"The Health Consequences of Smoking: Cancer," Overview of a Report of the Surgeon General

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THE PUBLIC HEALTH CIGARETTE SMOKING ACT of 1969 (Public Law 91-222) requires the Public Health Service to submit annual reports to Congress on the health consequences of smoking. The authors of the 1982 report examined the relationship of smoking to a single category of disease, cancer (*1*). The 322-page document is the first in-depth examination of the subject since "Smoking and Health. Report of the Advisory Committee to the Surgeon General of the Public Health Service" (*2*).

In that 1964 report, the Advisory Committee judged the association between cigarette smoking and lung cancer as "causal" for men and probably so for women. The authors of the 1982 report, applying the same criteria that the Advisory Committee used in 1964, examined the new research that has accumulated in the years since and came to the following conclusions:

- Approximately 30 percent of all cancer deaths are attributable to cigarette smoking.
- Smoking is a major cause of lung cancer and of cancers of the larynx, oral cavity, and esophagus.
- It is a contributory factor in the development of cancers of the bladder, pancreas, and kidney.
- An excess mortality has been found among cigarette smokers for cancers of the stomach and uterine cervix, but evidence presently available is deemed insufficient for conclusions about the nature of the association.
- To examine passive smoking, the authors of the report reviewed three studies that present evidence of an elevated carcinogenic risk among nonsmokers exposed to other people's smoking. Two of these studies yielded statistically significant associations, and one did not.

Criteria for Judgment of Causality

In 1951, Richard Doll and A. B. Hill initiated the first major prospective study of the effects of smoking on health, enrolling 40,000 British physicians in a study which continues to this day. It was the first of a total of eight major prospective studies that have been conducted in the United Kingdom, the United States, Sweden, Canada, and Japan (table 1). In total, they have amassed more than 17 million person-years of observation that includes more than 330,000 deaths. In all of these studies, elevated mortality ratios were observed for cigarette smokers compared to nonsmokers for cancer as well as for a number of other chronic diseases.

In 1964, the Advisory Committee considered five

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criteria to be necessary for judging the causal significance of data emanating from these studies. These criteria, which follow, were used by the authors of the 1982 report.

1. *Consistency of the association.* This criterion requires that diverse methods of approach provide similar conclusions. The association must be observed repeatedly by multiple investigators, in different locations and situations, at different times, using different methods of study.

2. *Strength of the association.* The most direct measure of the strength of the association between cigarette smoking and a particular disease is comparison of death rates from the disease among smokers with the rates experienced by nonsmokers.

3. *Specificity of the association.* Specificity is judged by how frequently the presence of one variable will predict the presence of another. Although the demonstration of specificity makes a causal hypothesis more acceptable, lack of specificity does not negate such an hypothesis.

4. *Temporal relationship of the association.* This criterion requires that exposure to the suspect etiological factor precede the disease.

5. *Coherence of the association.* The final criterion for the appraisal of causal significance of an association is its coherence with known facts in the natural history of the disease. Coherence requires that descriptive epidemiologic results on disease occurrence correlate with measures of exposure to the suspect agent. Perhaps the most important consideration here is the observation of a dose-response relationship between agent and disease, a progressively increasing occurrence of disease in increasingly heavily exposed groups.

In applying these criteria, the Advisory Committee in 1964 and the authors of the 1982 report emphasized that they were not construing the term "causal" in such a manner as to exclude other agents as causes. They also looked to converging evidence from such other sources as clinical, autopsy, and experimental studies.

Mortality Ratio

Presented in the 1982 report and in table 2 are mortality ratios linking cigarette smoking with cancers of the lung, larynx, oral cavity, esophagus, bladder, kidney, and pancreas. The ratios are highest for lung cancer, which has mortality ratios of 10 for smokers and 1 for nonsmokers.

