Executive Summary

This report of the Surgeon General on the health effects of smoking returns to the topic of active smoking and disease, the focus of the first Surgeon General's report published in 1964 (U.S. Department of Health, Education, and Welfare [USDHEW] 1964). The first report established a model of comprehensive evidence evaluation for the 27 reports that have followed: for those on the adverse health effects of smoking, the evidence has been evaluated using guidelines for assessing causality of smoking with disease. Using this model, every report on health has found that smoking causes many diseases and other adverse effects. Repeatedly, the reports have concluded that smoking is the single greatest cause of avoidable morbidity and mortality in the United States.

Of the Surgeon General's reports published since 1964, only a few have comprehensively documented and updated the evidence on active smoking and disease. The 1979 report (USDHEW 1979) provided a broad array of information, and the 1990 report on smoking cessation (U.S. Department of Health and Human Services [USDHHS] 1990) also investigated major diseases caused by smoking. Other volumes published during the 1980s focused on specific groups of diseases caused by smoking (USDHHS 1982, 1983, 1984), and the 2001 report was devoted to women and smoking (USDHHS 2001). Because there has not been a recent systematic review of the full sweep of the evidence, the topic of active smoking and health was considered an appropriate focus for this latest report. Researchers have continued to identify new adverse effects of active smoking in their ongoing efforts to investigate the health effects of smoking. Lengthy follow-ups are now available for thousands of participants in long-term cohort (follow-up) studies (National Cancer Institute [NCI] 1997).

This report also updates the methodology for evaluating evidence that the 1964 report initiated. Although that model has proved to be effective, this report establishes a uniformity of language concerning causality of associations so as to bring greater specificity to the findings of the report. Beginning with this report, conclusions concerning causality of association will be placed into one of four categories with regard to strength of the evidence: (1) sufficient to infer a causal relationship, (2) suggestive but not sufficient to infer a causal relationship, (3) inadequate to infer the presence or absence of a causal relationship, or (4) suggestive of no causal relationship.

This approach separates the classification of the evidence concerning causality from the implications of that determination. In particular, the magnitude of the effect in the population, the attributable risk, is considered under "implications" of the causal determination. For example, there might be sufficient evidence to classify smoking as a cause of two diseases but the number of attributable cases would depend on the frequency of the disease in the population and the effects of other causal factors.

This report covers active smoking only. Passive smoking was the focus of the 1986 Surgeon General's report and subsequent reports by other entities (USDHHS 1986; U.S. Environmental Protection Agency [EPA] 1992; California EPA 1997; International Agency for Research on Cancer [IARC] 2002). The health effects of pipes and cigars, also not within the scope of this report, are covered in another report (NCI 1998).

In preparing this report, the literature review approach was necessarily selective. For conditions for which a causal conclusion had been previously reached, there was no attempt to cover all relevant literature, but rather to review the conclusions from previous Surgeon General's reports and focus on important new studies for that topic. The enormous scope of the evidence precludes such detailed reviews. For conditions for which a causal conclusion had not been previously reached, a comprehensive search strategy was developed. Search strategies included reviewing previous Surgeon General's reports on smoking, publications originating from the largest observational studies, and reference lists from important publications; consulting with content experts; and conducting focused literature searches on specific topics. For this report, studies through 2000 were reviewed.

In addition, conclusions from prior reports concerning smoking as a cause of a particular disease have been updated and are presented in this new format based on the evidence evaluated in this report (Table 1.1). Remarkably, this report identifies a substantial number of diseases found to be caused by smoking that were not previously causally associated with smoking: cancers of the stomach, uterine cervix, pancreas, and kidney; acute myeloid leukemia; pneumonia; abdominal aortic aneurysm; cataract; and periodontitis. The report also concludes that smoking generally diminishes the health of smokers.

Table 1.1 Diseases and other adverse health effects for which smoking is identified as a cause in the current Surgeon General's report

Disease	Highest level conclusion from previous Surgeon General's reports (year)	Conclusion from the 2004 Surgeon General's report
Cancer		
Bladder cancer	"Smoking is a cause of bladder cancer; cessation reduces risk by about 50 percent after only a few years, in comparison with continued smoking." (1990, p. 10)	"The evidence is sufficient to infer a causal relationship between smoking and. . .bladder cancer."
Cervical cancer	"Smoking has been consistently associated with an increased risk for cervical cancer." (2001, p. 224)	"The evidence is sufficient to infer a causal relationship between smoking and cervical cancer."
Esophageal cancer	"Cigarette smoking is a major cause of esophageal cancer in the United States." (1982, p. 7)	"The evidence is sufficient to infer a causal relationship between smoking and cancers of the esophagus."
Kidney cancer	"Cigarette smoking is a contributory factor in the development of kidney cancer in the United States. The term 'contributory factor' by no means excludes the possibility of a causal role for smoking in cancers of this site." (1982, p. 7)	"The evidence is sufficient to infer a causal relationship between smoking and renal cell, [and] renal pelvis. . . cancers."
Laryngeal cancer	"Cigarette smoking is causally associated with cancer of the lung, larynx, oral cavity, and esophagus in women as well as in men. . . ." (1980, p. 126)	"The evidence is sufficient to infer a causal relationship between smoking and cancer of the larynx."
Leukemia	"Leukemia has recently been implicated as a smoking-related disease. . .but this observation has not been consistent." (1990, p. 176)	"The evidence is sufficient to infer a causal relationship between smoking and acute myeloid leukemia."
Lung cancer	"Additional epidemiological, pathological, and experimental data not only confirm the conclusion of the Surgeon General's 1964 Report regarding lung cancer in men but strengthen the causal relationship of smoking to lung cancer in women." (1967, p. 36)	"The evidence is sufficient to infer a causal relationship between smoking and lung cancer."
Oral cancer	"Cigarette smoking is a major cause of cancers of the oral cavity in the United States." (1982, p. 6)	"The evidence is sufficient to infer a causal relationship between smoking and cancers of the oral cavity and pharynx."

