Effect of Active and Passive Smoking on Ventilatory Function in Elderly Men and Women

Catherine Frette, Elizabeth Barrett-Connor, and Jack L. Clausen

Although it is well known that pulmonary function declines with age and that this decline is accelerated by cigarette smoking, the effects of such factors are not well established in elderly individuals. The authors examined the effect of active and passive smoking on ventilatory function assessed by spirometry in 1,397 community-dwelling men and women aged 51–95 years and observed that active smoking affected ventilatory function into advanced old age. Smokers who quit before age 40 had an age- and height-adjusted forced expiratory volume in 1 second (FEV$_1$) (in liters) that did not differ from that of never smokers in either men (3.06 (standard deviation (SD) = 0.58) vs. 3.06 (SD = 0.60), $p = 0.99$) or women (2.09 (SD = 0.51) vs. 2.13 (SD = 0.46), $p = 0.51$). In smokers who quit between ages 40 and 60, FEV$_1$ was lower than that of never smokers and higher than that of current smokers in both men and women. Male and female smokers who quit after age 60 had a FEV$_1$ similar to current smokers. FEV$_1$ correlated significantly with the duration since quitting smoking ($r = 0.24$, $p = 0.0001$ in men; and $r = 0.26$, $p = 0.0001$ in women) and with the duration of smoking ($r = -0.30$, $p = 0.0001$ in both men and women). FEV$_1$ and forced midexpiratory rate in 25–75 seconds were not lower in either male or female nonsmokers passively exposed to cigarette smoke at home. These results confirm the deleterious effect of active smoking and demonstrate a beneficial effect of quitting smoking before age 40, with an apparent lack of benefit on pulmonary function if cessation is delayed to age 60. Am J Epidemiol 1996; 143:757–65.

The decrease of ventilatory function with age and the effect of smoking on ventilatory function have been well established in adults (1–21). Several epidemiologic studies of pulmonary function have been conducted in elderly men and women from population-based samples (22–27); however, only a few of these studies included many subjects aged 75 years and older (24–27). Whether smoking accelerates ventilatory function loss similarly in the elderly compared with middle-aged or younger adults remains to be established. We examined the effects of age and active, passive, and quitting smoking as related to ventilatory function in a population-based sample of 1,397 subjects aged 51 to 95 years whose modal age was 73 years.

MATERIALS AND METHODS

Population

From 1972 to 1974, 82 percent of adult residents of Rancho Bernardo, a geographically defined Southern California community, participated in the Rancho Bernardo Heart and Chronic Disease Study. Respondents were representative of the total community (28). Between 1988 and 1991, 80 percent of local surviving participants had pulmonary function assessed by spirometry using standard American Thoracic Society (ATS) criteria.

Methods

Between 1988 and 1991, information on smoking history (age at onset and cessation, number of cigarettes smoked per day) and household exposure to passive smoking was collected in standardized interviews. Subjects were classified as never smokers, past smokers, and current smokers. Pack-years were calculated to quantify the degree and duration of exposure to cigarette smoking among ever smokers (1 pack-year = 20 cigarettes smoked per day for 1 year). Never smokers were defined as having smoked fewer than 100 cigarettes in their lifetime. Passive smoking in

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Abbreviations; ATS, American Thoracic Society; FEF$_{25–75}$, forced midexpiratory rate in 25–75 seconds; FEV$_1$, forced expiratory volume in 1 second; FVC, forced vital capacity; SD, standard deviation.

Department of Family and Preventive Medicine, University of California, San Diego, La Jolla, CA 92039–0607.

Reprint requests to Dr. Barrett-Connor, Department of Family and Preventive Medicine, Division of Epidemiology, University of California, San Diego, 9500 Gilman Drive, La Jolla, CA 92039–0607.
never smokers was defined as a positive answer to the question, "Have you ever lived in the same household with someone who smoked cigarettes or a pipe or cigar regularly?" Information on the presence of asthma ("Has a doctor ever told you that you had asthma?")

shortness of breath ("Do you get short of breath walking with other people at an ordinary pace on the level?")

wheezing ("Does your chest ever sound wheezy or whistling?")

and phlegm ("Do you usually bring up any phlegm from your chest?") was obtained by standardized questionnaire. Subjects were also asked whether they had physician-diagnosed emphysema, bronchitis, or heart disease.

