of emphysema found in patients with COLD to be present to a significant degree in nonsmokers.

Thurlbeck (1963) reported 19 patients who had severe emphysema at autopsy. All 19 were cigarette smokers, in contrast to 18 smokers out of 38 patients who did not have significant emphysema at autopsy. Anderson et al. (1964) conducted a more systematic evaluation of the relationship between cigarette smoking and the degree of emphysema at autopsy. They found that 12 of 23 patients without emphysema were cigarette smokers, whereas 55 of 84 with mild emphysema, 30 of 33 with moderate emphysema, and 14 of 15 with severe emphysema were cigarette smokers. Petty et al. (1967) reported similar findings, with 6 of 57 patients with moderate emphysema at autopsy being nonsmokers and only 1 of 61 patients with severe emphysema being a nonsmoker. Ryder et al. (1971) found that of 21 patients whose lungs showed more than 25 percent emphysema, only 1 was a nonsmoker.

Thurlbeck et al. (1974) examined the relationship of age to extent of emphysema in smokers compared with nonsmokers in the combined autopsy populations of the teaching hospitals in three separate cities. The severity of emphysema was quantified using a panel grading method, with a score under 25 representing mild emphysema. They found that the degree of emphysema increased slightly in nonsmokers beginning in the fifth decade and reached an average score of 10 to 15 in men and 4 to 6 in women by the eighth and ninth decades. In contrast, male smokers had an average score of 25 to 30 by the seventh decade and maintained this level for the next two decades.

Sutinen et al. (1978) (Table 13) examined the relationship between prevalence and extent of emphysema and duration of the smoking habit. As would be expected from previous studies, moderate or severe emphysematous changes were limited to smokers. However, these changes were also limited to those smokers who had smoked for 20 or more years, and severe emphysema was reported only in those who had smoked for 40 years or more. These data, coupled with that of Thurlbeck et al. (1974) describing only mild emphysematous changes in nonsmokers with advancing age, suggest that emphysema is a late pathologic change in cigarette-induced lung disease. This correlates well with the clinical experience of severe emphysema being rare prior to the fifth decade. It also suggests that cessation, even among middle-aged smokers, may have substantial impact on emphysema morbidity and mortality.

Dose–Response Relationships

Some studies have reported the extent of emphysematous change in smokers of different numbers of cigarettes per day. Spain et al. (1973) examined the lungs of 134 subjects who died suddenly and

TABLE 13.—Correlation between the severity of emphysema at autopsy and total smoking duration

Grade of emphysema	Prevalence of emphysema (percent) by total smoking years				
	0	1-19	20-39	40 or more	Total
No emphysema	61.6	81.6	21.2	8.8	43.1
Mild (grades 5 to 20)	38.4	15.4	69.7	50.0	45.8
Moderate (grades 30 to 50)	-	-	9.1	26.5	7.8
Severe (grade 60 or more)	-	-	-	14.7	3.3
All grades	38.4	15.4	78.8	91.8	56.9
Total number	73	13	33	34	153

NOTE: $P < 0.0005$; X^2 test, with groups of moderate and severe emphysema and of smoking times 1-19 and 20-39 years combined.

SOURCE: Sutinen et al. (1978).

who had no previous history of lung disease. They found emphysematous changes greater than grade 20 (mild emphysema) in 10 percent of nonsmokers, 36 percent of smokers of less than one pack per day, and 39 percent of smokers of more than one pack.

A much larger study was conducted by Auerbach et al. (1972, 1974), who examined whole lung sections from 1,443 men and 388 women autopsied between 1963 and 1970. Table 14 describes the relationship of age, smoking habits, and degree of emphysema graded on a scale of 0 to 9, with 9 representing severe emphysema. It is clear that severe emphysema is limited to smokers, and that the severity of emphysematous change at autopsy increases with increasing number of cigarettes smoked per day during life. This study also found that almost all (94.5 percent) smokers of more than one pack per day had some degree of emphysema (slight, moderate, advanced, or far advanced) (Table 15). In contrast, 93.8 percent of nonsmokers had either none or minimal emphysema. This evidence would suggest that emphysematous change is a nearly universal phenomenon in heavy smokers, but is rare in nonsmokers, and that it is the large ventilatory reserve of the lungs that restricts clinically manifest disease to those individuals with far advanced emphysema. Similar results were reported in a more limited number of autopsies done on female smokers (Auerbach et al. 1974) (Table 16).

A study of microscopic lung sections from the autopsies of 1,436 men and 388 women was also reported by Auerbach et al. (1974), and closely paralleled the results of the whole lung study. However, they also reported the results in smokers who had quit for more than or less than 10 years prior to death (Table 17). The degree of emphysematous change was still related to the amount smoked, but

TABLE 14.—Degree of emphysema in current smokers[a] and in nonsmokers, according to age groups

Age group	Degree of emphysema	Subjects who never smoked regularly	Current pipe or cigar smokers	Current cigarette smokers†			
				<½†	½-1†	1-2†	2+ †
<60	0-0.75	53	18	12	3	2	–
	1-1.75	2	11	4	9	24	5
	2-2.75		1	2	17	130	56
	3-3.75		1	5	12	50	38
	4-4.75				4	8	7
	5-6.75					4	5
	7-9.00			–		3	1
	Totals	55	31	23	45	221	112
	Mean	0.10	0.83	1.29	2.37	2.56	2.86
	SD	0.04	0.13	0.26	0.16	0.07	0.10
60-69	0-0.75	35	17	4	–	–	–
	1-1.75	1	8	1	–	4	1
	2-2.75	2	3	4	5	37	23
	3-3.75	2	2	2	9	42	24
	4-4.75			1	3	11	9
	5-6.75				1	8	1
	7-9.00				1	5	4
	Totals	40	30	12	19	107	62
	Mean	0.39	0.95	1.90	3.59	3.39	3.37
	SD	0.13	0.16	0.34	0.35	0.15	0.20
70 or older	0-0.75	68	21	2	–	–	–
	1-1.75	4	28	10	8	2	2
	2-2.75	5	22	13	23	40	9
	3-3.75	4	8	5	10	38	18
	4-4.75		2	1	7	11	7
	5-6.75		1		2	9	3
	7-9.00			–	1	12	5
	Totals	81	82	31	51	112	44
	Mean	0.50	1.66	2.15	2.98	3.68	3.91
	SD	0.39	0.11	0.17	0.20	0.17	0.27

[a] Subjects who smoked regularly up to time of terminal illness.
†Packages/day.

