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Morbidity and Mortality Weekly Report (*MMWR*)

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Fifty Years of Progress in Chronic Disease Epidemiology and Control

Supplements

October 7, 2011 / 60(04);70-77

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Introduction

During the past century in the United States, advances in public health and health care have increased life expectancy by approximately 30 years and led to dramatic changes in the leading causes of death (1). As chronic diseases became the leading causes of illness and death in the United States by the middle of the 20th century (2), public health researchers began to shift their focus to identifying their complex and interrelated causes. In addition, researchers began to study ways to prevent and control chronic diseases through clinical and community-based interventions. This increasing importance and interest in chronic diseases led to the establishment of the National Center for Chronic Disease Prevention and Health Promotion at CDC in 1988 and is reflected in the publication of articles about chronic diseases in *MMWR*, with few if any articles before 1980, increasing to about 20% of articles since 1990 (Figure 1).

Considerable progress has been made during the past 50 years in understanding the causes of chronic diseases, as well as in development of the evidence for effective strategies to prevent, detect, or control chronic diseases (3). This report focuses on progress in four areas by:

- Describing progress in understanding the causes of chronic disease through epidemiologic research;
- Describing advances in understanding the evidence base for prevention and control, through intervention research;
- Assessing the impact of these advances on the prevalence of chronic diseases in the United States, as measured by reductions in chronic disease morbidity and mortality; and

- Discussing the lessons learned during the past 50 years in translating this research into practice in the United States.

This report provides a synopsis of progress by using key examples within the four areas rather than an exhaustive review of chronic disease epidemiology and control during the past half-century.

Progress in Understanding the Causes of Chronic Diseases

By the 1960s, large-scale studies such as the Framingham Heart Study, the Seven Countries Study, and the British Doctors Study, began to identify the leading causes of chronic diseases (4). These studies elucidated the contributions of cigarette smoking, diet, physical inactivity, and high blood pressure to the leading causes of death. Over 50 years or more, these and other studies have helped establish the behavioral causes of many of the chronic diseases affecting humans. None of these studies has established the causes of any chronic disease by itself; rather, the causes have been established on the basis of a large number of studies that used different designs and were conducted in different populations (5).

The discovery that smoking caused lung cancer can be viewed as the first and most important advance in chronic disease etiology. The results from the first studies of lung cancer were summarized in the first *Surgeon General's Report on Smoking and Health*, published in 1964. Establishment of the "criteria for causality" in this report was critical in the evolution of the understanding of the causes of chronic disease, given the long latency between exposures and outcomes; the multiple causes of chronic diseases; and the multiple consequences of many of the risk factors. These criteria, subsequently called the "Hill criteria," would continue to be used over time to consider the causal risk factors for other chronic diseases (6).

During and after the 1960s, researchers continued to study the relationship between risk factors (e.g., poor diet, lack of exercise, high blood pressure) and major chronic diseases. For example, the "diet--heart" hypothesis was tested in observational studies such as the Framingham Heart Study, a prospective cohort study of residents of Framingham, Massachusetts (4). At the same time, researchers shifted their focus from chronic diseases to the behavioral risk factors preceding the diseases. In 1993, these studies were summarized in the seminal publication "Actual Causes of Death in the United States" by McGinnis and Foege (7). These researchers used the results from decades of epidemiologic research to demonstrate that approximately half of all deaths could be attributed to relatively few risk factors; their work was updated later by Mokdad (8) ([Table 1](#)).

In 1974, the Canadian Lalonde Report (9) concluded that the health of a population could be considered in four broad elements: human biology, environment, lifestyle, and health-care organization. This model of the "multiple determinants of health" provides a broad conceptual framework for considering the factors that influence health in a community (10). This model takes a multidisciplinary approach, uniting biomedical sciences, public health, psychology, statistics and epidemiology, economics, sociology, education, and other disciplines. Social, environmental, economic, and genetic factors are seen as contributing to differences in health status and, therefore, as presenting opportunities to intervene.

Other research during this time focused on the role of social and economic factors that increased risk for chronic disease. One of the most important investigators in this field is Sir Michael Marmot, whose studies of British civil servants clearly illustrate these concepts (11). His and others' research have since demonstrated that health behaviors alone do not explain the risk related to occupation, income, education, and other social determinants of health (12). A new academic field of social epidemiology developed during this same period and became best known for identifying the social gradient in health, in which health outcome effects exist not only at the extremes of high and low levels of education and income but also at most gradations in between (13,14).