Table 1.1 Continued

Disease	Highest level conclusion from previous Surgeon General's reports (year)	Conclusion from the 2004 Surgeon General's report
Pancreatic cancer	"Smoking cessation reduces the risk of pancreatic cancer, compared with continued smoking, although this reduction in risk may only be measurable after 10 years of abstinence." (1990, p. 10)	"The evidence is sufficient to infer a causal relationship between smoking and pancreatic cancer."
Stomach cancer	"Data on smoking and cancer of the stomach. . .are unclear." (2001, p. 231)	"The evidence is sufficient to infer a causal relationship between smoking and gastric cancers."
Cardiovascular diseases		
Abdominal aortic aneurysm	"Death from rupture of an atherosclerotic abdominal aneurysm is more common in cigarette smokers than in nonsmokers." (1983, p. 195)	"The evidence is sufficient to infer a causal relationship between smoking and abdominal aortic aneurysm."
Atherosclerosis	"Cigarette smoking is the most powerful risk factor predisposing to atherosclerotic peripheral vascular disease." (1983, p. 8)	"The evidence is sufficient to infer a causal relationship between smoking and subclinical atherosclerosis."
Cerebrovascular disease	"Cigarette smoking is a major cause of cerebrovascular disease (stroke), the third leading cause of death in the United States." (1989, p. 12)	"The evidence is sufficient to infer a causal relationship between smoking and stroke."
Coronary heart disease	"In summary, for the purposes of preventive medicine, it can be concluded that smoking is causally related to coronary heart disease for both men and women in the United States." (1979, p. 1-15)	"The evidence is sufficient to infer a causal relationship between smoking and coronary heart disease."
Respiratory diseases		
Chronic obstructive pulmonary disease	"Cigarette smoking is the most important of the causes of chronic bronchitis in the United States, and increases the risk of dying from chronic bronchitis." (1964, p. 302)	"The evidence is sufficient to infer a causal relationship between active smoking and chronic obstructive pulmonary disease morbidity and mortality."
Pneumonia	"Smoking cessation reduces rates of respiratory symptoms such as cough, sputum production, and wheezing, and respiratory infections such as bronchitis and pneumonia, compared with continued smoking." (1990, p. 11)	"The evidence is sufficient to infer a causal relationship between smoking and acute respiratory illnesses, including pneumonia, in persons without underlying smoking-related chronic obstructive lung disease."

Table 1.1 Continued

Disease	Highest level conclusion from previous Surgeon General's reports (year)	Conclusion from the 2004 Surgeon General's report
Respiratory effects in utero	"In utero exposure to maternal smoking is associated with reduced lung function among infants. . . ." (2001, p. 14)	"The evidence is sufficient to infer a causal relationship between maternal smoking during pregnancy and a reduction of lung function in infants."
Respiratory effects in childhood and adolescence	"Cigarette smoking during childhood and adolescence produces significant health problems among young people, including cough and phlegm production, an increased number and severity of respiratory illnesses, decreased physical fitness, an unfavorable lipid profile, and potential retardation in the rate of lung growth and the level of maximum lung function." (1994, p. 41)	"The evidence is sufficient to infer a causal relationship between active smoking and impaired lung growth during childhood and adolescence." "The evidence is sufficient to infer a causal relationship between active smoking and the early onset of lung function decline during late adolescence and early adulthood. " "The evidence is sufficient to infer a causal relationship between active smoking and respiratory symptoms in children and adolescents, including coughing, phlegm, wheezing, and dyspnea." "The evidence is sufficient to infer a causal relationship between active smoking and asthma-related symptoms (i.e., wheezing) in childhood and adolescence."
Respiratory effects in adulthood	"Cigarette smoking accelerates the age-related decline in lung function that occurs among never smokers. With sustained abstinence from smoking, the rate of decline in pulmonary function among former smokers returns to that of never smokers." (1990, p. 11)	"The evidence is sufficient to infer a causal relationship between active smoking in adulthood and a premature onset of and an accelerated age-related decline in lung function." "The evidence is sufficient to infer a causal relationship between sustained cessation from smoking and a return of the rate of decline in pulmonary function to that of persons who had never smoked."

Table 1.1 Continued

Disease	Highest level conclusion from previous Surgeon General's reports (year)	Conclusion from the 2004 Surgeon General's report
Other respiratory effects	"Smoking cessation reduces rates of respiratory symptoms such as cough, sputum production, and wheezing, and respiratory infections such as bronchitis and pneumonia, compared with continued smoking." (1990, p. 11)	"The evidence is sufficient to infer a causal relationship between active smoking and all major respiratory symptoms among adults, including coughing, phlegm, wheezing, and dyspnea." "The evidence is sufficient to infer a causal relationship between active smoking and poor asthma control."
Reproductive effects		
Fetal death and stillbirths	"The risk for perinatal mortality—both stillbirth and neonatal deaths—and the risk for sudden infant death syndrome (SIDS) are increased among the offspring of women who smoke during pregnancy." (2001, p. 307)	"The evidence is sufficient to infer a causal relationship between sudden infant death syndrome and maternal smoking during and after pregnancy."
Fertility	"Women who smoke have increased risks for conception delay and for both primary and secondary infertility." (2001, p. 307)	"The evidence is sufficient to infer a causal relationship between smoking and reduced fertility in women."
Low birth weight	"Infants born to women who smoke during pregnancy have a lower average birth weight. . .than. . .infants born to women who do not smoke." (2001, p. 307)	"The evidence is sufficient to infer a causal relationship between maternal active smoking and fetal growth restriction and low birth weight."
Pregnancy complications	"Smoking during pregnancy is associated with increased risks for preterm premature rupture of membranes, abruptio placentae, and placenta previa, and with a modest increase in risk for preterm delivery." (2001, p. 307)	"The evidence is sufficient to infer a casual relationship between maternal active smoking and premature rupture of the membranes, placenta previa, and placental abruption." "The evidence is sufficient to infer a causal relationship between maternal active smoking and preterm delivery and shortened gestation."

