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Over the past decade, cardiovascular disease (CVD) has emerged as the single most important cause of death worldwide. In 2010, CVD caused an estimated 16 million deaths and led to 293 million disability-adjusted life-years (DALYs) lost—accounting for approximately 30% of all deaths and 11% of all DALYs lost that year. Like many high-income countries (HICs) during the past century, now low- and middle-income countries (LMICs) are seeing an alarming and accelerating increase in CVD rates.

This chapter describes the features of the epidemiologic transition underlying this shift in CVD morbidity and mortality and evaluates the transition in different regions of the world. Also presented is a survey of the current burden of risk factors and behaviors associated with CVD and their regional variations and trends, followed by a review of the economic impact of CVD and the cost-effectiveness of various strategies to reduce it. Concluding the chapter is a discussion of the diverse challenges posed by the increasing burden of CVD for various regions of the world, as well as potential solutions to this global problem.

SHIFTING BURDEN OF CARDIOVASCULAR DISEASE

CVD now causes the most deaths in all low- and middle-income regions, with the exception of sub-Saharan Africa, where it is the leading cause of death among persons older than 45 years of age. Between 1990 and 2010, deaths from CVD increased from 26% to 29.5% of all deaths globally—a reflection of the rapidity of the epidemiologic transition—particularly in low- and middle-income regions (Fig. 1-1). Within the six World Bank-defined low-income and middle-income regions, vast differences exist in the CVD burden (Fig. 1-2), with CVD death rates as high as 60% in Eastern Europe and as low as 10% in sub-Saharan Africa. The CVD death rate is 36% in HICs.

EPIDEMIOLOGIC TRANSITION IN PREDOMINANT CAUSES OF DEATH

Sequence of Stages
The overall increase in the global burden of CVD and the distinct regional patterns result in part from the epidemiologic transition, which includes four basic stages (Table 1-1): pestilence and famine, receding pandemics, degenerative and manmade diseases, and delayed degenerative diseases. Progression through these stages has dramatically shifted the predominant causes of death over the past two centuries, from infectious diseases and malnutrition in the first stage to CVD and cancer in the third and fourth stages. Although the transition through the age of pestilence and famine has occurred much later in LMICs, it also has occurred more rapidly, driven largely by the transfer of low-cost agricultural technologies and public health advances.

Humans evolved during the age of pestilence and famine and have lived with these troubles for most of recorded history. Before 1900, infectious disease and malnutrition together constituted the most common cause of death in virtually every part of the world—with tuberculosis, pneumonia, and diarrheal diseases accounting for a majority of deaths. These conditions, along with high infant and child mortality rates, resulted in a mean life expectancy of approximately 30 years. Thanks largely to improved nutrition and public health measures, however, both communicable diseases and malnutrition declined, and life expectancy increased dramatically. Increased longevity and the impact of smoking, diets high in fat and carbohydrates, and other risk factors for chronic diseases, have now combined to make CVD and cancer the leading causes of death in most countries. This transformation in disease burden changes began in higher-income countries, but as they gradually have spread to LMICs, CVD mortality rates have increased globally. In absolute numbers, CVD causes four to five times as many deaths in LMICs as in HICs.
Per capita income and life expectancy increase during the age of **receding pandemics** as the emergence of public health systems, cleaner water supplies, and improved food production and distribution combine to drive down deaths from infectious disease and malnutrition. These advances, in turn, increase the productivity of the average worker, further improving the economic situation with more urban migration as economies move from agrarian to industrially based economies. Improvements in medical education follow, and along with other public health changes, contribute to dramatic declines in infectious disease mortality rates. Rheumatic valvular disease, hypertension, and stroke cause most CVD. **Coronary heart disease (CHD)** often occurs at a lower prevalence rate than that for stroke, and CVD accounts for 10% to 35% of deaths.

During the stage of **degenerative and manmade diseases**, continued improvements in economic circumstances, combined with urbanization and radical changes in the nature of work-related activities, led to dramatic changes in diet, activity levels, and behaviors such as smoking. For example, in the United States, deaths from infectious diseases decreased to fewer than 50 per 100,000 people per year, and life expectancy was up to almost 70 years. The increased availability of foods high in saturated fat, coupled with decreased physical activity, leads to an increase in atherosclerosis. In this stage, CHD and stroke predominate, and between 35% and 65% of all deaths link to CVD. Typically, the ratio of CHD to stroke is 2:1 to 3:1.

In the age of **delayed degenerative diseases**, CVD and cancer remain the major causes of morbidity and mortality, but CVD age-adjusted mortality rates are nearly cut in half—accounting for 25% to 40% of all deaths. Two significant advances have contributed to the decline in CVD mortality rates: new therapeutic approaches, and prevention measures targeted at people with CVD and people at risk for it.

Treatments once considered advanced—including the establishment of emergency medical systems and coronary care units and the

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</thead>
<tbody>
<tr>
<td>High-Income</td>
<td>27%</td>
<td>7%</td>
<td>35%</td>
<td>5%</td>
<td>28%</td>
<td>6%</td>
<td>32%</td>
<td>7%</td>
</tr>
<tr>
<td>Low- and Middle-Income</td>
<td>10%</td>
<td>6%</td>
<td>44%</td>
<td>7%</td>
<td>10.3%</td>
<td>8.1%</td>
<td>51.8%</td>
<td>6%</td>
</tr>
</tbody>
</table>

**Table 1-2** Cardiovascular disease deaths as a percentage of all deaths in each region and total regional population, 2010. (From Global Burden of Disease Study 2010. Global Burden of Disease Study 2010 mortality results 1970-2010. Seattle, Institute for Health Metrics and Evaluation, 2012.)

- East Asia and Pacific
- Middle East and North Africa
- High-Income
- Eastern Europe and Central Asia
- Latin America and the Caribbean
- South Asia
- Sub-Saharan Africa

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**Figure 1-1** Changing patterns of mortality, 1990 to 2010. CMNN = communicable, maternal, neonatal, and nutritional diseases; CVD = cardiovascular disease; INJ = injury; ONC = other noncommunicable diseases. (From Global Burden of Disease Study 2010. Global Burden of Disease Study 2010 mortality results 1970-2010. Seattle, Institute for Health Metrics and Evaluation, 2012.)

**Figure 1-2** Cardiovascular disease deaths as a percentage of all deaths in each region and total regional population, 2010. (From Global Burden of Disease Study 2010. Global Burden of Disease Study 2010 mortality results 1970-2010. Seattle, Institute for Health Metrics and Evaluation, 2012.)
widespread use of newer diagnostic and therapeutic technologies such as echocardiography, cardiac catheterization, angioplasty, bypass surgery, and implantation of pacemakers and defibrillators—have now become the standard of care. Advances in drug development also have had a major beneficial impact on both acute and chronic outcomes. Efforts to improve the acute management of myocardial infarction (MI) led to the application of life-saving interventions such as beta-adrenergic blocking agent (beta blocker) therapy, percutaneous coronary intervention (PCI), use of thrombolytics, and angiotensin-converting enzyme (ACE) inhibitor therapy (see Chapters 52 and 53). The widespread use of an “old” drug, aspirin, also has reduced the risk of dying of acute or secondary coronary events. Low-cost pharmacologic treatment for hypertension (see Chapter 44), and the development of highly effective cholesterol-lowering drugs such as statins, also have made major contributions to both primary and secondary prevention by reducing CVD deaths (see Chapter 45).

In concert with these advances, public health campaigns have conveyed that certain behaviors increase the risk of CVD and that lifestyle modifications can reduce risk. In this regard, smoking cessation has been a model of success. In the United States, for example, 57% of men smoked cigarettes in 1955; today, 23% of men smoke. The prevalence of smoking among U.S. women has fallen, from 34% in 1965 to 18.5% today. Campaigns beginning in the 1970s resulted in dramatic improvements in the detection and treatment of hypertension in the United States. This intervention likely had an immediate and profound effect on stroke rates, and a more subtle effect on CHD rates. Public health messages concerning saturated fat and cholesterol, for example, continue to decline. Overall, in this decade, the age-adjusted death rate has continued to decline at about 3% per year, from a rate of 341 per 100,000 population in 2000 to 245 per 100,000 in 2008.

Different Patterns of Epidemiologic Transition

Given the large amount of economic, social, demographic, and health data available (Table 1–2), the United States serves as a useful reference point for other countries for a classical rise and decline of CVD mortality rates, with CHD rates as high as 600 per 100,000 population at their peak. Several HICs have proceeded through four stages of the epidemiologic transition and are perhaps entering the fifth phase, roughly in the same pattern as for the United States. But many LICs (i.e., Portugal, Spain, Italy, France, Greece, and Japan) never reached the high mortality rates observed in the United States and other countries, with CHD mortality rates of 200 per 100,000 or less. Nor did some countries have the same rapid rate of decline, with slower rates in central European countries (i.e., Austria, Belgium, and

Is There a Fifth Phase: The Age of Inactivity and Obesity?

Troubling trends in certain risk behaviors and risk factors may foreshadow a new phase of the epidemiologic transition, the age of inactivity and obesity (see also Chapter 42). In many parts of the industrialized world, physical activity continues to decline while total caloric intake increases at alarming rates, resulting in an epidemic of overweight and obesity. Consequently, rates of type 2 diabetes, hypertension, and lipid abnormalities associated with obesity are rising—trends that are particularly evident in children. These changes are occurring at a time when measurable improvements in other risk behaviors and risk factors, such as smoking, have slowed. If these trends continue, age-adjusted CVD mortality rates, which have declined over the past several decades in HICs, could level out as they have for young women in the United States, or even increase in the coming years. This trend pertains particularly to age-adjusted stroke death rates. Also concerning, even in LMICs, is the uptick in obesity. According to a recent study, one in five people in China are overweight or obese. Other new data indicate that as many as 40% of South African women may be overweight.

