Howard (1970), Bates (1973), Sharp et al. (1973), Fletcher et al. (1976), Fletcher and Peto (1977), Bosse et al. (1981), Beck et al. (1982), and Clement and van de Woestijne (1982). Although these investigations did not characterize the course of airflow obstruction across the entire human lifespan, the results provide a conceptual model for considering its development (Figure 15). Ventilatory function, generally measured by the FEV_1, increases during childhood and reaches a maximum level during early adulthood (Cotes 1979; Knudson et al. 1983). From this peak; the FEV_1 gradually and progressively declines with age. In people who develop airflow obstruction, a similar gradual loss of function occurs, but at a more rapid rate (Fletcher et al. 1976; Speizer and Tager 1979). Continued excessive loss of FEV_1 eventually results in symptomatic airflow obstruction when ventilatory function reaches a level at which activities are limited and dyspnea occurs. Evaluation by a physician for symptoms may lead to a clinical diagnosis at this point in the natural history of the disease process. This model may not satisfactorily describe the development of airflow obstruction in all individuals (Burrows 1981), but the accumulating evidence, reviewed below, indicates that a sustained excessive loss of ventilatory function most often leads to the development of clinically important chronic airflow obstruction.

In the conceptual model (Figure 15), there are three different measures of the frequency of airflow obstruction in a particular population: the prevalence of reduced ventilatory function as measured by the FEV_1, the FEV_1/FVC ratio, or other physiological parameters; the prevalence of physician-diagnosed airflow obstruction; and the frequency of excessive functional loss in a population followed over time. The first two measures can be determined from a single cross-sectional survey, whereas the third requires longitudinal observation. At present, scant data are available for the third category. The prevalence of physician-confirmed airflow obstruction is determined not only by the proportion of affected people in the population, but also by the patterns of medical care access and usage and the diagnostic practices of individual physicians. Furthermore, the clinical labels applied by physicians to people with airflow obstruction are variable and may include "chronic bronchitis," "emphysema," "COLD," and other terms. Thus, estimates of disease prevalence based on reported physician diagnoses may differ from those derived from physiological assessment.

Prevalence of Airflow Obstruction

Numerous populations throughout the world have been surveyed to assess the prevalence of airflow obstruction (Stuart-Harris 1968a, 1968b; Higgins 1974). Most often, the investigative techniques have included a respiratory symptoms questionnaire and measurement of pulmonary function, generally with a spirometer or peak flow meter.

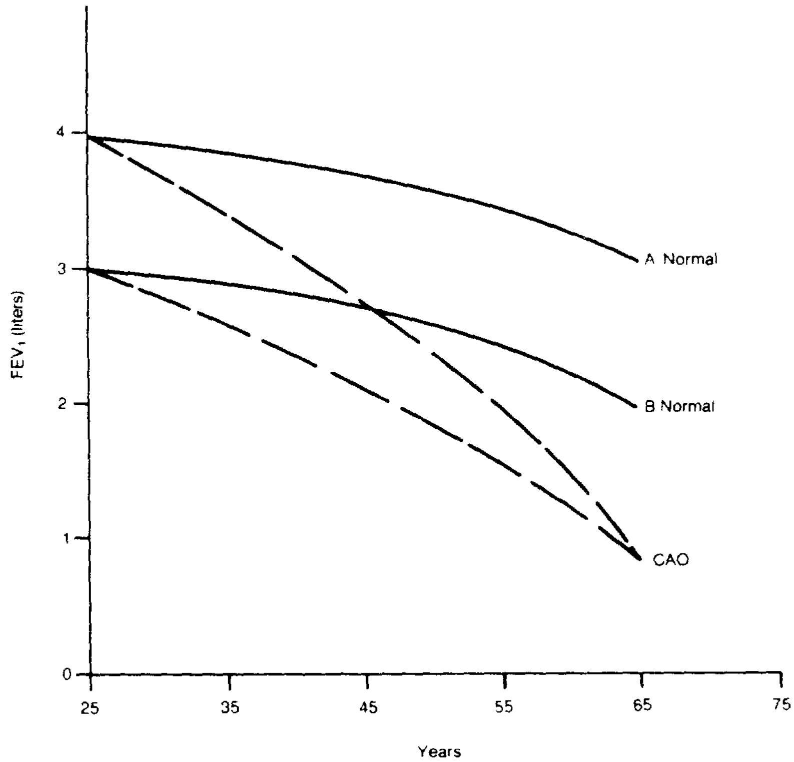


FIGURE 15.—Decline of FEV_1 at normal rate (solid line) and at an accelerated rate (dashed line)

NOTE: A: person who has attained a "normal" maximal FEV_1 during lung growth and development; B: person whose maximal FEV_1 has been reduced by childhood respiratory infection.

SOURCE: Samet et al. (1983).

The latter technique has the disadvantage of effort dependence. Early recognition of the potential problem of observer bias led to the development of standardized methods (Cochrane et al. 1951; Higgins 1974; Ferris 1978). Thus, most investigators throughout the world have used the British Medical Research Council questionnaire in the original form or with some modifications (Samet 1978). Standardization has been less uniform for lung function measurements, but minor variations in procedures would not introduce important differences in disease prevalence among the various populations examined.

Although many different populations have been surveyed since the 1950s, surprisingly few published reports provide data concerning the prevalence of airflow obstruction in the general population

(Tables 4 and 5). Comparisons among the available studies are limited by varying methodologies and inconsistent approaches in calculating rates. For example, only crude rates are available in some reports, and reference populations for age standardization also vary. The investigations summarized in Tables 4 and 5 were selected because they offer estimates of the prevalence of airflow obstruction in defined community-based samples. Those reports that describe mean levels of lung function parameters but not their distributions were excluded. Investigations of specific occupational groups were also excluded because prevalence estimates based on such populations may be biased by the overrepresentation of healthy persons (Monson 1980) and workplace exposures may have affected the frequency of disease.

For the United States, the available information spans the time period 1961 to 1979 and covers most geographic regions (Table 4). Regardless of the definition, it is apparent that airflow obstruction is common among adults in the United States. A higher proportion of men than women is affected, and the prevalence increases with age (Ferris and Anderson 1962; USPHS 1973; Lebowitz et al. 1975; Detels et al. 1979; Samet et al. 1982). Few minority populations have been studied. In New Mexico, Hispanic whites had a lower prevalence of physician-diagnosed current chronic bronchitis or emphysema than non-Hispanic whites (Samet et al. 1982). Although blacks have been included in several surveys (Bouhuys et al. 1979), prevalence estimates for this racial group have not been published. The available data (Table 4) do not permit a satisfactory assessment of changes in prevalence rates with time over the years 1961 to 1979.

