PART

1

A Public Health Perspective

CHAPTER

1

Cardiovascular Diseases: A Global Public Health Challenge

SUMMARY

Cardiovascular diseases comprise especially the major disorders of the heart and the arterial circulation supplying the heart, brain, and peripheral tissues. Their common occurrence in most populations and the great attendant mortality, loss of independence, impaired quality of life, and social and economic costs are compelling reasons for public health concern. The epidemiology and prevention of these diseases involve the understanding of their causes, identification of means of prevention, and monitoring of populations to assess the changing burden of these diseases and the measurable impact of interventions to control them. Together, the cardiovascular or circulatory diseases have figured prominently in the large shifts among causes of death, especially in industrial societies, during the 20th century. During this period they have become the predominant cause of death in many countries and in the world as a whole. The "theory of epidemiologic transition" offers an interpretation of these shifts. It may have special implications for developing countries, as increasing proportions of these populations attain older ages, social changes unfold, and disease patterns change. Evidence indicates that cardiovascular diseases are already epidemic in low- and middle-income as well as high-income regions of the world and have become deep-rooted in most societies in recent decades. Cardiovascular epidemiology has documented the nature and extent of the major atherosclerotic and hypertensive diseases as global phenomena. It has contributed substantially to establishing their underlying causal factors. It has also identified the potential for prevention on a population-wide scale, including prevention of the risk factors themselves. Together, the global burden and immense opportunities for prevention of cardiovascular diseases define a significant public health challenge.

THE EPIDEMIOLOGY AND PREVENTION OF CARDIOVASCULAR DISEASES: DEFINITION AND SCOPE

The cardiovascular diseases, or diseases of the heart and blood vessels, comprise many conditions that vary widely in manifestations and in public health importance. The present focus is chiefly on the atherosclerotic and hypertensive diseases. These are the cardiovascular conditions that develop on the basis of longstanding disease of the walls of arteries, especially in the heart, brain, and lower extremities, or of the aorta or as a consequence of persistently high blood pressure. In many but not all populations, these underlying processes—both atherosclerosis and hypertension—coexist. Heart attacks and strokes are very common manifestations of these conditions and are the chief contributors to their major public health importance. Also of public health concern are certain conditions affecting the venous circulation as well as disturbances of cardiac rhythm.

After the presentation of a public health perspective on the atherosclerotic and hypertensive diseases in Part I, these and several related conditions will be described in detail in Part II. Their main determinants have become scientifically established over a half century or more through research in populations as well as clinical and laboratory studies. This population research is the main subject of Part III. The contribution of cardiovascular epidemiology to strategies of prevention of these conditions, the evidence and rationale for public health approaches to prevention, and plans of action regarding public health

policy, practice, and research are addressed in Part IV, the concluding section.

Preceding a broad overview that addresses some historical and global dimensions of the atherosclerotic and hypertensive diseases, two notes may be useful for clarification. First, terminology varies widely as the conditions of concern are defined and discussed throughout the extensive literature of this field. For example, "CVD" may refer to cardiovascular disease, meaning specifically disease of the heart or its blood supply, or to cerebrovascular disease, affecting the circulation of the brain. A major condition of the heart, coronary heart disease, may be abbreviated as "CHD," "IHD" (ischemic heart disease), or "CAD" (coronary artery disease). Throughout the book, terminology of original sources is used in presentation of tables, figures, and sometimes text. It is hoped that fidelity to the source will not result in confusion for the reader. In general, the expressions "cardiovascular disease or diseases" or "heart disease and stroke" are used here as equivalent terms and refer to the full spectrum of the atherosclerotic and hypertensive diseases.

Second, an underlying view of epidemiology in general and of cardiovascular epidemiology in particular doubtless gives shape to the organization and presentation of what follows. One premise is that the utility of epidemiology, and a great part of its societal value, depends on application of its findings toward improvement of the public's health. Translated into cardiovascular epidemiology, the premise of this book is that the work of a half-century or more to understand the causes and discover the means of prevention of cardiovascular diseases on a national and global scale establishes not only the possibility but also the public health responsibility to seek effective action based on this science.

An overview follows that addresses issues of classification; the nature and magnitude of the public health challenge; rates and burdens of cardiovascular diseases past, present, and future; and concepts of cardiovascular disease development and prevention.

The Cardiovascular Diseases—An International Classification

What is the scope of cardiovascular diseases? Definition and classification of the cardiovascular diseases, as with other conditions, have evolved with changing concepts of disease and take many forms, in part because of different purposes. In epidemiology, special value attaches to a classification that is standardized and in common use in many or most hospitals, medical practices, states, countries, and regions of the world. In this way, some confidence is justified that reference to the same condition in different information sources corresponds to the same reality. The leading source of such a classification for use throughout the world is the World Health Organization publication, now in its 10th revision, the International Statistical Classification of Diseases and Related Health Problems (ICD 10).[1] Published in 1992, ICD 10 presents the category of Diseases of the Circulatory System as shown in Table 1-1.

Each three-character code in this classification has an alphabetic initial followed by two digits. The alpha code for this category is the letter I, with blocks of digits from 00-02 to 90-95 that distinguish 10 classes. Within a block, each two-digit code corresponds to a distinct subset of that class. Greater detail can be provided by use of an additional decimal place. For example, for "ischemic heart diseases" (I20-I25) the code I21 identifies acute myocardial in-

Table 1-1 Diseases of the Circulatory System (I00–I99)

I00–I02	Acute rheumatic fever
I05–I09	Chronic rheumatic heart diseases
I10–I15	Hypertensive diseases
I20–I25	Ischemic heart diseases
I26–I28	Pulmonary heart disease and diseases of pulmonary circulation
I30–I52	Other forms of heart disease
I60–I69	Cerebrovascular diseases
I70–I79	Diseases of arteries, arterioles, and capillaries
I80–I89	Diseases of veins, lymphatic vessels, and lymph nodes, not elsewhere classified
I90–I95	Other and unspecified disorders of the circulatory system

Note: Classification excludes congenital malformations, transient cerebral ischemic attacks and related syndromes, and certain others.

farction, or heart attack; codes I21.1 through I21.4 represent the anatomic location of the damage within the heart; and I21.9 is used for cases where location is not specified. Thus a case record, whether in the form of a death certificate or a hospital discharge summary, can potentially be coded in a consistent way, and cases with the same code can be collected and treated statistically as representing the same kind of circulatory event. The validity of such analyses depends, of course, on the quality of information available and the nosologic coding procedures applied.

