Global Burden of Cardiovascular Diseases: Part II: Variations in Cardiovascular Disease by Specific Ethnic Groups and Geographic Regions and Prevention Strategies

Salim Yusuf, Srinath Reddy, Stephanie Ôunpuu and Sonia Anand

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Global Burden of Cardiovascular Diseases

Part II: Variations in Cardiovascular Disease by Specific Ethnic Groups and Geographic Regions and Prevention Strategies

Salim Yusuf, FRCP, DPhil; Srinath Reddy, MD; Stephanie Önpuu, PhD; Sonia Anand, FRCP(C), MSc

Abstract—This two-part article provides an overview of the global burden of atherothrombotic cardiovascular disease. Part I initially discusses the epidemiological transition which has resulted in a decrease in deaths in childhood due to infections, with a concomitant increase in cardiovascular and other chronic diseases; and then provides estimates of the burden of cardiovascular (CV) diseases with specific focus on the developing countries. Next, we summarize key information on risk factors for cardiovascular disease (CVD) and indicate that their importance may have been underestimated. Then, we describe overarching factors influencing variations in CVD by ethnicity and region and the influence of urbanization. Part II of this article describes the burden of CV disease by specific region or ethnic group, the risk factors of importance, and possible strategies for prevention. (Circulation. 2001;104:2855-2864.)

Key Words: heart diseases ■ epidemiology ■ prevention

This second part of our article describes ethnic and regional variations in cardiovascular (CV) risk factors and disease and illustrates some of the changing rates for cardiovascular disease (CVD) in several countries. It also emphasizes the preventive strategies for CVD that have been used most successfully in developed countries and could be of potential value in preventing or reversing the rise in developing countries. We conclude with some recommendations for prevention that are likely to be of relevance globally.

European Origin

People of European origin include those who originate from diverse backgrounds in Northern Europe (Nordic countries), Western Europe (eg, United Kingdom and France), Southern Europe (eg, Spain and Italy), and Eastern Europe (eg, Poland and Ukraine).

Disease Burden

Differences in the Age-Standardized Mortality Rates (ASMR) vary widely between European populations. Data from the World Health Organization (WHO) indicate that the cardiovascular disease mortality rate is 6-fold higher among men and women in the Russian Federation compared with people in France. In 1996, the ASMR for coronary heart disease (CHD) among males in the Russian Federation was 390/100 000 compared with 60/100 000 among males in France.1 The cerebrovascular disease (CBVD) ASMR in the Russian Federation was 244/100 000 compared with 40/100 000 in France.1 Although the CVD mortality rates are much lower among women compared with men, similar variations among women between countries also exist. Eastern European countries such as the Ukraine, the Russian Federation, Hungary, and the Czech Republic have among the highest and increasing CVD rates in the world, which is in marked contrast to most economically stable European countries where declines in CVD mortality rates have been experienced over the past 30 years.

Risk Factors

CVD among European populations is mainly attributable to classical risk factors, namely diets high in saturated fats, elevated serum cholesterol and blood pressure (BP), diabetes, and smoking. The epidemic of CVD in Eastern European countries is partly related to high levels of smoking and excessive alcohol use (causing strokes) along with diets high in saturated fat2 and poor social conditions. Research to explain why the Italian and French populations remain relatively protected from CHD has yielded numerous hypotheses. It is believed that the high consumption of monounsaturated fats such as olive oil and antioxidants may be responsible for the low rates of CHD in Italy. In France, the CHD mortality rate remains very low.3 Although this relative protection from CHD has been attributed to high consumption of alcohol, and in particular wine,4 others believe the lower rate of CHD mortality may simply be due to a time-lag between increases in consumption of animal fat and elevations in serum cholesterol concentrations (which have occurred only recently) and the expected increase in mortality.5
Prevention

In Finland, which had one of the highest rates of CHD mortality in the 1960s and 1970s, an impressive 55% reduction in CHD mortality and stroke was observed between 1972 to 1992. About three quarters of this decline in CHD mortality can be explained by a lowering of serum cholesterol by 13% (0.88 mmol/L) in men and by 18% (1.18 mmol/L) in women, reductions in diastolic BP by 9% (8.6 mm Hg) in men and by 13% (12.2 mm Hg) in women, and a significant reduction in smoking rates (by 30% in men). Similar declines have been documented in several Western countries and is partially attributable to improved primary and secondary prevention as well as improved medical and surgical management in patients with established coronary disease. The declines in CHD have also paralleled changes in human behavior (regarding food, activity, etc.) that accompany changes in the economy from one that is predominantly based on manufacturing and extractive industry to one based on high technology and services. In Poland, during the 1990s about a 25% decrease in CHD deaths in early middle age was observed, which has been attributed in a large part to a marked decrease in animal fats and increase in vegetable fats consumption. By contrast, a marked increase in death rates from CVD, accidents, violence, and infectious diseases has been observed in Russia over a relatively short period of time and is thought to be due to socioeconomic upheaval. This illustrates the regressive stage (Stage V) of the epidemiological transition. Moreover, the rapidity with which CV diseases rise (as in Russia) or fall (as in Poland) indicate that societal factors can have a substantial and rapid impact on disease rates.