SOURCE: Auerbach et al. (1972).

was less in those who had quit for more than 10 years prior to death, suggesting that the cessation of smoking results in a slowing of the

TABLE 15.—Age-standardized percentage distribution of male subjects in each of four smoking categories, according to degree of emphysema

Degree of emphysema	Subjects who never smoked regularly (%)	Current pipe or cigar smokers (%)	Current cigarette smokers (%)	
			<1*	1+ *
0–0.75 (none)	90.0	46.5	13.1	0.3
1–1.75 (minimal)	3.8	33.0	16.4	5.2
2–2.75 (slight)	3.3	13.0	33.7	42.6
3–3.75 (moderate)	2.9	6.3	25.1	32.7
4–9.00 (advanced to far advanced)	0	1.2	11.7	19.2
Totals	100.0	100.0	100.0	100.0

*Packages day.

SOURCE: Auerbach et al. (1972).

TABLE 16.—Means of the numerical values given lung sections at autopsy of female current smokers, standardized for age

	Subjects who never smoked regularly	Current cigarette smokers	
		<1 Pk.	≥1 Pk.
Number of subjects	252	33	64
Emphysema	0.05	1.37	1.70
Fibrosis	0.37	2.89	3.46
Thickening of arterioles	0.06	1.26	1.57
Thickening of arteries	0.01	0.40	0.64

NOTE: Numerical values were determined by rating each lung section on scales of 0–4 for emphysema and thickening of the arterioles, 0–7 for fibrosis, and 0–3 for thickening of the arteries.

SOURCE: Auerbach et al. (1974).

rate of progression of emphysematous change in those who quit compared with those who continue to smoke.

Studies of Alpha$_1$-Proteinase-Inhibitor-Deficient Individuals

The deficiency of α_1-proteinase inhibitor is an experiment of nature with broad implications for understanding the pathogenesis of emphysema (Idell and Cohen 1983). Discovery of homozygous-deficient subjects (type PiZZ) with only 10 percent of normal plasma

TABLE 17.—Means of the numerical values given lung sections at autopsy of male former cigarette smokers, standardized for age

	Never smoked regularly	Stopped >10 years		Stopped <10 years	
		Formerly smoked			
		<1 Pack	>1 Pack	<1 Pack	>1 Pack
Number of subjects	175	35	66	51	131
Emphysema	0.09	0.24	0.70	1.08	1.69
Fibrosis	0.40	1.14	1.74	2.44	3.30
Thickening of arterioles	0.10	0.57	0.93	1.25	1.59
Thickening of arteries	0.02	0.04	0.16	0.36	0.61

NOTE: Numerical values for each finding were determined by rating each lung section on scales of 0–4 for emphysema and thickening of the arterioles, 0–7 for fibrosis, and 0–3 for thickening of the arteries.
SOURCE: Auerbach et al. (1974).

proteinase inhibitory activity and the demonstration of the frequent early development of emphysema in such subjects (Orell and Mazodier 1972) called attention to the critical step of fibrous tissue proteolysis in the remodeling of lung structure. It also pointed to at least one potential explanation for the variability in extent of emphysema among smokers.

Together with data from animal experiments, the discovery of the PiZZ defect and its association with emphysema has led to general acceptance of a theory of imbalance between the extracellular levels of proteinase and proteinase inhibitor in the lung as the cause of panacinar emphysema in subjects with this deficiency. The pathogenetic lessons learned from α_1-proteinase-inhibitor deficiency also afford plausible explanations for other forms of emphysema, especially emphysema associated with cigarette smoking.

Homozygous Deficient—PiZZ

In his classic description of the severe (PiZZ) deficiency of the α_1-proteinase inhibitor, Eriksson (1965) did not indicate an effect of cigarette smoking on the development of emphysema. Later studies, however, did recognize smoking as a potential aggravating factor (Kueppers and Black 1974; Larsson 1978) and reported that PiZZ persons who smoked cigarettes were destined to experience shortness of breath 10 to 15 years earlier (Figure 27) and to die sooner than PiZZ persons who did not smoke (Figure 28).

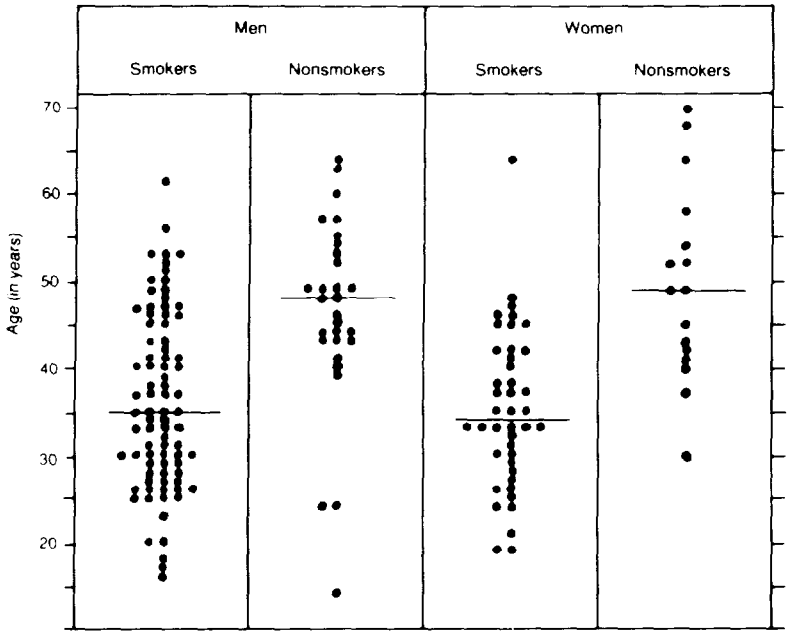

FIGURE 27.—Age at onset of dyspnea in 169 PiZZ individuals separated according to sex and smoking history

NOTE: The horizontal lines show the median values. The difference between nonsmokers and smokers was highly significant for both sexes and was 13 and 15 years for men and women, respectively.

SOURCE: Larsson (1978).

More recent studies, however, have shown considerable variation in the rate of decline of lung function among middle-aged PiZZ adults (Buist et al. 1983). In a comparison of 22 persons with PiZZ phenotype who had never smoked with 36 PiZZ smokers, Black and Kueppers (1978) found variability in symptoms and lung function abnormalities in both groups. Smokers generally sought medical attention earlier, and those who reached the older age groups, such as 60 to 69, had smoked less and started to smoke later in life. There was overlap in these characteristics between the age groups, however, and some smokers did live into the 50 to 69 age range. In this analysis, the correlations between pulmonary function test abnormalities and pack-years of cigarette smoking were small.