Fortunately, recent trends in the first decade of this century suggest there may be a tapering in the increases in obesity among adults, although the rates remain alarmingly high at nearly 34%. Furthermore, continued progress in the development and application of therapeutic advances and other secular changes appear to have offset the effects from the changes in obesity and diabetes—cholesterol levels, for example, continue to decline. Overall, in this decade, the age-adjusted death rate has continued to decline at about 3% per year, from a rate of 341 per 100,000 population in 2000 to 245 per 100,000 in 2008.

### TABLE 1–1 Five Typical Stages of Epidemiologic Transition in Predominant Causes of Death

<table>
<thead>
<tr>
<th>STAGE</th>
<th>DESCRIPTION</th>
<th>TYPICAL PROPORTION OF DEATHS CAUSED BY CVD (%)</th>
<th>PREDOMINANT TYPES OF CVD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pestilence and famine</td>
<td>Prevalence of malnutrition and infectious diseases as causes of death; high rates of infant and child mortality; low mean life expectancy</td>
<td>&lt;10</td>
<td>Rheumatic heart disease, cardiomyopathies caused by infection and malnutrition</td>
</tr>
<tr>
<td>Receding pandemics</td>
<td>Improvements in nutrition and public health lead to decrease in rates of deaths caused by malnutrition and infection; precipitous decline in infant and child mortality rates</td>
<td>10-35</td>
<td>Rheumatic valvular disease, hypertension, CHD, stroke</td>
</tr>
<tr>
<td>Degenerative and manmade diseases</td>
<td>Increased fat and caloric intake and decreased physical activity lead to emergence of hypertension and atherosclerosis; with increased life expectancy, mortality rates for chronic, noncommunicable diseases exceed those for malnutrition and infectious diseases</td>
<td>35-65</td>
<td>CHD, stroke</td>
</tr>
<tr>
<td>Delayed degenerative diseases</td>
<td>CVDs and cancer are the major causes of morbidity and mortality; better treatment and prevention efforts help avoid deaths among those with disease and delay primary events Age-adjusted CVD mortality declines, with CVD affecting older and older individuals</td>
<td>40-50</td>
<td>CHD, stroke, congestive heart failure</td>
</tr>
<tr>
<td>Inactivity and obesity</td>
<td>Increasing obesity and diabetes prevalence rates; some decrease in CVD mortality rates in women</td>
<td>33</td>
<td>CHD</td>
</tr>
</tbody>
</table>

CHD = coronary heart disease; CVD = cardiovascular disease.

CURRENT VARIATIONS IN THE GLOBAL BURDEN OF CARDIOVASCULAR DISEASE

Examination of regional trends is helpful in estimating global trends in the burden of disease, particularly CVD. Because 85% of the world’s population lives in LMICs, rates in these countries largely drive global CVD rates. Even as rates fall in HICs, CVD rates worldwide are accelerating, because most low- and middle-income regions are entering the second and third phases of the epidemiologic transition, marked by rising CVD rates.

Worldwide, the number of CVD deaths increased by 31% between 1990 and 2010, but age-adjusted death rates decreased by 21.2% in the same period, from 298 per 100,000 population to 235 per 100,000—suggesting significant delays in age at occurrence and/or improvements in case-fatality rates. DALYs lost as a result of CVD decreased as well, from 4540 per 100,000 to 4282 per 100,000. Unfortunately, not all countries appear to share in the reductions. The magnitude of the peak of the CVD epidemic has a great range (Fig. 1-3; see also Figs. 1-1 and 1-2), with concomitant variability in whether the peak has been achieved at all. In this section, we describe and highlight trends in the seven regions of the world as defined by the Global Burden of Disease (GBD) project, which includes HICs as one grouping and divides the remaining LMICs into six geographic regions with a variety of subregions, outlined further on.

Our data for lives lost and DALYs come from the Global Burden of Diseases, Injuries, and Risk Factors Study 2010 (GBD 2010), which identified and compiled mortality data from 187 countries from 1980 to 2010. Although extensive, data from GBD 2010 have limitations. The availability and reliability of data on cause of death—especially in LMICs without standardized protocols—are uncertain. Data for demographic and social indices are from the World Bank’s World Development Indicators (WDI); those for gross national income (GNI) per capita are reported using the Atlas method in 2011 U.S. dollars.

In 2010, CHD accounted for 13.3% of all deaths worldwide. The second largest cause of death was stroke, at 11.1% (equally split between ischemic stroke and hemorrhagic and other nonischemic forms of stroke). An estimated 12.9 million people died from CHD and stroke, which together accounted for nearly a quarter of all deaths worldwide in 2010.

Although still significant, deaths from communicable, neonatal, and maternal diseases are decreasing worldwide—a 17% decrease occurred between 1990 and 2010. Deaths from noncommunicable diseases increased in the same time period. In 2010, CHD accounted for the largest portion of global years of life lost (YLLs) and DALYs. Stroke was the third-largest contributor to global YLLs and DALYs. By contrast, in 1990, communicable diseases accounted for the largest portion of both YLLs and DALYs.
LMCs have a high degree of heterogeneity with respect to the phase of the epidemiologic transition. First, LMC sub-regions differ by age-adjusted CVD death rates, as well as by trends over the past 20 years (Fig. 1-4, see also Figs. 1-1 to 1-3). CVD mortality rates are increasing in most LMCs but are decreasing in HICs. Next, LMC subregions are unique, as illustrated by the different CVD disease rates by cause in each region (Fig. 1-5). Finally, in the East Asia and Pacific and sub-Saharan regions, stroke still exceeds CHD as a cause of CVD death (Fig. 1-6). Countries in the East Asia and Pacific region appear to be following more of a Japanese-like transition, with relatively high stroke rates. Higher stroke rates in Africa, on the other hand, may reflect these countries’ positions in an earlier stage of the epidemiologic transition. Hypertensive heart disease is the largest single contributor among remaining causes of CVD morbidity and mortality.

Variability in disease prevalence among various regions probably results from multiple factors. First, the countries are in various phases of the epidemiologic transition described earlier. Second, the regions may have cultural and/or genetic differences that lead to varying levels of CVD risk. For example, per capita consumption of dairy products (and thus consumption of saturated fat) is much higher in India than it is in China, although it is rising in both countries. Third, certain additional competing pressures exist in some regions, such as war or infectious diseases (human immunodeficiency virus infection/acquired immunodeficiency syndrome [HIV/AIDS]) in sub-Saharan Africa.

Because CHD afflicts a younger population in LMICs, an increased number of deaths affect the working population. For some LMICs, the severity of the epidemiologic transition has appeared to follow a reverse social gradient, with members of lower socioeconomic groups suffering the highest rates of CHD and the highest levels of various risk factors.6 Unfortunately, reductions in risk factors do not follow the same trend. Compared with people in the upper and middle socioeconomic strata, those in the lowest stratum are less likely to acquire and apply information on risk factors and behavior modifications, or to have access to advanced treatments. Consequently, CVD mortality rates decline later among those of lower socioeconomic status.

**High-Income Countries**

Demographic and Social Indices

Nearly 1 billion people (35% of the world’s population) live in HICs, which are divided into four subregions: Asia-Pacific, Australasia, Western Europe, and North America. A majority of the population—a close to 80%—is urban. Unlike other GBD regions, HICs are geographically dispersed but economically similar. The United States, the most populous of the HICs, has approximately 312 million people; Brunei Darussalam has the lowest population of 405,900 people.11 The highest life expectancies in the world occur in HICs, where the average life expectancy is 80 years.12 The GNI per capita in the region ranges from $18,620 in Malta to $88,890 in Norway. The United States is closer to the middle, with a GNI per capita of $48,450. The region has high health expenditure, accounting for nearly a tenth of the region’s gross domestic product (GDP). Brunei Darussalam and Singapore spend only 2.8% and 4.0% of their GDPs, respectively, on health care. The United States, on the other hand, spends nearly 18%, or $8362 per capita. Other HICs—such as Norway, Luxembourg, and Switzerland—have similar per capita expenditures, although these account for much smaller portions of their GDPs.14

**Burden of Disease**

In 2010, CVD was responsible for 35.8% of all deaths in high-income regions, and CHD caused more than half of these deaths (see Fig. 1-6). The movement of most HICs through the epidemiologic transition, with rising levels of risk factors and CVD death rates until the 1970s and then declines in both over the next 40 years, resembles what occurred in the United States. CHD is the dominant form, with rates that tend to be twofold to fivefold higher than stroke rates. Two notable exceptions are Portugal, where stroke rates for both men and women are nearly twofold higher than CHD rates, and Japan, where stroke causes far more fatalities than CHD. In both of these countries, however, the pattern seems to be moving toward that seen in other HICs, with more rapid declines in stroke rates than in CHD rates.
is manifest. Thus, the average age at death from CVD continues to climb, and as a result, CVD affects a larger retired population.

Western Europe, with a CVD mortality rate of 367 per 100,000 in 2010, had the highest mortality rates, while Australasia had the lowest at 259 per 100,000. As mentioned above, mortality rates for CHD are higher than those for stroke in high-income regions, where CHD also accounts for a larger portion of all CVD deaths. The exception is Asia-Pacific, where death rates for stroke and CHD are 130 per 100,000 and 94 per 100,000, respectively. Mortality rates and number of deaths attributable to stroke and CHD increased in this region between 1990 and 2010; stroke rates increased by approximately 18%, whereas CHD rates increased by nearly 40%. Japan is unique among HICs—as its communicable disease rates fell in the early 20th century, its stroke rates increased dramatically. CHD rates, however, did not rise as sharply as they did in other industrialized nations, and have remained lower than in any other industrialized country. Overall, CVD rates have fallen 60% since the 1960s, largely because of a decrease in age-adjusted stroke rates. Japanese men and women currently have the highest life expectancies in the world: 86.4 years for women and 79.6 years for men. The difference between Japan and other industrialized countries may stem in part from genetic factors, but the Japanese fish- and plant-based, low-fat diet, and resultant low cholesterol levels, probably have played a more important role. Nevertheless, as is true for so many countries, dietary habits in Japan are undergoing substantial changes. Since the late 1950s, cholesterol levels have progressively increased in both urban and rural populations. Although the prevalence of CVD risk factors is increasing in the Japanese population, the incidence of coronary artery disease remains low. This situation could change, however, as there seems to be a lag phase before dietary changes manifest as CHD events.