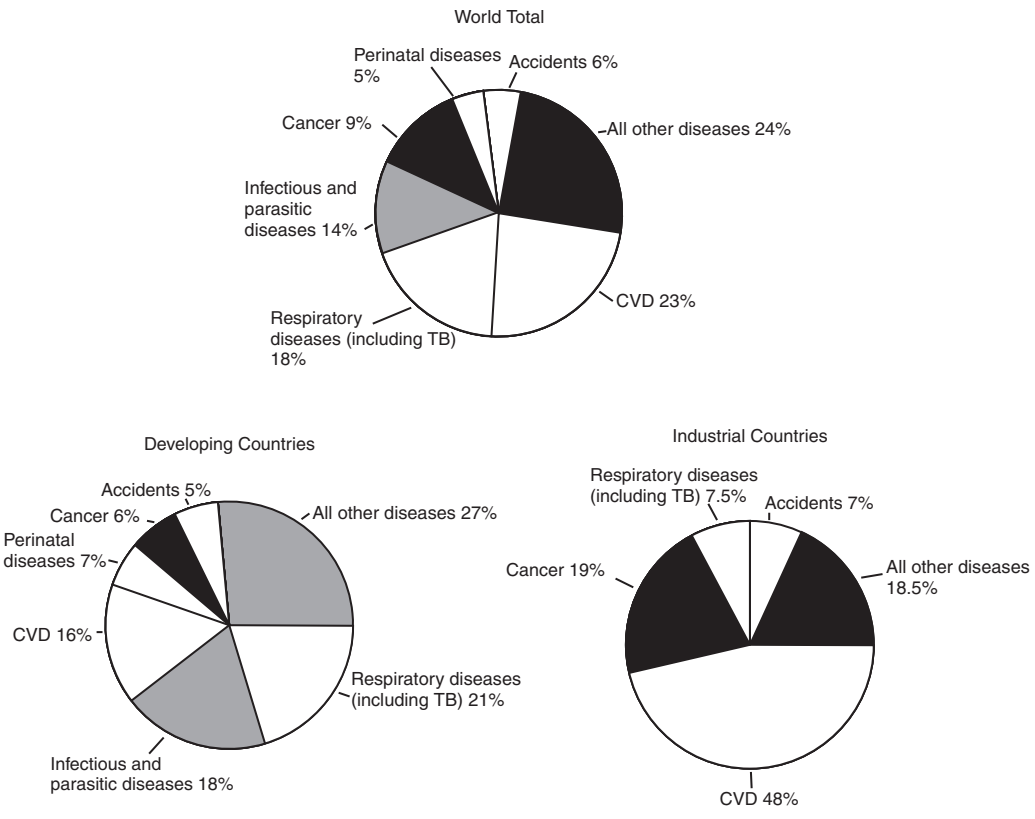
The conditions listed in Table 1-1 are those judged by the writers of ICD 10 to be classified best as diseases of the circulatory system. The conditions addressed in the following chapters are mainly I20-I25, I60-I69, and I10-I15. One additional category not shown in Table 1-1 also receives attention—transient cerebral ischemic attacks (TIA) or "light strokes." For present purposes, these events are considered to belong with the cerebrovascular diseases or circulatory conditions affecting the brain. More detailed classification of these conditions is addressed in Chapters 3–6, in which the atherosclerotic and hypertensive diseases and selected venous system disorders (essentially I10-I15, I20-I25, I26, I60-I69, and parts of I70-I79, I80-I89, and G45) are discussed.

In the chapters specific to a given condition, further detail of the ICD 10 codes will be noted, and earlier ICD codes will be referenced as needed. This is because ICD 10 has been widely implemented only recently; the data currently available on the conditions of interest therefore represent largely one or another of the previous versions, each of which was current for about a decade.

THE BASIS OF PUBLIC HEALTH CONCERN WORLDWIDE

The Magnitude of the Problem

Why do the cardiovascular diseases, taken together, warrant epidemiologic attention? The answer lies in part in the very large proportion of deaths, throughout the world, attributed to cardiovascular conditions. Figure 1-1 presents the percentages of deaths



Note: CVD, cardiovascular disease; TB, tuberculosis. Of the total deaths 78% are in developing countries.

Figure 1-1 Relative Contributions of Cardiovascular Death to Total Mortality in Developing and Industrial Countries and the World, 1980. *Source:* From *Disease Control Priorities in Developing Countries*, edited by DT Jamison et al., © 1993 by World Bank. Reproduced with permission of World Bank in the format Textbook via Copyright Clearance Center.

due to cardiovascular diseases ("CVD" in the figure) in the world as a whole (23%) and separately in developing countries (16%) and industrial countries (48%) as already recognized in 1980.[2] (This inclusive category comprises all cardiovascular deaths, which is heavily dominated by ischemic and hypertensive heart diseases and cerebrovascular disease.) Such estimates are subject to reservations, especially for the developing countries, as to the completeness of death registration and accuracy of cause-of-death assignment. Even allowing for these concerns, there is substantial support for the view that cardiovascular diseases have been increasing in frequency for some decades to constitute a rising public health problem of developing countries. In fact, the proportion of all deaths worldwide occurring in these populations is so great that the majority of cardiovascular deaths worldwide occur in developing countries.

Changing Patterns of Mortality in the United States

In industrialized countries, the prominence of heart disease among causes of death rose sharply during the 20th century, as shown for the United States, over the period 1900–1970 in Figure 1-2.[3] The importance of this early analysis of mortality in the United States is its contribution to a theory of population-wide changes in patterns of disease formulated in the 1970s, discussed below. The figure serves well even now to illustrate the changes in death rates, or the numbers of deaths per 100,000 population per year, due to multiple categories of causes over several decades. The relative shift for heart disease resulted from both an absolute increase in the rate of heart disease deaths (from a little more than 100 deaths to about 400 deaths per 100,000 population) and concurrent major decreases in other causes of death, especially in tuberculosis and other infectious diseases. Even before the 1920s, heart disease and stroke together exhibited mortality greater than that from any other category. In 2004 (the most recent year for which final mortality data were available at the time of writing), they still accounted for more than 35% of all deaths in the United States, as described in subsequent chapters.[4]