In addition to the eight major prospective studies described in table 1, hundreds of retrospective studies

Table 1. Outline of eight major prospective studies of smoking and mortality

Study and authors	Subjects	Total population	Females	Age range (years)	Year of enrollment	Years of followup	Number of deaths	Person years of experience
British physicians: R. Doll, A. B. Hill, R. Peto, M. C. Pike	British physicians	40,000	6,000	20–85+	1951	20–22	11,166	800,000
American Cancer Society, 25 State: E. C. Hammond	Males, females in 25 States	1 million	562,671	35–84	1960	12	150,000	8 million
U.S. veterans: H. F. Dorn, H. A. Kahn, E. Rogot	U.S. veterans	290,000	Less than 1 percent	35–84	1954 1957	16	107,500	3.5 million
Japanese: T. Hirayama	Total population of 2 health districts	265,000	142,857	40+	1966	13	39,100	3 million
Canadian veterans: E. W. R. Best, G. H. Josie, C. B. Walker	Canadian pensioners	92,000	14,000	30–90	1955	6	11,000	500,000
American Cancer Society 9 State: E. C. Hammond, D. Horn	White males in 9 States	187,000	....	50–69	1952	4	12,000	670,000
California males in 9 occupations: J. M. Weir, J. E. Dunn, G. Linden, L. Breslow	California males in various occupations	68,000	....	33–64	1954	5–8	4,700	480,000
Swedish: R. Cederlof, L. Friberg, Z. Hrubec, U. Lorich	Probability sample of Swedish population	55,000	27,700	18–69	1963	10	4,500	550,000

SOURCE: reference 1, page 33.

that have examined almost every aspect of the association between smoking and cancer have been published and reviewed. Researchers have studied this association in terms of type and quantity of tobacco smoked, duration of smoking, inhalation practices, and other exposure variables. Findings in these retrospective studies have consistently supported results of the prospective studies.

Cancer of the Lung

In 1950, lung cancer accounted for 18,300 deaths in the United States. It is estimated that, in 1982, some 111,000 Americans will die of the disease. Although nearly three-fourths of these deaths occur among males, the lung cancer death rate among females is currently rising at a faster rate than that of males. The trend among women mimics that observed among men some 25 years earlier, and it parallels differences in cigarette smoking patterns between men and women. If this trend continues, the age-adjusted lung cancer death rate among women will soon exceed that of breast cancer, perhaps as early as 1983.

The 5-year survival rate for lung cancer is less than 10 percent, unchanged since the 1960s. Early diagnosis and treatment do not appreciably alter this grim statistic. Lung cancer, which accounts for 25 percent of all cancer deaths in this country, is, to a large extent, preventable. Smokers are 10 times more likely to die from lung cancer than are nonsmokers, and those who smoke more than a pack of cigarettes a day have a risk 15 to 25 times greater than nonsmokers. It is estimated that 85 percent of lung cancer deaths could have been avoided if the persons had not taken up smoking.

Cancers of the Larynx and Oral Cavity

Over the last 30 years, epidemiologic, pathological, and experimental investigations have established a strong association between smoking and cancers of the larynx and oral cavity. Cancers of the oral cavity include malignant tumors of the lip, tongue, salivary gland, floor of the mouth, mesopharynx, and hypopharynx. Laryngeal and oral cavity cancers are more easily diagnosed and have much higher survival rates than lung cancer. It is estimated that, in 1982, there will be 3,700 deaths due to laryngeal cancer and 9,150 deaths from cancers of the oral cavity.