Table 1.1 Continued

Disease	Highest level conclusion from previous Surgeon General's reports (year)	Conclusion from the 2004 Surgeon General's report
Other effects		
Cataract	"Women who smoke have an increased risk for cataract." (2001, p. 331)	"The evidence is sufficient to infer a causal relationship between smoking and nuclear cataract."
Diminished health status / morbidity	"Relationships between smoking and cough or phlegm are strong and consistent; they have been amply documented and are judged to be causal. . . ." (1984, p. 47) "Consideration of evidence from many different studies has led to the conclusion that cigarette smoking is the overwhelmingly most important cause of cough, sputum, chronic bronchitis, and mucus hypersecretion." (1984, p. 48)	"The evidence is sufficient to infer a causal relationship between smoking and diminished health status that may be manifest as increased absenteeism from work and increased use of medical care services." "The evidence is sufficient to infer a causal relationship between smoking and increased risks for adverse surgical outcomes related to wound healing and respiratory complications."
Hip fractures	"Women who currently smoke have an increased risk for hip fracture compared with women who do not smoke." (2001, p. 321)	"The evidence is sufficient to infer a causal relationship between smoking and hip fractures."
Low bone density	"Postmenopausal women who currently smoke have lower bone density than do women who do not smoke." (2001, p. 321)	"In postmenopausal women, the evidence is sufficient to infer a causal relationship between smoking and low bone density."
Peptic ulcer disease	"The relationship between cigarette smoking and death rates from peptic ulcer, especially gastric ulcer, is confirmed. In addition, morbidity data suggest a similar relationship exists with the prevalence of reported disease from this cause." (1967, p. 40)	"The evidence is sufficient to infer a causal relationship between smoking and peptic ulcer disease in persons who are *Helicobacter pylori* positive."

Sources: U.S. Department of Health, Education, and Welfare 1964, 1967, 1979; U.S. Department of Health and Human Services 1980, 1982, 1983, 1984, 1989, 1990, 1994, 2001.

Despite the many prior reports on the topic and the high level of public knowledge in the United States of the adverse effects of smoking in general, tobacco use remains the leading preventable cause of disease and death in the United States, causing approximately 440,000 deaths each year and costing approximately $157 billion in annual health-related economic losses (see Chapter 7, "The Disease Impact of Cigarette Smoking and Benefits of Reducing Smoking"). Nationally, smoking results in more than 5.6 million years of potential life lost each year. Although the rates of smoking continue to decline, an estimated 46.2 million adults in the United States still smoked cigarettes in 2001 (Centers for Disease Control and Prevention [CDC] 2003a). In 2000, 70 percent of those who smoked wanted to quit (CDC 2002b). An increasingly disturbing picture of widespread organ damage in active smokers is emerging, likely reflecting the systemic distribution of tobacco smoke components and their high level of toxicity. Thus, active smokers are at higher risk for cataract, cancer of the cervix, pneumonia, and reduced health status generally.

This new information should be an impetus for even more vigorous programs to reduce and prevent smoking. Smokers need to be aware that smoking carries far greater risks than the most widely known hazards. Health care providers should also use the new evidence to counsel their patients. For example, ophthalmologists may want to warn patients about the increased risk of cataract in smokers, and geriatricians should counsel their patients who smoke, even the oldest, to quit. This report shows that smokers who quit can lower their risk for smoking-caused diseases and improve their health status generally. Those who never start can avoid the predictable burden of disease and lost life expectancy that results from a lifetime of smoking.

Preparation of the Report

This report of the Surgeon General was prepared by the Office on Smoking and Health, National Center for Chronic Disease Prevention and Health Promotion, CDC, USDHHS. Initial chapters were written by 19 experts who were selected because of their expertise and familiarity with the topics covered in this report. Their various contributions were summarized into six major chapters that were then reviewed by more than 60 peer reviewers. The entire manuscript was then sent to more than 20 scientists and experts, who reviewed it for its scientific integrity. After each review cycle was completed, the drafts were revised by the editors on the basis of the experts' comments. Subsequently, the report was reviewed by various institutes and agencies within USDHHS.

Publication lags, even short ones, prevent an up-to-the-minute inclusion of all recently published articles and data. Therefore, by the time the public reads this report, there may be additional published studies or data. To provide published information as current as possible, this report includes an appendix of more recent studies that represent major additions to the literature.

This report is also accompanied by a companion database of key evidence that is accessible through the Internet (see http://www.cdc.gov/tobacco). The database includes a uniform description of the studies and results on the risks of smoking that were presented in a format compatible with abstraction into standardized tables. Readers of the report may access these data for additional analyses, tables, or figures. The Office on Smoking and Health at CDC intends to maintain this database and will periodically update its contents as new reports are published.

Organization of the Report

This report covers major groups of the many diseases associated with smoking: cancers, cardiovascular diseases, respiratory diseases, reproductive effects, and other adverse health consequences. Chapter 1 includes a discussion of the concept of causation and introduces new concepts of causality that are used throughout this report. Chapter 2 discusses each of the main sites of cancer and their relationship to smoking. Cardiovascular diseases, including atherosclerosis, coronary heart disease, stroke, and abdominal aortic aneurysm are the focus of Chapter 3, which begins with an extensive review of newer findings on the mechanisms by which smoking causes this group of very common diseases. Chapter 4 includes both acute respiratory diseases associated with smoking and the chronic respiratory diseases long known to be caused by smoking, including accelerated loss of lung function with aging. The full scope of adverse reproductive effects caused by smoking in both men and women is covered in Chapter 5. Chapter 6 discusses other specific effects of smoking on the eyes, the bones, and oral health, along with evidence on more general adverse effects related to health status overall. Chapter 7 updates prior estimates of the burden of diseases caused by smoking. Finally, Chapter 8 discusses "A Vision for the Future" outlining broad strategies and courses of action for tobacco control in the future.