### East Asia and Pacific

**Demographic and Social Indices**

The EAP region is the most populated low-income and middle-income region in the world, with nearly 2 billion people; approximately 49% of the region is urban. The GNI per capita is $4243, ranging from $4420 in Thailand to $1130 in Laos. In 2004, total health expenditure was 4.8% of total GDP, or $183 per capita. The region is divided into three distinct subregions: Southeast Asia, East Asia, and Oceania. China is by far the most populated country, representing almost 70% of the region. Life expectancy has risen quickly across the EAP region in past decades, up to an average of 72 years. In China, the increase has been dramatic: from 37 years in the mid-1950s to 73 years in 2010. This increase has been accompanied by a large rural to urban migration pattern, rapid urban modernization, aging of the population, decreased birth rates, major dietary changes, increasing tobacco use, and a transition to work requiring low levels of physical activity.

### Burden of Disease

CVD caused more than 4.5 million deaths in the EAP region in 2010, accounting for 35.2% of all deaths in the region. More than half of those deaths resulted from ischemic heart disease, whereas only 31% were due to stroke (see Fig. 1-6). CVD death rates differed significantly between subregions, most notably in Oceania. Mortality rates were highest in East Asia, at 234 per 100,000 in 2010. Death rates in Oceania, on the other hand, were 110 per 100,000, well below the global average. Between 1990 and 2010, death rates for CVD increased in all three subregions, although to various degrees. Rates in East Asia and Southeast Asia increased by approximately 24%, but by only 3% in Oceania. In Southeast Asia, and East Asia, CVD accounts for the largest percentage of total DALYs lost in the regions (26 million and 67 million, respectively).

Stroke and CHD are the leading causes of death in the East Asia and Southeast Asia subregions. In Oceania, however, lower respiratory infections and diabetes account for the largest proportion of
deaths. Whereas stroke and CHD rates increased in both East Asia and Southeast Asia, stroke rates decreased slightly in Oceania, from 40 per 100,000 to 36 per 100,000. China appears to be straddling the second and third stages of a Japanese-like epidemiologic transition. Among men in China 35 to 64 years of age, stroke death rates are 217 to 243 per 100,000, versus CHD death rates of 64 to 106 per 100,000.

Even with high stroke rates, CHD is emerging as a large and growing burden in East Asia. Data from the largest death registration and classification study in China showed that CHD accounted for 13% to 22% of overall CVD deaths and 4% to 9% of total deaths, with the higher percentages seen in urban areas. In 2004, the World Health Organization (WHO) estimated that nearly 400,000 people in China died from CHD, and that 652,000 cases of CHD were diagnosed. The rates for age-adjusted mortality from CHD were 90 to 128 per 100,000 for men and 57 to 98 per 100,000 for women. Higher rates were seen in urban areas than in rural areas (by a factor of six), in higher-income areas than in lower-income areas, and in northeastern areas of China than in southern areas.

CHD rates have grown quickly over the past two decades in China. Age-adjusted CHD mortality increased 39% in women and 41% in men, 35 to 74 years of age, between 1984 and 1999. Furthermore, the incidence of CHD increased by 2.7% annually in men and 1.2% annually in women. Although rates are higher, hospitalizations are somewhat low. Acute MI was the diagnosis in 4.1% of all hospital discharges in 2004 in large cities, and in 2.1% of discharges in smaller cities and rural areas.

### Central and Eastern Europe and Central Asia

**Demographic and Social Indices**

Of the three subregions that constitute this region—Central Asia, Central Europe, and Eastern Europe—Eastern Europe is the most populated. Russia alone accounts for more than 30% of the region’s 404 million inhabitants. Sixty-five percent of the population in the region is urban, with an average life expectancy of 71 years. The average GNI per capita for the region ranges from $49 per capita in Tajikistan to $23,610 in Slovenia. Russia has a GNI of $10,400. On average, the region spends more than 6% of total GDP on health. Health expenditure per capita ranges from $49 per capita in Tajikistan to $2154 in Hungary. Russia spends about $225 per capita, or 5.1% of its GDP.

**Burden of Disease**

The highest rates of CVD mortality occur in this region. CVD mortality rates are 866 per 100,000 in Eastern Europe and 604 per 100,000 in Central Europe. Overall rates resemble those seen in the United States in the 1960s, when CVD was at its peak. CHD is generally more common than stroke, which suggests that the countries that constitute Eastern Europe and Central Asia are largely in the third phase of the epidemiologic transition. As expected in this phase, the average age of people who develop and die of CVD is lower than that in high-income economies. In 2010, CVD accounted for nearly two thirds of all deaths in the region, 58.3% of which were due to CHD and 33.5% due to stroke. In Eastern Europe alone, 29.7 million DALYs were lost as a result of CHD in 2010.

A country-level analysis reveals important differences in CHD profiles within the region (see Fig. 1.3). Since the dissolution of the Soviet Union, CVD rates have increased surprisingly in some of these countries, with the highest rates (nearly 800 per 100,000 for men) in Ukraine, Bulgaria, Belarus, and Russia. In Russia, increased CVD rates have contributed to falling life expectancy—particularly for men, whose life expectancy dropped steadily from 71.6 years in 1986 to as low as 58 years in 1999. Yet, life expectancy has trended upward in more recent years—67.6 years for men in 2010—even as CVD mortality rates have increased.
By 2010, CVD mortality rates in the region were the highest in the world. Importantly, deaths resulting from CHD in these countries are not restricted to older adults. The GBD study estimates that working-age populations (15 to 69 years of age) have a significant CHD burden. Nearly a third of all deaths in persons 45 to 69 years of age, for example, result from CVD. For people 60 to 64 years of age, CVD accounts for half of all deaths, 27% of which are due to CHD.  

Latin America and the Caribbean  
Demographic and Social Indices  
The Latin America and Caribbean (LAM) region comprises Andean Latin America, Central Latin America, Southern Latin America, Tropical Latin America, and the Caribbean. The region has a total population of 589 million, 79% of which is urban.  

Latin America and the Caribbean  
Demographic and Social Indices  
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Burden of Disease  
This area bears a substantial CVD burden. In 2010, CVD caused 28.8% of all deaths in the region. Unlike in HICs, where CHD dominates among circulatory diseases, CHD and cerebrovascular disease contribute similarly to mortality in this region (see Fig. 1-6), pointing to relatively higher rates of untreated hypertension. 

Mortality rates vary significantly by subregion (see Fig. 1-3). Mortality rates for CHD and stroke are highest in the Caribbean (100 deaths per 100,000 population and 125 per 100,000, respectively); unlike global trends, both mortality rates increased between 1990 and 2010. Death rates also increased in Central Latin America and Andean Latin America; similar increases in mortality rates occurred in Tropical Latin America. Together, CHD (14%), stroke (6.9%), and hypertensive heart disease (2.1%) accounted for nearly a quarter of all deaths in Central Latin America in 2010. Southern Latin America—which includes Argentina, Chile, and Uruguay—was the only subregion to follow global patterns in mortality rates. Overall CVD, CHD, and stroke mortality rates decreased in this subregion between 1990 and 2010, but to a lesser extent than for global changes. The lower reductions in the region are attributed to rapid lifestyle changes—unfavorable dietary changes, increased smoking, increased obesity, and less exercise.

North Africa and the Middle East  
Demographic and Social Indices  
The 19 countries of the North Africa and Middle East region represent approximately 5% of the world’s population (357 million people). Egypt and Iran are the two most populous countries in the region, with Egypt representing 24% of total inhabitants and Iran 22%. Approximately 59% of the population is urban, with an average life expectancy of 72 years. The average GNI per capita for the region is $3869, ranging from $1070 in Yemen to $48,900 in Kuwait. Approximately 5.3% of the GDP, or approximately $203 per capita, is used for health expenditures in the region. The per capita health expenditure ranges from $63 in Yemen to $1450 in the United Arab Emirates.

Burden of Disease  
Forty-two percent of all deaths in the region are attributable to CVD, 47% of which are due to CHD and 30% are due to stroke. CVD mortality rates for the region are lower than global averages. In 2010, the death rate per 100,000 for CHD, stroke, and overall CVD were 93, 59, and 199, respectively. 

Individual country data show that 12 of the region’s countries rank in the top 50 in age-adjusted CHD mortality rates. Somalia, Iraq, and the Sudan are in the top 25 with rates of 219, 214, and 212 per 100,000, respectively. Iran may have a higher prevalence burden than other countries, including Saudi Arabia and Jordan. A study of a random sample of 3725 people in Iran found that 11.3% had coronary symptoms, and an additional 1.4% had an MI; the age-adjusted prevalence was therefore 12.7%. In Jordan, a study showed that 5.9% of 3083 participants had an MI.