Approximately 50 to 70 percent of oral and laryngeal cancer deaths are associated with smoking. Heavy

Table 2. Cancer mortality ratios—smokers to nonsmokers—in eight major prospective studies

Study and population	Lung cancer	Laryngeal cancer	Oral cavity cancer	Esophageal cancer	Bladder cancer	Kidney cancer	Pancreatic cancer
British physicians:							
Males	14.00	[1] 13.00	[1] 13.00	4.70	2.11	2.66	1.60
Females	5.00	....	....	....	....	....	....
American Cancer Society 25-State:							
Males	8.53	[1] 6.52	[1] 6.52	3.96	2.55	1.42	2.14
Females	3.58	[1] 3.25	[1] 3.25	4.89	2.80	1.57	1.42
U.S. veterans: males	11.28	11.49	[2] 4.22, 14.05	6.43	2.15	1.41	1.79
Japanese:							
Males	3.76	13.59	2.88	2.35	2.00	1.20	1.57
Females	2.03	6.52	1.22	....	2.55	....	1.94
Canadian veterans: males	14.20	....	....	....	1.40	....	1.96
American Cancer Society 9-State:							
Males	10.73	....	5.06	5.06	2.00	1.58	1.50
California males in 9 occupations	7.61	> 2.90	2.76	1.82	2.89	2.46	2.43
Swedish:							
Males	7.00	....	....	....	1.80	....	3.1
Females	4.50	....	....	....	1.60	....	2.5

[1] Mortality rates were calculated from oral and laryngeal cancer data.
[2] The buccal cancer ratio was 4.22, pharyngeal cancer ratio was 14.05.

SOURCE: reference 1.

smokers have a mortality risk for laryngeal cancer 20 to 30 times greater than the risk for nonsmokers. In contrast to lung cancer, the 5-year survival rate for laryngeal cancer has been improving over the past 15 years and is now about 60 percent. For oral cancer, the 5-year survival rate is 40 percent.

Cancer of the Esophagus

Esophageal cancer has one of the poorest survival rates of all cancers: the median survival rate is less than 6 months following diagnosis, and the 5-year survival is only about 3 percent. The number of deaths caused by this cancer was slightly less than 3,900 in 1950, but by 1977 the number had increased to more than 7,000; an estimated 8,300 deaths are expected to occur in 1982.

Cigarette smoking is estimated to be a factor in over half of esophageal cancer deaths, with smokers having mortality ratios approximately four to five times higher than nonsmokers. Heavy smokers (more than one pack per day) in the British physicians' and U.S. veterans' studies had mortality risks 10 times those of nonsmokers.

Cancer of the Bladder and Kidney

More than 50,000 Americans are expected to develop cancer of the bladder or kidney in 1982, resulting in an estimated 20,000 deaths. About half of the patients who develop cancer of these sites will survive 5 years or longer. Thirty to 40 percent of bladder cancers are estimated to be smoking related.

In both prospective and retrospective studies, investigators have consistently noted higher rates of bladder and kidney cancers among smokers than among nonsmokers. However, the increased risk is not as strong as that noted for the association between smoking and cancers of the lung, larynx, oral cavity, and esophagus. The term "contributory factor" by no means excludes the possibility of a causal role for smoking in cancers of the bladder and kidney.

Cancer of the Pancreas

Mortality from cancer of the pancreas is rising faster than mortality from most other cancers, with the notable exception of lung cancer. Approximately 24,000 people will develop pancreatic cancer in 1982, and there will be an estimated 22,000 deaths. The disease is generally undetected until late in its course, due to difficulties in diagnosis, the nonspecific nature of the presenting symptoms, and relatively early metastasis. Like cancers of the lung and esophagus, the survival rate is dismal—at 5 years only 2 percent of victims are alive, and the mean survival time after diagnosis is less than 6 months.

In prospective studies the increased risk for smokers was approximately twofold that for nonsmokers, and in four studies there was an increased risk with an increased amount smoked per day.

Dose-Response and Cessation

The dose-response relationship between cigarette smoking and cancer of a specific site is one criterion for

causality. Such a relationship means that the incidence of the disease changes with increasing number of cigarettes smoked, depth of inhalation, number of years smoked, age when smoking began, or type of cigarettes smoked. The dose-response relationship for lung (table 3), laryngeal, oral, and esophageal cancers is strong; a lesser dose-response has been shown for cancer of the urinary bladder, kidney, and pancreas.