Major Conclusions

Forty years after the first Surgeon General's report in 1964, the list of diseases and other adverse effects caused by smoking continues to expand. Epidemiologic studies are providing a comprehensive assessment of the risks faced by smokers who continue to smoke across their life spans. Laboratory research now reveals how smoking causes disease at the molecular and cellular levels. Fortunately for former smokers, studies show that the substantial risks of smoking can be reduced by successfully quitting at any age. The evidence reviewed in this and prior reports of the Surgeon General leads to the following major conclusions:

1. Smoking harms nearly every organ of the body, causing many diseases and reducing the health of smokers in general.
2. Quitting smoking has immediate as well as long-term benefits, reducing risks for diseases caused by smoking and improving health in general.
3. Smoking cigarettes with lower machine-measured yields of tar and nicotine provides no clear benefit to health.
4. The list of diseases caused by smoking has been expanded to include abdominal aortic aneurysm, acute myeloid leukemia, cataract, cervical cancer, kidney cancer, pancreatic cancer, pneumonia, periodontitis, and stomach cancer.

Chapter Conclusions

Chapter 2. Cancer

Lung Cancer

1. The evidence is sufficient to infer a causal relationship between smoking and lung cancer.
2. Smoking causes genetic changes in cells of the lung that ultimately lead to the development of lung cancer.
3. Although characteristics of cigarettes have changed during the last 50 years and yields of tar and nicotine have declined substantially, as assessed by the Federal Trade Commission's test protocol, the risk of lung cancer in smokers has not declined.
4. Adenocarcinoma has now become the most common type of lung cancer in smokers. The basis for this shift is unclear but may reflect changes in the carcinogens in cigarette smoke.
5. Even after many years of not smoking, the risk of lung cancer in former smokers remains higher than in persons who have never smoked.
6. Lung cancer incidence and mortality rates in men are now declining, reflecting past patterns of cigarette use, while rates in women are still rising.

Laryngeal Cancer

7. The evidence is sufficient to infer a causal relationship between smoking and cancer of the larynx.
8. Together, smoking and alcohol cause most cases of laryngeal cancer in the United States.

Oral Cavity and Pharyngeal Cancers

9. The evidence is sufficient to infer a causal relationship between smoking and cancers of the oral cavity and pharynx.

Esophageal Cancer

10. The evidence is sufficient to infer a causal relationship between smoking and cancers of the esophagus.

11. The evidence is sufficient to infer a causal relationship between smoking and both squamous cell carcinoma and adenocarcinoma of the esophagus.

Pancreatic Cancer

12. The evidence is sufficient to infer a causal relationship between smoking and pancreatic cancer.

Bladder and Kidney Cancers

13. The evidence is sufficient to infer a causal relationship between smoking and renal cell, renal pelvis, and bladder cancers.

Cervical Cancer

14. The evidence is sufficient to infer a causal relationship between smoking and cervical cancer.

Ovarian Cancer

15. The evidence is inadequate to infer the presence or absence of a causal relationship between smoking and ovarian cancer.

Endometrial Cancer

16. The evidence is sufficient to infer that current smoking reduces the risk of endometrial cancer in postmenopausal women.

Stomach Cancer

17. The evidence is sufficient to infer a causal relationship between smoking and gastric cancers.

18. The evidence is suggestive but not sufficient to infer a causal relationship between smoking and noncardia gastric cancers, in particular by modifying the persistence and/or the pathogenicity of *Helicobacter pylori* infections.

Colorectal Cancer

19. The evidence is suggestive but not sufficient to infer a causal relationship between smoking and colorectal adenomatous polyps and colorectal cancer.

Prostate Cancer

20. The evidence is suggestive of no causal relationship between smoking and risk for prostate cancer.

21. The evidence for mortality, although not consistent across all studies, suggests a higher mortality rate from prostate cancer in smokers than in nonsmokers.

Acute Leukemia

22. The evidence is sufficient to infer a causal relationship between smoking and acute myeloid leukemia.

23. The risk for acute myeloid leukemia increases with the number of cigarettes smoked and with duration of smoking.

Liver Cancer

24. The evidence is suggestive but not sufficient to infer a causal relationship between smoking and liver cancer.

Adult Brain Cancer

25. The evidence is suggestive of no causal relationship between smoking cigarettes and brain cancer in men and women.

Breast Cancer

26. The evidence is suggestive of no causal relationship between active smoking and breast cancer.

27. Subgroups of women cannot yet be reliably identified who are at an increased risk of breast cancer because of smoking, compared with the general population of women.

28. Whether women who are at a very high risk of breast cancer because of mutations in *BRCA1* or *BRCA2* genes can lower their risks by smoking has not been established.

Chapter 3. Cardiovascular Diseases

Smoking and Subclinical Atherosclerosis

1. The evidence is sufficient to infer a causal relationship between smoking and subclinical atherosclerosis.

Smoking and Coronary Heart Disease

2. The evidence is sufficient to infer a causal relationship between smoking and coronary heart disease.

3. The evidence suggests only a weak relationship between the type of cigarette smoked and coronary heart disease risk.

Smoking and Cerebrovascular Disease

4. The evidence is sufficient to infer a causal relationship between smoking and stroke.

Smoking and Abdominal Aortic Aneurysm

5. The evidence is sufficient to infer a causal relationship between smoking and abdominal aortic aneurysm.

Chapter 4. Respiratory Diseases

Acute Respiratory Illnesses

1. The evidence is sufficient to infer a causal relationship between smoking and acute respiratory illnesses, including pneumonia, in persons without underlying smoking-related chronic obstructive lung disease.

2. The evidence is suggestive but not sufficient to infer a causal relationship between smoking and acute respiratory infections among persons with preexisting chronic obstructive pulmonary disease.

3. In persons with asthma, the evidence is inadequate to infer the presence or absence of a causal relationship between smoking and acute asthma exacerbation.

Chronic Respiratory Diseases

4. The evidence is sufficient to infer a causal relationship between maternal smoking during pregnancy and a reduction of lung function in infants.