The British Thoracic Society, in a multicentered study of PiZZ individuals (Tobin et al. 1983), reported an association between

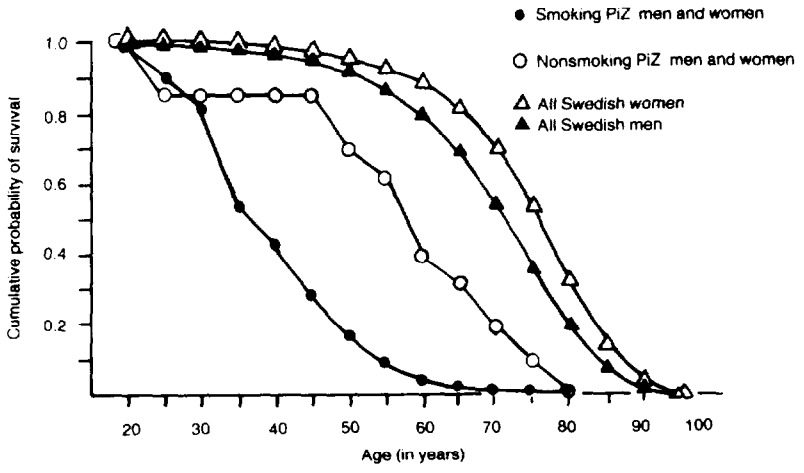

FIGURE 28.—The cumulative probability of survival, given that 20 years of age is reached, in smoking and nonsmoking Swedish PiZZ individuals, compared with all Swedish men and women

NOTE: Survival was higher for PiZZ nonsmokers than for PiZZ smokers in both sexes above age 35.
SOURCE: Larsson (1978).

cigarette smoking and the onset of pulmonary symptoms and deterioration of lung function, but demonstrated no significant correlation between the quantity of tobacco consumed and the extent of pulmonary dysfunction. A notable finding in this study, applicable to other studies of the natural history of disease related to α_1-proteinase-inhibitor deficiency, was the impressive difference between individuals found because of medical complaints (index cases) and those detected by surveys (nonindex cases). Nonindex cases had better pulmonary function and survived longer than index cases, irrespective of other variables such as age and smoking history. The distinction between these two categories of subjects suggests the importance of factors besides the PiZZ phenotype in the development of symptomatic lung disease in PiZZ persons.

PiZZ individuals who smoke increase their risk for early onset of symptomatic chronic obstructive lung disease and for a shortened lifespan, compared with nonsmoking PiZZ individuals. However, pulmonary function data have shown only limited differences in diffusing capacity and elastic recoil between the smokers and the nonsmokers (Black and Kueppers 1978).

Heterozygous Deficient—PiMZ

The PiMZ phenotype of α_1-antiproteinase inhibitor occurs in approximately 3 percent of the population. Because of the high frequency of emphysema in PiZZ persons, it is important to establish whether PiMZ individuals also have an increased risk of emphysema and chronic obstructive lung disease. From the unpredictability of obstructive lung disease even among those with the PiZZ phenotype, however, one might expect difficulty in discerning the effect of the PiMZ phenotype.

Among adults with symptomatic chronic obstructive lung disease, the PiMZ phenotype is more prevalent than expected (Mittman 1978). It is uncertain whether this means of subject identification is appropriate, as was noted concerning index and nonindex PiZZ individuals. Madison et al. (1981) emphasized the complexity of this issue by noting that the PiMZ phenotype was only one of several factors that appeared to be related to the risk of obstructive lung disease. Other factors identified as relevant included smoking, a family history of lung diseases, and being male.

From studies of children and young adults it is evident that the PiMZ phenotype does not strongly predispose to chronic pulmonary disease. Thus, PiMZ children (Buist et al. 1980) failed to show any early changes of lung dysfunction analogous to what has been observed in some young PiZZ individuals; PiMZ adults below the age of 40 had the same results by spirometry and the single breath N_2 test as PiMM individuals matched for smoking history (Buist et al. 1979b).

Numerous studies involving older subjects indicate that PiMZ individuals preserve their lung function, as measured by spirometry, compared with controls matched for smoking (Tattersall et al. 1979, de Hamel and Carrell 1981). The elastic properties of the lungs may be different in PiMZ persons, but if there are differences, they are small. Larsson et al. (1977) reported that 50-year-old PiMZ men who smoked had reduced elastic recoil at total lung capacity compared with PiMZ nonsmokers, even though they had no evidence of impaired air flow. The PiMZ nonsmokers were indistinguishable from PiMM nonsmokers. Tattersall et al. (1979) also found no effect upon airflow in PiMZ middle-aged men, and a statistically nonsignificant decrease in elastic recoil. Using an index of the slope of the pressure–volume curve, Knudson and Kaltenborn (1981) found no significant reduction in elastic recoil of PiMZ subjects compared with matched PiM controls.

There is little direct information about the occurrence of emphysema among PiMZ individuals. In an autopsy study, Eriksson et al. (1975) found emphysema among 13 of 26 subjects with diastase-resistant PAS-positive inclusions in the liver, compared with an incidence of emphysema of only 18 percent in the controls. Although

these findings suggest an increased occurrence of emphysema with the PiMZ phenotype, this study should be interpreted cautiously because the smoking histories of the subjects and the quantification of the emphysema were not included. Moreover, the significance of the PAS-positive inclusions is not certain, because one recent study found that such inclusions represented immunoreactive α_1-proteinase inhibitor in only half of the tissue studied (Qizilbash and Young-Pong 1983).

It may be concluded from the studies involving α_1-proteinase-inhibitor-deficient people that for those with the PiMZ phenotype, smoking has not been shown to promote a greater risk of emphysema than it does in PiMM persons. In the rare individual with PiZZ, the risk of emphysema is extremely high in both smokers and nonsmokers, but PiZZ smokers experience an earlier onset and more severe chronic obstructive lung disease than PiZZ nonsmokers.

Observations in Experimental Animals

Experimental animals have been subjected to cigarette smoke to examine whether changes typical of emphysema result. As noted below, it appears that cigarette smoke exposure can produce emphysematous-like changes in the lungs under experimental conditions, but the exposure must be quite prolonged and intense, or additional factors must be employed to "sensitize" the lungs to the effects of cigarette smoke.

Pioneering studies in dogs exposed to cigarette smoke, by Hernandez et al. (1966) and by Auerbach et al. (1967), indicated effects consistent with emphysema, but these reports did not include quantitative morphology or data about the mechanical properties of the lungs. Moreoever, the exposures may have created problems of hypoxemia and infection that may have influenced the responses to cigarette smoke. Contrary to these findings, in later studies, beagles that inhaled cigarettes by face mask in four sessions per day for up to 1 year—an inhalation sufficient to raise the blood carboxyhemoglobin saturation to 5.4 $\pm$ 0.9 percent—had no statistically significant changes in mean linear intercept or internal surface area, although their large airways showed epithelial cell hyperplasia, proliferation of goblet cells, and peribronchial inflammation (Park et al. 1977).