Because a dose-response relationship exists for these cancer sites, it is logical to expect that cessation of smoking would lead to a decrease in mortality rates. This association has been found for all types of cancers mentioned previously. The ex-smoker's risk of dying from lung cancer gradually decreases with the number of years off cigarettes and approaches that of the nonsmoker after 15 to 20 years, whereas for the continuing cigarette smoker, the lung cancer risk remains more than 10 times that of the nonsmoker. The ex-smoker's risk for laryngeal and oral cavity cancers similarly decreases gradually with the number of years off cigarettes and approaches that of nonsmokers after 10 to 15 years. Ex-smokers have only about one-third the risk of esophageal cancer of current smokers, and their disease rates approach those of nonsmokers after 4 years.

For all these conditions, however, the nonsmoker faces a much lower risk than does a smoker who quits, in addition to a decreased risk for other smoking-related diseases. The residual risk for former smokers is directly proportional to overall lifetime exposure to tobacco smoke.

Lower Yield and Filter Cigarettes

Filtered cigarettes were introduced in the mid-1950s and were quickly adopted by smokers, particularly women. Most of today's filtered cigarettes have lower tar and nicotine values compared to nonfilterd cigarettes. By 1981, 93 percent of the more than 600 billion cigarettes smoked in the United States were filtered, and approximately 33 percent contained less than 15 milligrams of tar. Among smokers of either filtered or reduced tar and nicotine (lower yield) cigarettes, the relative risk ratios for lung cancer were lower than those for smokers of nonfilter or higher tar and nicotine cigarettes. For smokers of lower tar and nicotine cigarettes, the risk is still considerably higher than that for nonsmokers, however.

Evidence on relative risk for other cancers according to cigarette characteristics is sparse, indicating only a possible reduced risk of laryngeal cancer for smokers of filtered cigarettes compared to smokers of unfiltered cigarettes.

Occupation

It is difficult to obtain reliable data on the relationship of cigarette smoking and occupational factors to the risk for various cancers. Lung cancer has been linked to factors in the work environment, such as chemicals, dust, fumes, fibers, and vapors; bladder cancer has been associated with aromatic amines. Of particular concern for lung cancer risk is the synergistic relationship that exists between smoking and certain occupational agents such as asbestos and, possibly, radio-

Table 3. Lung cancer mortality ratios for men and women, by current number of cigarettes smoked per day

Population and cigarettes smoked per day	*Men's mortality ratios*	*Women's mortality ratios*
ACS 25-State study:		
Nonsmoker	1.00	1.00
1–9	4.62	1.30
10–19	8.62	2.40
20–39	14.69	4.90
40 or more	18.71	7.50
British physicians study:		
Nonsmoker	1.00	1.00
1–14	7.80	1.28
15–24	12.70	6.41
25 or more	25.10	29.71
Swedish study:		
Nonsmoker	1.00	1.00
1–7	2.30	1.80
8–15	8.80	11.30
16 or more	13.70	....
Japanese study: [1]		
Nonsmoker	1.00	1.00
1–19	3.49	1.90
20–39	5.69	4.20
40 or more	6.45	....
U.S. veterans study:		
Nonsmoker	1.00	....
1–9	3.89	....
10–20	9.63	....
21–39	16.70	....
40 or more	23.70	....
ACS 9-State study:		
Nonsmoker	1.00	....
1–9	8.00	....
10–20	10.50	....
20 or more	23.40	....
Canadian veterans:		
Nonsmoker	1.00	....
1–9	9.50	....
10–20	15.80	....
20 or more	17.30	....
California males in 9 occupations:		
Nonsmoker	1.00	....
about ½ pack	3.72	....
about 1 pack	9.05	....
about 1½ packs	9.56	....

[1] Categories for Japanese women were less than 20 and 20–29 cigarettes.
NOTE: ACS American Cancer Society.
SOURCE: reference 1, page 38.

active aerosols. Asbestos workers who smoke cigarettes have 5 time the risk for lung cancer as smokers without asbestos exposure and more than 50 times the risk of individuals who neither smoke nor work with asbestos. The risk for uranium miners who smoke is at least four times greater than for cigarette smokers who do not work in the mines.