Research has increasingly demonstrated the contributions to health by factors beyond the physical environment, medical care, and health behaviors. These include socioeconomic position, race/ethnicity, social networks and support, work conditions, economic inequality, and social capital (15). These contributors were summarized in the Institute of Medicine's *Future of the Public's Health in the 21st Century*, which stated that "the greatest

advances in understanding the factors that shape population health during the last 2 decades...has been the identification of social and behavioral conditions that influence morbidity, mortality, and functioning" (16).

Progress in Developing Evidence-Based Chronic Disease Prevention and Control Programs and Policies

As information about the causes of chronic diseases accumulated during the 1960s and 1970s, research began to focus on intervention studies. Systematic reviews have been conducted to determine which interventions are effective in preventing or controlling chronic diseases (17). Information about hundreds of evidence-based interventions is now available from a variety of sources, including the *Guide to Clinical Preventive Services* (18), *The Guide to Community Preventive Services* (19), *MMWR Recommendations and Reports*, The National Guideline Clearinghouse (20), and the Cochrane Reviews. More recently, the emphasis has shifted from what constitutes acceptable intervention evidence to what processes in public health settings will enable more widespread use of evidence-based practices. Several leading discoveries that have reduced, or have the potential to reduce, the impact of chronic diseases are described below.

Clinical Preventive Services

Research demonstrated that certain clinical preventive services, including screening, counseling, and preventive medications, are effective in preventing or controlling the leading chronic diseases. During the past 50 years, for example, research has demonstrated effective ways to counsel smokers to quit; screen for breast, colon, and cervical cancer; and detect and treat high blood pressure and high blood cholesterol. The evolution of this clinical research led to establishment of the US Preventive Services Task Force in 1984 to rigorously and impartially assess scientific evidence for the effectiveness of these and other clinical interventions. Its recommendations are considered the standard for clinical preventive services. The premier publication of the Task Force, *The Guide to Clinical Preventive Services*, provides information about preventive services that should be incorporated routinely into primary medical care, and for which populations (18).

Media and Policy Advocacy

Media messaging and policy advocacy can be important methods for preventing chronic diseases. For example, research has demonstrated that media and policy advocacy are effective low-cost strategies for reducing smoking rates in the population. Specifically, comprehensive programs that focus on policy changes (e.g., advertising restrictions, policies regarding clean indoor air) can effectively reduce smoking rates in populations (21), and these policy changes can be supported by media advocacy (22). Changes in the policy environment can increase demand for effective clinical interventions (e.g., physician advice to patients for smoking cessation, access to cessation services) and smoking prevention programs in organizational settings (e.g., curricula in schools that focus on effective prevention strategies).

Environmental Interventions

Research has demonstrated that environmental interventions might be effective in promoting physical activity and healthy eating (23,24). The built environment---the physical form of communities---includes land-use patterns (how land is used), large- and small-scale built and natural features (e.g., architectural details, quality of landscaping, access to grocery stores), and the transportation system (facilities and services that link one location to another). Together, these elements shape access to opportunities for physical activity and healthy eating.

Progress in Reducing the Impact of Chronic Diseases

Public health surveillance can be used to assess the effectiveness of the interventions described above on reducing the health burden from chronic diseases. Trends in selected chronic disease death rates and related risk factors are described below.

Trends in the Leading Causes of Death

Since 1960, death rates for chronic diseases have changed dramatically, especially reductions in deaths caused by heart disease and stroke ([Figure 2](#)). Heart disease death rates have declined by almost two thirds during the past 50 years, and stroke rates have declined by more than three quarters. If the 1960 death rates for heart disease and stroke had persisted, almost 1.5 million more deaths from these causes would occur each year today. These major declines have resulted largely from declines in smoking and improvements in diet, detection and treatment of high blood pressure and high blood cholesterol, and medical care and treatment ([25](#)).

Overall death rates for cancer have changed relatively little during the past 5 decades, declining only 8%. This translates to 49,000 fewer deaths each year today than during the 1960s ([26](#)). These trends vary by patient sex and type of cancer. For example, death rates for stomach, colon, uterine, breast, and prostate cancers have declined during the past few decades ([27](#)). However, this progress has been counterbalanced by a dramatic increase in the rate of lung cancer deaths during the past 50 years. Lung cancer became the leading cause of cancer death among men in the 1950s and among women in the 1990s. Although lung cancer rates now have started to decline, they remain substantially higher today than in the 1960s ([Figures 3 and 4](#)).