The National Health and Nutrition Examination Surveys (NHANES 1) included spirometry in their evaluation of a representative sample of the U.S. population. The numerical values for these measures are reported by age, sex, and smoking status for the white population in the tables in the appendix to this chapter. The changes in mean values of these measures between age groups are also presented for white male and female smokers and nonsmokers in Figures 16 through 23. Differences between smokers and nonsmokers are evident for each of these spirometric measures. These differences are portrayed for successive age groups at one point in time, and therefore cannot be used to describe the changes with age or smoking status that one would expect in an individual or population followed sequentially. These data represent only those people in the study population who were willing and physically able to maximally exert themselves on the various spirometry tests. Others were disqualified by the examining physician because of existing medical conditions. The sampling nonresponse was higher among segments of the population expected to perform less well on the test, including people with existing airflow limitation. Therefore,

TABLE 4.—Prevalence of indices of airflow obstruction in selected U.S. adult populations

Author, year of study, location, reference	Number and type of population	Index	Prevalence (per 100)
Higgins and Kjelsberg, 1959–1960, Tecumseh, Michigan (*1967*)	4,500 men and women, 20 years or older, community sample	Emphysema based on physician history and examination	Men 4.1[1] Women 1.1[1]
Higgins, 1962–1979, Tecumseh, Michigan (*1983*)	4,916, 4,443, and 4,930 men and women, 16 to 74 years old, in 1962–65, 1967–69, 1978–79	Obstructive airways disease: FEV_1 less than 65% predicted, and FEV_1/FVC ratio less than 80%	Men / Women 1962–65: 4.8[2] / 2.5[2] 1967–69: 3.7[2] / 1.4[2] 1978–79: 3.7[2] / 2.2[2]
Ferris and Anderson, 1961, Berlin, New Hampshire (*1962*)	1,167 men and women, community sample	Irreversible obstructive lung disease, including wheezing, dyspnea, or FEV_1/FVC ratio less than 60%	Men 8.6[1] Women 8.1[1]
Mueller et al., 1967, Glenwood Springs, Colorado (*1971*)	609 men and women, community sample	Chronic airway obstruction: FEV_1/FVC ratio less than 60%	Men 13.2[1] Women 1.5[1]
U.S. Public Health Service, 1970, United States (*1973*)	116,000 men and women, nationwide sample	Presence of the condition during the previous year	Chronic bronchitis Men 3.1[1] Women 3.4[1] Emphysema Men 1.0[1] Women 0.3[1]

TABLE 4.—Continued

Author, year of study, location, reference	Number and type of population	Index	Prevalence (per 100)
Lebowitz et al., 1972–1973, Tucson, Arizona (*1975*)	3,805 men and women, adults and children, community sample	Physician-confirmed illness, current	Men over 44 years Chronic bronchitis 10.2 Emphysema 13.3[1] Women over 44 years Chronic bronchitis 9.0[1] Emphysema 4.3[1]
Knudson et al., 1972–1973, Tucson, Arizona (*1976*)	3,805 men and women, adults and children, community sample	FEV_1 and FEV_1/FVC ratio lower than 95th percentile for "normal"	Asymptomatic cigarette smokers FEV_1 7.8[1] FEV_1/FVC 8.1[1]
Detels et al., 1973–1974, Burbank and Lancaster, California (*1979*)	3,465 and 4,509 men and women, in Burbank and Lancaster, respectively, community samples	FEV_1 less than 50% of predicted value	Lancaster 18–59 yrs 0.8[2] 60 yrs 6.5[2] Burbank 18–59 yrs 1.0[2] 60 yrs 6.2[2]
Tager et al., 1973-1974, East Boston, Massachusetts (*1978*)	1,770 men and women, community sample of index subjects and their relatives	FEV_1 less than 65% of predicted	Men 5.6[1] Women 3.4[1]
Ferris et al., 1974–1977, six cities in the U.S. (*1979*)	7,909 men and women, community sample	FEV_1/FVC less than, equal to 60%	Men 5.0[1] Women 1.9[1]

TABLE 4.—Continued

Author, year of study, location, reference	Number and type of population	Index	Prevalence (per 100)	
			Non-Hispanic whites	
Samet et al., 1978–1979, Albuquerque, New Mexico (*1982*)	1,722 men and women, community sample	Physician-diagnosed current chronic bronchitis or emphysema	Men	3.6[2]
			Women	3.4[2]
			Hispanic whites	
			Men	0.8[2]
			Women	1.8[2]

[1] Crude rate.
[2] Age-adjusted rate.
[3] Age and sex-adjusted rate.

TABLE 5.—Prevalence of indices of airflow obstruction in selected adult non-U.S. populations

Author, year of study, location, reference	Number and type of population	Index	Prevalence (per 100)	
Anderson et al., 1963, Chilliwack, British Columbia (*1965*)	558 men and women, community sample	Obstructive lung disease, including wheezing, dyspnea, or FEV_1/FVC ratio less than 60%	Men Women	12.6[1] 8.7[1]
		FEV_1/FVC ratio less than 60%	Men Women	7.3[1] 3.5[1]
Mimica, 1969, Croatia, Yugoslavia (*1975*)	4,214 men and women, samples of six communities	FEV_1/FVC ratio less than 60%	Men Women	8.3[1] 1.9[1]
Sawicki, 1968, Krakow, Poland (*1977*)	4,355 men and women, community sample	FEV_1/FVC ratio less than 60%	Men Women	7.0[1] 5.0[1]
Huhti et al., 1968-1970, Hankasalmi, Finland (*1978*)	1,162 men, community sample	FEV_1/FVC ratio less than 60%	Men	7.6[1]
Brown and Gajdusek, year not stated, Western Caroline Islands (*1978*)	240 men and women, community sample	Chronic obstructive airway disease: clinical and spirometric criteria	Men and women	7.9[1]
Anderson, year not stated, Lufa, Papua New Guinea (*1979*)	770 men and women, 25 years or older, community sample	FEV_1/FVC ratio less than 60%	Men Women	9.0[1] 3.6[1]

[1] Crude rate.

the estimated means are probably overestimates of the true population values. Nevertheless, the figures clearly portray the magnitude of the effect that smoking exerts on expiratory flow rates in a national population sample.

Airflow obstruction is also prevalent outside the United States (Table 5). The disease can be identified in both technologically advanced and less developed populations. As in the United States, in other countries the prevalence of airflow obstruction is higher among men than among women.