South Asia  
Demographic and Social Indices  
The South Asia region (SAR), one of the world’s most densely populated regions, comprises about 24% of the world’s population with more than 1.6 billion residents. India, home to nearly 75% of the region’s inhabitants, is the largest country in the region. Only 31% of the region is urban, and life expectancy is approximately 65 years.
Average GNI per capita for the region is $1299, ranging from $540 in Nepal to $6530 in Maldives. India’s GNI per capita of $1410 sits near the regional average. Countries in the SAR spend an average of 3.9% of the total GDP, or $47 per capita, on health care. Maldives spends the most per capita at $218, and India spends $31, or 5% of its GDP. The lowest expenditures for health care are $22 per capita in Pakistan and $23 in Bangladesh.16

**Burden of Disease**

CVD accounts for 20% of all deaths in the SAR. CHD was the leading cause of mortality in 2010—responsible for 10.6% of total reported fatalities, or 1.8 million deaths, and more than half of CVD mortality. Cerebrovascular disease accounted for 6.8% of all deaths and 30% of CVD deaths. Nearly 60.5 million DALYs are lost due to CVD in the region, accounting for 10% of all DALYs lost. CHD is responsible for 4.6% of the DALYs lost because of CVD, nearly twice as high as for stroke.17 Mortality rates for CVD are increasing in the region.

Several studies in India and Pakistan suggest substantial morbidity and mortality resulting from CHD in this region. In 1990, 1.18 million people died in India as a consequence of CHD; by 2010, this number increased to an estimated 2.03 million.17 CVD probably represents 25% of all deaths in India. Studies also show that CHD prevalence is higher in men and in urban residents.18 Prevalence of CHD in India recently was estimated at more than 10% in urban areas and 4.5% in rural areas.19 The GBD study in Pakistan found a prevalence of approximately 6% in men and 4% in women, but active ischemia was twice as frequent in women. The study authors suggest that one in five adults in urban parts of Pakistan have CHD,20 and that only a fourth of these adults are aware of their disease and seeking medical care. In contrast with the epidemiologic transition in HICs, recent evidence suggests that residents of the SAR of lower socioeconomic status are developing a higher burden of CHD first.21 Tobacco use and hypertension, for example, were both significantly more prevalent among cohorts with lower levels of education.22

Another demographic trend in the SAR is a considerable increase in urban residents, a shift that usually correlates with increased rates of CHD. Currently, 31% of all inhabitants in the region live in an urban setting, a number that is expected to rise.23 A review of epidemiologic studies in the country found that between 1965 and 2005, CHD prevalence increased from approximately 4% to 12% in urban populations.24 Rural populations are experiencing similar increases in CHD prevalence. More recent data from the rural region of Andhra Pradesh in South India suggest an actually higher prevalence in many rural regions.25 CHD death rates exceeded 15% in this study, meaning that the rural-versus-urban protection factor no longer exists—or that the urban rates, if reported more carefully, could be much higher.

The rise in CHD mortality contributes to the economic burden in the Indian subcontinent. Data indicate that symptoms of CHD arise a full 5 to 10 years earlier in this region than in Western European and Latin American countries.26 Furthermore, CVD affects a substantial proportion of working-age citizens. A study in rural India, for example, found that 51% of all CVD deaths occurred in individuals younger than 70 years of age.27

**Sub-Saharan Africa**

**Demographic and Social Indices**

The GBD study divides sub-Saharan Africa into four subregions: Central Africa, East Africa, Southern Africa, and Western Africa. Approximately 875 million people live in these four regions, with Nigeria being the most populous (163 million) and Cape Verde being the least populous (500,600). Only 36% of the population in the region is urban. The average GNI per capita is $1255, ranging from $250 in Burundi to $7480 in Botswana. Overall, the region also has the lowest average life expectancy—54 years.

Average public and private health care expenditures for the region are 6.5% of the total GDP, or $84 per capita. The range of health care expenditures per capita for the region is similar to the GDP range for this region, from $3 in Burundi to $511 in Seychelles. Nigeria spends $23 per capita, or 4.6% of the total GDP.28

**Burden of Disease**

In Western Africa, CVD accounts for 7.5% of all deaths. The highest portion of CVD-caused deaths occurred in Southern Africa, where 13% of all deaths were due to CVD. Mortality rates in the region are lower than global averages, and are decreasing, in line with global trends. The exception is Southern Africa, where rates increased from 129 per 100,000 to 136 per 100,000. Communicable, neonatal, and maternal disorders still dominate causes of death in the sub-Saharan region. Malaria and HIV/AIDS are the leading causes of death, accounting for nearly half of all deaths in the region.29

**Human Immunodeficiency Virus Infection and Coronary Heart Disease**

In view of the large burden of disease attributable to HIV/AIDS, the potential risk of CVD among persons being treated with antiretroviral medications is of growing concern (see Chapter 70). As in HICs, CVD death appears to be rising among people older than 65 years of age in rural South Africa.30 For those between 50 and 64 years of age, however, CVD deaths appear to have halved in South Africa, probably as a consequence of competing HIV/AIDS mortality.31 HIV-seropositive men older than 50 years of age have a higher prevalence of dyslipidemia, diabetes, and peripheral artery disease (50% of cases were asymptomatic), compared with their noninfected counterparts.32 Of note, 55% of these HIV-infected men were prior smokers, and they also were more likely to use antihypertensive drugs, lipid-lowering agents, and antidiabetic medications. A recent study of 95 patients initiating antiretroviral drugs indicated that patients who had high baseline lipid levels showed a marked increase in lipoprotein(a).33 The coupling of HIV infection with expanding uptake of antiretroviral therapy (ART), particularly in South and East Africa,34,35 adds another layer of complexity. Today, HIV/AIDS can be regarded as a treatable chronic illness, with the expectation that persons with HIV/AIDS will live longer and lead more active lives, consequently increasing their communicable disease risk.36 HIV infection appears to have an independent cardiovascular effect, and treatment with ART may cause dyslipidemia.37,38 Further studies suggest that in addition to these mechanisms, HIV seropositive status may serve as a marker to identify a subgroup of persons at high risk for development of CVD.39 Collectively, these data indicate that the interaction of seropositive HIV status, ART, and risk for acquiring CVD warrants continued attention.

**RISK FACTORS**

CVD worldwide is largely driven by modifiable risk factors, such as smoking, lack of physical activity, and diets high in fat and salt (see also Chapters 42 to 45 and 61). The INTERHEART study showed that smoking, hypertension, abdominal obesity, physical inactivity, and a high-risk diet were responsible for a significant component of MI risk. Elevated levels of blood pressure (BP) and cholesterol remain the leading causes of CHD; tobacco, obesity, and physical inactivity remain important contributors as well.

The GBD project estimated that the population-attributable fraction (PAF) for individual risk factors for CHD in LMICs in 2001 were as follows: high BP, 44%; high cholesterol, 46%; overweight and obesity, 16%; low fruit and vegetable intake, 30%; physical inactivity, 21%; and smoking, 15%. Unique features regarding some CHD risk factors in LMICs are described next.

**Tobacco**

By many accounts, tobacco use is the most preventable cause of death in the world. Over 1.3 billion people use tobacco worldwide, more than 1 billion of whom smoke34,35; the rest use oral or nasal tobacco. More than 80% of tobacco use occurs in LMICs, and if current trends continue unabated, tobacco will cause more than 1 billion deaths during the 21st century (Fig. 1-7).

Tobacco use varies greatly across the world (see Fig. 1-7). Although historically greatest in HICs, tobacco consumption has shifted...
High rates of smoking are not limited to men. Smoking prevalence among women is high—and increasing—in several countries in the world, including Kiribati (42.9%), Austria (45.1%), Nauru (50%), and Greece (41.4%). In general, however, considerably more men than women smoke. Exceptions to this pattern include Nauru and Greece, which have comparable tobacco use prevalence in men and in women. Where they do occur, variations by sex can be substantial. In China, for example, tobacco use prevalence is 50% in men but only 2.2% in women. Indonesia has similarly diverging trends: prevalence in men is 61.3%, and only 5.1% in women. Significant variations...
also occur in North Africa, the Middle East, and some countries in sub-Saharan Africa. Tobacco use is generally less than 1% in women in these regions, but is much higher in men.

Other forms of tobacco use increase risk for CHD. Bidis (hand-rolled cigarettes common in South Asia), kretek (clove and tobacco cigarettes), hookah pipes (water pipes used for smoking flavored tobacco), and smokeless tobacco all link to increased CHD risk.31,42 The combined use of different forms of tobacco is associated with a higher risk of MI than using one type.

Secondhand smoke is another well-established cause of CHD. In 2011, approximately 600,000 nonsmokers died as a consequence of exposure to secondhand smoke. A retrospective analysis of 192 countries found that the largest portion of secondhand smoke–related deaths in 2004 resulted from ischemic heart disease.32 These observations may explain the large and immediate drop seen in communities such as Helena, Montana, and in Scotland, which implemented smoke-free laws and found 20% to 40% decreases in admissions for MI, controlling for time, locality, and other variables.33 Smoking bans have both immediate and long-term effects in reducing admissions for acute coronary syndrome (ACS). In Ireland, which implemented a country-wide smoking ban in workplaces, ACS-related hospital admissions promptly decreased by 12%, and 2 years after the implementation of the ban such admissions decreased by an additional 13%.

Hypertension

Elevated BP is an early indicator of epidemiologic transition. Rising mean population BP occurs as populations industrialize and move from rural to urban settings. Worldwide, approximately 62% of strokes and 49% of CHD cases are attributable to suboptimal (above 115 mm Hg systolic) BP, a factor thought to account for more than 7 million deaths annually. A relatively recent study by Lawes and co-workers estimated that 14% of deaths and 6% of DALYs lost globally were due to nonoptimal levels of BP.34 Although most societies define hypertension as a systolic BP greater than 140 mm Hg, Lawes and colleagues found that just over half of the attributable CVD burden occurs among persons with a systolic BP less than 145 mm Hg. The high rate of undetected, and therefore untreated, hypertension presents a major concern in LMICs. The high prevalence of undetected and untreated hypertension probably drives the elevated rates of hemorrhagic stroke throughout Asia.