Death rates for several other chronic diseases (e.g., diabetes, chronic lung disease, chronic kidney disease) have changed little or even increased during the past 50 years. Although trends in diabetes-related deaths are difficult to assess because diabetes often is listed as a contributing cause of death, the prevalence rates of diagnosed and undiagnosed diabetes have increased steadily since the first National Health and Nutrition Examination Survey during 1960–1962 ([28](#)). This increase has been seen in all age groups, both sexes, and all racial/ethnic groups and across the United States. The substantial increase in obesity since the 1980s and the increased survival rates among persons with the disease have contributed to the increase in diabetes.

Death rates for chronic lower respiratory diseases, such as bronchitis and emphysema, have increased by approximately 50% during the past 30 years, from 12.5 deaths per 100,000 persons in 1980 to 42.2 per 100,000 in 2009. The increased death rate during 1960–2007 has been responsible for an excess of about 42,000 deaths each year ([Table 2](#)). Death rates have continued to increase during the past 20 years in both sexes and all racial/ethnic groups ([29](#)).

Trends in Risk Factors for Chronic Diseases

One of the most important successes since 1960 has been the slow but substantial reduction in smoking rates in the general population ([Figure 5](#)). The annual per capita consumption of cigarettes peaked in 1963, and except for an increase during 1971–1973, consumption has steadily declined since then. Smoking rates in the general population declined from about four of every 10 adults during the early 1960s (51.2% for men and 33.7% for women) to about two of every 10 adults today (22.0% for men and 17.5% for women) with greater declines for men than women ([Figure 4](#)) ([30](#)). Rates for teens remained relatively stable from 1975 to the mid-1990s but have declined steadily during the past decade ([30,31](#)).

In contrast, the rates of obesity for adults and children have more than doubled since the 1960s ([Figure 5](#)) ([30,32](#)). Prevalence rates of obesity (body mass index >30) among adults increased from <15% during the 1960s to >35% today, with most of that increase occurring since the 1980s ([30](#)). Although the magnitude of increase varies, the increase is observed in all age groups, both sexes, all racial/ethnic groups, and all states ([30,32](#)).

The causes of this obesity epidemic are complex. Since the National Health and Nutrition Examination Survey was first administered in 1971, many changes have occurred in food consumption. The quantity of food and beverages consumed, the fraction of meals eaten outside the home, portion sizes, and energy density have increased substantially ([33](#)). Although diets have decreased in saturated fats and cholesterol, including less red meat and more chicken, total calories consumed might have increased. In addition, evidence suggests that rates of physical activity have decreased over time ([34](#)). As expected, rates of diabetes and other obesity-related chronic diseases have increased during this time.

The rates of alcohol use, as measured by apparent per capita alcohol sales (gallons of ethanol) increased during

the past 50 years, from 2.1 gallons per person aged >15 years in 1960 to 2.3 in 2007, after peaking at 2.8 in 1981 (35). However, long-term trends in the prevalence of alcohol abuse and dependence in the United States are difficult to assess. Population-based studies conducted during 1991--2002 showed that the prevalence of alcohol dependence decreased significantly (from 4.4% to 3.8%), whereas the prevalence of alcohol abuse increased significantly (from 3.0% to 4.6%) (36). This increase occurred among both sexes and was especially marked among young black, Hispanic, and Asian women.

Looking Back: Lessons Learned during the Past 50 Years of Chronic Disease Epidemiology and Control

Considerable progress has been made during the past 50 years in understanding the causes of chronic diseases. The successes and failures of efforts to translate this research into practice have taught some important lessons.

National Outreach and Education Programs

Despite advances in chronic disease epidemiology and control, a long latency period exists between scientific understanding of a viable chronic disease control method and its widespread application on a population basis. One of the first nationwide programs that successfully accelerated translation of evidenced-based interventions into practice was the National High Blood Pressure Education Program. It was established by the U.S. Congress in 1972 to promote nationwide detection, treatment, and control of hypertension through education programs and referrals. The program used a consensus-building approach to develop strategies to address hypertension through a broad-based partnership among federal agencies, national voluntary organizations, state health departments, and community-based programs.

Similar programs were used to accelerate dissemination of cholesterol screening and treatment and, more recently, a large-scale program to promote early detection of breast and cervical cancers. This CDC-supported initiative is the National Breast and Cervical Cancer Early Detection Program, which provides screening for breast and cervical cancers to low-income, uninsured, and underserved women in all 50 states, the District of Columbia, five U.S. territories, and 12 American Indian/Alaska Native tribes or tribal organizations (37).