Determinants of Airflow Obstruction

Introduction

Current understanding of the natural history of airflow obstruction suggests that risk factors operative during both childhood and adulthood may influence the development of disease. In the conceptual model proposed in Figure 15, childhood factors might increase the risk of airflow obstruction by lowering the maximum FEV_1 attained during lung growth and development, by predisposing to increased FEV_1 decline during adulthood, or by both mechanisms (Speizer and Tager 1979). During adulthood, in the model of Figure 15, risk factors for airflow obstruction must increase the rate at which lung function deteriorates.

Many endogenous and exogenous determinants of the development of airflow obstruction have been postulated (Tables 6 and 7). However, in spite of over 30 years of intensive investigation, the available data are definitive only for cigarette smoking and for α_1-antitrypsin deficiency (Speizer and Tager 1979; USDHHS 1980).

Cigarette Smoking and Chronic Airflow Obstruction

In nearly every population studied worldwide, cigarette smoking is the predominant determinant for the prevalence of airflow obstruction (Tables 8, 9, and 10). The uncommon exceptions primarily involve populations in whom severe chest infections or wood smoke exposure may have an etiological role (Woolcock et al. 1973; Anderson 1979a). The relationship between cigarette smoking and airflow obstruction has been variably described in the published reports. In some, the prevalence of airflow obstruction has been considered; in others, mean values of lung function parameters have been compared across categories of smoking use. In several more recent analyses, multiple regression or other multivariate techniques have been used for more careful characterization of dose-response relationships. Because the epidemiologic criteria for airflow obstruction are generally based on the FEV_1, this section focuses on studies that have included measurements of this parameter. The selected studies involve community samples (Tables 8 and 9) and

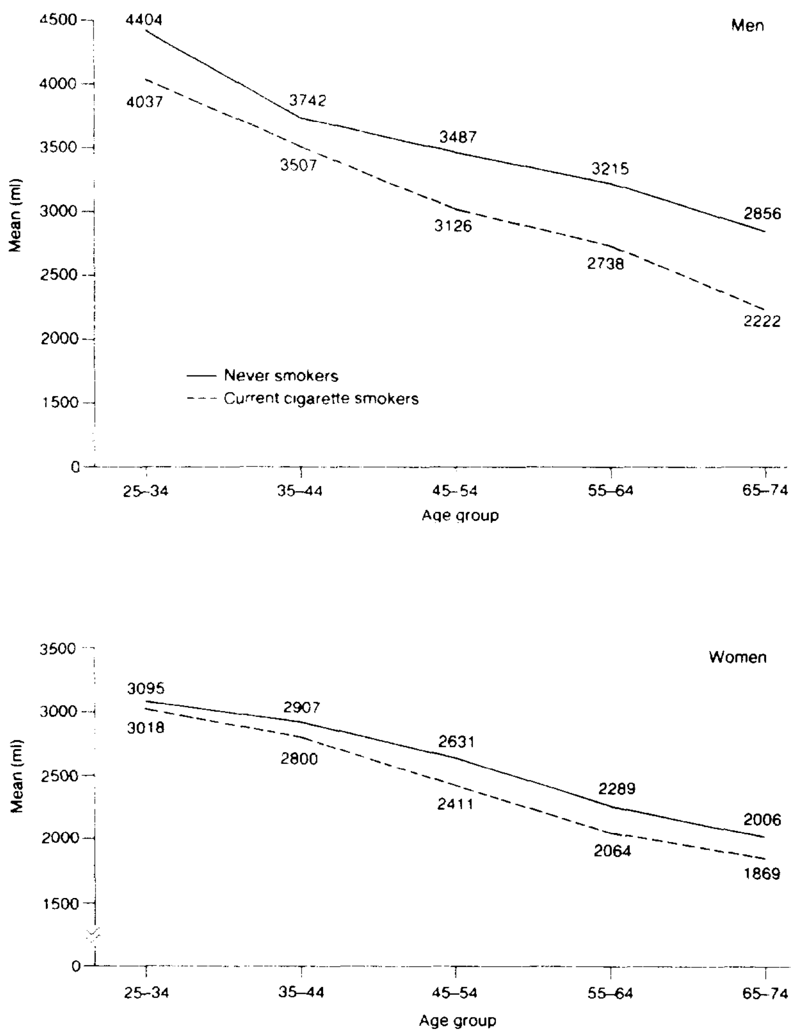


FIGURE 16.—Mean FEV_1 for white persons by smoking status, sex, and age, United States, 1971–1975

NOTE: Values adjusted by the direct method to reflect the age distribution of the U.S. population at the midpoint of the survey.

SOURCE: National Center for Health Statistics. Unpublished data from the first National Health Nutrition and Examination Survey (NHANES 1).