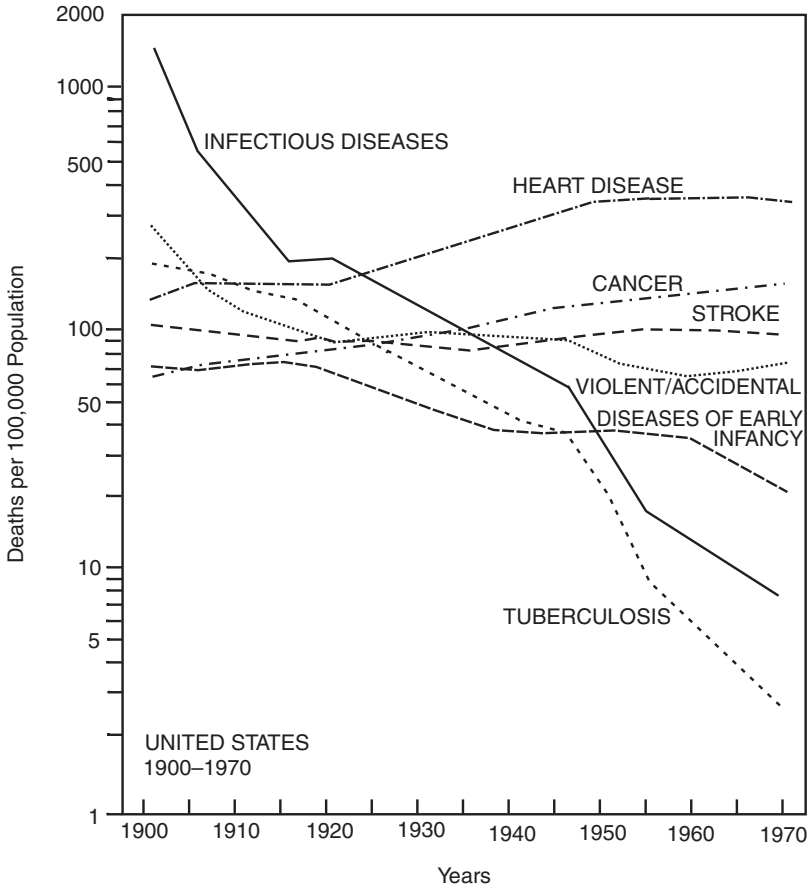


Figure 1-2 Secular Trends for Cardiovascular Disease and Other Cause-Specific Death Rates in the United States, 1900–1970. *Source:* From the *Population Bulletin*. © 1977, Courtesy of the Population Reference Bureau, Inc., Washington, DC.

Such vast shifts in causes of death stimulate strong epidemiologic interest because they must reflect profound changes in the factors that influence health and disease. Factors identified or confirmed through their association with such trends may constitute clues to causation or point to potential interventions. As will be seen, major increases or decreases in disease occurrence have until recently proven to be difficult to explain in retrospect. Methods of data analysis that incorporate information on factors related to prevention and treatment are currently used to sort out the contributions of these influences (see Chapter 4). But the experience of the United States indicated in Figure 1-2 is not unique, and such changes in patterns of mortality may be in progress in many countries. This creates the possibility of observing these changes—to the extent they may escape effective control measures—as they actually unfold in some populations. The likelihood of this is suggested both by epidemiologic theory and by a number of observations illustrated in the following section.

The "Theory of Epidemiologic Transition"

The theoretical basis for this view is that of "epidemiologic transition," formulated by Omran in an analysis of long-term patterns of mortality in human societies and first published in 1971.[5] According to Omran, "Conceptually, the theory of epidemiologic transition focuses on the complex change in patterns of health and disease and on the interactions between these patterns and their demographic, economic, and sociologic determinants and consequences …"[5, p 509] Omran distinguished three stages of progression, historically over centuries, in the dominant patterns of mortality: the "age of pestilence and famine," the "age of receding pandemics," and the "age of degenerative and man-made diseases." In a later extension of the theory, Olshansky and Ault have proposed a fourth stage, the "age of delayed degenerative diseases."[6]

These four stages of the epidemiologic transition are indicated in a representation by Gaziano and others published in the second edition of a major World Bank publication, *Disease Control Priorities in Developing Countries*, in 2006 (Table 1-2).[7] These authors elaborate on an earlier version presented by Pearson and others[2] by expanding the description of each stage and adding information on life expectancy, the percentage of the world's population in each stage, and the regions affected. In addition, they note "CHF"—chronic heart failure—among dominant forms of cardiovascular diseases present in the fourth phase (see Chapter 6).

One point of particular interest in this and the previous version of the table is the "percentage of deaths attributable to CVD." These estimates of proportionate mortality due to cardiovascular diseases in each stage were introduced by Pearson and colleagues as approximations based on their judgment (T.A. Pearson, personal communication, 2004). The shift from very low to much higher frequencies of circulatory diseases

Table 1-2 The Epidemiologic Transition

Phase of Epidemiologic Transition	Deaths from Circulatory Disease (%)	Circulatory Problems	Risk Factors
Age of pestilence and famine	5–10	Rheumatic heart disease; infectious and deficiency-induced cardiomyopathies	Uncontrolled infection; deficiency conditions
Age of receding pandemics	10–35	As above, plus hypertensive heart disease and hemorrhagic stroke	High-salt diet leading to hypertension; increased smoking
Age of degenerative and man-made diseases	35–55	All forms of stroke; ischemic heart disease	Atherosclerosis from fatty diets; sedentary lifestyle; smoking
Age of delayed degenerative diseases	Probably under 50	Stroke and ischemic heart disease[a]	Education and behavioral changes leading to lower levels of risk factors

Note: Omran introduced the concept of epidemiologic transition with discussion of phase 1, 2, and 3. Olshansky and Ault added the concept of a fourth phase.

[a]At older ages. Represents a smaller proportion of deaths.

Source: From *Disease Control Priorities in Developing Countries*, edited by DT Jamison et al. Copyright © 1993 The International Bank for Reconstruction and Development/The World Bank. Used by permission of Oxford University Press, Inc.

as causes of death is much like that demonstrated in Figure 1-2.

As shown in Table 1-1, under this theory circulatory diseases increase from a minor proportion of all deaths in the first stage to become the predominant cause of death in the third stage; finally, they may decrease slightly in relative importance, though still perhaps representing the largest single category of deaths. Characteristic shifts also occur in the predominance of particular forms of circulatory disease over the successive phases: first, solely rheumatic heart disease and cardiomyopathies; second, these and also hypertensive heart disease and hemorrhagic stroke; third, all forms of stroke plus ischemic heart disease; and fourth, the latter causes persisting but occurring at older ages and as a somewhat reduced proportion of all deaths.

In the United States and other countries undergoing industrialization in the 19th and 20th centuries, this epidemiologic transition is already far advanced into the third or fourth stage. Developing countries, however, have widely been thought to remain in the first or second stage because proportionate mortality from circulatory conditions remained low; but absolute rates reached levels of concern even while dominance of communicable diseases persisted. Two decades and more ago, demographic changes already under way were thought capable of producing more rapid transition in these countries than was experienced by the already-industrialized countries. Dodu, of the World Health Organization Cardiovascular Diseases Unit in Geneva, wrote in 1988 of the emergence of cardiovascular diseases in developing countries.[8] He presented data (Figure 1-3), based on Omran's work, to show that the percentage of deaths due to cardiovascular diseases (and cancer) in a population increases as life expectancy at birth increases. This would be anticipated because cardiovascular disease death rates are very much higher for successively older age groups in adulthood. As shown by Dodu, when the average person attains age 61 or 62 years, cardiovascular diseases are expected to predominate over infectious diseases as a cause of death.