Recently, Hoidal and Niewoehner (1983) presented data suggesting that cigarette smoke may be an important cofactor in the development of elastase-induced emphysema. They found that inhalation of cigarette smoke led to severe emphysema in hamsters if used in conjunction with doses of elastase that did not produce emphysema when used alone. In this study, hamsters were exposed to cigarette smoke for 15 minute periods, six times per day, 6 days per week for 7 weeks in standardized chambers. The animals were challenged with small doses of elastase given intratracheally; controls consisted of

animals given either elastase or smoke exposure or neither. Animals receiving only smoke or only elastase showed no changes of mean linear intercept or volume–pressure relationship of the excised lungs, compared with animals given neither elastase nor smoke exposure. The combinations of smoking followed by elastase or smoking both before and after elastase produced statistically significant increases of mean linear intercept, displacement upward and to the left of the volume–pressure curves (Figure 29), and marked emphysema by light microscopy of inflation-fixed lungs. The mechanism of the synergism between elastase and smoking was not elucidated. One possibility considered was that cigarette smoke impaired the repair mechanism normally triggered by elastase exposure, a possibility supported by Osman et al. (1982), who found that hamsters exposed to cigarette smoke after intratracheal elastase did not show the heightened lung elastin synthesis typically seen after lung injury produced by elastase.

Summary

Clinically significant degrees of emphysematous lung destruction are commonly present in individuals with COLD. Severe emphysema occurs almost exclusively in cigarette smokers and those with homozygous α_1-antitrypsin deficiency. The extent of emphysematous change increases with increasing numbers of cigarettes smoked per day and with the duration of the smoking habit. While clinically significant emphysema is limited to a minority of those who smoke, most heavy smokers have some degree of emphysematous change by the sixth decade of life.

Individuals with homozygous α_1-antitrypsin deficiency have an exceptionally high risk of developing emphysema. This risk is present for both smokers and nonsmokers, but smokers with α_1-antiprotease deficiency develop clinical symptoms earlier in life. It is unclear whether individuals with heterozygous antiprotease phenotypes are at increased risk of developing COLD.

Summary and Conclusions

1. Cigarette smoking is the major cause of COLD morbidity in the United States; 80 to 90 percent of COLD in the United States is attributable to cigarette smoking.
2. In population-based studies in the United States, cigarette smoking behavior is often the only significant predictor for the development of COLD. Other factors improve the predictive equation only slightly, even in those populations where they have been found to exert a statistically significant effect.
3. In spite of over 30 years of intensive investigation, only cigarette smoking and α_1-antiprotease deficiency (a rare genet-

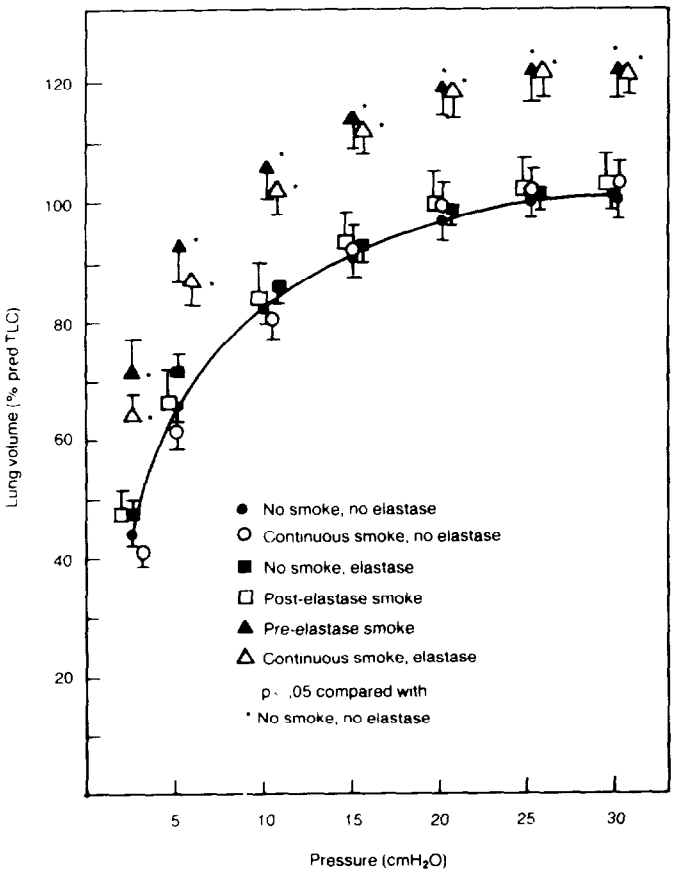

FIGURE 29.—The effects of combining cigarette smoking and elastase upon the pressure–volume characteristics of the lungs of experimental animals

NOTE: The in vitro measurements of lung volume are shown as percentage of predicted total lung capacity (TLC) relative to transpulmonary pressure of hamster lungs following in vivo exposure to various combinations of cigarette smoke and intratracheally administered pancreatic elastase. Values are the mean ± SEM of measurements made during deflation. The animals that smoked and then received elastase (Pre-Elastase Smoke) and those that smoked both before and after elastase (Continous Smoke, Elastase) had significant changes in the elastic properties of the lungs. There were no changes from control if elastase or smoking were used separately or when smoking occurred only after elastase.

SOURCE: Hoidal and Niewoehner (1983).

ic defect) are established causes of clinically significant COLD in the absence of other agents.

4. Within a few years after beginning to smoke, smokers experience a higher prevalence of abnormal function in the small airways than nonsmokers. The prevalence of abnormal small airways function increases with age and the duration of the

smoking habit, and is greater in heavy smokers than in light smokers. These abnormalities in function reflect inflammatory changes in the small airways and often reverse with the cessation of smoking.

5. Both male and female smokers develop abnormalities in the small airways, but the data are not sufficient to define possible sex-related differences in this response. It seems likely, however, that the contribution of sex differences is small when age and smoking exposure are taken into account.
6. There is, as yet, inadequate information to allow a firm conclusion to be drawn about the predictive value of the tests of small airways function in identifying the susceptible smoker who will progress to clinical airflow obstruction.
7. Smokers of both sexes have a higher prevalence of cough and phlegm production than nonsmokers. This prevalence increases with an increasing number of cigarettes smoked per day and decreases with the cessation of smoking.
8. Differences between smokers and nonsmokers in measures of expiratory airflow are demonstrable by young adulthood and increase with number of cigarettes smoked per day.
9. The rate of decline in measures of expiratory airflow with increasing age is steeper for smokers than for nonsmokers; it is also steeper for heavy smokers than for light smokers. After the cessation of smoking, the rate of decline of lung function with increasing age appears to slow to approximately that seen in nonsmokers of the same age. Only a minority of smokers will develop clinically significant COLD, and this group will have demonstrated a more extensive decline in lung function than the average smoker. The data are not yet available to determine whether a rapid decline in lung function early in life defines the subgroup of smokers who are susceptible to developing COLD.
10. Clinically significant degrees of emphysema occur almost exclusively in cigarette smokers or individuals with genetic homozygous α_1-antiprotease deficiency. The severity of emphysema among smokers increases with the number of cigarettes smoked per day and the duration of the smoking habit.