Prevention and Control Interventions

Successful chronic disease prevention and control interventions generally have used comprehensive approaches that have focused on environmental and policy changes. Success in reducing health risk behaviors in the population has resulted largely from comprehensive integration of numerous environmental and policy approaches that have complemented individual behavior and lifestyle modification strategies (38). For example, progress in reducing smoking rates has been greatest when state-based programs have used a comprehensive strategy including such interventions as tax increases, policies regarding clean indoor air, youth access limitations, media advocacy, and counteradvertising (39). A comprehensive strategy can benefit all persons exposed to the environment, in contrast to a strategy that focuses on changing the behavior of one person at a time. In nearly all cases, these interventions have required new skills and nontraditional partnerships with individuals and organizations not working directly in public health. For example, to address the major physical barriers to an active lifestyle in U.S. cities, urban planners, transportation experts, and persons working in parks and recreation are essential to developing an environment and political will that can promote physical activity.

Unintended Consequences of Interventions

One unintended consequence of many public health interventions to prevent or control chronic diseases is the development of health disparities among poor and less educated persons and minorities. Despite major progress in reducing chronic diseases and their risk factors during the past 50 years, health disparities have persisted and, in some cases, have arisen where none existed before. The most obvious example involves the trends in smoking since 1965. At that time, smoking rates were unrelated to the level of education, but today level of education is a major predictor for smoking (Figure 6). These differences in smoking rates will lead to subsequent disparities in smoking-related chronic diseases (40).

Disparities tend to develop as an unintended consequence when programs or policies are most effective for persons with higher levels of education (e.g., information campaigns), higher incomes (e.g., promoting healthier but more expensive foods); or health insurance (e.g., promoting the use of clinical preventive services, such as colonoscopy). Relatively few programs have been developed to specifically reduce health disparities by focusing on populations in greatest need.

Surveillance Data

Surveillance data can be effective in mobilizing action toward community health. Public health surveillance has evolved during the past 50 years, broadening its scope from infectious diseases to chronic diseases. For example, CDC's National Program of Cancer Registries now supports central cancer registries in 45 states, the District of Columbia, Puerto Rico, and the U.S. Pacific Island jurisdictions, representing 96% of the U.S. population. Together with the National Cancer Institute's Surveillance, Epidemiology, and End Results (SEER) Program, cancer incidence data are available now for the entire U.S. population.

During the 1980s, CDC established surveillance systems to monitor trends in risk factors for chronic diseases among adults (Behavioral Risk Factor Surveillance System [BRFSS]) and children (Youth Risk Behavior Surveillance System [YRBSS]). These state-based systems for the first time provided information for state and local health departments (e.g., the Selected Metropolitan/Micropolitan Area Risk Trends BRFSS (SMART BRFSS) for program planning and evaluation. The colored maps showing the increasing rates of obesity in every state during the past several decades have been seen by countless professionals, students, and members of the public.

The Future

The past 50 years have seen major progress in understanding of the causes of the leading chronic diseases, from the role of behaviors to the importance of social, economic, and environmental factors. This better understanding has been used to develop effective interventions in both clinical and community settings. However, despite some success, much more must be done to reduce further the effects of chronic diseases during the next 50 years.

First, epidemiologic research must continue to elucidate the causes of several important chronic diseases, such as Alzheimer disease and other dementias; mental disorders, such as depression; and substance abuse. Large, prospective population-based studies are needed to determine the influence of genetic, behavioral, social, economic, and environmental exposures on health outcomes over the lifespan. In addition, more research is needed to identify the specific social, cultural, or environmental factors that influence health behaviors, such as exercise and healthy diets.

Second, continued development of evidence for chronic disease prevention and control programs and policies is needed and must move beyond the "what" to the "how." Systematic reviews such as the *Community Guide* may illustrate the potentially effective interventions. Equally important for practitioners is better information about the factors that need to be considered when a research-tested program or policy is implemented in a different setting or in a different population. If the adaptation changes the original intervention to such an extent that the original efficacy data might no longer apply, then the program should be viewed essentially as a new intervention.

Third, continued support is needed for broad-based programs that accelerate translation of research into practice. Most importantly, perhaps, changes are needed in means of funding health care, shifting the incentives from paying for more care to paying for good health. With such a system, demand for evidence-based programs and policies would increase and further accelerate their adoption. Current efforts, such as CDC's state-based chronic disease prevention and control programs, address most major chronic diseases and risk factors, but in many cases they do not cover all states and in many other cases are not comprehensive enough to reach populations at highest risk for disease. Increasing support might be challenging, given the current economic

climate in the United States and competing demands for government revenue.

Fourth, trends in chronic diseases and their risk factors should continue to be monitored, and surveillance should be expanded to focus on certain policy issues. Public health surveillance is a cornerstone of public health (41). The United States now has excellent epidemiologic data for estimating the person, place, and time dimensions for chronic diseases. Better information about a broad array of environmental and policy factors is needed to supplement these data. For example, future environmental and policy surveillance systems may include information about perceived access to healthy foods or places for physical activity. When implemented properly, such novel surveillance systems can be an enormous asset for policy development and evaluation.