Spirometric measurements were performed in seated subjects using a water-sealed spirometer (Warren E. Collins Inc., Eagle models, Braintree, Massachusetts). Forced expiratory volume in 1 second (FEV₁), forced vital capacity (FVC), and forced midexpiratory flow rate in 25-75 seconds (FEF₂₅₋₇₅) were measured. FEF₂₅₋₇₅ was calculated from the volume-time curve with the largest sum of FVC and FEV₁. All testing was done by a specially trained technician, with quality control before and during the study in accordance with ATS guidelines (29).

Whenever possible, a minimum of three acceptable maneuvers were performed (ATS acceptability criteria) followed by additional forced expiratory efforts until ATS reproducibility criteria were met. The values recorded were the largest of the first three satisfactory attempts. All measured values were corrected for body temperature, air pressure, and water saturation. Of the 1,657 participants, 84.8 percent of the men and 83.9 percent of the women were able to perform ventilatory function tests according to ATS acceptability and reproducibility criteria. Individuals unable to perform spirometry with recommended criteria (102 men and 158 women) were significantly older and had poorer ventilatory function than the others; however, their smoking habits did not differ. Spirometric data also were calculated but were analyzed separately for the subjects whose data did not meet ATS criteria for acceptability and reproducibility.

Data analysis

Statistical analysis was carried out using SAS software. Ventilatory function variables were normally distributed. The association of categorical variables was evaluated using chi-square tests. For continuous variables, analysis of variance, multiple linear regression, and correlation were used. Ventilatory function measurements were adjusted for age and height, for example, FEV₁, either 1) as calculating age- and height-adjusted FEV₁ values as the observed FEV₁ = (a (age) + b (height) + c)/s, where a and b are the age

and height regression coefficients, c is the intercept, and s² is the residual variance; or 2) as including age and height in the multiple linear regressions of observed FEV₁ in the groups of never, past, and current smokers. Adjustment of ventilatory function measurements for height was performed by successive use of height and height squared. As the two methods led to the same conclusions, we present only the models with height. To estimate the decrease of ventilatory function with aging, the relations of FEV₁ and FVC to age were explored in analyses conducted by the following decades: less than 70 years, between 70 and 79 years, and older than 80 years of age. The potential acceleration of decline of ventilatory function with aging was tested 1) evaluating the linearity of the relation of FEV₁ to age, and 2) applying a multiple linear regression model of FEV₁ to height, age, and age squared. To minimize the effect of disease on the association between FEV₁ and age, the relation of FEV₁ to age was explored in the healthy subsample of the population who had no factor known to significantly influence the FEV₁, i.e., having never smoked and having no respiratory symptoms, asthma, emphysema, bronchitis, or heart disease. The basic analysis concerned 1,397 subjects with data satisfying ATS criteria. Repeating the analysis in the whole sample (including subjects whose tests did not meet ATS criteria) did not change any results. Statistical significance was set at a two-tailed p ≤ 0.05.

RESULTS

There were 571 men and 826 women aged 51 to 95 years whose pulmonary data satisfied ATS criteria. Current smokers were significantly younger (in years) than never and past smokers both in men (73.5 (standard deviation (SD) = 9.3), 72.9 (SD = 9.3), and 67.6 (SD = 8.4) for never, past, and current smokers, respectively; p = 0.0004) and in women (73.1 (SD = 9.8), 72.0 (SD = 8.4), and 68.0 (SD = 8.5); p = 0.0001). Men who were smokers at enrollment had a higher death rate after 15 years follow-up than never smokers, with 51 percent of those who reported past smoking at baseline dead and 50 percent of those who reported current smoking at baseline dead, compared with 42 percent of never smokers. Death rates did not differ by smoking habits at enrollment in women (31 percent of baseline past smokers, 32 percent of baseline current smokers, and 35 percent of never smokers were dead after 15 years of follow-up). In survivors, refusal rates for the spirometry visit did not vary by smoking habits at the enrollment survey in men or women.