Appendix Tables

TABLE A.—FEV_1 for white adults, by smoking status, sex, and age, United States, 1971–1975

Cigarette smoking status (by age)	Both sexes					Men					Women				
	N	n	Mean	SD	SE	N	n	Mean	SD	SE	N	n	Mean	SD	SE
Never smokers															
25–74			3140[1]		21[1]			3669[1]		39[1]			2664[1]		19[1]
25–34	6733	394	3607	791	51	2633	130	4404	584	63	4099	264	3095	372	26
35–44	5278	291	3171	607	49	1669	81	3742	591	73	3609	210	2907	397	40
45–54	4942	353	2840	594	35	1206	85	3487	626	72	3736	268	2631	401	29
55–64	3660	251	2511	589	31	880	59	3215	531	81	2781	192	2289	401	29
65–74	2875	235	2148	549	36	481	43	2856	627	96	2394	192	2006	402	36
Ex-smokers															
25–74			3112		24			3623		37			2651		28
25–34	2811	160	3677	810	80	1359	66	4303	627	92	1452	94	3091	441	55
35–44	3086	171	3566	767	69	1828	94	4013	643	70	1258	77	2916	361	44
45–54	3323	213	3155	742	65	2345	143	3414	683	69	978	70	2535	454	65
55–64	2669	181	2845	693	63	1826	130	3087	649	63	843	51	2319	456	90
65–74	1769	157	2388	686	66	1270	121	2533	699	78	499	36	2020	487	92
Smokers															
25–74			2878		20			3281		32			2514		27
25–34	8885	487	3567	752	44	4792	239	4037	639	51	4093	248	3018	435	41
34–44	5849	320	3166	655	47	3027	158	3507	639	71	2822	162	2800	439	43
45–54	5606	374	2761	623	37	2743	182	3126	579	49	2863	192	2411	437	40
55–64	3251	192	2416	631	50	1700	108	2738	632	63	1551	84	2064	400	50
65–74	933	84	2071	653	86	534	56	2222	556	79	400	28	1869	714	155

TABLE A.—Continued

Cigarette smoking status (by age)	Both sexes					Men					Women				
	N	n	Mean	SD	SE	N	n	Mean	SD	SE	N	n	Mean	SD	SE
Light smokers															
25–74			2951		38			3311		57			2626		52
25–34	2162	113	3425	650	97	879	43	3914	508	102	1283	70	3089	508	88
35–44	1267	72	3106	618	93	308	17	3775[2]	515	139	859	55	2891	479	83
45–54	1090	76	2683	490	73	383	24	3009	409	95	707	52	2507	437	76
55–64	1043	57	2408	573	83	313	18	2919[2]	660	150	730	39	2190	350	62
65–74	304	21	2150	737	185	131	11	2222[2]	426	130	172	10	2095[2]	901	305
Moderate smokers															
25–74			2878		23			3335		40			2466		25
25–34	4269	235	3671	810	60	2534	123	4136	684	69	1735	112	2991	393	51
35–44	2413	130	3217	646	68	1214	66	3593	624	99	1199	64	2836	395	47
45–54	2715	179	2679	634	53	1145	75	3106	622	79	1570	104	2368	429	51
55–64	1287	82	2406	589	68	690	45	2776	455	60	597	37	1977	408	70
65–74	464	44	2023	609	105	261	28	2279	572	126	203	16	1693[2]	484	124
Heavy smokers															
25–74			2785		32			3202		52			2409		38
25–34	2417	136	3514	699	70	1363	72	3927	597	82	1054	64	2979	393	80
35–44	2148	116	3143	684	71	1505	75	3382	646	89	643	41	2582	373	64
45–54	1779	118	2930	649	70	1193	82	3184	579	75	586	36	2411	440	92
55–64	922	53	2440	741	118	697	45	2619	737	133	224	8	1883[2]	398	121
65–74	154	18	2038[2]	606	151	130	16	2096[2]	638	172	24	2	1733[2]	215	150

NOTE: N = weighted population estimate in thousands; n = number of people in sample; SD = standard deviation; SE = standard error.

[1] Adjusted by the direct method to reflect the age distribution of the U.S. population at the midpoint of the survey.

[2] Does not meet standards of reliability.

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

TABLE B.—Flow at 25 percent of FVC for white adults, by smoking status, sex, and age, United States, 1971–1975

Cigarette smoking status (by age)	Both sexes					Men					Women				
	N	n	Mean	SD	SE	N	n	Mean	SD	SE	N	n	Mean	SD	SE
Never smokers															
25–74			6253[1]		47[1]			7261[1]		91[1]			5343[1]		36[1]
25–34	6733	394	6639	1591	98	2633	130	7871	1513	157	4099	264	5847	1042	89
35–44	5278	291	6377	1484	114	1669	81	7715	1545	176	3609	210	5758	952	80
45–54	4942	353	5742	1586	90	1206	85	7262	1796	213	3736	268	5252	1141	70
55–64	3660	251	5368	1397	101	880	59	6543	1593	265	2781	192	4996	1091	83
65–74	2875	235	4626	1576	102	481	43	6097	1951	298	2394	192	4331	1303	108
Ex-smokers															
25–74			6093		62			7095		107			5188		67
25–34	2811	160	6835	1855	203	1359	66	8042	1715	285	1452	94	5705	1126	165
35–44	3086	171	7020	2041	176	1828	94	7956	2059	232	1258	77	5659	965	116
45–54	3323	213	6270	1896	164	2345	143	6765	1919	185	978	70	5084	1176	151
55–64	2669	181	5783	1764	144	1826	130	6261	1820	160	843	51	4749	1058	197
65–74	1769	157	4918	1948	207	1270	121	5194	2091	265	499	36	4213	1278	197
Smokers															
25–74			5647		47			6362		88			5002		52
25–34	8885	487	6760	1694	102	4792	239	7606	1663	126	4093	248	5769	1081	83
35–44	5849	320	6157	1740	123	3027	158	6848	1875	180	2822	162	5415	1200	102
45–54	5606	374	5471	1658	92	2743	182	6130	1783	137	2863	192	4840	1233	106
55–64	3251	192	5123	1815	132	1700	108	5567	2041	223	1551	84	4636	1372	169
65–74	933	84	3954	1586	181	534	56	4199	1745	238	400	28	3627	1274	255