Finally, public health needs to ensure that all groups in the population benefit from progress in the whole population. The federal Healthy People 2020 process, as well as state and local counterparts, can play critical roles by focusing on improving health outcomes among all groups in society. Most importantly, these efforts must have the means to regularly assess progress and engage stakeholders who share accountability for improving the public's health. The full potential of science will be achieved only when all available scientific knowledge is applied to practice and for all societal groups.

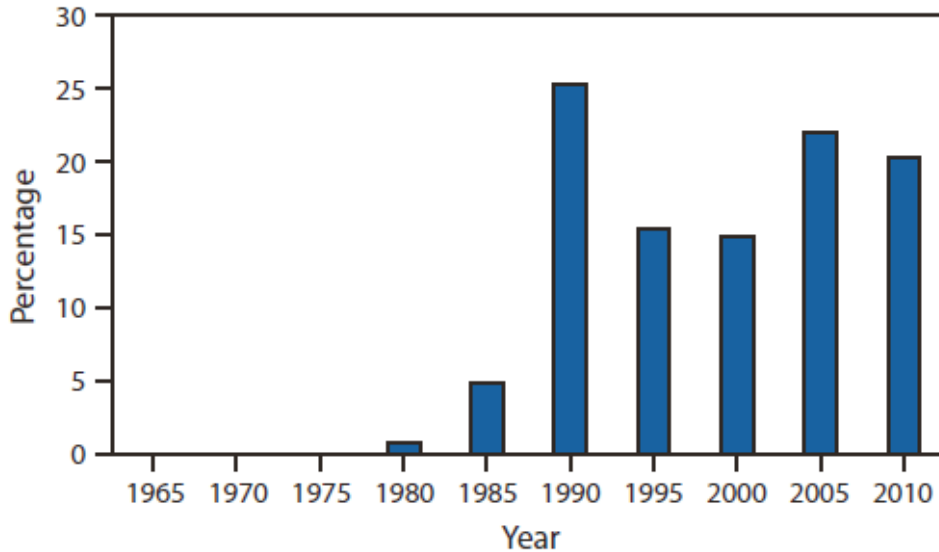
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FIGURE 1. Percentage of MMWR articles about chronic diseases, conditions, or risk factors --- United States, 1965--2010



Alternate Text: The figure is a bar graph that presents the number of MMWR reports related to chronic diseases, conditions, or risk factors in the United States during 1965-September 10, 2010.

TABLE 1. Actual causes of death --- United States, 2000

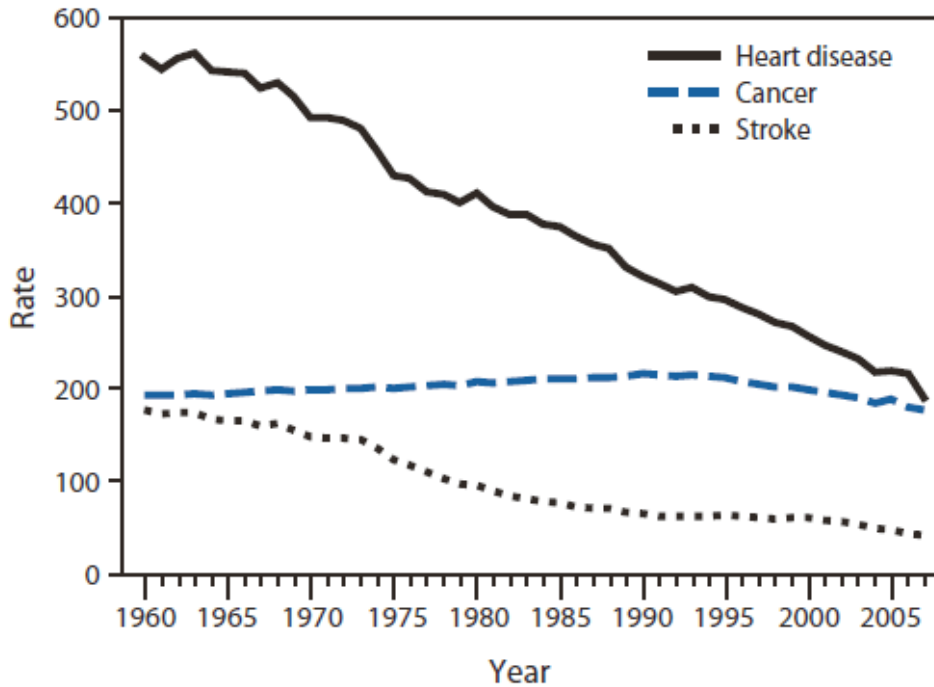
Cause	No.	(%*)
Tobacco	435,000	(18.1)
Poor diet and physical inactivity	400,000	(16.6)
Alcohol consumption	85,000	(3.5)
Microbial agents	75,000	(3.1)
Toxic agents	55,000	(2.3)
Motor vehicles	43,000	(1.8)
Firearms	29,000	(1.2)
Sexual behavior	20,000	(0.8)
Illicit drug use	17,000	(0.7)
Total	1,158,000	(48.2)