The most recent update of the GBD study analyzed mean systolic BP between 1980 and 2008 using multiple published and unpublished health surveys and epidemiologic studies. The analysis—which applied a Bayesian hierarchical model to each sex by age, country, and year—found a global decrease in mean systolic BP between 1980 and 2008 in both men and women.35 Worldwide, the age-standardized prevalence of uncontrolled hypertension has decreased from 33% to 29% in men, and from 29% to 25% in women, between 1980 and 2008. But the number of people with uncontrolled hypertension (systolic BP of 140 mm Hg or higher) has increased—in 1980, 605 million had uncontrolled hypertension, and by 2008, the number increased to 978 million. The trend results largely from population growth and aging. Globally, mean systolic BP has decreased by 0.8 mm Hg per decade among men; the number is slightly higher among women, at 1.0 mm Hg per decade. In 2008, the combined regions of Australasia, North America, and Western Europe had a mean total cholesterol of 5.24 mmol/L in men and 5.23 mmol/L in women. In Greenland, mean total cholesterol was as high as 5.7 mmol/L for both sexes. Sub-Saharan Africa had the lowest levels for both sexes. Some cohorts—largely, men in Southern African countries like Liberia, Nigeria, and Burkina Faso—had levels less than 4.0 mmol/L.

Between 1980 and 2008, mean total cholesterol levels decreased by 0.08 mmol/L per decade in men and by 0.07 mmol/L per decade in women. The most significant decreases in cholesterol levels occurred in the Central Europe, Eastern Europe, and Central Asia regions: 0.23 mmol/L per decade in men, and 0.24 mmol/L per decade in women. The high-income regions of Australasia, North America, and Western Europe had similarly large decreases in cholesterol levels: 0.19 mmol/L per decade in men, and 0.21 mmol/L per decade in women. Countries like Finland and Sweden had notably faster decreases in cholesterol levels than other Western European countries.

Several exceptions to the worldwide downward trend in cholesterol levels occurred. In the EAP region, levels increased by 0.05 mmol/L per decade in men and by 0.09 mmol/L per decade in women. The high-income Asia-Pacific subregion showed a similar trend, but the increase was more moderate (0.1 mmol/L per decade). South Korea demonstrated no change in cholesterol levels as a result of maintaining a diet low in saturated fats. Singapore data were also

The most significant decreases occurred in high-income regions, where mean systolic BP decreased by 2.4 mm Hg per decade in men and 3.1 mm Hg per decade in women. The decrease in men ranged from 1.7 mm to 2.8 mm Hg per decade, with the greatest decrease occurring in the North America subregion. The decrease in mean systolic BP in women ranged from 2.3 mm Hg per decade in North America to 3.9 mm Hg per decade in Australasia.

Mean systolic BP increased in several regions. In South Asia, systolic BP increased by 0.8 mm Hg per decade in men and 1.0 mm Hg per decade in women. Southeast Asia saw similar increases: 0.9 mm Hg per decade in men and 1.3 mm Hg per decade in women. In East Africa, mean systolic BP increased by 1.6 mm Hg per decade in men and 2.5 mm Hg per decade in women. The most significant increases in men occurred in East Africa (1.6 mm Hg per decade). In women, mean systolic BP increased the most in Oceania (2.7 mm Hg per decade).

Notable sex differences occurred in Oceania and West Africa. In Oceania, mean systolic BP increased by 2.7 mm Hg per decade, the largest increase in any female cohort in the world. In men in this region, on the other hand, mean systolic BP increased by only 1.2 mm Hg per decade. Data from West Africa show diverging trends in mean systolic BP in men and women. Although mean systolic BP decreased in men in West Africa by 0.4 mm Hg per decade, systolic BP in women in this subregion increased by 2.3 mm Hg per decade.

Lipids

Worldwide, high cholesterol causes some 56% of ischemic heart disease and 18% of strokes amounting to 4.4 million deaths annually. Unfortunately, most LMICs have limited data on cholesterol levels, and often only total cholesterol values are collected. In HICs, mean population cholesterol levels are generally decreasing, but in LMICs, these levels vary widely. As countries move through the epidemiologic transition, mean population plasma cholesterol levels typically rise. Changes accompanying urbanization clearly play a role, as plasma cholesterol levels tend to be higher among urban residents than among rural residents. This shift results largely from greater consumption of dietary fats—primarily from animal products and processed vegetable oils—and decreased physical activity.

Globally, mean serum total cholesterol levels have decreased.46 The GBD study analyzed data between 1980 and 2008 using a bayesian model to estimate mean total cholesterol by age, country, and year. Age-standardized mean total cholesterol was 4.64 mmol/L (179.6 mg/dL) in men and 4.76 mmol/L in women in 2008 (184.2 mg/dL). Some of the highest levels of cholesterol occurred in high-income regions (Fig. 1–9). In 2008, the combined regions of Australasia, North America, and Western Europe had a mean total cholesterol of 5.24 mmol/L in men and 5.23 mmol/L in women. In Greenland, mean total cholesterol was as high as 5.7 mmol/L for both sexes. Sub-Saharan Africa had the lowest levels for both sexes. Some cohorts—largely, men in Southern African countries like Liberia, Nigeria, and Burkina Faso—had levels less than 4.0 mmol/L.

Regional and sex variations exist in systolic BP (Fig. 1–8). The highest mean systolic BP in 2008 occurred in East and West African countries, where both men and women had systolic BP levels that were significantly higher than global averages. In Mozambique and São Tomé and Príncipe, for example, mean systolic BP in women was 135.4 mm Hg and 136.3 mm Hg, respectively. In men, mean systolic BP was as high as 137.5 mm Hg in Mozambique and 139.4 mm Hg in Niger. Men in Eastern Europe had mean systolic BP levels comparable to those in East and West Africa. Mean systolic BP was lowest in high-income regions such as Australasia (systolic BP of 117.4 mm Hg in Australian women) and North America (systolic BP of 123.3 mm Hg in U.S. men).
Eighty percent of people with diabetes live in LMICs (Fig. 1-10). The highest regional prevalence for diabetes occurs in the Middle East and North Africa, where an estimated 12.5% of the adult population (20 to 79 years of age) has diabetes. Future growth will be concentrated in LMICs, especially in regions such as sub-Saharan Africa, Middle East and North Africa, and Southeast Asia. In addition, a majority of cases will remain within the 45-to-64-year age group in LMICs, whereas those older than 65 years of age are most affected in HICs.

Rising rates of obesity, and the aging and urbanization of the population, likely link to the diabetes epidemic. Nearly 90% of type 2 diabetes cases relate to obesity, and diabetes and its related complications are the costliest consequence of obesity. Mortality from diabetes is also on the rise, with approximately 4.6 million deaths in 2011. Asian countries face a relatively larger burden of diabetes, compared with the Europe and Central Asia or Latin America and Caribbean regions. India and China, for example, have the largest numbers of diabetics in the world—61.3 million and 90 million, respectively. Asian populations may have a higher risk for developing diabetes.

Notable: In the 1980s, cholesterol levels decreased for both men and women, but beginning in 2000, the downward trend ended in men. In women, the trend reversed, increasing from 4.7 mmol/L in 2000 to 5.3 mmol/L in 2008. Several regions—including North Africa and Middle East, sub-Saharan Africa, and South Asia—showed no notable change in cholesterol levels, owing in part to a lack of available historical data. In general, women in low-income and middle-income subregions had higher total cholesterol than their counterparts in HICs.

**Diabetes**

The incidence of diabetes has grown rapidly worldwide in the past 30 years. According to the GBD study, an estimated 346 million people worldwide have diabetes. The more expansive International Diabetes Foundation (IDF) Atlas definition—which, in addition to fasting plasma glucose (FPG) as in the GBD study, includes oral glucose tolerance and HbA1c tests—found that 366 million people had diabetes in 2011. Nearly 50% of these cases were undiagnosed. By 2030, the number of people with diabetes is expected to increase to 522 million. This increase is estimated to occur at 2.7% annually, a higher growth rate than that of the total world adult population.\footnote{From Goodarz D, Finucane MM, Lin JK, et al: National, regional, and global trends in serum total cholesterol since 1980: Systemic analysis of health examination surveys and epidemiological studies with 786 country-years and 5.4 million participants. Lancet 377:568, 2011.}
Global Burden of Cardiovascular Disease

Obesity
Obesity is increasing throughout the world, and particularly in LMICs, where the trajectories are steeper than those in HICs. According to the latest GBD study, nearly 1.46 billion adults were overweight (BMI

even at a lower BMI, because of a greater tendency toward visceral obesity. In addition, this population may experience both undernutrition (during the perinatal period) and rapid weight gain (during childhood), a combination that increases the risk for insulin resistance.25

The most recent GBD study found a global increase in mean FPG. The study analyzed multiple published and unpublished health surveys and epidemiologic studies by applying a bayesian hierarchical model for each sex by age, country, and year. Between 1980 and 2008, mean FPG increased by 0.07 mmol/L (1.26 mg/dL) per decade in men and 0.08 mmol/L (1.44 mg/dL) per decade in women. The upward trend in FPG was nearly universal.29 In almost every region worldwide, mean FPG increased or remained unchanged; regions that displayed apparent decreases (men in the East Asia and South-east Asia region, for example) were not statistically different from flat trends (posterior probabilities of 0.80 or less).

Although some regions had unchanging mean FPG levels, other regions—including southern and tropical Latin America, Oceania, and high-income regions—experienced significant increases. The most notable region is Oceania. Between 1980 and 2008, mean FPG increased by 0.22 mmol/L per decade in men and 0.32 mmol/L per decade in women. By 2008, Oceania had the highest mean FPG for both sexes (6.09 mmol/L for men; 6.09 mmol/L for women) and the highest prevalence of diabetes (15.5% in men; 15.9% in women) in the world.