TABLE B.—Continued

Cigarette smoking status (by age)	Both sexes					Men					Women				
	N	n	Mean	SD	SE	N	n	Mean	SD	SE	N	n	Mean	SD	SE
Light smokers															
25–74			5834		91			6569		142			5171		112
25–34	2162	113	6549	1652	209	879	43	1688	1690	293	1283	70	5769	1071	140
35–44	1267	72	6045	1481	211	308	17	7250[2]	1634	369	959	55	5658	1193	188
45–54	1090	76	5545	1476	217	383	24	6373	1572	311	707	52	5096	1203	193
55–64	1043	57	5222	1534	238	313	18	6096[2]	1616	399	730	39	4849	1333	249
65–74	304	21	3779	1272	345	131	11	3742[2]	1279	482	172	10	3807[2]	1266	489
Moderate smokers															
25–74			5661		66			6430		118			4967		76
25–34	4269	235	6909	1719	136	2534	123	7647	1667	164	1735	112	5831	1120	132
35–44	2413	130	6384	1786	194	1214	66	7348	1738	236	1199	64	5408	1212	170
45–54	2715	179	5269	1490	111	1145	75	5821	1661	183	1570	104	4867	1202	137
55–64	1287	82	5065	1787	202	690	45	5576	1897	334	597	37	4475	1439	265
65–74	464	44	3950	1717	304	261	28	4356	1892	404	203	16	3427[2]	1285	319
Heavy smokers															
25–74			5485		85			6219		151			4822		111
25–34	2417	136	6691	1659	166	1363	72	7468	1640	225	1054	64	5685	1018	176
35–44	2148	116	5964	1815	198	1505	75	6363	1902	261	643	41	5031	1084	186
45–54	1779	118	5712	1940	207	1193	82	6326	1920	251	586	36	4458	1257	260
55–64	922	53	5090	2117	321	697	45	5322	2288	434	224	8	4370[2]	1202	355
65–74	154	18	4155[2]	1653	401	130	16	4180[2]	1758	463	24	2	4025[2]	904	628

NOTE: N = Weighted population estimate, in thousands; *n = number of people in sample*; SD = *standard deviation*; SE = *standard error*.

[1] Adjusted by the direct method to reflect the age distribution of the U.S. population at the midpoint of the survey.

[2] Does not meet standards of reliability.

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

TABLE C.—Flow at 50 percent of FVC for white adults, by smoking status, sex, and age, United States, 1971–1975

Cigarette smoking status (by age)	Both sexes					Men					Women				
	N	n	Mean	SD	SE	N	n	Mean	SD	SE	N	n	Mean	SD	SE
Never smokers															
25–74			3743[1]		38[1]			4083[1]		86[1]			3342[1]		34[1]
25–34	6733	394	4381	1194	69	2633	130	4998	1255	128	4099	264	3984	963	78
35–44	5278	291	3904	1164	84	1669	81	4315	1221	152	3609	210	3713	989	91
45–54	4942	353	3366	1212	84	1206	85	3972	1287	150	3736	268	3170	1119	90
55–64	3660	251	3090	1087	74	880	59	3736	1220	180	2781	192	2886	955	72
65–74	2875	235	2535	1045	73	481	43	3157	1060	174	2394	192	2410	996	84
Ex-smokers															
25–74		3579	59		4188	67		3123	81						
25–34	2811	160	4329	1292	120	1359	66	5029	1243	195	1452	94	3674	949	114
35–44	3086	171	4249	1384	129	1828	94	4702	1410	180	1258	77	3590	1037	160
45–54	3323	213	3474	1404	114	2345	143	3749	1428	143	978	70	2816	1091	147
55–64	2669	181	3110	1411	118	1826	130	3294	1362	127	843	51	2711	1432	293
65–74	1769	157	2524	1296	121	1270	121	2578	1364	153	499	36	2384	1092	167
Smokers															
25–74			3169		39			3475		59			2892		54
25–34	8885	487	4126	1268	74	4792	239	4546	1296	103	4093	248	3634	1037	90
35–44	5849	320	3552	1298	87	3027	158	3764	1399	140	2822	162	3325	1137	98
45–54	5606	374	2924	1208	76	2743	182	3257	1278	92	2863	192	2604	1040	94
55–64	3251	192	2587	1248	107	1700	108	2793	1364	148	1551	84	2361	1062	144
65–74	933	84	1922	1220	159	534	56	1889	1174	175	400	28	1965	1279	252

TABLE C.—Continued

Cigarette smoking status (by age)	Both sexes					Men					Women				
	N	n	Mean	SD	SE	N	n	Mean	SD	SE	N	n	Mean	SD	SE
Light smokers															
25–74			3313		74			3676		110			2984		102
25–34	2162	113	3964	1230	169	879	43	4617	1248	222	1283	70	3516	994	162
35–44	1267	72	3630	1076	151	308	17	4190[2]	943	226	959	55	3450	1054	168
45–54	1090	76	2911	864	107	383	24	3150	969	197	707	52	2781	771	103
55–64	1043	57	2756	1375	205	313	18	3542[2]	1643	395	730	39	2420	1080	200
65–74	304	21	2056	1252	292	131	11	1706[2]	883	366	172	10	2321[2]	1415	425
Moderate smokers															
25–74			3207		57			3561		79			2888		71
25–34	4269	235	4246	1239	96	2534	123	4640	1297	126	1735	112	3671	872	47
35–44	2413	130	3781	1182	124	1214	66	4039	1198	171	1199	64	3520	1107	142
45–54	2715	179	2775	1205	111	1145	75	3079	1243	124	1570	104	2553	1125	140
55–64	1287	82	2665	1186	167	690	45	2873	1191	207	597	37	2425	1134	245
65–74	464	44	1881	1239	218	261	28	2131	1316	279	203	16	1558[2]	1047	266
Heavy smokers															
25–74			3043		68			3283		92			2828		110
25–34	2417	136	4067	1333	153	1363	72	4326	1305	197	1054	64	3733	1295	247
35–44	2148	116	3239	1469	166	1505	75	3456	1550	227	643	41	2731	1103	185
45–54	1779	118	3152	1355	147	1193	82	3458	1377	168	586	36	2526	1062	222
55–64	922	53	2286	1123	173	697	45	2379	1222	221	224	8	1997[2]	651	232
66–74	154	18	1760[2]	1113	285	130	16	1559[2]	1059	274	24	2	2834[2]	703	490

NOTE: N = weighted population estimate, in thousands; n = number of people in sample; SD = standard deviation; SE = standard error.

[1] Adjusted by the direct method to reflect the age distribution of the U.S. population at the midpoint of the survey.

[2] Does not meet standards of reliability.