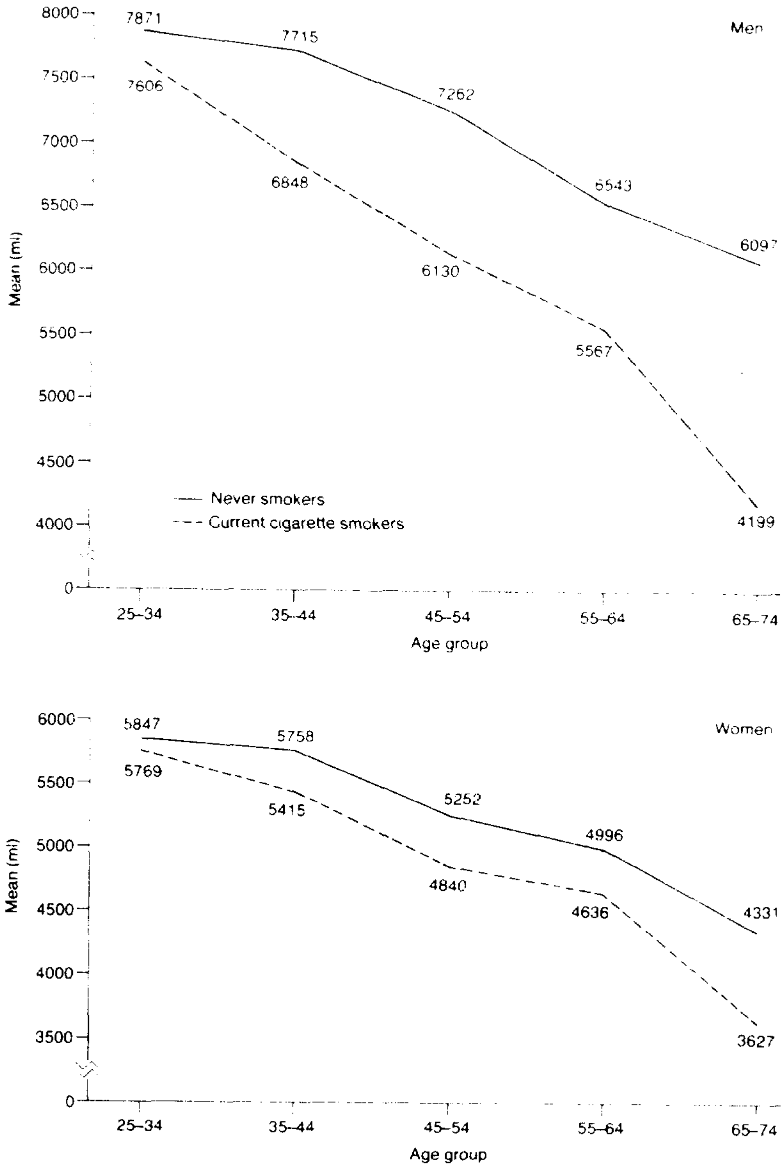


FIGURE 17.—Mean flow at 25 percent of FVC for white persons by smoking status, sex, and age, United States, 1971–1975

NOTE: Values adjusted by the direct method to reflect the age distribution of the U.S. population at the midpoint of the survey.

SOURCE: National Center for Health Statistics. Unpublished data from the first National Health Nutrition and Examination Survey (NHANES 1).

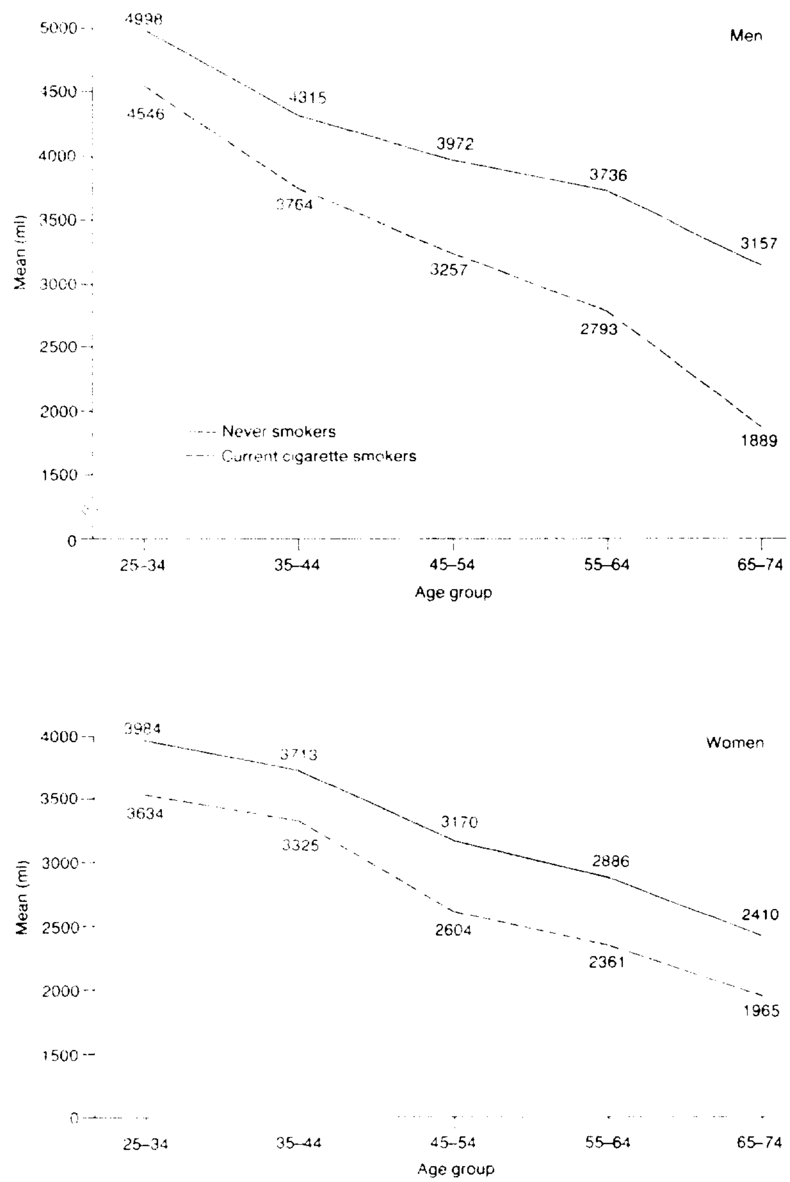


FIGURE 18.—Mean flow at 50 percent of FVC for white persons by smoking status, sex, and age, United States, 1971–1975

NOTE: Values adjusted by the direct method to reflect the age distribution of the U.S. population at the midpoint of the survey.

SOURCE: National Center for Health Statistics. Unpublished data from the first National Health Nutrition and Examination Survey (NHANES I).

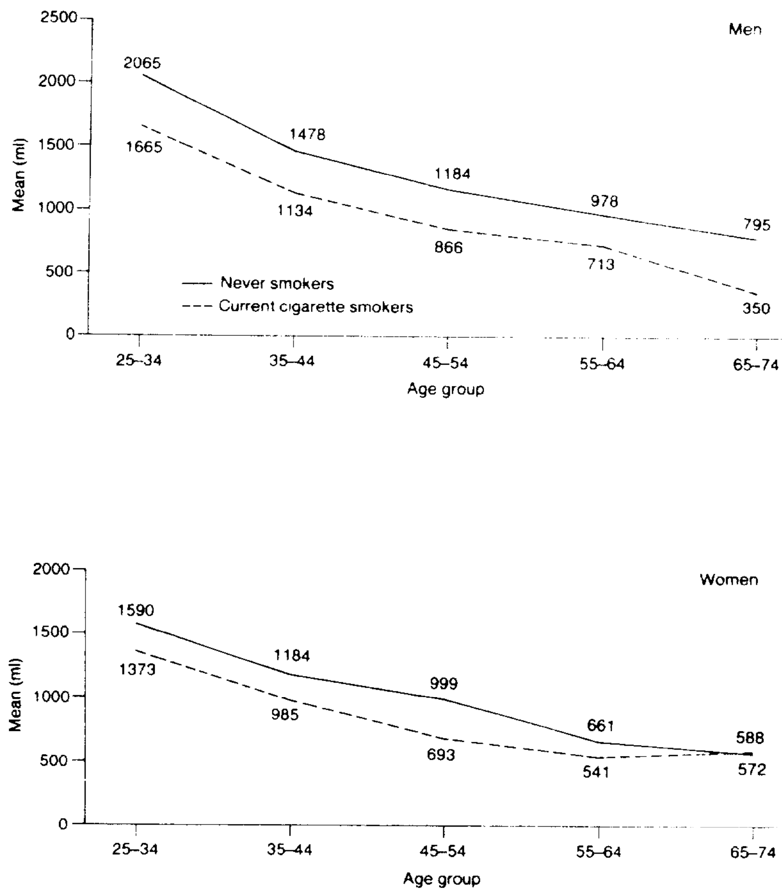


FIGURE 19.—Mean flow at 75 percent of FVC for white persons by smoking status, sex, and age, United States, 1971–1975

NOTE: Values adjusted by the direct method to reflect the age distribution of the U.S. population at the midpoint of the survey.