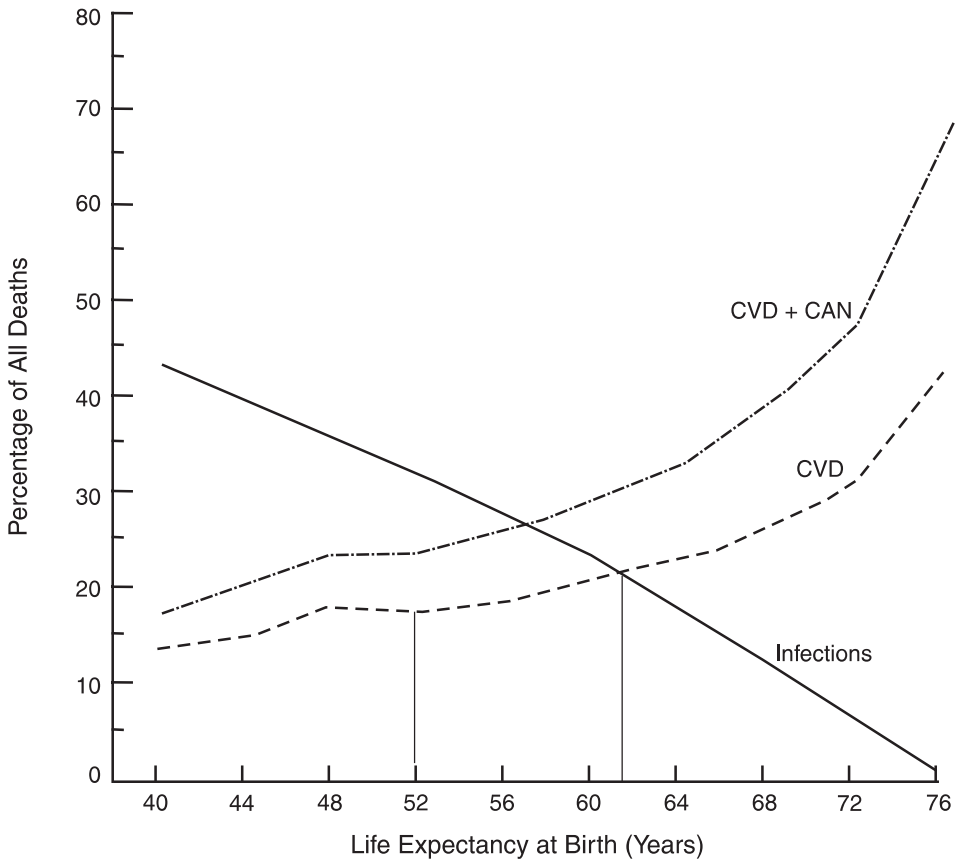


Figure 1-3 Percentages of Deaths Due to Cardiovascular Diseases (CVD), Cancer (CAN), and Infections, in Relation to Life Expectancy at Birth. *Source:* From *Cardiology*, Vol 75, Emergence of Cardiovascular Diseases in Developing Countries, SRA Dodu, © 1988 S Karger AG, Basel. Reproduced with permission from United Nations Secretariat, p 58.

Dodu further demonstrated, as shown in Figure 1-4, that life expectancy at birth increased sharply in developing regions of the world in the third quarter of the 20th century. Further, this increase was projected to continue, so that by the year 2000 even Africa would attain an average life expectancy at birth of nearly 60 years. This value would be exceeded slightly by that for the population of South Asia but by far for East Asia and Latin America. This changing demographic picture alone, influenced partly by recession of infectious diseases as a cause of neonatal and infant mortality, leads to an expectation of an increasing proportion of deaths from circulatory diseases, in accordance with the theory of epidemiologic transition. As a concrete example, Dodu cited the experience of Singapore, where in 30 years (1948–1979) life expectancy increased from about 40 years to 70 years, and cardiovascular diseases shifted from only 5% to more than 30% of all deaths.

Economic Considerations

Worldwide public health concern about cardiovascular diseases is partly because of the high frequency of occurrence of these diseases as a cause of death. This reality continues in industrialized countries and is increasingly recognized in developing countries. In addition, among the personal and social costs of cardiovascular diseases, both fatal and nonfatal, are their

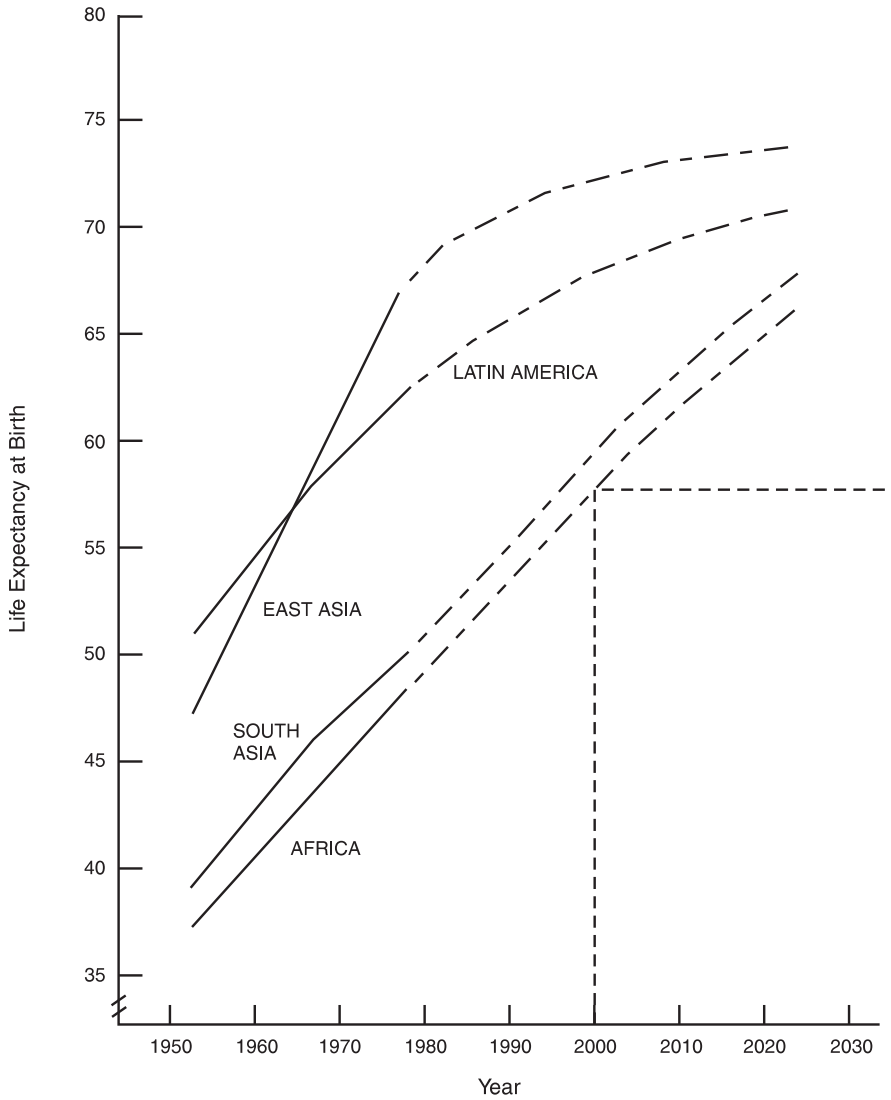


Figure 1-4 Life Expectancy in Relation to Calendar Time, by Region of the World, 1950–2030. *Source:* From *Cardiology*, Vol 75, Emergence of Cardiovascular Diseases in Developing Countries, SRA Dodu, © 1988 S Karger AG, Basel. Reproduced with permission from United Nations Secretariat, p 62.

economic costs, which are increasingly important. In the United States in the year 2009, for example, the cost of medical care alone for cardiovascular diseases is projected to be $313.8 billion, with additional indirect costs due to disability and death in working years of $161.5 billion, making the total one-year economic burden $475.3 billion.[4] The World Health Organization estimated the economic burden of lost income (analogous to the indirect costs above) due to heart disease, stroke, and diabetes for nine countries across a spectrum of income levels, over the years 2005–2015.[9] For China, such losses were projected to reach 18.3 billion international dollars for 2005 and 131.8 billion dollars in 2015. These macroeconomic dimensions of cardiovascular diseases lend importance to intensified efforts to prevent these diseases in populations throughout the world, in both industrialized and developing countries.