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

TABLE D.—Flow at 75 percent of FVC for white adults, by smoking status, sex, and age, United States, 1971–1975

Cigarette smoking status (by age)	Both sexes					Men					Women				
	N	n	Mean	SD	SE	N	n	Mean	SD	SE	N	n	Mean	SD	SE
Never smokers															
25–74			1230[1]		28[1]			1329[1]		42[1]			1073[1]		24[1]
25–34	6733	394	1776	714	52	2633	130	2065	649	72	4099	264	1590	691	62
35–44	5278	291	1277	621	49	1669	81	1478	843	129	3609	210	1184	456	32
45–54	4942	353	1044	636	44	1206	85	1184	664	74	3736	268	999	620	53
55–64	3660	251	737	511	36	880	59	978	612	83	2781	192	661	449	34
65–74	2875	235	609	463	32	481	43	795	408	64	2394	192	572	465	38
Ex-smokers															
25–74			1152		29			1403		41			992		37
25–34	2811	160	1695	678	61	1359	66	1925	664	109	1452	94	1480	616	72
35–44	3086	171	1460	664	62	1828	94	1623	693	92	1258	77	1224	538	59
45–54	3323	213	1026	625	48	2345	143	1148	666	59	978	70	734	378	53
55–64	2669	181	734	541	54	1826	130	778	446	41	843	51	638	694	156
65–74	1769	157	588	506	43	1270	121	592	516	47	499	36	578	481	87
Smokers															
25–74			967		22			1053		29			889		34
25–34	8885	487	1530	688	41	4792	239	1665	655	60	4093	248	1373	692	65
35–44	5849	320	1062	552	34	3027	158	1134	599	57	2822	162	985	486	35
45–54	5606	374	778	511	31	2743	182	866	530	41	2863	192	693	478	43
55–64	3251	192	631	536	42	1700	108	713	580	63	1551	84	541	468	56
65–74	933	84	452	689	100	534	56	350	445	77	400	28	588	901	199

TABLE D.—Continued

Cigarette smoking status (by age)	Both sexes					Men					Women				
	N	n	Mean	SD	SE	N	n	Mean	SD	SE	N	n	Mean	SD	SE
Light smokers															
25–74			1049		44			1120		64			985		67
25–34	2162	113	1480	679	94	879	43	1647	606	113	1283	70	1366	703	127
35–44	1267	72	1122	534	63	308	17	1294[2]	484	101	959	55	1067	537	73
45–54	1090	76	837	431	57	383	24	840	500	137	707	52	836	388	42
55–64	1043	57	706	540	85	313	18	931[2]	652	182	730	39	609	450	88
65–74	304	21	660	1040	264	131	11	393[2]	587	231	172	10	864[2]	1244	414
Moderate smokers															
25–74			970		28			1107		41			846		32
25–34	4269	235	1603	685	57	2534	123	1755	686	82	1735	112	1382	620	76
35–44	2413	130	1134	499	52	1214	66	1265	517	78	1199	64	1000	443	58
45–54	2715	179	717	480	49	1145	75	801	416	47	1570	104	656	514	67
55–64	1287	82	643	598	72	690	45	784	637	119	597	37	481	503	69
65–74	464	44	373	366	68	261	28	381	375	85	203	16	363[2]	353	103
Heavy smokers															
25–74			882		47			956		38			815		82
25–34	2417	136	1447	689	95	1363	72	1503	593	101	1054	64	1374	790	172
35–44	2148	116	940	595	63	1505	75	995	647	85	643	41	811	422	69
45–54	1779	118	836	589	57	1193	82	941	624	73	586	36	620	438	79
55–64	922	53	529	410	57	697	45	545	416	62	224	8	479[2]	388	160
65–74	154	18	297[2]	453	112	130	16	258[2]	408	98	24	2	505[2]	603	420

NOTE: N = weighted population estimate, in thousands; n = number of people in sample; SD = standard deviation; SE = standard error.

[1] Adjusted by the direct method to reflect the age distribution of the U.S. population at the midpoint of the survey.

[2] Does not meet standards of reliability.

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

TABLE E.—FEV_1/FVC ratio for white adults, by smoking status, sex, and age, United States, 1971–1975

Cigarette smoking status (by age)	Both sexes					Men					Women				
	N	n	Mean	SD	SE	N	n	Mean	SD	SE	N	n	Mean	SD	SE
Never smokers															
25–74			79.1[1]		0.21[1]			77.9[1]		0.34[1]			80.2[1]		0.23[1]
25–34	6733	394	82.5	6.08	0.34	2633	130	80.7	5.91	0.69	4039	264	83.6	5.93	0.44
35–44	5278	291	80.3	5.67	0.37	1669	81	78.8	5.25	0.64	3609	210	80.9	5.73	0.45
45–54	4942	353	78.7	5.84	0.38	1206	85	77.5	5.95	0.77	3736	268	79.0	5.75	0.41
55–64	3660	251	77.6	5.03	0.35	880	59	75.8	5.13	0.81	2781	192	78.2	4.85	0.39
65–74	2875	235	76.5	6.41	0.52	481	43	73.5	7.59	1.14	2394	152	77.0	5.97	0.55
Ex-smokers															
25–74			77.7		0.30			76.6		0.44			78.7		0.41
25–34	2811	160	81.7	5.92	0.53	1359	66	80.9	5.94	0.94	1452	94	82.4	5.81	0.78
35–44	3086	171	79.5	6.26	0.56	1828	94	78.8	6.78	0.83	1258	77	80.4	5.26	0.69
45–54	3323	213	76.2	6.58	0.50	2345	143	75.9	7.10	0.66	978	70	77.0	5.04	0.69
55–64	2669	181	73.7	7.79	0.70	1826	130	72.7	8.07	0.79	843	51	76.0	6.60	1.36
65–74	1769	157	71.5	9.34	1.05	1270	121	70.0	9.83	1.20	499	36	75.3	6.58	1.05
Smokers															
25–74			75.9		0.26			74.0		0.36			77.5		0.39
25–34	8885	487	80.3	6.78	0.38	4792	239	79.2	6.50	0.52	4093	248	81.7	6.85	0.61
35–44	5849	320	76.7	7.28	0.46	3027	158	75.3	7.92	0.71	2822	162	78.2	6.16	0.47
45–54	5606	374	74.2	7.05	0.41	2743	182	73.0	7.55	0.59	2863	192	75.4	6.32	0.52
55–64	3251	192	73.1	8.73	0.59	1700	108	70.6	9.59	1.03	1551	84	76.0	6.61	0.75
65–74	933	84	69.8	9.40	1.44	534	56	67.0	8.94	1.54	400	28	73.6	8.67	2.09