SOURCE: National Center for Health Statistics. Unpublished data from the first National Health Nutrition and Examination Survey (NHANES 1).

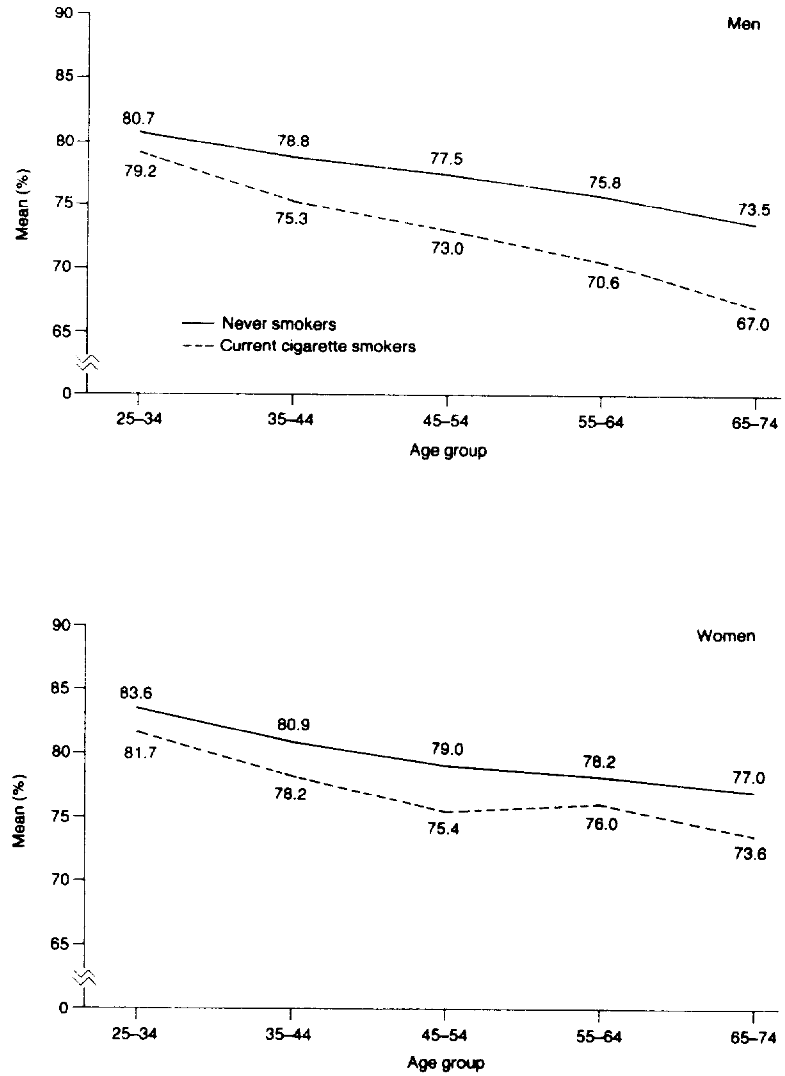
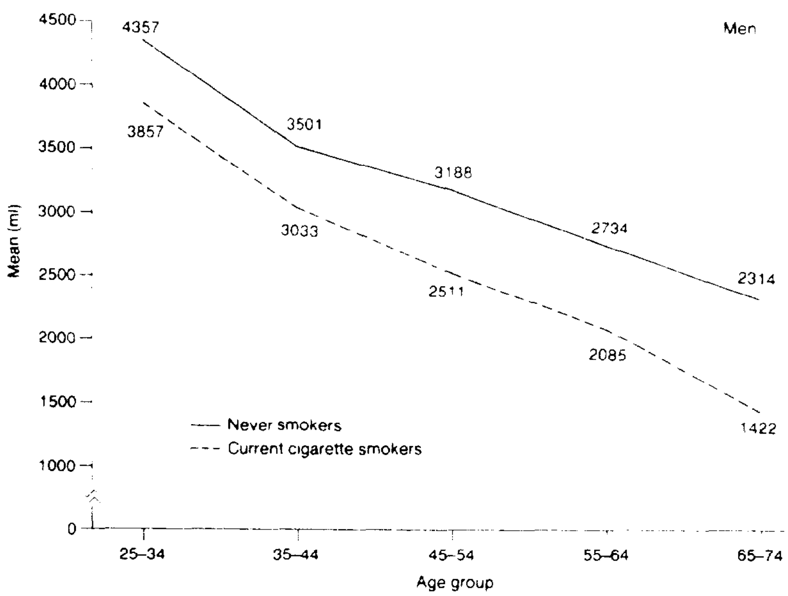


FIGURE 20.—Mean FEV$_1$/FVC ratio for white persons by smoking status, sex, and age, United States, 1971–1975

NOTE: Values adjusted by the direct method to reflect the age distribution of the U.S. population at the midpoint of the survey.

SOURCE: National Center for Health Statistics. Unpublished data from the first National Health Nutrition and Examination Survey (NHANES 1).



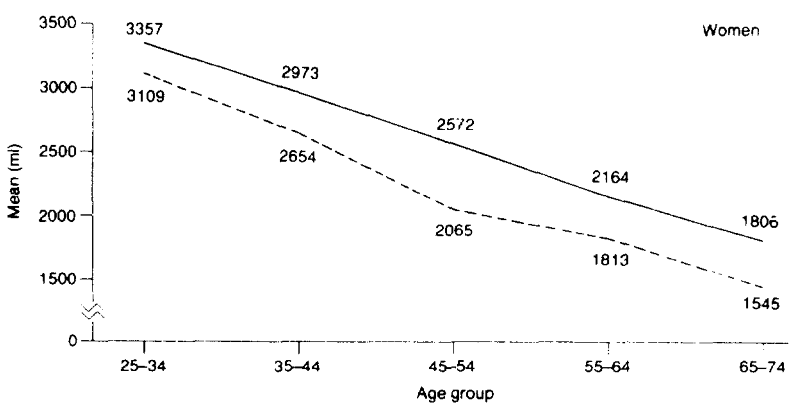


FIGURE 21.—Mean MMEF for white persons by smoking status, sex, and age, United States, 1971–1975

NOTE: Values adjusted by the direct method to reflect the age distribution of the U.S. population at the midpoint of the survey.