5. The evidence is suggestive but not sufficient to infer a causal relationship between maternal smoking during pregnancy and an increase in the frequency of lower respiratory tract illnesses during infancy.

6. The evidence is suggestive but not sufficient to infer a causal relationship between maternal smoking during pregnancy and an increased risk for impaired lung function in childhood and adulthood.

7. Active smoking causes injurious biologic processes (i.e., oxidant stress, inflammation, and a protease-antiprotease imbalance) that result in airway and alveolar injury. This injury, if sustained, ultimately leads to the development of chronic obstructive pulmonary disease.

8. The evidence is sufficient to infer a causal relationship between active smoking and impaired lung growth during childhood and adolescence.

9. The evidence is sufficient to infer a causal relationship between active smoking and the early onset of lung function decline during late adolescence and early adulthood.

10. The evidence is sufficient to infer a causal relationship between active smoking in adulthood and a premature onset of and an accelerated age-related decline in lung function.

11. The evidence is sufficient to infer a causal relationship between sustained cessation from smoking and a return of the rate of decline in pulmonary function to that of persons who had never smoked.

12. The evidence is sufficient to infer a causal relationship between active smoking and respiratory symptoms in children and adolescents, including coughing, phlegm, wheezing, and dyspnea.

13. The evidence is sufficient to infer a causal relationship between active smoking and asthma-related symptoms (i.e., wheezing) in childhood and adolescence.

14. The evidence is inadequate to infer the presence or absence of a causal relationship between active smoking and physician-diagnosed asthma in childhood and adolescence.

15. The evidence is suggestive but not sufficient to infer a causal relationship between active smoking and a poorer prognosis for children and adolescents with asthma.

16. The evidence is sufficient to infer a causal relationship between active smoking and all major respiratory symptoms among adults, including coughing, phlegm, wheezing, and dyspnea.

17. The evidence is inadequate to infer the presence or absence of a causal relationship between active smoking and asthma in adults.

18. The evidence is suggestive but not sufficient to infer a causal relationship between active smoking and increased nonspecific bronchial hyperresponsiveness.

19. The evidence is sufficient to infer a causal relationship between active smoking and poor asthma control.

20. The evidence is sufficient to infer a causal relationship between active smoking and chronic obstructive pulmonary disease morbidity and mortality.

21. The evidence is suggestive but not sufficient to infer a causal relationship between lower machine-measured cigarette tar and a lower risk for cough and mucus hypersecretion.

22. The evidence is inadequate to infer the presence or absence of a causal relationship between a lower cigarette tar content and reductions in forced expiratory volume in one second decline rates.

23. The evidence is inadequate to infer the presence or absence of a causal relationship between a lower cigarette tar content and reductions in chronic obstructive pulmonary disease-related mortality.

24. The evidence is inadequate to infer the presence or absence of a causal relationship between active smoking and idiopathic pulmonary fibrosis.

Chapter 5. Reproductive Effects

Fertility

1. The evidence is inadequate to infer the presence or absence of a causal relationship between active smoking and sperm quality.

2. The evidence is sufficient to infer a causal relationship between smoking and reduced fertility in women.

Pregnancy and Pregnancy Outcomes

3. The evidence is suggestive but not sufficient to infer a causal relationship between maternal active smoking and ectopic pregnancy.

4. The evidence is suggestive but not sufficient to infer a causal relationship between maternal active smoking and spontaneous abortion.

5. The evidence is sufficient to infer a causal relationship between maternal active smoking and premature rupture of the membranes, placenta previa, and placental abruption.

6. The evidence is sufficient to infer a causal relationship between maternal active smoking and a reduced risk for preeclampsia.

7. The evidence is sufficient to infer a causal relationship between maternal active smoking and preterm delivery and shortened gestation.

8. The evidence is sufficient to infer a causal relationship between maternal active smoking and fetal growth restriction and low birth weight.

Congenital Malformations, Infant Mortality, and Child Physical and Cognitive Development

9. The evidence is inadequate to infer the presence or absence of a causal relationship between maternal smoking and congenital malformations in general.

10. The evidence is suggestive but not sufficient to infer a causal relationship between maternal smoking and oral clefts.

11. The evidence is sufficient to infer a causal relationship between sudden infant death syndrome and maternal smoking during and after pregnancy.

12. The evidence is inadequate to infer the presence or absence of a causal relationship between maternal smoking and physical growth and neurocognitive development of children.

Chapter 6. Other Effects

Diminished Health Status

1. The evidence is sufficient to infer a causal relationship between smoking and diminished health status that may manifest as increased absenteeism from work and increased use of medical care services.

2. The evidence is sufficient to infer a causal relationship between smoking and increased risks for adverse surgical outcomes related to wound healing and respiratory complications.

Loss of Bone Mass and the Risk of Fractures

3. The evidence is inadequate to infer the presence or absence of a causal relationship between smoking and reduced bone density before menopause in women and in younger men.

4. In postmenopausal women, the evidence is sufficient to infer a causal relationship between smoking and low bone density.

5. In older men, the evidence is suggestive but not sufficient to infer a causal relationship between smoking and low bone density.

6. The evidence is sufficient to infer a causal relationship between smoking and hip fractures.

7. The evidence is inadequate to infer the presence or absence of a causal relationship between smoking and fractures at sites other than the hip.

Dental Diseases

8. The evidence is sufficient to infer a causal relationship between smoking and periodontitis.

9. The evidence is inadequate to infer the presence or absence of a causal relationship between smoking and coronal dental caries.

10. The evidence is suggestive but not sufficient to infer a causal relationship between smoking and root-surface caries.

Erectile Dysfunction

11. The evidence is suggestive but not sufficient to infer a causal relationship between smoking and erectile dysfunction.

Eye Diseases

12. The evidence is sufficient to infer a causal relationship between smoking and nuclear cataract.

13. The evidence is suggestive but not sufficient to infer that smoking cessation reduces the risk of nuclear opacity.

14. The evidence is suggestive but not sufficient to infer a causal relationship between current and past smoking, especially heavy smoking, with risk of exudative (neovascular) age-related macular degeneration.