Synergism With Alcohol

Alcohol plays an important synergistic role with cigarette smoking in the production of cancers of the larynx, oral cavity, and esophagus. The mechanisms of interaction of these two factors is not known. Part of the increased risk among alcohol abusers may be attributed to heavier smoking by this group, but there remains an excess risk associated with alcohol use. The findings in one study suggested that the laryngeal cancer risk for smoking drinkers is approximately 50 percent greater than the sum of the excess risks posed by either smoking or drinking.

Other Forms of Tobacco Use

Pipe and cigar smoking is associated with a number of cancers. In contrast to cigarette smokers, most pipe and cigar smokers report that they do not inhale the smoke. As a result, the risk of developing lung cancer for pipe and cigar smokers is less than for cigarette smokers; however, their mortality ratios are somewhat higher than for nonsmokers. In countries where pipe and cigar smoke is inhaled, the rates of lung cancer approach those of cigarette smokers. Unlike the risk for lung cancer, the risk for cancers of the larynx, oral cavity, and esophagus are comparable to that of cigarette smokers. In some studies an elevated risk for smokers of pipes or cigars for cancer of the bladder has been noted.

Chewing tobacco and snuff are increasingly popular, especially among teenagers. Snuff dipping is placing and retaining finely ground or powdered tobacco between the gum and cheek. A correlation between snuff dipping or chewing tobacco and oral cancer has been observed in several studies. In one recent study, there was a fourfold increase in the risk for oral cancer among female snuff dippers compared to nonusers; the risk for cancers of the cheek and gum was nearly fiftyfold among long-term users.

Transplacental Effects

Investigators in several experimental studies have suggested that tobacco smoke has transplacental carcinogenic effects. A number of tobacco smoke's constituents, which need metabolic activation to acquire carcinogenic properties, are known transplacental carcinogens. Among these are volatile N-nitrosamines and vinyl chloride. The role of nicotine in possible transplacental effects of tobacco smoke also requires further elucidation, since its transplacental migration into the animal fetus has long been known. Further research is needed to examine the potential carcinogenic transplacental effects of tobacco products.

Involuntary Smoking and Lung Cancer

The smoke generated during the active inhalation of a tobacco product is mainstream smoke. While the product smolders between puffs, sidestream smoke is freely emitted into the air; during puffing little smoke escapes from the burning cigarette into the surrounding environment. Compounds found in greater amounts in sidestream smoke than in mainstream smoke include nitrogen oxides, nitrosamines, ammonia and amines, and total particulate matter. However, sidestream smoke components are diluted by air before they are inhaled and the particulates settle rather quickly on environmental surfaces.

There is much concern today about the harmfulness of sidestream cigarette smoke for the nonsmoker. Many people find it irritating; others who suffer from certain conditions such as heart disease or asthma find that it affects their health adversely. Children of smoking parents have been shown to suffer more bronchitis and pneumonia during the first year of life. In recent years, attention has focused on the possibility that lung cancer may be caused by passive inhalation of smoke by nonsmokers.

The authors of the 1982 smoking and health report reviewed the evidence from three epidemiologic studies published in 1981. In two studies, which were conducted in the more traditional societies of Greece and Japan, there was a statistically significant increased risk of lung cancer among the nonsmoking wives of smoking husbands. In these studies, the nonsmoking wife's risk of lung cancer increased in relation to the extent of the husband's smoking. In the third study, an analysis of data from the American Cancer Society's prospective study (1960–72), the risk of lung cancer among nonsmoking wives of smoking husbands was also increased, but the difference was not statistically significant.

Although the evidence from these investigations suggests that involuntary smoke exposure may increase the risk of lung cancer in nonsmokers, the limitations in data and study design do not allow a judgment on causality at this time. However, prudence dictates that nonsmokers' exposure to second-hand tobacco smoke be minimized to the greatest extent possible.