Source: Reference 8. Mokdad AH, Marks JS, Stroup DE, Gerberding JL. Actual cases of death in the United

States, 2000. JAMA 2004;291:1238--45.

* Percentages of all deaths.

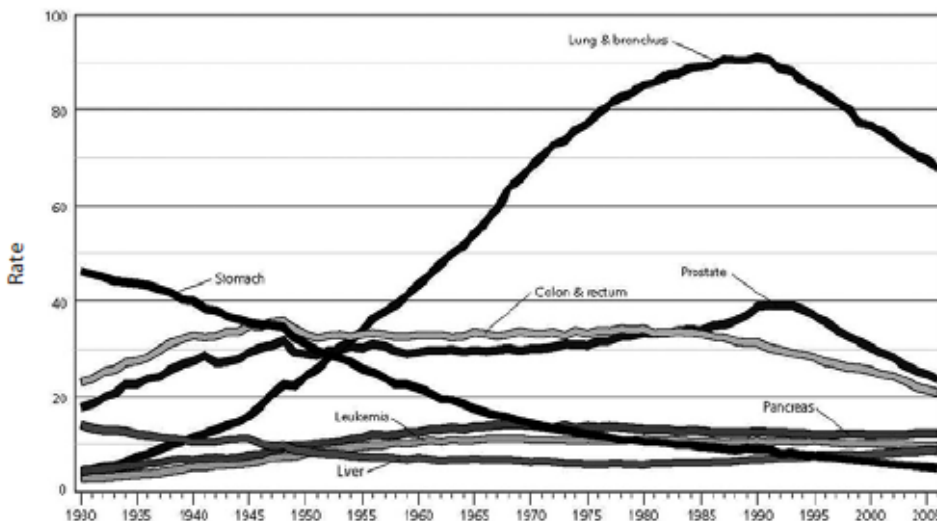
FIGURE 2. Trends in age-adjusted death rates for the leading chronic diseases --- United States, 1960--2007



Source: National Center for Health Statistics. Health, United States, 2010. Hyattsville, MD: US Department of Health and Human Services, CDC, National Center for Health Statistics; 2011. Available at www.cdc.gov/nchs/data/hus/hus10.pdf .

Alternate Text: The figure is a line graph that presents trends in death rates for six of the leading chronic diseases in the United States during 1960-2007.

FIGURE 3. Trends in age-adjusted cancer death rates* for males --- United States, 1930--2006†



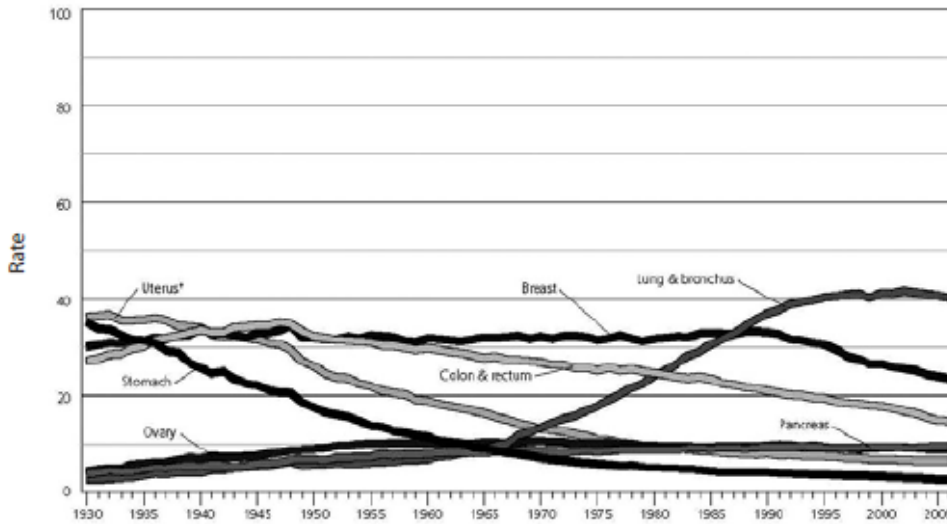
Source: US Mortality Data, 1960 to 2006, US Mortality Volumes, 1930 to 1959, National Center for Health Statistics, Centers for Disease Control and Prevention, 2009.