SOURCE: National Center for Health Statistics. Unpublished data from the first National Health Nutrition and Examination Survey (NHANES 1).

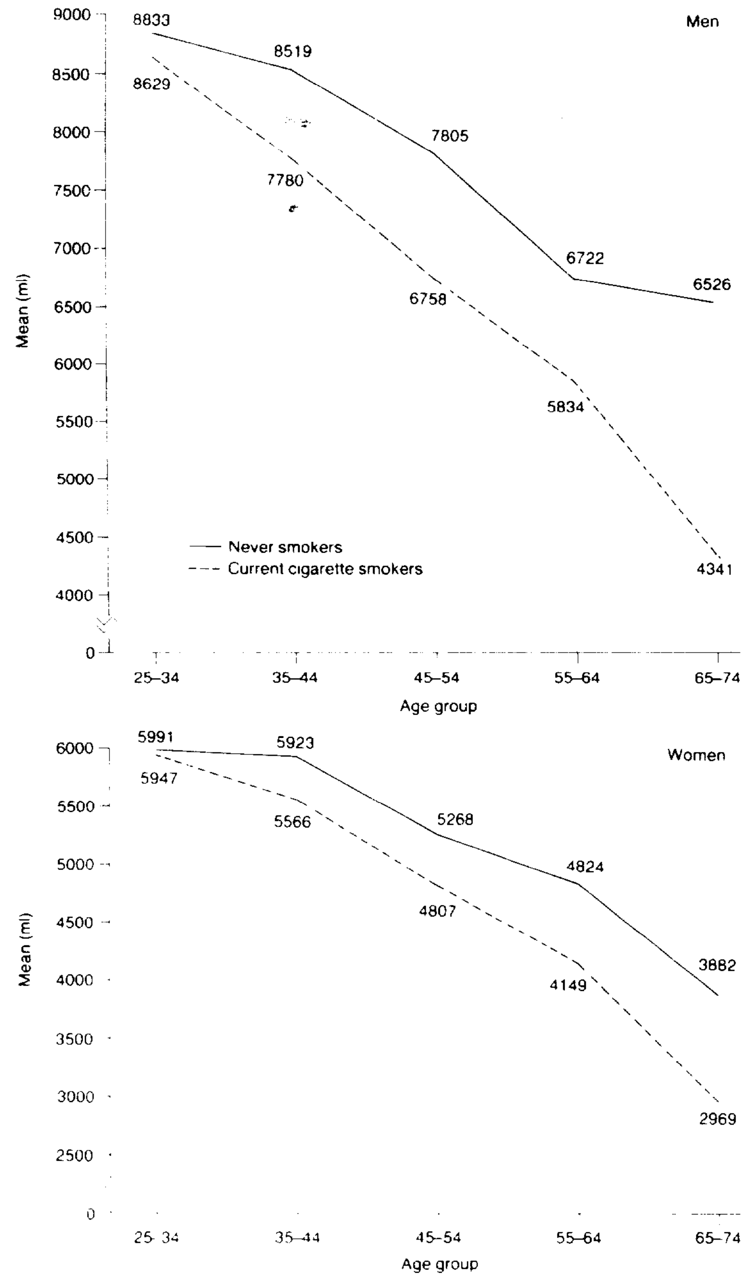


FIGURE 22.—Mean MEFR for white persons by smoking status, sex, and age, United States, 1971–1975

NOTE: Values adjusted by the direct method to reflect the age distribution of the U.S. population at the midpoint of the survey.

SOURCE: National Center for Health Statistics. Unpublished data from the first National Health Nutrition and Examination Survey (NHANES 1).

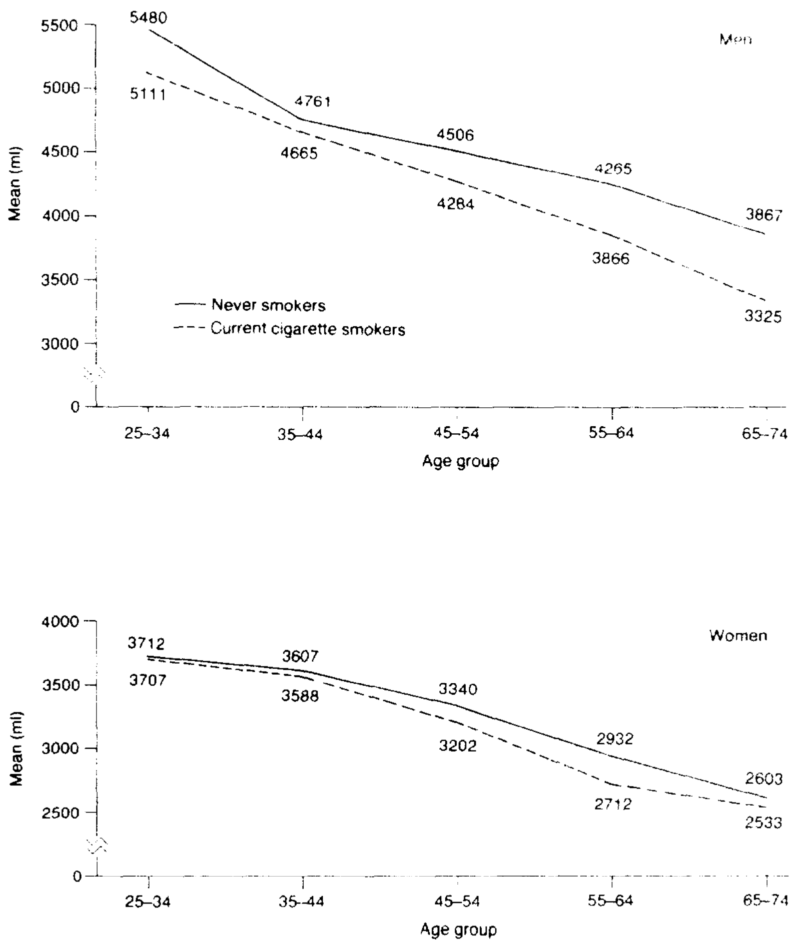


FIGURE 23.—Mean forced vital capacity for white persons by smoking status, sex, and age, United States, 1971–1975

NOTE: Values adjusted by the direct method to reflect the age distribution of the U.S. population at the midpoint of the survey.

SOURCE: National Center for Health Statistics. Unpublished data from the first National Health Nutrition and Examination Survey (NHANES 1).