As shown in table 1, smoking habits differed significantly by sex: More than 50 percent of the women
had never smoked, compared with 31 percent of men. More than 60 percent of the men were past smokers, compared with nearly 40 percent of women. Only 8 percent of men and 10 percent of women were current smokers. Among current smokers, men had smoked more than women (average pack-years = 50.6 (SD = 21.3) vs. 38.2 (SD = 18.9), \( p = 0.001 \)); however, the duration of smoking was nearly equal (49.2 (SD = 8.5) years vs. 45.6 (SD = 10.8) years; \( p = 0.05 \)). The age at quitting smoking ranged from 17 to 81 years among men and from 19 to 83 years among women; on average, men quit smoking earlier than women (age at quitting = 47.6 (SD = 13.0) years vs. 50.9 (SD = 14.3) years; \( p = 0.01 \)). Women had more shortness of breath and wheezing than men, but not asthma or phlegm, as shown in table 1. Subjects with shortness of breath were significantly older than the others. Men with phlegm were significantly older than the other men. Asthmatic women were significantly older than the other women. No relation was observed between wheezing and age in men or in women (data not shown). As expected, male and female subjects with any respiratory symptom or asthma had a lower FEV\(_1\) than the others.

Overall, the decrease of FEV\(_1\) was 41 (SD = 2) ml per year of age among men and 27 (SD = 2) ml per year of age among women. There was no sex difference in the relation of FEV\(_1\) or FVC to age. The decrements in FEV\(_1\) per year of age were smaller in the oldest old men than in other men. The decrements of FEV\(_1\) per year of age were equal to 45 (SD = 7) ml per year, 26 (SD = 15) ml per year, and 22 (SD = 15) ml per year in men aged <70, 70–79, and \( \geq 80 \) years, respectively. Among women, the decrement in FEV\(_1\) per year of age was slightly greater in the oldest old women than in other women. The decrements of FEV\(_1\) per year of age were equal to 43 (SD = 4) ml per year, 26 (SD = 8) ml per year, and 28 (SD = 10) ml per year in women aged <70, 70–79, and \( \geq 80 \), respectively. The test for linearity of models with age did not exclude a linear model. Including an age squared term showed that deceleration in FEV\(_1\) with age was significant in women and of borderline significance in men. The effect of aging on ventilatory function was similar among those with and without asthma. The decrements of FEV\(_1\) per year of age were as follows: for men, 49 (SD = 10) ml per year in asthmatics versus 40 (SD = 3) ml per year in nonasthmatics; and for women, 33 (SD = 6) ml per year in asthmatics versus 26 (SD = 1) ml per year in nonasthmatics. In the healthy sample of men (never smokers and without respiratory symptoms, asthma, emphysema, bronchitis, or heart disease), the decrease in FEV\(_1\) with age became the strongest among the oldest; however, these differences were not significant (either considering the linearity test or including age squared in the model). The decrements of FEV\(_1\) per year of age were 5 (SD = 17) ml per year, 28 (SD = 25) ml per year, and 31 (SD = 19) ml per year among men aged <70, 70–79, and \( \geq 80 \), respectively. In the healthy sample of women (as defined above), FEV\(_1\) and FVC were related inversely to age in every decade. The decrements of FEV\(_1\) per year of age were 39 (SD = 8) ml per year, 22 (SD = 11) ml per year, and 39 (SD = 17) ml per year among women aged <70, 70–79, and \( \geq 80 \), respectively. Thus, the inverse relation of ventilatory function to age among the oldest men or women was not completely explained by the presence of subjects with respiratory symptoms or disease in the population.