15. The evidence is suggestive but not sufficient to infer a causal relationship between smoking and atrophic age-related macular degeneration.

16. The evidence is suggestive of no causal relationship between smoking and the onset or progression of retinopathy in persons with diabetes.

17. The evidence is inadequate to infer the presence or absence of a causal relationship between smoking and glaucoma.

18. The evidence is suggestive but not sufficient to infer a causal relationship between ophthalmopathy associated with Graves' disease and smoking.

Peptic Ulcer Disease

19. The evidence is sufficient to infer a causal relationship between smoking and peptic ulcer disease in persons who are *Helicobacter pylori* positive.

20. The evidence is inadequate to infer the presence or absence of a causal relationship between smoking and peptic ulcer disease in nonsteroidal anti-inflammatory drug users or in those who are *Helicobacter pylori* negative.

21. The evidence is suggestive but not sufficient to infer a causal relationship between smoking and risk of peptic ulcer complications, although this effect might be restricted to nonusers of nonsteroidal anti-inflammatory drugs.

22. The evidence is inadequate to infer the presence or absence of a causal relationship between smoking and the treatment and recurrence of *Helicobacter pylori*-negative ulcers.

Chapter 7. The Impact of Smoking on Disease and the Benefits of Smoking Reduction

1. There have been more than 12 million premature deaths attributable to smoking since the first published Surgeon General's report on smoking and health in 1964. Smoking remains the leading preventable cause of premature death in the United States.

2. The burden of smoking attributable mortality will remain at current levels for several decades. Comprehensive programs that reflect the best available science on tobacco use prevention and smoking cessation have the potential to reduce the adverse impact of smoking on population health.

3. Meeting the *Healthy People 2010* goals for current smoking prevalence reductions to 12 percent among persons aged 18 years and older and to 16 percent among youth aged 14 through 17 years will prevent an additional 7.1 million premature deaths after 2010. Without substantially stronger national and state efforts, it is unlikely that this health goal can be achieved. However, even with more modest reductions in tobacco use, significant additional reductions in premature death can be expected.

4. During 1995–1999, estimated annual smoking attributable economic costs in the United States were $157.7 billion, including $75.5 billion for direct medical care (adults), $81.9 billion for lost productivity, and $366 million for neonatal care. In 2001, states alone spent an estimated $12 billion treating smoking attributable diseases.

A Vision for the Future

This report of the Surgeon General on the health effects of smoking returns to the topic of the first Surgeon General's report on active smoking and disease. This current report discusses many diseases associated with smoking including cancer, cardiovascular diseases, respiratory diseases, reproductive effects, and other adverse health consequences, and also updates prior estimates of the burden of diseases caused by smoking.

The courses of action highlighted below are potential next steps presented by the Surgeon General. Given his role as the nation's spokesman on matters of public health, these recommendations represent a vision for the future built on information available today. They do not constitute formal policy statements, but are intended to inform and guide policymakers, public health professionals, professional and advocacy organizations, researchers, and most important, the American people, to ensure that efforts to prevent and control tobacco use are proportionate to the harmful effects it causes.

Tremendous Progress Since 1964

The publication of the first Surgeon General's report on smoking and health in January of 1964 (U.S. USDHEW 1964) was a landmark and pivotal event in the history of public health. By that time, there was a rapidly accumulating amount of evidence on the dangers of smoking, and it was inevitable that action would follow the publication of a comprehensive expert report with the powerful conclusion that smoking causes disease. Since 1964, there has been a broad societal shift in the acceptability of tobacco use and in the public's knowledge about the accompanying health risks. In 1963, per capita annual adult consumption in the United States peaked at 4,345 cigarettes, a figure that included both smokers and nonsmokers (Giovino et al. 1994). By 2002, per capita annual consumption in this country had declined to 1,979 cigarettes, the lowest level since before the start of World War II (U.S. Department of Agriculture 2003). In 1964, the majority of men smoked and an increasing number of women were becoming smokers. Today, there are more former smokers than current smokers, and each year over half of all daily smokers try to quit (CDC 2003a). In 1964, smoking a cigarette was viewed as a "rite of passage" by almost all adolescents. Today, only about half of all high school seniors have ever smoked a cigarette and less than one in four is a current smoker, the lowest level since researchers started monitoring smoking rates among high school seniors in the mid-1970s (University of Michigan 2003).

In 1964, smoking was permitted almost everywhere, and even the U.S. Public Health Service had logo ashtrays on its conference tables. Today, secondhand tobacco smoke is widely accepted as a public health hazard and levels of exposure among nonsmokers have declined dramatically over the last decade. In fact, there is an unprecedented level of activity to achieve clean indoor air quality at both the local and state levels. More communities and states are considering and adopting laws that are even more comprehensive in the range of venues they cover. The 1964 Surgeon General's report on smoking and health started this country on an epic process of change toward a society free of tobacco-related disease and death. Yet many challenges remain.

The Need for a Sustained Effort

Smoking remains the leading preventable cause of disease and death in the United States, resulting in more than 440,000 premature deaths each year (CDC 2002a; see also Chapter 7, "The Impact of Smoking on Disease and the Benefits of Smoking Reduction"). In 1964, the list of diseases known to be caused by smoking was short: chronic bronchitis and cancers of the lung and larynx (USDHEW 1964). Each subsequent Surgeon General's report has expanded the understanding of the magnitude of the health consequences of tobacco use. According to this 2004 report, the number of diseases caused by smoking has continued to increase. The list is now so long, this report concludes that smoking harms nearly every organ of the body and causes generally poorer health. For this reason, the burden of tobacco use on the physical and economic health of this country remains staggering. Since the release of the 1964 Surgeon General's report on smoking and health, more than 12 million Americans have died prematurely due to smoking. Currently, estimates of annual smoking attributable economic costs in the United States are over $157 billion (CDC 2002a; see also Chapter 7, "The Impact of Smoking on Disease and the Benefits of Smoking Reduction").