RATES OF OCCURRENCE IN SELECTED POPULATIONS AND CHANGES IN RECENT DECADES

World Bank Regions, 1985

The status of the major regions of the world with respect to mortality from circulatory system diseases toward the end of the 20th century is summarized in Table 1-3.[2] For the total world population and for each geographic/economic area distinguished by the World Bank, Table 1-3 indicates for 1985 the total numbers of deaths (in thousands), the percentages of the total due to circulatory diseases (as discussed above), and the death rate (per 100,000 population, adjusted for differences between regions in age composition) for all circulatory diseases and for two of the component categories, ischemic heart disease and cerebrovascular disease.

The percentages of deaths from circulatory diseases were highest for the industrial economies, both market economies such as the United States (46%) and nonmarket ones such as the countries of the former Soviet Union (47%). They were only one-half to one-quarter as high for the remaining four regions (10–22%). The total death rate was highest for the industrial nonmarket economies (357 per 100,000). This group of countries experienced a 60% higher death rate from "ischemic disease" and a 65% higher death rate from cerebrovascular disease than did the industrial market economies.

Scrutiny of Table 1-3 reveals something of a paradox. The lower percentages of deaths due to circulatory diseases in all of the nonindustrial regions might be taken as consistent with the epidemiologic transition and give the impression that circulatory diseases are not yet important in these regions. However, this interpretation is refuted by the actual death rates for ischemic disease and cerebrovascular disease. These rates were nearly as high or higher for nonindustrial as for industrial market economies—such as the United States. Asia was again exceptional, in this instance by having the lowest mortality for "ischemic disease" of any region (46 per 100,000) and the highest for cerebrovascular disease (91 per 100,000) outside the industrial nonmarket region. Clearly, both categories of circulatory disease were as well established in the nonindustrial regions of the world as in the industrial market economies as measured by mortality experience as

Table 1-3 Estimated Mortality from Circulatory System Diseases, World Bank, 1985

Region	Deaths (Thousands)	Total Deaths (%)	Age-Standardized Death Rate (per 100,000 Population)[a]		
			Total	Ischemic Disease	Cerebrovascular Disease
Industrial market economies	3355	46	235	99	59
Industrial nonmarket economies	2220	47	357	164	106
Latin America and the Caribbean	691	22	222	69	57
Sub-Saharan Africa	756	10	273	85	74
Middle East and North Africa	602	14	250	82	68
Asia	3841	17	195	46	91
Total	11,465	23	243	84	81

[a]Rates are standardized using the 1985 world age structure.

Source: From *Disease Control Priorities in Developing Countries*, edited by DT Jamison et al. Copyright © 1993 The International Bank for Reconstruction and Development/The World Bank. Used by permission of Oxford University Press, Inc.

early as 1985, more than two decades ago. These rates were simply dominated in these regions by persistent high mortality from noncirculatory causes, resulting in low proportionate mortality despite substantial circulatory death rates. The epidemiologic transition had evidently taken a different course in these regions than in the industrialized parts of the world.

Change from 1988–1998 in 15 Countries

As of the late 20th century, marked differences—2- to 3-fold in Table 1-2—in mortality from specific cardiovascular causes were demonstrable in populations comprising major economic and geographic regions of the world. The mortality pattern of a single country such as the United States was seen to have evolved throughout much of the last century. But a country may experience striking change in ischemic heart disease mortality within a decade or less, as shown in Figure 1-5.[7]

In this figure, data on ischemic heart disease mortality are presented as the percentage change in death rates among people aged 35–74 years at death, from 1988 to 1998 for 15 selected countries. The changes in rates are shown for both males and females in each country. The resulting picture is one of a continuous gradient of change that ranges from +62% to −49% for males in Croatia and Denmark, respectively, and from +61% to −52% for females in Croatia and Australia, respectively. That the adverse, upward changes were clustered in Eastern European countries of the former Soviet Union is noteworthy, as is the exceptional situation of Hungary with virtually no change. Also noteworthy is the similarity in patterns of change—in both direction and magnitude—for males and females in the same countries.

These differences over time in changes in mortality are of great epidemiologic interest because of the between-population dimension of variation that they represent and resulting possibilities for comparative investigation. Deeper insight into the causes of these large population changes and the potential for prevention or control of the underlying epidemic processes would be anticipated as a result.

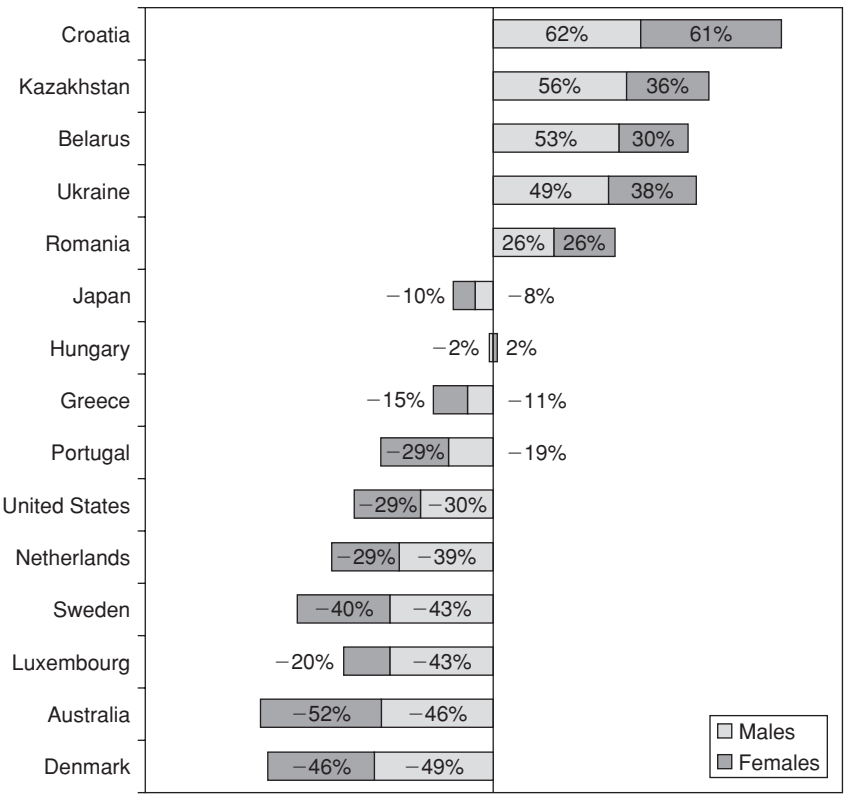


Figure 1-5 Percentage Change in Ischemic Heart Disease Death Rates in People Age 35–74, 1988–1998, Selected Countries. *Source:* Reproduced with permission from *Disease Control Priorities in Developing Countries*, 2nd edition, edited by DT Jamison et al., © 2006 by World Bank. Courtesy of the International Bank for Reconstruction and Development/The World Bank.