In age-adjusted analyses in both men and women, FEV\(_1\) was significantly lower in current smokers than in never smokers, with intermediate values in past smokers (figure 1). To assess the effect of smoking on ventilatory function aging, regressions of FEV\(_1\) on age were studied by smoking habit categories and decades. FEV\(_1\) decreased significantly with age in each smoking habit category, as shown in figures 2 and 3. In never smokers, the apparent effect of age on FEV\(_1\) was equal to a 34-ml decrement per year in men and to a 28-ml decrement per year in women. Data pertaining to the relation of FEV\(_1\) and FVC to age according to smoking habits in men and in women are presented in tables 2 and 3, respectively. Whereas in the whole sample, there was a slight deceleration in the decrease of ventilatory function with age in the oldest old men,
never smokers, although it was not significant.

Age-adjusted FEV₁ was significantly higher in male and female past smokers than in male and female smokers who had not quit. In both male and female past smokers, FEV₁ decreased significantly with increasing age and quitting (figure 4). Past smokers who quit before age 40 had a FEV₁ (in liters) similar to never smokers both in men (3.06 (SD = 0.58) vs. 3.06 (SD = 0.60), p = 0.99) and in women (2.09 (SD = 0.51) vs. 2.13 (SD = 0.46); p = 0.51). In smokers who quit between ages 40 and 60 years, FEV₁ (in liters) was lower than in never smokers and higher than in current smokers both in men (2.88 (SD = 0.74) vs. 3.06 (SD = 0.60) in nonsmokers, p = 0.01; and vs. 2.61 (SD = 0.73) in current smokers, p = 0.02) and in women (2.02 (SD = 0.55) in past smokers vs. 2.13 (SD = 0.46) in never smokers, p = 0.02; and vs. 1.71 (SD = 0.55) in current smokers, p = 0.0001). Male and female smokers who quit after age 60 had a FEV₁ (in liters) similar to current smokers (2.50 (SD = 0.85) vs. 2.61 (SD = 0.73), p = 0.44 in men and 1.72 (SD = 0.57) vs. 1.71 (SD = 0.55), p = 0.85 in women). Adjustment for consumption of cigarettes in pack-years did not change these results. Duration since quitting smoking was positively correlated with FEV₁ (r = 0.24, p = 0.0001 in men; and r = 0.26, p = 0.0001 in women) and duration of smoking was negatively correlated with FEV₁ (r = −0.30, p = 0.0001 in both men and women). After adjusting for cigarette pack-years, FEV₁ (in liters) was lower (although not significantly lower) in current smokers than in past smokers (in men, 2.76 (SD = 0.76) vs. 2.88 (SD = 0.74), p = 0.30; and in women, 1.90 (SD = 0.53) vs. 1.99 (SD = 0.55), p = 0.16). These differences become significant after considering all subjects and including sex in the model. Among the past smokers, there was a deceleration in the decrease of FEV₁ with age both in men (table 2) and in women (table 3).

Of the 176 never smoking men, 59 percent were exposed to smoke at home, as were 75 percent of the 415 never smoking women. Nonsmokers exposed to smoke were significantly younger (in years) than the others (71.5 (SD = 9.1) vs. 76.2 (SD = 8.9), p = 0.001 in men; and 72.3 (SD = 9.9) vs. 75.7 (SD = 8.8), p = 0.002 in women). Passive smokers had a FEV₁ (in liters) similar to never exposed subjects, as shown in figure 3 (3.00 (SD = 0.58) vs. 3.14 (SD = 0.63), p = 0.15 in men; and 2.12 (SD = 0.46) vs. 2.13 (SD = 0.44), p = 0.89 in women). Male passive smokers had a lower FVC (in liters) than the nonexposed men, with a difference of borderline significance (3.90 (SD = 0.74) vs. 4.10 (SD = 0.81), p = 0.08). No difference was observed in women (2.72 (SD = 0.56) vs. 2.71 (SD = 0.58), p = 0.98). No difference in FEF₂₅₋₇₅ was observed between subjects

