiratory disease. *Am. Rev. Resp. Dis.* 86, 855–857.

DENSEN, P. M., JONES, E. W., BASS, H. E., AND BREUER, J. (1967). A survey of respiratory disease among New York City postal and transit workers. I. Prevalence of symptoms. *Environ. Res.* 1, 265–286.

FERRIS, B. G., JR., AND ANDERSON, D. O. (1962). The prevalence of chronic respiratory disease in a New Hampshire town. *Am. Rev. Resp. Dis.* **86**, 165–177.

HOLLAND, W. W., REID, D. D., SELTSER, R., AND STONE, R. W. (1965). Respiratory disease in England and the United States. *Arch. Environ. Health* **10**, 338–343.

OLSEN, H. C., AND GILSON, J. C. (1960). Respiratory symptoms, bronchitis and ventilatory capacity in men: An Anglo-Danish comparison with special reference to difference in smoking habits. *Brit. Med. J.* **1**, 450–456.

SOLAND, J. A. (1962). Chronic Respiratory Disease Project: I. Graphs of Poor Quality. II. Regression Analysis. Report of a student training project in statistics. The Medical and Health Research Association of New York City, Inc., and the New York City Health Department (mss.).