* Per 100,000, age adjusted to the US standard population.

† Due to changes in International Classification of Diseases coding, numerator information has changed over time. Rates for cancer of the liver, lung and bronchus, and colon and rectum are affected by these coding changes.

Alternate Text: The figure is a line graph that presents trends in cancer death rates among males in the United States during 1930-2006.

FIGURE 4. Trends in age-adjusted cancer death rates* for females --- United States, 1930--2006†



Source: US Mortality Data, 1960 to 2006, US Mortality Volumes, 1930 to 1959, National Center for Health Statistics, Centers for Disease Control and Prevention, 2009.

* Per 100,000, age adjusted to the US standard population. Rates are uterine cervix and uterine corpus combined.

† Due to changes in International Classification of Diseases coding, numerator information has changed over time. Rates for cancer of the lung and bronchus, colon and rectum, and ovary are affected.

Alternate Text: The figure is a line graph that presents trends in cancer death rates among females in the United States during 1930-2006

TABLE 2. Trends in the leading causes of chronic disease--related deaths --- United States, 1960 and 2009

Disease†	Rate,* by year		Trends, 2009 vs. 1960		No. lives saved (lost)§
	1960	2009	% Change	Rate difference*	
Heart disease	559	180	--68%	--379	1,137,000
Cancer	194	174	--10%	--20	60,000

Stroke	178	38.9	--78%	--139	417,300
Diabetes	22.5	20.9	--7%	--1.6	4,800
Liver disease	13.3	9.2	--31%	--4.1	12,300
Pneumonia & influenza	53.7	16.2	--70%	--38	112,500
Accidents	62.3	37	--41%	--25	75,900
Suicide	12.5	11.7	--6%	--0.8	2,400
Homicide	5.0	5.5	+10%	+0.5	(1,500)
Total					820,700

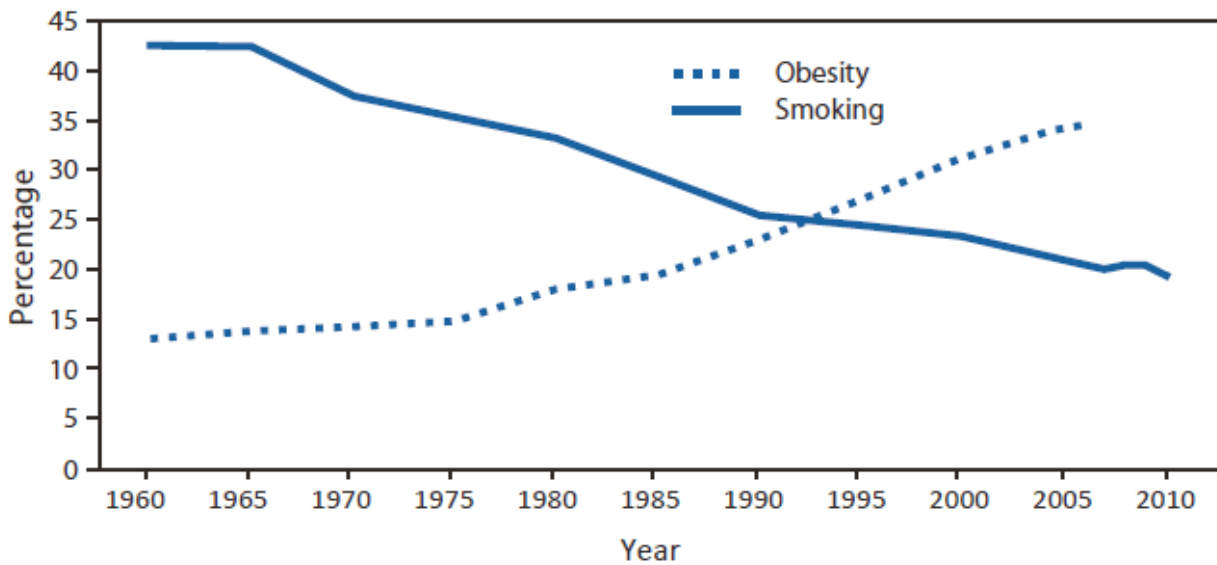
Sources: Health, United States, 2010: with special feature on death and dying. Hyattsville, MD: US Department of Health and Human Services, CDC, National Center for Health Statistics; 2011. Available at www.cdc.gov/nchs/data/hus/hus10.pdf; and Kochanek KD, Xu JQ, Murphy SL, et al. Deaths: preliminary data for 2009. National Vital Statistics Reports 2011;59(4). Available at http://www.cdc.gov/nchs/data/nvsr/nvsr59/nvsr59_04.pdf.