TABLE E.—Continued

Cigarette smoking status (by age)	Both sexes					Men					Women				
	N	n	Mean	SD	SE	N	n	Mean	SD	SE	N	n	Mean	SD	SE
Light smokers															
25–74			77.3		0.47			75.7		0.76			78.7		0.60
25–34	2162	113	80.9	7.43	0.84	879	43	80.3	7.10	1.11	1283	70	81.4	7.62	1.30
35–44	1267	72	78.4	6.18	0.79	308	17	77.1[2]	6.14	1.54	959	55	78.8	6.13	1.30
45–54	1090	76	76.5	4.94	0.66	383	24	75.1	6.06	1.58	707	52	77.3	4.01	0.54
55–64	1043	57	76.9	7.06	0.97	313	18	74.8[2]	9.00	2.25	730	39	77.8	5.81	0.87
65–74	304	21	71.4	10.59	2.65	131	11	64.6[2]	10.84	4.17	172	10	76.5[2]	6.90	2.64
Moderate smokers															
25–74			75.8		0.36			74.6		0.48			76.9		0.47
25–34	4269	235	80.4	6.36	0.53	2534	123	79.3	6.29	0.70	1735	112	81.9	6.16	0.73
35–44	2413	130	77.9	6.18	0.65	1214	66	77.3	6.61	0.85	1199	64	78.6	5.64	0.77
45–54	2715	179	73.6	7.48	0.69	1145	75	71.3	7.87	0.96	1570	104	75.3	6.67	0.80
55–64	1287	82	73.2	7.46	0.81	690	45	72.1	8.00	1.38	597	37	74.3	6.58	1.07
65–74	464	44	69.3	8.30	1.48	261	28	68.4	7.63	1.58	203	16	70.4[2]	8.98	2.42
Heavy smokers															
25–74			75.1		0.58			72.8		0.57			77.2		1.06
25–34	2417	136	79.1	6.85	0.73	1363	72	78.0	6.33	0.89	1054	64	81.9	6.90	1.16
35–44	2148	116	74.2	8.24	0.92	1505	75	73.3	8.68	1.21	643	41	76.2	6.64	1.15
45–54	1779	118	73.7	7.21	0.74	1193	82	74.0	7.34	0.86	586	36	73.2	6.91	1.30
55–64	922	53	68.9	10.08	1.42	697	45	67.1	10.09	1.81	224	8	74.6[2]	7.63	2.40
65–74	154	18	68.0[2]	9.78	2.65	130	16	65.9[2]	8.75	2.42	24	2	79.4[2]	6.66	4.63

NOTE: N = weighted population estimate, in thousands; n = number of people in sample; SD = standard deviation; SE = standard error.

[1] Adjusted by the direct method to reflect the age distribution of the U.S. population at the midpoint of the survey.

[2] Does not meet standards of reliability.

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

TABLE F.—MMEF for white adults, by smoking status, sex, and age, United States, 1971–1975

Cigarette smoking status (by age)	Both sexes					Men					Women				
	N	n	Mean	SD	SE	N	n	Mean	SD	SE	N	n	Mean	SD	SE
Never smokers															
25–74			3020[1]		29[1]			3392[1]		52[1]			2684[1]		26[1]
25–34	6733	394	3748	1023	64	2633	130	4357	1008	106	4199	264	3357	820	58
35–44	5278	291	3140	827	58	1669	81	3501	911	106	3609	210	2973	727	58
45–54	4942	353	2724	837	50	1206	85	3198	1021	119	3736	268	2572	703	48
55–64	3660	251	2301	730	43	880	59	2734	763	104	2781	192	2164	663	51
65–74	2875	235	1891	679	51	481	43	2314	827	130	2394	192	1806	611	56
Ex-smokers															
25–74			2910		41			3324		66			2537		51
25–34	2811	160	3753	1066	102	1359	66	4321	1014	162	1452	54	3222	809	103
35–44	3086	171	3500	1165	106	1828	94	3882	1237	157	1258	77	2944	765	104
45–54	3323	213	2800	1111	91	2345	143	3021	1171	114	978	70	2270	714	102
55–64	2669	181	2318	948	75	1826	130	2463	953	87	843	51	2005	857	180
65–74	1769	157	1826	873	82	1270	121	1865	922	99	499	36	1728	723	115
Smokers															
25–74			2553		31			2786		49			2343		41
25–34	8885	437	3512	1069	66	4792	239	3857	1101	93	4093	248	3109	872	77
35–44	5849	320	2850	970	65	3027	158	3033	1073	107	2822	162	2654	800	63
45–54	5606	374	2283	896	54	2743	182	2511	1007	78	2863	192	2065	709	66
55–64	3251	192	1955	854	67	1700	108	2065	985	106	1551	84	1813	654	78
65–74	933	84	1474	831	118	534	56	1422	677	104	400	28	1545	995	220

TABLE F.—Continued

Cigarette smoking status (by age)	Both sexes					Men					Women				
	N	n	Mean	SD	SE	N	n	Mean	SD	SE	N	n	Mean	SD	SE
Light smokers															
25–74			2736		57			2985		93			2510		77
25–34	2162	113	3457	1034	144	879	43	3923	1044	196	1283	70	3137	807	153
35–44	1267	72	2936	839	110	308	17	3400[2]	760	184	959	55	2787	808	124
45–54	1090	76	2334	641	84	383	24	2521	806	173	707	52	2232	502	68
55–64	1043	57	2252	894	124	313	18	2694[2]	1239	321	730	39	2063	605	87
65–74	304	21	1667	1023	257	131	11	1339[2]	568	238	172	10	1917[2]	1206	404
Moderate smokers															
25–74			2542		41			2848		64			2266		40
25–34	4269	235	3605	1106	93	2534	123	3960	1132	123	1735	112	3087	828	98
35–44	2413	130	2993	907	99	1214	66	3257	968	145	1199	64	2725	752	92
45–54	2715	179	2169	823	74	1145	75	2345	891	92	1570	104	2041	744	95
55–64	1287	82	1894	811	103	690	45	2144	848	162	597	87	1604	655	106
65–74	464	44	1395	738	126	261	28	1535	746	159	203	16	1214[2]	687	157
Heavy smokers															
25–74			2404		53			2620		72			2210		87
25–34	2417	136	3389	1018	120	1363	72	3614	1045	167	1054	64	3122	911	187
35–44	2148	116	2628	1063	119	1505	75	2777	1144	157	643	41	2280	735	123
45–54	1779	118	2421	1087	125	1193	82	2663	1145	150	536	36	1926	786	185
55–64	922	53	1706	764	166	697	45	1754	828	136	224	8	1557[2]	439	169
65–74	154	18	1313[2]	591	151	130	16	1247[2]	601	160	24	2	1665[2]	369	257

NOTE: N = weighted population estimate, in thousands; n = number of people in sample; SD = standard deviation; SE = standard error.

[1] Adjusted by the direct method to reflect the age distribution of the U.S. population at the midpoint of the survey.

[2] Does not meet standards of reliability.

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