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exposed to smoke at home in men (2.66 (SD = 1.08) liters/second vs. 2.80 (SD = 1.00) liters/second, \( p = 0.41 \)) or in women (2.00 (SD = 0.79) liters/second vs. 1.99 (SD = 0.72) liters/second, \( p = 0.91 \)). Including sex in the model (instead of stratifying) did not change the results, and there was no interaction with sex. The relation of FEV\(_1\) to age did not differ significantly in those exposed to passive smoking compared with the unexposed. The decrement of FEV\(_1\) was equal to 38 (SD = 31) ml per year in men and 30 (SD = 24) ml per year in women.

**DISCUSSION**

In this community-dwelling cohort, pulmonary function continued to decrease with age in elderly nonsmoking men and women. Ventilatory function aging was accelerated by active smoking. A beneficial effect of quitting smoking, especially before age 40, was evident. Exposure to passive smoking at home was unrelated to ventilatory function loss.

A major effect of active cigarette smoking on ventilatory function in elderly men and women has been reported previously (1, 11, 17, 25). The proportion of the Rancho Bernardo population that comprised active smokers between 1988 and 1991 (8 percent of men and 10 percent of women) was lower than that noted in most other studies with populations of similar age: 21 percent in men and 19 percent in women in 1972–1973 in the population-based survey in Tucson, Arizona (30), 25 percent in men and 17 percent of women from a 1982–1983 population-based study in Boston, Massachusetts (31), but similar to the values of 10 percent in men and 13 percent in women in the 1989–1990 Cardiovascular Health Study (27). The differences between studies may reflect regional and temporal variations in smoking habits or survival bias. The 1988–1991 Rancho Bernardo prevalence of current smokers was lower than that observed at enrollment between 1972 and 1974, when 22 percent of men and 27 percent in women were current smokers (28). Cross-sectional studies underestimate the effects of smoking in old age because smokers are more likely to be missing from study populations than nonsmokers, re-

| TABLE 2. Change in FEV\(_1\)* and FVC* with age by smoking habits of elderly men, Rancho Bernardo, California, 1988–1991 |
|---|---|---|---|---|
| Age (years) | No. | Change per year (ml) | 95% confidence interval | Change per year (ml) | 95% confidence interval |
| Never smokers | | | | |
| <70 | 62 | -10 | -37 to 17 | -11 | -48 to 28 |
| 70–79 | 57 | -28 | -75 to 19 | -39 | -94 to 16 |
| ≥80 | 57 | -37 | -70 to -4 | -42 | -67 to 1 |
| Past smokers | | | | |
| <70 | 128 | -53 | -73 to -33 | -45 | -70 to -19 |
| 70–79 | 112 | -27 | -64 to 10 | -17 | -56 to 22 |
| ≥80 | 107 | -14 | -57 to 29 | -29 | -76 to -5 |
| Current smokers | | | | |
| <70 | 31 | -70 | -105 to -35 | -34 | -79 to 11 |
| 70–79 | 9 | -91 | -303 to 120 | -24 | -273 to 225 |
| ≥80 | 8 | 367 | -13 to 747 | 145 | -345 to 635 |

* FEV\(_1\), forced expiratory volume in 1 second; FVC, forced vital capacity.

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reflecting their increased mortality and morbidity (32, 33).