TABLE 6.—Postulated risk factors for airflow obstruction during childhood

Active cigarette smoking
Air pollution, indoor and outdoor
Airways hyperreactivity
Atopy
Familial factors
Passive exposure to tobacco smoke
Respiratory illnesses
Socioeconomic status

TABLE 7.—Morbidity

ESTABLISHED RISK FACTORS FOR AIRFLOW OBSTRUCTION DURING ADULTHOOD
Active cigarette smoking
$Alpha_1$-antitrypsin deficiency
PUTATIVE RISK FACTORS FOR AIRFLOW OBSTRUCTION DURING ADULTHOOD
ABH secretor status
Air pollution
Airways hyperreactivity
Alcohol consumption
Atopy
Childhood respiratory illnesses
Familial factors
Occupation
Passive exposure to tobacco smoke
Respiratory illnesses
Socioeconomic status

occupational groups (Table 10) with exposures that have little or no effect on lung function. The selected studies are all cross sectional in design and thus describe the relationship between cigarette smoking and lung function level at only a single point in time.

Investigations in the United States, spanning the time period 1958 to 1977, convincingly demonstrate that cigarette smoking is a strong determinant of FEV_1 level and the prevalence of airflow obstruction (Table 8). In every population for which prevalence data are available, airflow obstruction is more common among smokers than among nonsmokers (Mueller et al. 1971; Knudson et al. 1976; Detels et al. 1979; Rokaw et al. 1980). In fact, in a multivariate analysis of determinants of airflow obstruction in East Boston, lifetime cigarette consumption was the only statistically significant predictor (Tager et al. 1978). Data from populations outside the United States (Table 9) and from a variety of occupational groups (Table 10) confirm the importance of cigarette smoking. Effects of cigarette smoking on FEV_1 level have been readily demonstrated in employed populations

TABLE 8.—Association between cigarette smoking and FEV_1 level in selected U.S. adult populations

Author, year of study, location, reference	Number and type of population	Findings		
Ashley et al., 1958, Framingham, Massachusetts, (*1975*)	1,238 men and women, 37 to 69 years of age	By linear regression, significant decline of FEV_1/FVC ratio with pack-years of cigarette consumption in men; similar decline demonstrated in women, but not significant for all age groups		
Higgins and Kjelsberg 1959–1960, Tecumseh, Michigan (*1967*)	5,140 men and women, 16 to 79 years of age	Age-adjusted mean FEV_1 (liters)	Men	Women
		Nonsmokers	3.32	2.34
		Ex-smokers	3.31	2.34
		Current smokers	3.12	2.28
Higgins et al., 1963, Marion County, West Virginia (*1968a*)	926 white men, 20 to 69 years of age	Mean FEV_1 (liters)		
		Nonsmokers	3.64	
		Ex-smokers	3.25	
		Current smokers		
		1-14/day	3.67	
		15–24/day	3.51	
		≥25/day	3.30	
Higgins et al., 1962–1965, Tecumseh, Michigan (*1977*)	4,669 men and women, 20 to 74 years of age	Mean normalized FEV_1 score	Men	Women
		Nonsmokers	10.2	10.1
		Ex-smokers	9.9	10.0
		Current smokers		
		<20/day	9.8	9.9
		≥20/day	9.5	9.6

TABLE 8.—Continued

Author, year of study, location, reference	Number and type of population	Findings
Mueller et al., 1967, Glenwood, Colorado (*1971*)	609 men and women, 20 to 69 years of age	Prevalence of $FEV_1/FVC < 60\%$ Men / Women Nonsmokers: 3 / 1 Current smokers: 19 / 2
Ferris et al., 1967, Berlin, New Hampshire (*1973*)	848 men and women, 30 to 80 years of age	By multiple regression, in men and women, FEV_1 drops by 0.01 liters for each cigarette smoked per day
Burrows et al., 1972–1973, Tucson, Arizona (*1977*)	2,369 men and women, above 14 years of age	By multiple regression analysis, FEV_1 drops by 0.31 and 0.24 percent of predicted value per pack-year of smoking in men and women, respectively
Knudson et al., 1972–1973, Tucson, Arizona (*1976*)	2,735 men and women, all ages	Prevalence (%) of abnormal FEV_1 and/or FEV_1/FVC Asymptomatic nonsmokers: 8.3 Asymptomatic smokers: 13.3
Tager and Speizer, 1973–1974, East Boston, Massachusetts (*1976*)	633 men and women, 15+ years of age	By multiple regression, in men and women, significant reduction of an FEV_1 score with increasing lifetime consumption, and in smokers compared with nonsmokers
Tager et al., 1973–1974, East Boston, Massachusetts (*1978*)	1,251 men and women,	By multiple logistic analysis, lifetime cigarette consumption only significant predictor of airflow obstruction, defined as FEV_1 less than 65% predicted
Beck et al., 1972–1974, Lebanon and Ansonia, Connecticut, Winnsboro, South Carolina (*1981*)	4,690 men and women, 7+ years of age	By multiple regression analysis, significant dose–response relationships of adjusted residual FEV_1 with measures of cigarette smoking: duration, pack-years, and cigarettes per day

TABLE 8.—Continued

Author, year of study, location, reference	Number and type of population	Findings		
Ferris et al., 1974–1977, U.S. communities (*1979*)	8,480 men and women, 25 to 74 years of age	Mean residual FEV_1 (liters) after correction for height and age		
		Lifetime packs	Men	Women
		None	0.25	0.06
		< 3,000	0.21	0.04
		3,000–8,999	0.01	–0.05
		9,000–17,999	–0.19	–0.20
		≥ 18,000	–0.45	–0.28
Detels et al., Rokaw et al., 1973–1975, Burbank, Lancaster, Long Beach, California (Detels et al., 1979, Rokaw et al., 1980)	Approximately 8,000 men and women, 18 years or older	Prevalence (%) of FEV_1 below 75% predicted, age and sex-adjusted		
			Never smoked	Current smoker
		18–59 years old		
		Burbank	6.6	12.5
		Lancaster	3.4	6.6
		Long Beach	5.3	10.0
		≥ 60 years old		
		Burbank	15.9	23.5
		Lancaster	13.4	21.7

TABLE 9.—Association between cigarette smoking and lung function in selected non-U.S. populations