Some may view the progress achieved in the country since 1964 as evidence that the problem has been solved. Unfortunately, the data indicate that future reductions in the morbidity, mortality, and economic costs of tobacco use will require a continuing and sustained effort. Since 1965, the overall proportion of adults in this country who are current smokers has been reduced by half; however, the rate of decline in adult smoking prevalence has slowed in recent years (CDC 2003a). Equally disturbing, the rates of smoking among some racial and ethnic minority populations and among less educated Americans remain high (CDC 2003a). Although the percentage of high school seniors who are current smokers has been reduced from 36.5 percent in 1997 to 24.4 percent in 2003, the trends in youth smoking over the last few years indicate that the rate of decline is slowing appreciably (CDC 2003d; University of Michigan 2003). Although the level of secondhand tobacco smoke that nonsmokers are exposed to has declined significantly in the last decade, the decline has been greater among adults than among children, who are largely exposed at home. Currently, levels of exposure to this known human carcinogen are more than twice as high among nonsmoking children than among nonsmoking adults (CDC 2003c). Finally, while the knowledge that smoking can adversely affect health has become widespread among the general public, the grave health risks remain poorly understood.

In recognition of the need to enhance public understanding of these health consequences of smoking, this Surgeon General's report introduces a "Public Summary" that will serve as the foundation of a continuing effort to disseminate the findings of this report more widely and comprehensively at the national, community, and local levels (among individuals and families). In 1964, the conclusion that smoking causes lung cancer was major news; today, it is widely accepted. Unfortunately for many people, the multiple ways in which smoking damages almost every organ of the human body are not well understood.

To help educators, the media, and health professionals more fully understand the scientific basis for all of the conclusions in this Surgeon General's report, a companion database of the more than 1,600 articles cited in this report will be available for the first time on the Internet at <http://www.cdc.gov/tobacco>. This database will be easily accessed with readily available search criteria that can create detailed evidence tables related to each of the health topics reviewed in this report, such as cancer risks at individual organ sites, various types of cardiovascular and lung risks and diseases, reproductive health effects, and other health outcomes. This comprehensive database will be regularly updated as new studies are published and as the scientific knowledge about the health consequences of tobacco use continues to expand. Thus, it will be a living resource that health professionals and the general public can use to keep up with the latest findings.

The Need for a Comprehensive Approach

The 2000 Surgeon General's report, *Reducing Tobacco Use*, provided a detailed framework for comprehensive tobacco use prevention and control efforts: educational, clinical, regulatory, economic, and social approaches (USDHHS 2000). That report noted that "…our recent lack of progress in tobacco control is attributable more to the failure to implement proven strategies than it is to a lack of knowledge about what to do" (USDHHS 2000, p. 436). A comprehensive approach—one that optimizes synergy from a mix of educational, clinical, regulatory, economic, and social strategies—has emerged as the guiding principle for effective efforts to reduce tobacco use.

There is a very strong scientific base to guide these sustained efforts. In addition to recent Surgeon General's reports, the Community Preventive Services Task Force, the U.S. Public Health Service, and other professional bodies have reviewed the efficacy of specific strategies (Fiore et al. 2000; *American Journal of Preventive Medicine* 2001). Additionally, CDC's *Best Practices for Comprehensive Tobacco Control Programs* provides a broad framework for comprehensive statewide tobacco control programs (CDC 1999). Recent analyses of evidence from these state programs conclude that the magnitude and rate of change in smoking behaviors are significantly related to the level and continuity of investments in comprehensive program efforts (Farrelly et al. 2003; Stillman et al. 2003). The results from these programs indicate that reducing youth initiation rates, promoting smoking cessation, and increasing protections for nonsmokers from secondhand tobacco smoke exposure necessitate changing many facets of the social and policy environments. Thus, *Best Practices* provides effective guidance for efforts at the state level, but a comprehensive national tobacco control effort requires strategies that go beyond guidance to the states. Based on the evidence reviewed in *Reducing Tobacco Use* (USDHHS 2000), a comprehensive national effort should involve a broad mix of strategies. That report also noted that some of the program and policy changes needed within these strategies can be most effectively addressed at the national level.

There is a need for a continuing and sustained national tobacco use prevention and control effort. Many factors encourage tobacco use in this country: the positive imagery of smoking in movies and in the popular culture, the billions of dollars spent by the tobacco industry to advertise and promote cigarettes (e.g., $11.2 billion in 2001 [Federal Trade Commission 2003]), acceptance of secondhand smoke in public places, and the perception by some that the problem has been solved. Additionally, funding levels for many effective state and national counter-advertising campaigns were recently reduced. We know enough to take action. As in many areas of public health, there is a need to improve the dissemination, adoption, and implementation of effective, evidence-based interventions, and to continue to investigate new methods to prevent and reduce tobacco use.

Continuing to Build the Scientific Foundation

Progress in tobacco control always has been built upon a foundation of conclusive scientific knowledge. Each of the previous 27 Surgeon General's reports on smoking and health has contributed to this ever-enlarging foundation not only about the health consequences of tobacco use, but also about effective strategies to prevent tobacco use among youth, to help current tobacco users quit, and to protect nonsmokers from exposure to secondhand tobacco smoke. Progress in tobacco control always has been built upon a foundation of conclusive scientific knowledge. Each of the previous 27 Surgeon General's reports on smoking and health, as well as numerous other publications, have contributed to this ever-enlarging foundation of data. These reports include information about the health consequences of tobacco use, effective strategies to prevent tobacco use among young people and to help current tobacco users quit, and approaches to protect nonsmokers from exposure to secondhand tobacco smoke (Fiore et al. 1996, 2000; NCI 1999, 2001). Nevertheless, there are scientific questions remaining to be addressed on the adverse health effects of tobacco use, methods for the efficient surveillance of the tobacco-related epidemic, strategies to eliminate tobacco-related disparities, and innovative approaches for the prevention of tobacco use and treatment of nicotine addiction.