In addition to Oceania, the Caribbean and North Africa and the Middle East have the highest mean FPG levels in the world. Between 21% and 25% of men and between 21% and 32% of women in these countries have diabetes. By contrast, men in sub-Saharan Africa and women in high-income Asia-Pacific countries had the lowest mean FPG in 2008—5.27 mmol/L and 5.17 mmol/L, respectively. The only significant decrease in mean FPG occurred in women in Singapore, where levels fell by 0.21 mmol/L per decade.

Trends in mean FPG also varied by sex. In sub-Saharan Africa, for example, mean FPG increased by 0.05 mmol/L per decade in men, but by 0.13 mmol/L per decade in women. The Central Asia, North Africa and Middle East region had similar differences in sex: mean FPG increased by 0.06 mmol/L per decade in men, and by 0.16 mmol/L per decade in women.

Obesity
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IF OF CARDIOVASCULAR DISEASE ≥ activity levels are expected to decline as urbanization leads to a shift to the poor in the burden of overweight and obesity. predominantly the higher-income group in LMICs, a recent analysis occupations. increased use of motorized vehicles and a change to more sedentary food consumption tripled in China from the 1950s to 1990s. Physical activity levels are expected to decline as urbanization leads to increased use of motorized vehicles and a change to more sedentary occupations.

Unlike data from the 1980s, which showed that obesity affected predominantly the higher-income group in LMICs, a recent analysis shows a shift to the poor in the burden of overweight and obesity. Although higher-income groups still have the highest prevalence of overweight and obesity, rates are increasing faster in lower-income groups. The poor have relatively more susceptibility to obesity as a developing country’s GNP approaches the middle-income range. Higher GDP also is associated with faster rates of increase in the prevalence of overweight and obesity in lower-income groups.

The literature spotlights two groups: Women are more affected than men, with overweight women generally outnumbering underweight women as indicated by data from 36 LMICs. In the same survey, prevalence of overweight women exceeded 20% in more than 90% of surveyed countries. Even rural areas in half of the countries surveyed exhibited such rates. Adolescents are at particular risk, with 1 in 10 children currently estimated to be overweight. The number of overweight children is increasing in countries as diverse as China, Brazil, India, Mexico, and Nigeria. According to the most recent WHO estimates, 40 million children younger than 5 years of age are overweight. Brazil saw an alarming rise—from 4% to 14% over a two-decade period. In 1980, the worldwide obesity prevalence rate was 4.8% in men and 7.9% in women. By 2008, prevalence rates had nearly doubled to 9.8% in men and 13.8% in women. Globally, BMI rose in both men and women. The GBD study analyzed published and unpublished health examination surveys and epidemiologic studies (linear regressions were developed to estimate mean BMI from overweight or obesity prevalence, when available) and found that between 1980 and 2008, global BMI rose by 0.4 kg/m² per decade in men and 0.5 kg/m² per decade in women.

BMI varied substantially between regions and by sex (Fig. 1-11). In 2008, the age-standardized mean BMI in the United States was 28.5 kg/m² in men and 28.3 kg/m² in women. In contrast with the United States and other HICs with similarly high BMIs, the sub-Saharan Africa and Asia regions have some of the lowest mean BMIs. Although regional trends generally showed concordance between sexes, some exceptions occurred. There was no change in mean BMI in South Asian men, but mean BMI in women increased at a rate close to the global average, 0.4 kg/m² per decade. The most significant discrepancy in sex trends occurred in Central Africa. BMI in men in Central Africa decreased by 0.2 kg/m² per decade. The number of overweight children is increasing in countries as diverse as China, Brazil, India, Mexico, and Nigeria. According to the most recent WHO estimates, 40 million children younger than 5 years of age are overweight. Brazil saw an alarming rise—from 4% to 14% over a two-decade period. In 1980, the worldwide obesity prevalence rate was 4.8% in men and 7.9% in women. By 2008, prevalence rates had nearly doubled to 9.8% in men and 13.8% in women. Globally, BMI rose in both men and women. The GBD study analyzed published and unpublished health examination surveys and epidemiologic studies (linear regressions were developed to estimate mean BMI from overweight or obesity prevalence, when available) and found that between 1980 and 2008, global BMI rose by 0.4 kg/m² per decade in men and 0.5 kg/m² per decade in women.


Diet

As humans have evolved, selective pressures have favored the ability to conserve and store fat as a defense against famine. This adaptive mechanism has become unfavorable in light of the larger portion sizes, processed foods, and sugary drinks that many people now regularly consume. Between 1970 and 2010, the average daily per capita calories in the United States increased from 2076 to 2534. As per capita income increases, so does consumption of fats and simple carbohydrates, whereas intake of plant-based foods decreases. A key
element of this dietary change is an increased intake of saturated animal fats and inexpensive hydrogenated vegetable fats, which contain atherogenic trans fatty acids. New evidence suggests that high intake of trans fats may also lead to abdominal obesity, another risk factor for CVD. (See Chapters 42 and 46 for further discussion of diet and CVD.)

China provides a good example of such a “nutritional transition”—rapid shifts in diet linked to social and economic changes. The China Nationwide Health Survey found that between 1982 and 2002, calories from fat increased from 25% to 35% in urban areas and from 14% to 28% in rural areas, as calories from carbohydrates fell from 70% to 47%. As recently as 1980, the average BMI for Chinese adults was about 20 kg/m² and less than 1% had a BMI of 30 kg/m² or greater. From 1992 to 2002, the number of overweight adults increased by 41%, while the number of obese adults increased by 97%.

Another facet of the nutritional transition for countries adopting a Western diet is the introduction of soft drinks and other high-sugar beverages, which are associated with weight gain and increased risk for development of type 2 diabetes. A recent study of American women shows that these beverages may be linked to CHD. Drinking full-calorie sugar-sweetened beverages on a regular basis was associated with a higher risk of CHD, even after accounting for other unhealthful lifestyle or dietary factors.

**Physical Inactivity**

In HICs, the widespread prevalence of physical inactivity produces a high population-attributable risk of cardiovascular consequences. Physical inactivity is also increasing in low- and middle-income regions of the world, where a shift from physically demanding agriculture-based work to largely sedentary service industry–based and office-based work is occurring. A switch from physically demanding transportation to mechanized transportation accompanies this work shift.
Current guidelines call for moderate exercise for at least 30 minutes five or more days a week, or vigorous exercise for 20 minutes three days a week. Gallup’s November 2011 Health and Healthcare poll found that 51.6% of adults in the United States say they exercise three or more times a week. These numbers have remained essentially unchanged since 2008. Physical inactivity levels are similarly high in other regions of the world. In the Middle East and North Africa region, for example, physical inactivity is fairly common, with a prevalence ranging from 32.9% in Syria to 56.7% in Iraq. In urban China, the proportion of adults who participate in moderate- and high-level activity has decreased significantly, whereas participation in low-level activity has increased. Between 1986 and 2006, the proportion of adults who participate in low-level activity increased from 44.8% to 66.7%. Of interest, the Cuban economic crisis that began in 1989 when Cuba lost the Soviet Union as a trading partner, and the resultant hardship for its people, improved their overall cardiovascular health. The crisis worsened for the next 5 years, and complete recovery did not take place until 2000. Sustained food rationing led to a reduction in per capita food intake, and the lack of public transportation resulting from fuel shortages meant that more people were walking and riding bikes. During the crisis period, the proportion of physically active adults increased from 30% to 67%, and a 1.5-unit shift in BMI distribution was observed. From 1997 to 2002, deaths attributed to diabetes, CHD, and stroke decreased by 51%, 35%, and 20%, respectively.

The time of transition to an older population is sharply shorter in LMICs. For example, whereas it took the United States and Canada more than 65 years to double their over-65 population, China will do so in 26 years, Turkey in 24, and Brazil in 21. Currently, 77% of the growth in the older adult population is occurring in low-income and middle-income regions. Such acute changes in the population structure leave less time to expand an already overburdened health infrastructure to treat the chronic diseases of older adults, which prominently include cardiovascular conditions.

Fetal Origins
Adverse influences, such as undernutrition during fetal life (fetal “programming”) and early postnatal life, appear to affect the prevalence of adult CVD and to contribute to its risk factors. Barker, in his “developmental origins of adult disease” hypothesis, suggested that adverse influences early in development, particularly during intrauterine life, could result in permanent changes in the physiology and metabolism of the pancreas, kidney, muscle, and vascular endothelium, resulting in adult insulin resistance, metabolic syndrome, hypertension, and CHD. Factors such as maternal adiposity, gestational weight gain, maternal nutritional deprivation, fetal exposure to an environment of maternal hyperglycemia, hypercholesterolemia, and exposure to smoking, were identified as the key initiating factors that may lead to CVD later. Recent evidence indicates that the first 2 years of postnatal life are a sensitive or “critical” period of development, and any stimulus or insult during this period appears to have lasting or lifelong significance for adult-onset CVD. Several epidemiologic studies have demonstrated these associations, and two randomized trials from Guatemala and India on nutritional supplementation for pregnant mothers demonstrated favorable cardiovascular risk profiles among the children of mothers who received such supplementation. The mechanisms of increased risk appear to be both biologic (alterations in fetal tissues and postnatal epigenetic modifications) and social (cognitive impairment, low productivity, and higher prevalence of cardiovascular risk factors among those with lower birth weight and early-life adverse influences), and the risk is further compounded by childhood obesity and sedentary habits.

Thus the prevention of adverse fetal exposures and subsequent long-term consequences requires a holistic approach. An understanding of prenatal risk factors and their early childhood modifiers will provide an opportunity for prior to development of risk factors. These include improved maternal nutrition during pregnancy and lactation, emphasis on breastfeeding through early infancy, and assuring adequate balanced nutrition to infants. On the basis of our current understanding, policymakers and health care professionals should design and develop preventive strategies that effectively influence these very early determinants of CVD development.