The effect of quitting smoking on ventilatory function is not well established, particularly in the elderly (34, 35). In this study, current smokers had poorer ventilatory function than past smokers who quit before age 60. This is in agreement with cross-sectional (3, 27) and longitudinal studies (15, 16). The beneficial effect of quitting smoking parallels results from a cross-sectional study (27) and a longitudinal study (15) of elderly subjects. In contrast, Burrows and coworkers saw no difference between current and past smokers after adjusting for number of cigarettes smoked (36). In the present study, as in the Cardiovascular Health Study (27) and the Tucson cohort (37), the earlier men and women quit smoking, the better their ventilatory function in old age. Those in Rancho Bernardo who quit before age 40 had ventilatory function similar to never smokers, consistent with observations in Tucson subjects who quit before age 35 (15). Nevertheless, it does not necessarily follow that smoking before age 40 has no effect on health because past smokers in an older community-dwelling cohort constitute the healthy survivors. As the healthy survivor effect is the greatest in the oldest old, it is difficult to assess the effect of late smoking cessation among very old subjects. Quitting smoking after age 60 did not appear to have a beneficial effect in the Rancho Bernardo cohort, again compatible with results from Tucson where there was no effect of quitting smoking after age 70 (15). Past smokers constitute a heterogeneous group, as suggested by the greater variance of FEV1 in this group compared with never smokers. Former smokers are likely to differ by how long they smoked, the age at onset and cessation, and the reason they quit smoking, which may partially explain the discrepant consequences of past smoking in different studies. It is difficult to disentangle the role of various time-dependent variables with cross-sectional data (38) and, in the present analysis, to study smoking cessation with variables such as age, pack-years, and duration since quitting.

Studies of passive smoking have also yielded conflicting results (39). Some authors reported an association between secondary exposure to cigarette smoke and reduced ventilatory function in adults, although the pulmonary function parameters that were found to

| TABLE 3. Change In FEV1* and FVC* with age by smoking habits of elderly women, Rancho Bernardo, California, 1988–1991 |
|-----------------|-----------------|-----------------|-----------------|
|                 | FEV1            | FVC             |
| Age (years)     | Change per year (ml) | 95% confidence interval | Change per year (ml) | 95% confidence interval |
| Never smokers  |                  |                  |
| <70             | 146             | −37             | −49 to −25       | −40             | −54 to −26       |
| 70–79           | 136             | −23             | −42 to −3        | −24             | −47 to −1        |
| ≥80             | 133             | −35             | −54 to −15       | −32             | −54 to −10       |
| Past smokers   |                  |                  |
| <70             | 126             | −44             | −60 to −28       | −38             | −54 to −22       |
| 70–79           | 138             | −28             | −52 to 4         | −22             | −47 to 3         |
| ≥80             | 64              | −20             | −67 to 27        | −38             | −89 to 13        |
| Current smokers|                  |                  |
| <70             | 51              | −49             | −71 to −27       | −48             | −73 to −23       |
| 70–79           | 23              | −74             | −143 to 5        | −74             | −146 to −1       |
| ≥80             | 9               | −112            | −210 to −14      | −127            | −252 to −2       |

* FEV1, forced expiratory volume in 1 second; FVC, forced vital capacity.

![FIGURE 4. Relation of age- and height-adjusted forced expiratory volume in 1 second (FEV1) (mean and standard deviation) to age at quitting smoking among elderly men (p < 0.0001, analysis of variance) and women (p < 0.0001, analysis of variance), Rancho Bernardo, California, 1988–1991. □, men; ●, women.](image)
differ varied in different studies (30, 40–45). Other authors reported no effect of passive smoking on FEV₁ (27), only a slightly impaired FEV₁ among passive smokers (46), or a relation among French but not American exposed women of the same age (47). These different results may be explained by the heterogeneity of the methods, such as assessment of tobacco exposure (in the household (42) or at work (45)), the design of the study (case-control (40) or prospective (46)), and the population sample (volunteers (45) or population-based (30), rural (43) or urban, and young (30, 44) or older (27, 42) individuals). The lack of association between passive smoking and pulmonary function in Rancho Bernardo is consistent with the only other population-based study of passive smoking in older men and women (27). The failure to demonstrate a clear effect of passive smoking on ventilatory function could be attributable to several factors. Survival bias may underestimate the effect of passive smoking; nonsmoking women in Rancho Bernardo may have had increased mortality due to ischemic heart disease compared with wives of never smokers (48). In addition, the typical three-bedroom house for this middle- to upper-middle class cohort, coupled with the temperate climate in Southern California, makes it more likely that nonsmoking spouses receive less exposure to secondhand smoke than might be the case if they lived in smaller residences and were housebound in the winter. In addition, the questionnaire used here did not make a distinction between past and present exposure and did not query exposure to secondhand smoke outside the home. This assessment of exposure to passive smoking was relatively crude, possibly leading to an underestimate of harmful effects. To address the issue of the effects of passive smoking on ventilatory function in the elderly, future studies should better assess past and current exposure to tobacco smoke in the home and elsewhere.