CURRENT BURDENS OF MAJOR CARDIOVASCULAR DISEASES IN THE UNITED STATES AND THE WORLD

US Mortality and Morbidity Among Adults, Children, and Youth at Mid-Decade, 2000–2010

In the United States, not only vital statistics but also extensive survey data from several sources contribute to an ongoing assessment of the cardiovascular disease burden. The Centers for Disease Control and Prevention (CDC) operate multiple surveillance systems, including those of the National Center for Health Statistics. The National Health and Nutrition Examination Survey (NHANES) began with periodic surveys first conducted in 1960–1962 and has now become a continuous data collection process with a complete new probability sample of the civilian, noninstitutionalized population of the nation as a whole every 2 years. The Behavioral Risk Factor Surveillance System (BRFSS) is a telephone interview survey conducted annually in a probability sample of each of the 50 states and the District of Columbia. Numerous other systems collect data on specific behaviors, hospital and ambulatory medical care, and other related topics. The National Heart, Lung and Blood Institute conducts continuing multicenter population studies across the adult age range—most renowned being the Framingham Heart Study—and including the Coronary Artery Risk Development in Young Adults Study (CARDIA), the Atherosclerosis Risk in Communities Study (ARIC), the Cardiovascular Health Study (CHS), and others.

Each year the American Heart Association, through the work of a committee representing these agencies and the broader cardiovascular epidemiology community, compiles data from these and other sources into an extensive update published online (www.americanheart.org) as well as in the journal *Circulation*.

The 2008 update concluded with summary tables illustrated by Table 1-4a, for adults, and Table 1-4b, for children and youth.[4] The estimated numbers and percentages of persons in the United States as a whole and numbers or percentages by sex within categories of race/ethnicity are indicated. With few exceptions these data represent the years 2006 or 2007.

To appreciate these summary data fully requires familiarity with the design and methods of each source, for which references are provided in the publication. It is important to note certain limitations, however. Not all population groups of interest are represented, such as American Indian/Alaska Natives or Asians, for whom limited available data are provided in the body of the report. Prevalence estimates are based on sample surveys and projected to the population as a whole, with whatever limitations of sampling error and bias from nonparticipation may apply. Reference to "new and recurrent" CHD and strokes reflects inability from available data to distinguish between first events and recurrences, and numbers of events could include multiple events in the same individual.

Among persons age 20 or older, more than 80 million are estimated to have some form of cardiovascular disease (Table 1-4a). Included in this total are CHD, stroke, high blood pressure (HBP), and heart failure (HF), as well as other conditions. Coronary heart disease is by far the dominant condition with respect to reported deaths (more than 450,000), with

Table 1-4a **Prevalence of Selected Cardiovascular Conditions in Adults,[a] by Sex and Race/Ethnicity, United States, 2006**

	Total CVD[b]	CHD[c]	Stroke	High Blood Pressure	Heart Failure
All Adults ($\times 10^6$)	80.0	16.8	6.5	73.6	5.7
Females (%)					
Whites	33.3	6.6	3.2	30.3	1.8
Blacks	45.9	9.0	4.1	43.9	4.2
Mexican Americans	32.5	6.3	3.8	30.4	1.4
Males (%)					
Whites	37.8	8.8	2.3	34.1	3.1
Blacks	45.9	9.6	3.9	44.4	4.2
Mexican Americans	26.1	5.4	2.1	23.1	2.1

[a]Ages $\geq$ 20 years.

[b]CVD, cardiovascular diseases.

[c]CHD, coronary heart disease.

Source: Data from *Heart Disease and Stroke Statistics—2009 Update*. A Report from the American Heart Association Statistics Committee and Stroke Statistics Committee. D Lloyd-Jones et al., © 2008. Courtesy of the American Heart Association/American Stroke Association.

Table 1-4b **Prevalence of Selected Cardiovascular Risk Factors in Children and Youth, by Sex and Race/Ethnicity, United States, 2007**[a]

	Current Cigarette Smoking (%) (Grades 9–12)[b]	Mean Total Cholesterol Concentration (mg/dl) (Ages 12–19 Years)[c]	Meet Current Physical Activity Recommendations (%) (Grades 9–12)[b]	Overweight (%) (Ages 2–19 Years)[c]
Females				
White	22.5	165.0	27.9	29.5
Black	8.4	162.8	21.0	39.2
Hispanic[b] or Mexican American[c]	14.6	163.1	21.9	35.0
Males				
White	23.8	154.5	46.1	31.9
Black	14.9	161.7	41.3	30.8
Hispanic[b] or Mexican American[c]	18.7	158.2	38.6	40.8

[a]Mean total cholesterol concentration from the National Health and Nutrition Examination Survey, 2005–2006; overweight from the National Health and Nutrition Examination Survey, 2006. [b]Data for Hispanics. [c]Data for Mexican Americans.

Source: Data from *Heart Disease and Stroke Statistics—2009 Update*. A Report from the American Heart Association Statistics Committee and Stroke Statistics Committee. D Lloyd-Jones et al., © 2008. Courtesy of the American Heart Association/American Stroke Association.

stroke deaths occurring about one-third as frequently (150,000). More than one-half of the total cardiovascular disease deaths are due to coronary heart disease. Because the total prevalence for the four specified conditions would be 100.1 million, it is evident that some persons are affected by multiple conditions. High blood pressure predominates in the prevalence estimates overall and in each sex-race/ethnicity group and differs notably in prevalence among groups—from 23.1% in persons identified as Mexican American males to 43.9% in Black females. Differences between Blacks and Whites in prevalence of total CVD and several components parallel their differences in high blood pressure. The importance of these prevalence figures is that they represent the numbers of persons who continue to live with each condition, perhaps having disability or incurring substantial medical care costs, as well as high risk of recurring cardiovascular events. They also underscore the fact that mortality data, which have been considered alone up to this point in the discussion, do not provide a complete picture of the cardiovascular diseases. Information of other kinds is needed for adequate assessment of their importance in the population.

It is striking that large proportions of the population—children and youth as well as adults (Tables 1-4a and 1-4b)—are affected by the indicated risk factors: tobacco use, high blood cholesterol, physical inactivity, being overweight or obesity, and diabetes. Each of these and several other factors are examined in detail in Part III.