ECONOMIC BURDEN
Despite some overlap, at least three approaches can measure the economic burden associated with CHD. The first source of financial burden is defined by the costs incurred in the health care system itself and reported in “cost-of-illness” studies. In these studies, the cost of CHD includes the costs of hospitalizations for angina and MI, as well as heart failure attributable to CHD. The costs of specific treatments or procedures related to CVD, such as thrombolytics, catheterization, and PCI, and the costs associated with outpatient management and secondary prevention, including office visits and pharmaceutical costs, are also included. In addition, nursing home, rehabilitation (inpatient and outpatient), and home nursing costs require consideration.

The second economic assessment is based on microeconomic studies that assess the household impact of catastrophic health events such as MI. These studies look at out-of-pocket expenses incurred by the individual patient or family that might have other downstream economic impacts, such as loss of savings or sale of property to cover medical costs. Many LMICs lack an extensive insurance scheme, and health care costs are almost entirely borne by individuals. So microeconomic studies to date have not considered CHD exclusively, instead looking more generally at chronic diseases overall. Furthermore, the limited data do not confirm the causality between chronic disease and individual or household poverty. Expenditures for coronary disease or its addictive risk factors such as tobacco, however, could lead to substantial and even impoverishing effects.

The third method of determining financial burden from CHD is based on a macroeconomic analysis. These assessments look at lost worker productivity, or economic growth lost by adults with CHD or their caregivers being partially or completely out of the work force because of illness. The data for the impact of chronic diseases on labor supply and productivity are more robust. An additional cost not often accounted for is the intangible loss of welfare associated with pain, disability, or suffering by the affected person. These indirect costs are often accounted for by “willingness-to-pay” analyses, asking generally how much would an individual pay to avert suffering or dying prematurely from CHD. The gains are not merely improved work performance, but also enjoying activities beyond production. Studies in the United States suggest that as much as 1% to 3% of GDP is attributable to the cost of care for CVD, with almost half of that related to CHD. In China, annual direct costs of CVD are estimated at more than $40 billion (U.S.), or 4% of GNI. In South Africa, 2% to 3% of GNI is devoted to the direct treatment of CVD, which equates to roughly 25% of South African health care expenditures. The indirect costs are estimated at more than double that of the direct costs. Although few cost-of-illness studies for CHD have been performed in other regions, such studies have reported on the financial burdens attributed to risk factors for CHD. For example, the direct costs caused by diabetes in the Latin American and Caribbean countries were estimated at $10 billion (U.S.). Indirect costs were estimated at more than $50 billion in 2000. The limited studies available
suggest that obesity-related diseases account for 2% to 8% of all health care expenditures in HICs. In India and China, the costs for obesity are about 1.1% and 2.1% of GDP, respectively.

Recently, the costs attributable to nonoptimal BP levels as mediated through stroke and MI were evaluated for all regions of the world. Globally, the health care costs of elevated BP were estimated at $370 billion (U.S.) for 2001; this amount represented approximately 10% of all global health care expenditures for that year. Regional variations do exist, with hypertension being responsible for up to 25% of health care costs in the Eastern European region (Fig. 1-12). Over a 10-year period, BP-related health care costs could equal $1 trillion (U.S.) globally, and indirect health care costs attributed to BP could be nearly four times as much.

That a high proportion of CVD burden occurs earlier among adults of working age augments its macroeconomic impact in LMICs. Under current projections, in LMICs such as South Africa, CVD will strike 40% of adults between 35 and 64 years of age, compared with 10% in the United States. India and China will have death rates in the same age group that are two and three times that for most HICs. In view of the large populations in these two rapidly growing economies, this trend could have profound economic effects over the next 25 years, as workers in their prime succumb to CVD.

COST-EFFECTIVE SOLUTIONS

The large reductions in age-adjusted CVD mortality rates that have occurred in HICs result from three complementary types of interventions. One strategy targets those with acute or established CVD. A second entails risk assessment and targeting persons at high risk because of multiple risk factors for intervention before their first CVD event. The third strategy uses mass education or policy interventions directed at the entire population to reduce the overall level of risk factors. This section reviews various cost-effective interventions (see also Chapter 42). Much work remains undone in LMICs to determine the best strategies given limited resources, but if implemented, these interventions could go a long way toward reducing the burden. Table 1-3 lists the cost-effectiveness ratios for many high-yield interventions that could be or have been adopted in low- and middle-income regions.

Established Cardiovascular Disease Management

People at highest risk are those suffering an MI or stroke; as many as half die before they ever receive medical attention. For those who do make it to a hospital, standard medical therapies were examined in a cost-effectiveness analysis in the Disease Control Priorities Project in Developing Countries. 1,2

Four incremental strategies were evaluated for the treatment of MI and compared with a strategy of no treatment as a control for the six World Bank low- and middle-income regions. The four strategies compared were (1) aspirin; (2) aspirin and atenolol; (3) aspirin, atenolol, and streptokinase; and (4) aspirin, atenolol, and tissue plasminogen activator (t-PA). The incremental cost per quality-adjusted life-year (QALY) gained for both the aspirin and beta blocker interventions was less than $25 for all six regions. Costs per QALY gained for streptokinase were between $630 and $730 across the regions. Incremental cost-effectiveness ratios for t-PA were around $16,000/QALY gained, compared with streptokinase. Minor variations occurred between regions as a result of small differences in follow-up care based on regional costs.

Secondary prevention strategies are equally cost effective in LMICs. Studies show that a combination of aspirin, an ACE inhibitor, a beta blocker, and a statin for secondary prevention can lead to acceptable cost-effectiveness ratios in all low- and middle-income regions. Use of currently available generic agents, even in the absence of the so-called “polypill,” could be highly cost-effective, on the order of $300 to $400 per person per QALY gained.

FIGURE 1-12 Percentage of health care expenditures attributed to high blood pressure. EAP = East Asia and Pacific; ECA = Europe and Central Asia; LAM = Latin America and the Caribbean; MNA = Middle East and North Africa; SAR = South Asia region; SSA = sub-Saharan Africa.

TABLE 1-3 Cost-Effectiveness for a Selection of CHD Interventions in Developing Regions

<table>
<thead>
<tr>
<th>INTERVENTION</th>
<th>COST-EFFECTIVENESS RATIO ($U.S./QALY)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drug Treatments</td>
<td></td>
</tr>
<tr>
<td>Acute myocardial infarction</td>
<td></td>
</tr>
<tr>
<td>ASA, BB (global)</td>
<td>11-22</td>
</tr>
<tr>
<td>ASA, BB, SK (global)</td>
<td>634-734</td>
</tr>
<tr>
<td>ASA, BB, IPA (global)</td>
<td>15,860-18,893</td>
</tr>
<tr>
<td>Prehospital thrombolysis (Brazil)</td>
<td>457/LY</td>
</tr>
<tr>
<td>Secondary Treatment (CHD)</td>
<td></td>
</tr>
<tr>
<td>Multidrug regimen (ASA, BB, ACEI, statin) (global)</td>
<td>1686-2026</td>
</tr>
<tr>
<td>Coronary artery bypass graft (global)</td>
<td>24,040-72,345</td>
</tr>
<tr>
<td>Primary prevention</td>
<td></td>
</tr>
<tr>
<td>Cholesterol-lowering (Brazil)</td>
<td>44/LY</td>
</tr>
<tr>
<td>Multidrug regimen (AR &gt;20%-25%) (global)</td>
<td>771-1195</td>
</tr>
<tr>
<td>Policy Interventions</td>
<td></td>
</tr>
<tr>
<td>Tobacco</td>
<td></td>
</tr>
<tr>
<td>Price increase of 33%</td>
<td>2-85</td>
</tr>
<tr>
<td>Non-Policy Interventions</td>
<td>33-1432</td>
</tr>
<tr>
<td>Salt reduction</td>
<td></td>
</tr>
<tr>
<td>2- to 8-mm Hg reduction</td>
<td>Cost saving—250</td>
</tr>
<tr>
<td>Fat-related interventions</td>
<td></td>
</tr>
<tr>
<td>Reduced saturated fat intake</td>
<td>Cost saving—2900</td>
</tr>
<tr>
<td>Trans fat replacement—7% reduction in</td>
<td></td>
</tr>
<tr>
<td>CHD</td>
<td>50-1500</td>
</tr>
<tr>
<td>Devices</td>
<td></td>
</tr>
<tr>
<td>Cardioverter-defibrillators—primary</td>
<td>50,345 (US$PPP/QALY)</td>
</tr>
<tr>
<td>prevention (Brazil)</td>
<td></td>
</tr>
</tbody>
</table>

ACEI = angiotensin-converting enzyme inhibitor; AR = absolute risk; ASA = aspirin; BB = beta blocker; CHD = coronary heart disease; SK = streptokinase; IPA = tissue plasminogen activator.

*Across six World Bank regions.

†Range includes different estimates of cost of interventions, as well as blood pressure reduction (<$10-$60).

‡Range includes estimates of cost of interventions (<$50-$150).

Risk Assessment

Primary prevention is paramount for the large number of people who are at high risk for acquiring CVD. In view of limited resources, finding low-cost prevention strategies is a top priority. Using predictive rules or risk scores to identify persons at higher risk in order to target specific behavioral or drug interventions is a well-established primary prevention strategy and has proved to be cost-effective in LMICs. Most such scoring systems include age, sex, hypertension, smoking status, diabetes mellitus, and lipid values; some also include family history. Recently, many investigators have examined whether additional laboratory-based risk factors can add to predictive discrimination of the risk factors used in the Framingham Heart Study risk score. The recent analyses in the Atherosclerosis Risk in Communities (ARIC) Study and the Framingham Offspring Study suggested that little additional information was gained when other blood-based novel risk factors were added to the traditional risk factors. Although the Reynolds risk score for women—which added family history, C-reactive protein (hsCRP), and homoglobin A1c levels—had only a marginally higher C-statistic (0.808) than the Framingham covariates (0.791), it correctly reclassified many persons at intermediate risk (see also Chapters 10 and 42 in this regard). Some women deemed to be at low risk by the Framingham risk score were reclassified as being in the intermediate or high risk category according to the Reynolds score, and thus women that were not different from those obtained using the Framingham-based risk tool. Furthermore, the results of goodness-of-fit tests suggest that the non-laboratory-based model is well calibrated across a wide range of absolute risk levels and without changes in risk classification. The ankle-brachial index (ABI) also appears to add to risk discrimination and improve the NRI as an alternative noninvasive tool.