Author, year of study, location, reference	Number and type of population	Findings		
Higgins, 1956, Vale of Glamorgan, Wales (*1957*)	581 men and women, 25 to 74 years of age	In men, reduced peak flow rates and indirect maximum voluntary ventilation in smokers compared with nonsmokers; no effect of smoking in women		
Higgins et al., 1957 Stavely, England (*1959*)	776 men, aged 25 to 34 and 55 to 64	Mean indirect maximal breath capacity (liters)		
			25 to 34 yrs	55 to 64 yrs
		Nonsmokers	145	101
		Ex-smokers	143	89
		Current smokers		
		Light	140	87
		Heavy	133	80
Higgins et al., 1958, Rhondda Fach, Wales (*1961*)	537 men, aged 35 to 64, and 173 women, aged 55 to 64	Mean indirect maximal breathing capacity (liters), men		
			Miners	Nonminers
		Nonsmokers	93.1	114.6
		Ex-smokers	93.6	105.9
		Current smokers		
		Light	89.0	104.1
		Heavy	88.3	99.4
		No effect of smoking in women		

TABLE 9.—Continued

Author, year of study, location, reference	Number and type of population	Findings		
College of General Practitioners, 1958, Britain (*1961*)	787 men and 782 women, aged 40 to 64	Age-adjusted mean PEFR[1] (liters/minute)		
			Men	Women
		Nonsmokers	448	318
		Ex-smokers	417	300
		Current smokers		
		1–14/day	412	314
		15–24/day	399	310
		≥25/day	398	265
Sluis-Cremer and Sichel, 1962–1963, Carletonville, South Africa (*1968*)	533 men, 35 years or older	Reduced FEV_1 and PEFR[1] with increased tobacco consumption		
Huhti, 1961, Harjavalta, Finland (*1967*)	420 men, 608 women, aged 40 to 64	All women, nonsmokers; in men, reduced FEV_1 and PEFR[1] in smokers compared with nonsmokers		
Wilhelmsen et al., 1963, Göteborg, Sweden (*1969*)	339 men, aged 50	Mean FEV_1 (liters)		
		Nonsmokers	3.72	
		Ex-smokers	3.71	
		Current smokers		
		1–14 g/day	3.58	
		≥15 g/day	3.36	
Huhti et al., 1968–1970, Hankasalmi, Finland (*1978*)	1,162 men, aged 25 to 69	Reduced FEV_1 in smokers compared with nonsmokers; increased prevalence of FEV_1/FVC ratio less than 60% in smokers		

TABLE 9.—Continued

Author, year of study, location, reference	Number and type of population	Findings		
Mimica, 1969, Croatia, Yugoslavia (*1975*)	4,214 men and women, 35 to 54 years of age		Mean FEV_1 (liters)	
			Men	Women
		Nonsmokers	3.58	2.62
		Ex-smokers	3.57	2.70
		Current smokers		
		Light	3.42	2.64
		Heavy	3.42	2.60
Neri et al., 1969–1973, Sudbury and Ottawa, Canada (*1975*)	5,488 men and women, 14 years of age or older	Declining ratio of FEV_1/FVC with number of cigarettes smoked daily		
Manfreda et al., 1974, Portage la Prairie and Charleswood, Canada (*1978*)	502 men and women, 25 to 55 years of age	Significant regression of FEV_1/FVC ratio on number of cigarettes smoked daily		
Anderson, year not stated, Karkar Island, Papua New Guinea (*1976*)	548 men and women, 25 years of age or older		Age and height-adjusted mean FEV_1 (liters)	
			Men	Women
		Nonsmokers	2.56	2.13
		Smokers	2.40	2.01
Anderson, year not stated, Lufa, Papua New Guinea (*1979*)	733 men and women 25 years of age or older		Age and height-adjusted mean FEV_1 (liters)	
			Men	Women
		Nonsmoker	2.58	2.36
		Ex-smoker	2.62	2.27
		Occasional	2.57	2.29
		Regular	2.63	2.43

[1] Peak expiratory flow rate

TABLE 10.—Association between cigarette smoking and lung function level in selected occupational groups

Author, year of study, location, reference	Number and type of population	Findings	
Sharp et al., 1960–1961, Chicago, U.S. (*1965*)	1,887 men, aged 43 to 58 years, employed at an electronics plant	Mean FEV_1 (liters)	
		Nonsmokers	3.15
		Smokers	
		<one pack per day	3.02
		≥one pack per day	2.90
Fletcher et al., 1961, London, England (*1976*)	1,136 men aged 30 to 59, employed at bank or in maintenance of transportation equipment	Adjusted FEV_1 (liters)	
		Nonsmokers	3.28
		Ex-smokers	3.16
		Current smokers	
		1–4 cigarettes/day	2.81
		5–14 cigarettes/day	3.05
		15–24 cigarettes/day	2.99
		≥25 cigarettes/day	2.94
Goldsmith et al., 1961, San Francisco, U.S. (*1962*)	3,311 longshoremen	Mean FEV_1 percent of predicted value	
		Never smokers	100
		Ex-smokers	97
		Current smokers	
		10 cigarettes/day	93
		11–39 cigarettes/day	93
		≥40 cigarettes/day	94

TABLE 10.—Continued

Author, year of study, location, reference	Number and type of population	Findings
Balchum et al., 1961, Los Angeles, U.S. (*1962*)	1,456 men employed in various industries	Prevalence (per 100) of FEV_1/FVC ratio less than 70 percent Nonsmokers: 7.6 Smokers: 18.8
Coates et al., 1962, Detroit, U.S. (*1965*)	1,584 male and female postal employees, aged 40 or older	Reduced FEV_1 and FEV_1/FVC ratio in smokers of 25 or more cigarettes daily compared with nonsmokers
Densen et al., 1961–1963, New York City, U.S. (*1969*)	12,500 males employed as postal or transit workers	Age- and height-adjusted FEV_1 (liters) Postal workers (White / Nonwhite); Transit workers (White / Nonwhite) Nonsmokers: 3.29 / 3.05; 3.39 / 3.08 Cigarette smokers $<$25 g per day: 3.14 / 2.95; 3.15 / 3.00 $\geq$25 g per day: 3.06 / 2.93; 3.02 / 2.95
Bandé et al., 1960–1975, Belgium (*1980*)	7,123 male military personnel, a few over age 45	By multiple regression, in cross-sectional analysis, significant effect of smoking on FEV_1 level after age 35
Comstock et al., 1962–1963 and 1967, U.S. and Japan (*1973*)	Three cross-sectional studies of men working for telephone company; U.S.—1,302 and 1,194 subjects, aged 40 to 65, 6% in study; Japan—592 subjects, aged 40 to 60	Mean FEV_1 level as percent predicted Cigarettes per day: U.S. Study 1 / U.S. Study 2 / Japan None: 106 / 103 / 99 1-14: 104 / 101 / 100 15-24: 98 / 92 / 98 $\geq$25: 95 / 93 / 99