World Income Groups and Regions, 2001

To update the global experience of cardiovascular mortality from the previous pictures of 1980 and 1985 (Figure 1-1 and Table 1-3), the recent World Bank publication, *Global Burden of Disease and Risk Factors*, provides estimated ischemic heart disease and cerebrovascular disease mortality as numbers of deaths and percentages of all deaths in 2001 for economic (high- and low- and middle-income) and geographic regions of the world (Table 1-5).[10] It is important to recall discussion of proportionate mortality in the context of the theory of epidemiologic transition, above. Here, a portion of circulatory mortality is represented by the sum of percentages of death in the two major categories shown: among low- and middle-income countries, from 47.9% in Europe and Central Asia to 6.5% in sub-Saharan Africa, versus 27.2% in the aggregate of high-income countries. Europe and Central Asia include the nonmarket industrial economies, in which death rates from these causes were highest among world regions in the 1985 World Bank data (Table 1-2). Together, these two components of circulatory mortality in 2001 accounted for 2,714,000 deaths in the region. But even in sub-Saharan Africa, 698,000 deaths were attributed to these two causes. They also represented more than 10 million deaths in low- and middle-income countries overall, and just over 2 million in high-income countries. These estimates indicate a substantial public health burden from ischemic heart disease and cerebrovascular disease in the developing world by the year 2001; other estimates date the establishment of these conditions in developing countries earlier.

Table 1-5 Percentages and Numbers of Deaths Attributed to Ischemic Heart Disease and Cerebrovascular Disease, by Broad Income Group and by Region Among Low- and Middle-Income Countries, 2001

Income Group and Region	Ischemic Heart Disease		Cerebrovascular Disease	
	(%)	*N* (×1000)	(%)	*N* (×1000)
Low- and Middle-Income				
- East Asia and Pacific	8.8	1151	14.6	1902
- Europe and Central Asia	29.7	1685	18.2	1029
- Latin America and the Caribbean	10.9	358	8.2	267
- Middle East and North Africa	16.9	323	6.8	130
- South Asia	13.6	1838	6.8	923
- Sub-Saharan Africa	3.2	343	3.3	355
All	11.8	5699	9.5	4608
High-Income				
	17.3	1364	9.9	781

Source: Data from Global Burden of Diseases Study, edited by AD Lopez. © 2006. The International Bank for Reconstruction and Development/ The World Bank.

Projected Cardiovascular Contributions to the Global Burden of Disease

Early assessments of the global burden of cardiovascular diseases focused on available mortality data, which are often the most readily found health indicator albeit with important and sometimes severe limitations. Two significant new approaches were undertaken with a major initiative under leadership of C.J.L. Murray and A.D. Lopez, the Global Burden of Disease and Injury Series that began in 1988.[11] First, it represented a major new investment in making country-level estimates for the world population both for a baseline year, 1990, and projected to 2020, thus providing insight for health policy that might reduce or avert the anticipated burdens of specific diseases. Second, the project went beyond mortality data to estimate burdens due to disability and to deaths within the working years. Extensive discussion of methods and detailed presentation of country- and region-specific data occupy several volumes of published material from this study, including the 2006 publication that provided the data for Table 1-5.

Deaths, Years Lost, and Disability

Three aspects of the projections for ischemic heart disease and stroke, from 1990 to 2020, are presented here (Table 1-6). First is the relative position of these two conditions among all major causes of death worldwide, as estimated for each of these years. Ischemic heart disease and cerebrovascular disease were found to be the first and second leading causes of death worldwide as of 1990 and were projected to remain in this rank 30 years later, in 2020.

Second, years of life lost (YLL) were estimated, taking into account predicted ages at death in relation to an assumed life expectancy of 82.5 years. In these computations, ischemic heart disease was projected to advance from fourth to first rank and cerebrovascular disease from seventh to third rank between 1990 and 2020. Not only the fact of death but also the age at death is taken into account in estimating the burden.

Third, in addition to years of life lost, years lived with disability of given severity is combined to yield the measure of disability-adjusted life years (DALYs). When attributed to specific causes, these can then similarly be ranked as to their contribution to disease burden for a given population. The results for ischemic heart disease and stroke were, respectively, increases from fifth to first rank and from sixth to fourth rank from 1990 to 2020. It is noteworthy that both conditions contribute importantly to disease burden in terms

Table 1-6 Rank Order of Ischemic Heart Disease and Cerebrovascular Disease as Causes of Death, Years of Life Lost (YLL), and Disability-Adjusted Life Years (DALYs), 1990 and 2020

Condition	Death		YLLs		DALYs	
	1990	2020	1990	2020	1990	2020
Ischemic heart disease	1	1	4	1	5	1
Cerebrovascular disease	2	2	7	3	6	4

Source: Data from Global Burden of Diseases Study, edited by CJL Murray and AD Lopez, © 1996. Harvard School of Public Health.

not only of death but also of reduced life expectancy and disability. Ischemic heart disease ranks first among all health conditions in all three measures by 2020 scarcely more than a decade from now.

The World Health Organization has developed maps of the global distribution of DALYs lost to coronary heart disease and to stroke that are accessible at: http://www.who.int/cardiovascular_diseases/resources/atlas/en/index.html.

Productive Years of Life Lost

In a further approach to gauging the population impact of death and disability attributable to cardiovascular diseases, Leeder and colleagues reported a subsequent analysis, *A Race Against Time: The Challenge of Cardiovascular Disease in Developing Countries*.[12] The study was undertaken in an effort to put cardiovascular diseases on the world map after it was neglected, as were the chronic diseases overall, in a major report on macroeconomics and global health. Its message was that death and disability from cardiovascular diseases will strike working age populations with a devastating impact on economic development of low- and middle-income countries unless effective public health action is taken urgently.

The strategy of *A Race Against Time* was to examine "productive years of life lost" by focusing on the projected cardiovascular disease mortality occurring in the workforce at ages from 35 to 64 years. The impact was estimated for the year 2000 and projected to 2030, in five countries—Brazil, South Africa, Russia, China, and India. The United States and Portugal were assessed as comparison countries, the former with markedly declining cardiovascular mortality and the latter with the lowest rates among the high-income countries of Europe. Details of the methods are presented in the report, and the central findings are summarized in Table 1-7.

The specific age group of interest, with sufficiently high cardiovascular disease mortality to be significantly affected, was persons from 35 to 64 years of age. The 30-year projections indicate a major increase in years of life lost from 2000 to 2030 for India and China and a similar relative (though much lesser absolute) increase for Brazil. The 2030 rate for the United States of 1661 years of life lost/100,000 population is not markedly less than that for China, 1863/100,000—but the relative population sizes of the countries contribute to a five-fold greater impact in China. Among 10-year age groups within the workforce, the 45–54 year age group generally experiences the heaviest burden. Among the authors' conclusions is this central point: "that without concerted, ongoing intervention to prevent the precursors and reverse the negative effects of CVD in developing countries, a global health crisis in the current workforces (and later among the elderly) of those countries will occur—and sooner, rather than later."[12, p 84]

OPPORTUNITIES FOR PREVENTION

An overview of the major cardiovascular diseases as a public health challenge would be incomplete without recognizing opportunities for prevention. It is the potential impact of effective public health action that makes the challenge more than an academic interest and a matter of urgent national and global health policy. In Part IV, concepts and strategies of prevention, supporting evidence and the case for prevention, and finally a plan of public health action to prevent cardiovascular diseases on a population level are discussed in some detail. But briefly, here, before the major conditions themselves and their determinants are addressed in Parts II and III, a closing note on prevention is included for perspective.