* Per 100,000 population (age adjusted to the 2000 US population).

† For chronic obstructive pulmonary disease, comparison is 1980 vs. 2009, as follows: 1980 rate---28.3; 2009 rate---42.2; % change, 2009 vs. 1980---+49%; rate difference---+14; no. lives saved: 41,700.

§ Estimated by multiplying the rate difference by the 2010 US population (300 million persons) rounded to the nearest 1,000.

FIGURE 5. Trends in the prevalence of smoking and obesity --- United States, 1960--2010

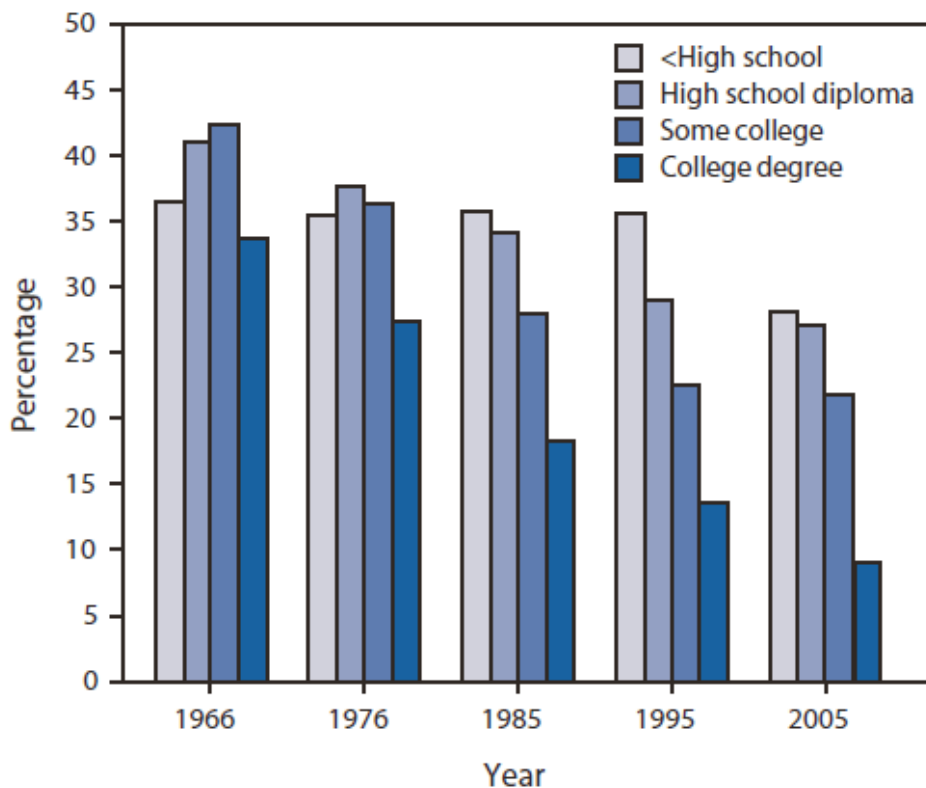


Source: Obesity data: National Center for Health Statistics. Health, United States, 2010. Hyattsville, MD: US Department of Health and Human Services, CDC, National Center for Health Statistics; 2011. Available at www.cdc.gov/nchs/data/hus/hus10.pdf. Smoking data: CDC. Current cigarette smoking among adults aged

≥18 years---United States, 2005--2010. MMWR 2011;60:1207--1212..

Alternate Text: The figure is a line graph that presents trends in smoking and obesity in the United States during 1960-2010.

FIGURE 6. Trends in the prevalence of smoking, by education level --- United States, 1966--2005



Sources: CDC. Reducing the health consequences of smoking: 25 years of progress---a report of the Surgeon general. Rockville, MD: US Department of Health and Human Services, Public Health Service, 1989; 269, and National Center for Health Statistics. Table 59. Age-adjusted prevalence of current cigarette smoking among adults 25 years of age and over, by sex, race, and education level: United States, selected years 1974--2009. In: health, United States, 2010. Hyattsville, MD: US Department of Health and Human Services, CDC; 2010; 231.

Alternate Text: The figure is a bar graph that presents trends in the prevalence of smoking, by education level, in the United States during 1966-2005.

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Page last reviewed: October 07, 2011

Page last updated: October 07, 2011

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