One major topic in need of more research is to complete the understanding of the mechanisms by which tobacco-related diseases are caused. A greater understanding of these causal mechanisms should have implications for disease prevention that extend to agents other than smoking. This report reviews the association between smoking and cancer, cardiovascular diseases, respiratory diseases, reproductive effects, and other health consequences, and defines a variety of specific research questions and issues related to the biologic mechanisms by which the multiple toxic agents in tobacco products and tobacco

smoke cause specific adverse health outcomes. For example, the lung remains the primary site for elevated tobacco-related cancer risk; however, during the past 40 years, the type of lung cancer caused by smoking has changed for reasons still unknown. Similarly, as the evidence that smoking damages the heart and circulatory system and is a primary preventable cause of heart disease and stroke continues to expand, important research questions remain about how smoking interacts with other cardiovascular risk factors and accelerates the atherosclerotic disease process. With respect to these and the other research questions, the public health message remains the same: smoking greatly increases the risk of many adverse health effects. Therefore, never start smoking or quit as soon as possible.

For several organ sites, there is a need for more evidence regarding the possible causal role of smoking on cancer risk (see Chapter 2, "Cancer"). For prostate and colorectal cancers, the evidence is suggestive but not sufficient to determine a possible causal relationship. For breast cancer, even though there is no evidence overall for a causal role of smoking, on a genetic basis some evidence suggests that some women may be at an increased risk if they smoke. For other sites such as the liver, confounding exposures to other risk factors have made the evaluation of the risk of smoking very complex, but this report finds the evidence to be suggestive of causation. There should be further research on those sites where the evidence is suggestive but not yet sufficient to warrant a causal conclusion. As this new evidence emerges it will be evaluated using the causal criteria and standardized language applied in the Surgeon General's reports to express the strength of the evidence bearing on causality for all adverse health effects of smoking. As new evidence emerges with respect to the research questions raised in this report, the individual chapter conclusions in this report will be re-evaluated.

Chapter 6, "Other Effects," of this report concludes that, overall, smokers are less healthy than nonsmokers. Most often the risks of smoking are discussed with respect to a specific cancer, to heart disease, or to respiratory disease risk. Unfortunately, because smoking is such a powerful cause of disease, most smokers suffer from adverse health effects in many parts of their bodies at once. Additionally, before a death from one of the diseases caused by smoking, which is often quite premature, many smokers live for years with a diminished quality of life from the burden of chronic and disabling health effects (e.g., reduced breathing capacity, poor heart functioning, greater susceptibility to lung infections, visual loss due to cataracts, and others). More research emphasis needs to be placed on the broad health consequences of smoking—namely, how smoking has a negative impact on many aspects of the body at the same time, and how these multiple adverse health effects combine to produce an overall reduced quality of life and greater health care costs prior to causing premature death. Recently, preliminary estimates indicated that for every premature death caused each year by smoking, there were at least 20 smokers living with a smoking-related disease (CDC 2003b).

This report highlights the diversity of the health effects caused by smoking, and how dramatically smoking affects the risk of the leading causes of death in this country (e.g., cancer, heart disease, respiratory disease). These findings emphasize that tobacco prevention and control should be key elements in a national prevention strategy for all of these major causes of death. Additionally, there is great disparity in tobacco-related disease and death among populations and the need to address the research gaps that exist for many special populations. Research is needed not only on disease outcome but also on the development of more effective strategies to reach and involve high risk populations (e.g., race/ethnicity, low income, low education, the unemployed, blue-collar and service workers, and heavily addicted smokers).

Finally, more research is needed on how changing tobacco products, as well as pharmaceutical products, have affected and could continue to affect health. In this report, one major conclusion finds that cigarettes with lower machine-measured yields of tar and nicotine (i.e., low-tar/nicotine cigarettes) have not produced a lower risk of smoking-related diseases. Yet there are rapidly growing numbers of modified tobacco products characterized as Potentially Reduced Exposure Products (PREPs) (Institute of Medicine 2001). Research has demonstrated that with the expectation of reducing risk, many smokers switched to low machine-measured tar/nicotine cigarettes, and may thus have been deterred from quitting (National Cancer Institute 2001). Therefore, it is critically important that the health risks of the emerging PREPs be evaluated comprehensively and quickly to avoid a replication of that unfortunate low-tar/nicotine cigarette experience. Research on the biologic mechanisms by which the multiple toxic agents in tobacco products and tobacco smoke cause specific adverse health outcomes can help establish an important scientific foundation for evaluating the potential health effects of PREPs. Similarly, the public health and policy

implications of changes in manufactured cigarettes, other tobacco-containing products, and pharmaceutical products will require the continued attention of public health researchers and policymakers.

Tobacco Control in the New Millennium

As the world enters this new millennium, it is faced with many new public health challenges even as many of the old risks to good health remain. During the last 40 years, people have become increasingly more aware of the adverse health consequences of tobacco use. Currently, tobacco use is the leading cause of preventable illness and death in this nation, in the majority of other high-income nations, and increasingly in low- and middle-income nations. Unfortunately, the high rates of tobacco-related illnesses and deaths will continue until tobacco prevention and control efforts worldwide are commensurate with the harm caused by tobacco use. At the start of the last century, lung cancer was a very rare disease. Now lung cancer is the leading cause of cancer deaths in both men and women in this country (see Chapter 2, "Cancer"; USDHHS 2001). Our success in reducing tobacco use during the last 40 years has led to a reversal in the epidemic of lung cancer among men; nationwide, rates of lung cancer deaths among men have declined since the early 1990s (Weir et al. 2003). In California, where there has been a comprehensive tobacco control program in place since 1989, reductions in rates of tobacco-related disease and deaths already have been observed (CDC 2000; Fichtenberg and Glantz 2000; Scott et al. 2003). If we apply what we know works, we can make lung cancer a rare disease again by the end of this century!

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