Table 4. Cancer deaths caused by tobacco, United States, 1978

Certified cause of death	Observed deaths	Estimated deaths had Americans not smoked	Approximate excess attributed to tobacco	
			Number	Percent
Total males	218,337	....	94,782	43.4
Lung	71,006	6,439	64,567	90.9
Mouth, pharynx, larynx, or esophagus	14,282	3,584	10,698	74.9
Bladder	6,771	2,960	3,811	56.3
Pancreas	11,010	6,585	4,425	40.2
Other specified sites	100,799	....	5,000	5.0
Unspecified sites	14,469	8,188	6,281	43.4
Total females	183,618	....	27,266	14.8
Lung	24,080	5,454	18,626	77.4
Mouth, pharynx, larynx, or esophagus	5,100	2,916	2,184	42.8
Bladder	3,078	2,170	908	29.5
Pancreas	9,767	7,291	2,476	25.4
Other specified sites	127,642	....	1,000	....
Unspecified sites	13,951	11,879	2,072	14.9
Total males and females	401,955	....	122,048	30.4

SOURCE: reference 1, page 149.

Smoking Behavior: Cessation

The majority of people who have quit smoking have done so without the aid of an organized smoking cessation program. Effective self-help programs in smoking cessation are clearly needed. Those most likely to quit on their own or with minimal intervention appear to be psychologically healthier, smoke less heavily and for fewer years, and generally may be more skillful in controlling their own behavior. The other reliable predictor of outcome seems to be motivation, as measured by participants' willingness to comply with written instructions.

Major reviews in recent years have emphasized the importance of procedures directed specifically at maintenance in order to improve the generally low 6-month abstinence rates. The importance of social support in maintaining abstinence can work in reverse; a smoking spouse or smoking friends can adversely affect others' attempts to quit. A few studies have used social support involving buddy systems or individual group contact, with mixed results. The Multiple Risk Factor Intervention Trial (MRFIT) obtained 40 percent or better abstinence rates over a 4-year period by using an intense intervention with a strong continuing social support component (*3*).

Spontaneous cessation rates among adolescent regular smokers (those who smoke once a week or more often) approximate 25 percent. Some factors positively associated with the probability of quitting include not adhering to stereotypes of smoking or smokers, having nonsmoking friends, and pursuing an education (completing high school and going on to college).

Recently a number of researchers have developed and tested programs to encourage adolescents not to take up smoking. The programs that have met with consistent success share a number of features. They are targeted for the most part at seventh graders. Most demonstrate the short-term consequences of smoking; depict typical pressures to smoke from peers, parents, and the media; show role models resisting smoking pressures; use peer leaders to conduct programs; emphasize general life skills training with a focus on adolescents' developmental experience, rather than on smoking alone. In general, results have shown a 50 percent or more reduction in the rates of smoking initiation among young people.

Summary

Cancer is the second most frequent cause of death in this country. Unlike deaths from other major diseases, cancer deaths have continued to increase in the last several decades, because of the rise in cancer deaths attributable to cigarette smoking, and in particular, to the risk in deaths from lung cancer.

The total number of cancer deaths attributable to smoking is shown in table 4. Of 401,000 such deaths observed in 1978, a total of 122,000 or 30 percent may be attributed to smoking. These included some 80,000 deaths from lung cancer and 13,000 deaths from cancer of the mouth, pharynx, larynx, or esophagus. In all, 43 percent of cancer deaths among males and 15 percent among females were attributed to cigarette smoking. Applying this 30 percent figure to the estimated number of cancer deaths in 1982 results in an estimated 129,000 cigarette-related cancer deaths.

NOTE: Single copies of "The Health Consequences of Smoking: Cancer," 1982, are available from the Office on Smoking and Health, Rockville, Md. 20857. Additional copies are for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

References

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