In this cohort, FEV₁ and FVC continued to decrease with age even among the oldest men and women. In agreement with previous reports (9, 17), the decline with age was similar in men and women. The FEV₁ decrease per year among never smokers was similar (34 ml per year for men and 28 ml per year for women) to that reported for subjects of the same age in other cross-sectional or longitudinal studies, with approximately 28 ml per year for men (7, 10, 49, 50) and 21–32 ml per year in women (7, 10, 50). The fact that pulmonary function continued to decrease with age in the oldest old extends previous observations to subjects in the ninth decade of life and confirms the few previous observations in the very elderly (7, 22). We did not observe an accelerated decrement of FEV₁ with age among the oldest, in disagreement with the results from another cross-sectional study (51). The situation among men aged 80 years or older who were current smokers is an exception to several of these observations. The apparent positive relation of FEV₁ to age observed among the oldest male smokers may reflect survivor bias and was previously observed by Knudson and coworkers in the Tucson cohort (7). This selection bias, which could be called the “healthy male smoker effect,” is consistent with the greater death rate of male but not female subjects according to their smoking habits at the time of enrollment.

Data on the prevalence of asthma among the elderly are scanty. Asthma was reported by 4.1 percent of adults in Tecumseh, Michigan (52), and by 6.6 percent in Tucson (53). In one survey, current asthma was found to be more prevalent in men (5.1 percent) than in women (1.8 percent) older than 70 years (54). In Tucson, 11.1 percent of men and 9.1 percent of women aged 65 to 95 years had asthma (55), as did 9.6 percent in Southampton, England, in men and women aged 65–91 years (56). The prevalence of asthma in the two last studies and Rancho Bernardo was similar and based on a definition of the disease that includes both current and previous asthma.

In this cohort, men and women who were unable to perform ventilatory function tests meeting ATS standardization (acceptability or reproducibility) criteria were older and had poorer ventilatory function than the others. Spirometry test failure may be a marker for poor health status. Failure to provide an acceptable test has been shown to be associated with a lower FEV₁ level (57, 58), a faster rate of annual loss of ventilatory function (59, 60), respiratory symptoms (57, 58), and excess mortality (57, 58). Because elderly subjects with the poorest pulmonary function are less able to perform acceptable ventilatory function tests, their exclusion underestimates decrements of ventilatory function in the oldest old. Their exclusion did not, however, appear to explain the associations or lack of associations reported here inasmuch as their inclusion did not materially change the results.

In the Rancho Bernardo cohort, 85 percent belonged to the top three (of seven) social classes described by the Hollingshead Index (61), and nearly 50 percent had attended college. Although these observations may not be applicable to other socioeconomic or ethnic groups with occupational exposures to air pollutants and other pulmonary toxins, studies of white collar workers are less confounded by exposure to occupational pulmonary risk factors or inadequate access to medical care. More than 90 percent of the Rancho Bernardo cohort had visited a physician in the year before the survey; record review validated self-
reported diseases in 85–95 percent of common diagnoses in this cohort.

In summary, we observed a graded decrement in pulmonary function with age in men and women, which was accentuated by cigarette smoking and reduced by quitting smoking, especially before age 40. These findings provide further evidence of the beneficial effect of smoking cessation on preventing the progression of functional respiratory impairment.

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REFERENCES