Policy and Community Interventions

Education and public policy interventions that have reduced smoking rates, lowered mean BP levels, and improved lipid profiles are recognized to contribute to reduction in CHD rates. Education and policy efforts directed at tobacco consumption have contributed substantially to the reductions in CVD. In addition, salt and cholesterol reduction has been evaluated as a cost-effective strategy to reduce stroke and MI in LMICs by WHO investigators. Community interventions have reduced levels of multiple risk factors and, in some cases, CHD mortality (see also Chapter 42).

Tobacco Use

Tobacco control can be conceptualized in terms of strategies that reduce the supply of, or demand for, tobacco. Most public health and clinical strategies to date focus on reducing demand through economic disincentives (taxes), health promotion (media and packaging efforts), restricted access (to advertising and tobacco), or clinical assistance for cessation. The WHO effort to catalyze the creation of a global treaty against tobacco use was a key milestone. In May 2003, the WHO World Health Assembly unanimously adopted the WHO Framework Convention in Tobacco Control (FCTC), the first global tobacco treaty. The FCTC had been ratified by 168 countries as of April 2009, making it one of the most widely embraced treaties in the United Nations. The FCTC has spurred efforts for tobacco control across the globe by providing both rich and poor nations with a common framework of evidence-based legislation and implementation strategies known to reduce tobacco use. Jha and colleagues presented a landmark analysis of tobacco control cost-effectiveness in 2006. They calculated the reductions in future tobacco deaths as a result of a range of tax, treatment, and non-price interventions among smokers alive in 2000. They found that a 33% price increase would result in a reduction of between 19.7 million and 56.8 million (5.4% to 15.9% of total) deaths in smokers from the developing world who were alive in 2000. Calculations show that nicotine replacement therapy (NRT) could reduce the number of deaths by between 2.9 million and 14.3 million (0.8% to 4.0% of total) in the 2000 cohort. A range of nonprice interventions such as advertising bans, health warnings, and smoke-free laws would reduce deaths by between 5.7 million and 28.6 million (1.6% to 7.9% of total) in that cohort. These reductions would translate into developing world cost-effectiveness values of between $33 and $42/QALY saved for tax increases (not including tax revenue), $55 to $761/QALY for NRT, and $54 to $674/QALY for nonprice measures. Critically important for patients who have had a coronary event, smoking cessation saves lives at a greater rate than any individual medical treatment. Mohliuddin and associates conducted a randomized controlled trial of a behavioral and medication smoking cessation program for smokers who were hospitalized with a coronary event in the critical care unit. These investigators observed nearly threefold higher quit rates and a decrease in all-cause mortality at 1 year by an absolute risk of 9% (77% reduction in relative risk). This reduction corresponded with a number needed to treat (NNT) of 11 for smoking cessation to prevent 1 death in the year after a major coronary cardiac event. This NNT for secondary prevention is more favorable than that for statins, beta blockers, or even aspirin.

Salt and Lipid Reductions

The cost-effectiveness analyses on salt reduction achieved as a result of public education are quite favorable. The intervention ranges from being cost-saving to $200/DALY averted. The results of a campaign for reducing saturated fat and replacing it with polyunsaturated fats was also likely cost-effective. In the base case, a 3% decline in cholesterol and a $6 per capita education cost were assumed. Findings included a cost as low as $1800/DALY averted in the South Asia region, and up to $4000/DALY averted in the Middle East and North Africa region. If the cost for the education plan were halved, however, the ratio is approximately $900/DALY, which would be cost-saving if the reduction could be achieved for under $0.50 per capita—a possibility in areas with less expensive access to media.

Community Interventions

In the 1970s and 1980s, a series of population-based community intervention studies were conducted to reduce risk factors for chronic disease, and are reviewed elsewhere. These studies focused on changes in health behaviors or risk factors such as tobacco use, body weight, cholesterol, and BP, as well as a reduction in CVD morbidity and mortality. In general, they included a combination of community-wide actions and those focused on persons identified as being at high risk for CVD-related health problems. One of the earliest and most often-cited community interventions is the North Karelia project in Finland, begun in 1972. The community-based interventions included health education, screening, a hypertension control program, and treatment. Over the first 5 years of the study, reductions in risk factors occurred, along with a decline in CHD mortality by 2.9% per year—versus a 1% per year decline in the rest of Finland. During the next 10 years, declines were greater in the
rest of Finland. Over a follow-up period of 25 years, a large decline in CHD occurred in both the North Karelia region (73%) and the rest of Finland (63%). Although the overall difference in the decline in CHD deaths was not significantly greater in the study area of North Karelia, the reduction in tobacco-related cancers in men was significant. A similar study in the Stanford, California, area showed reductions in risk factors—cholesterol (2%), BP (4%), and smoking rates (13%)—compared with sites without the intervention, but no impact on disease endpoints.

Later, community interventions in HICs showed mixed results, with some showing improvements in risk factors beyond the secular decline that was occurring throughout most HICs and others exhibiting no additional decline. A meta-analysis of the randomized multiple risk factor interventions, however, showed net significant decreases in systolic BP (4.2 mm Hg), smoking prevalence (4.2%), and cholesterol (0.14 mmol/L). The declines in total and CHD mortality of 3% and 4% were not significant. All of these projects are limited by the challenge of detecting small changes that, on a population level, may be significant—a 10% reduction in mortality could have been missed.

Several community intervention studies have been conducted in LMICs, including China, Mauritius, and South Africa. The Tianjin project showed reductions in hypertension and obesity. The Mauritius project, among other interventions, resulted in a government-led program where the prime cooking oil from a predominantly saturated fat palm oil to a soybean oil in unsaturated fatty acids. Overall total cholesterol levels fell 14% during the 5-year study period from 1987 to 1992. Changes in other risk factors were mixed with declines in BP and smoking rates and increases in obesity and diabetes. The Coronary Risk Factor Study in South Africa compared a control community with two communities receiving interventions at two different levels of intensity. The interventions included mass media messages, group sponsored educational sessions, and BP screening and follow-up with the health sector when appropriate. Both high-intensity and low-intensity interventions resulted in improvements in BP, smoking rates, and HDL–to–total cholesterol ratio over the control community, but with little difference between the two intervention communities.

Another significant reduction in CHD came not through a concerted community intervention but through changes in fiscal policy. In Poland, reductions in subsidies for animal products such as butter and lard led to a switch from saturated to polyunsaturated fats, mainly rapeseed-based and soybean-based oils. The decrease in CHD mortality by more than 25% between 1991 and 2002 could not be explained by increased fruit consumption or decline in smoking rates. Success stories such as in Poland and Mauritius are rare, however, suggesting the challenges for achieving meaningful changes targeting single risk factors at a national level.

SUMMARY AND CONCLUSIONS

CVD remains a significant global problem. The swift pace of economic and social transformation in a postindustrial world with rapid globalization presents a greater challenge for low- and middle-income economies than for high-income economies. Although CVD rates have declined in HICs, they are increasing in virtually every other region of the world. From a worldwide perspective, the rate of change in the global burden of CVD is accelerating, reflecting the changes in the low- and middle-income economies, which represent 85% of the world’s population. This preventable epidemic will have substantial consequences on many levels: individual mortality and morbidity, family suffering, and staggering economic costs—both the direct costs of diagnosis and treatment and the indirect costs of lost productivity.

Different regions of the world face different stages of the epidemic. In HICs, managing an ever-older population with chronic manifestations such as heart failure will strain health care budgets. Currently, the Eastern European countries and members of the former Soviet Union face enormous burdens, with more than half of all deaths attributed to CVD. Meanwhile, countries in sub-Saharan Africa are just beginning to see increases in these chronic illnesses while still grappling with HIV/AIDS. No single global solution to the rising burden of CVD exists, in view of the vast differences in social, cultural, and economic circumstances. HICs must minimize disparities, reverse unfavorable trends in CVD risk factors and behaviors, and deal with the increasing prevalence of CVD in an aging population. The most complex challenges face LMICs—with increasing access to low-cost tobacco products and ready access to less than favorable dietary options. Preventing the poverty-inducing effects of catastrophic CVD events will require efforts to improve access to low-cost prevention strategies at both the societal and the individual level.

A reduction in the disease burden would similarly require both policy and personal changes. In the long run, the allocation of resources to lower-cost strategies will likely prove more cost-effective than dedicating resources to high-cost management of CVD. From a societal perspective, efforts to strengthen tobacco control strategies, improve dietary choices, and increase physical activity will be paramount. At the personal level, risk assessment strategies and treatment modalities require simplification. Furthermore, alternative deployments of allied health workers such as community health workers will need evaluation, in view of the limited human resources in most LMICs. HICs must share with leading and emerging middle-income countries the burden of research and development into every aspect of prevention and treatment. Through further expansion of the knowledge base, particularly regarding the economic consequences of various treatment and prevention strategies, the efficient transfer of low-cost preventive and therapeutic strategies may alter the natural course of the epidemiologic transition in every part of the world, thereby reducing the excess global burden of preventable CVD.

References


Current Variations in Global Burden of Cardiovascular Disease

Risk Factors


Cost-Effective Solutions