Table 1-7 **Productive Years of Life Lost (Thousands) Due to Cardiovascular Diseases by Decade of Age and Overall, 35–64 Years, in Selected Countries, Years 2000 and 2030**

	Age 35–44		Age 45–54		Age 55–64		Age 35–64		Rate[a] in
Country	2000	2030	2000	2030	2000	2030	2000	2030	2030
Brazil	358	487	457	740	246	514	1061	1742	1957
S. Africa	112	125	123	157	67	110	302	392	2667
Russia	976	740	1427	1420	911	1012	3314	3208	5887
China	1551	1768	3070	3695	2046	4998	6667	10460	1863
India	2260	3691	3959	7790	3002	6456	9221	17937	3707
US	481	443	714	741	437	789	1631	1,972	1661
Portugal	13	12	16	22	12	19	41	53	1317

[a]Rate/100,000 population at age 35–64.

Source: Data from *A Race Against Time*, © 2004, The Trustees of Columbia University in the City of New York.

The past half-century, in which cardiovascular epidemiology came into being, saw not only extensive documentation of the occurrence of cardiovascular diseases throughout the world but also successful investigation of its underlying causes and means of prevention. Strategies of prevention were derived from the concept of risk factors, introduced in 1961 by Dawber and colleagues in the Framingham Heart Study.[13] Rose articulated most clearly, in 1981 and after, the idea of two complementary approaches to shifting adverse population distributions of risk factors toward more favorable ones, by a "high-risk" strategy of intensive intervention targeting those at the extreme of risk and a "mass" or "population-wide" strategy to shift the whole distribution toward lower risk.[14] Strasser, meanwhile, had proposed in 1978 what he termed "primordial prevention."[15] This was conceived as a means of preventing, on a worldwide front, the epidemics of risk factors themselves that Rose's strategies were devised to reverse. In 2004, Stamler and colleagues reviewed the history of research that established the major risk factors—serum total cholesterol, blood pressure, cigarette smoking, body mass index, diabetes, and, the "pivotal" factor, adverse diet. He emphasized the concept of maintaining low risk, or absence of risk factors, in increasing proportions of the population through "safe improvements in population lifestyles, especially dietary habits from childhood on."[16,17] The concept of primordial prevention is clearly embedded in the idea of maintaining low risk, on a population-wide basis and beginning in childhood.

Growing recognition of the global dimensions of the cardiovascular disease epidemic, evidenced for example in the attention paid by the World Bank, has stimulated efforts to place cardiovascular diseases and, more broadly, chronic diseases on national and global health agendas. This effort has itself been a challenge. In the United States, for example, a report in the mid-1990s on this nation's investment in chronic disease prevention indicated that less than 3% of the aggregate budgets of state health departments, where constitutional responsibility for public health resides, and a similarly small proportion of public health personnel were dedicated to chronic disease prevention.[18] *A Race Against Time*, published in 2004, was a rejoinder to the World Health Organization Commission on Macroeconomics and Health that failed to acknowledge the role of chronic diseases among major health-related impediments to economic development.[12] The editor of *The Lancet* in 2005 addressed "The neglected epidemic of chronic disease" in introducing a set of reports exhorting health policy-makers throughout the world, and especially in India and China, to take meaningful action in this area.[19–23]

It is significant that the recently expanded report *Global Burden of Disease and Risk Factors* incorporates a detailed assessment of risk factors, as well as diseases on a national, regional, and global scale.[24] Among the extensive data presented are estimates of the contributions of selected risk factors to the burden (in DALYs) and mortality due to ischemic heart disease and stroke, both worldwide and separately for high- and low- and middle-income regions (Table 1-8). The population attributable fraction (PAF) for each risk factor and outcome represents the percentage of "burden" (in DALYs) or mortality that would be avoided if the lowest population risk, or "theoretical-minimum-risk exposure distribution," rather than the actual or assumed distribution were present for the population in question. Each factor is considered separately, although factors frequently overlap in their occurrence. As a result, the cumulative percentages for multiple risk factors may exceed 100%. Mazzati and coauthors present details of methods for estimating joint effects of multiple risk factors (Joint PAF).

For the risk factors considered individually, high blood pressure stands out as the leading factor for stroke and is nearly equivalent to high cholesterol for ischemic heart disease. For example, if the blood pressure distribution of the high-income region were reduced to the theoretical-minimum-risk exposure (estimated to be 115 mm Hg with a standard deviation of 6 mm Hg), the burden of stroke in DALYs would be expected to be 56% lower for the region. Attributable fractions for blood pressure and cholesterol, as well as for smoking and alcohol use, are higher in high-income than in low- and middle-income regions, although the differences in PAF for high blood pressure are negligible. Low fruit and vegetable intake and physical inactivity contribute more strongly to risk of ischemic heart disease than to stroke. Urban air pollution, though minor in relation to other factors, does contribute to both outcomes, to a greater degree in the low- and middle-income than the high-income region. Importantly, the joint contribution of these risk factors accounts for the great majority (80%) of ischemic heart disease as well as the majority (60–70%) of stroke, with only minor differences between economic regions.

This glimpse of evidence based on epidemiologic observations suggests a vast potential for prevention, if public health strategies can be devised, implemented, and sustained to preserve low risk or restore

Table 1-8 **Individual and Joint Contributions of Risk Factors to Ischemic Heart Disease and Stroke, World Total and by Broad Income Group**

	Ischemic Heart Disease			Stroke		
Factor	PAF for individual factor (%)			PAF for individual factor (%)		
	High-Income	Low- and Middle-Income	World	High-Income	Low- and Middle-Income	World
High blood pressure	48	44	45	56	54	54
High cholesterol	57	46	48	25	15	16
Overweight and obesity	27	16	18	20	10	12
Low fruit and vegetable intake	19	30	28	9	11	11
Physical inactivity	21	21	21	8	6	7
Smoking	23	15	17	21	12	13
Alcohol use	13	4	2	11	5	3
Urban air pollution	1	2	2	1	4	3
Joint PAF—burden (%)	84	80	80	68	64	65
Joint PAF—mortality (%)	80	78	79	54	61	60

Source: Data from Global Burden of Diseases Study, edited by AD Lopez. © 2006. The International Bank for Reconstruction and Development/The World Bank.

the more favorable distributions of risk that can be presumed to have existed historically. Here, then, is the global challenge, to be addressed country by country: to recognize and acknowledge the immense burden of chronic diseases, and of cardiovascular diseases in particular, and the need for concerted public health action to achieve the demonstrated potential for major reductions in risk.

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