Japanese

Disease Burden

In parallel with a rise in economic prosperity, CVD rates in Japan have declined more markedly than those of western countries, and the life expectancy in Japan is among the highest in the world. Mortality rates from CHD have traditionally been much lower in Japan than in western countries. In Japan, the ASMR for CHD in males is 43/100 000 and in females is 22/100 000, which is one-fourth the rate of CHD in North America, and for CBVD is 72/100 000 and 46/100 000 among males and females, respectively. This pattern of higher CBVD compared with CHD among Japanese differs from western populations.

Risk Factors

Hypertension is the most important CVD risk factor among Japanese, more so than cholesterol and cigarette smoking. The Hisayama prospective population–based study showed a decline in BP level from 1961 to 1987, likely due to improved diagnosis and treatment of hypertension. This has been accompanied by a marked decline in stroke mortality. Low serum cholesterol related to a diet low in saturated fat and cholesterol is also likely responsible for the low rates of CHD mortality observed in the Japanese. The prevalence of non–insulin dependent diabetes mellitus (NIDDM) in Japanese males (13%) and females (9%) is higher than the rates in most western countries. During 1961 to 1987, with westernisation there was a 2- to 3-fold increase in glucose intolerance, NIDDM, obesity, and hypercholesterolemia (the mean cholesterol is only 10% lower than in the US in 1989). It is possible that as cholesterol and glucose levels rise, the impact of the high cigarette smoking on increased CVD rates may become manifest.

Prevention

With increasing adoption of western lifestyles in Japan, the rates of CHD risk factors could approach those of Americans. Although the prevalence of smoking among men decreased from 80% in 1961 to 50% in the mid 1980s, it remains high among males. Combined with increasing rates of elevated cholesterol and obesity, Japan may soon experience a significant epidemic of CHD after a lag of a few years. Therefore, maintenance of a low fat diet and avoidance of obesity through both decreased energy intake and regular physical activity will likely prevent the development of glucose intolerance, elevated cholesterol, and hypertension. Furthermore, avoidance of cigarette smoking is also critical in preventing a future increase in CHD in Japan.

Chinese

Disease Burden

Death rates from CVD (particularly CHD) have been increasing in China in recent decades. Although the CVD mortality rate in China is approximately the same as that in the US, the CHD mortality rates are approximately 50% lower than the rates observed in most western countries, and the CBVD rate is significantly higher. In 1996, in urban China, the ASMR for CHD for men and women aged 35 to 74 was 100/100 000 in men and was 69/100 000 in women. However, the ASMR for CBVD in men and women aged 35 to 74 was 251/100 000 in men and 170/100 000 in women. Intracerebral hemorrhage occurs between 2 and 3 times more frequently in the Chinese than in white Caucasians. Only 6% to 12% of strokes in European populations are reported as intracerebral hemorrhages compared with 25% to 30% of hemorrhagic strokes in Chinese.

Risk Factors

A case-control study from Hong Kong of acute myocardial infarction (AMI) sufferers indicates that conventional risk factors (eg, cigarette smoking, hypertension, or diabetes) are important. Although the mean serum cholesterol among Chinese is low (mean 4.2 mmol/L at baseline) by western standards, serum cholesterol was directly related (continuous relationship) to CHD mortality even at relatively low levels. Cigarette smoking is highly prevalent among Chinese males (over 60%) and increasing.

Geographic Variations

The CHD mortality rate is higher in northern China (Beijing) than in southern China (Shanghai and Guangzhou) and higher in urban than rural areas, yet surprisingly the stroke rates only differ modestly between urban and rural areas. The prevalence of hypertension, mean levels of serum cholesterol, and body mass index (BMI) were all lower in the south.
Disease Burden

There are relatively few mortality studies from India, as there is no uniform completion of death certificates and no centralized death registry for CVD. However, the WHO and the World Bank estimate that deaths attributable to CVD have increased in parallel with the expanding population in India, and that CVD now accounts for a large proportion of disability adjusted life years (DALY) lost. Of all deaths in 1990, approximately 25% were attributable to CVD, compared with 10% from diarrheal diseases, 13% from respiratory infections, and 8% from tuberculosis. SA migrants to the United Kingdom, South Africa, Singapore, and North America experience 1.5 to 4.0 times higher CHD mortality compared with indigenous populations.

Temporal Trends

In India, the CHD rate is expected to rise in parallel with the increase in life expectancy secondary to increases in per capita income and declining infant mortality. The average life expectancy has increased from 41 years in the years 1951 to 1961, to 61.4 years in the years 1991 to 1996 and is projected to reach 72 years by 2030, which could lead to large increases in CVD prevalence. By contrast, in the UK and Canada, although the CHD mortality rate of SAs compared with other populations remains high, a decline in CHD rates has been observed over the past 10 years. These data indicate that the high rates of CHD with economic changes are reversible and perhaps even avoidable. Therefore, lessons learnt from migrant SAs may be helpful in developing prevention strategies for the Indian subcontinent.

Risk Factors

Compared with Europeans, SAs (in the UK and Canada) do not display high rates of smoking, hypertension, or elevated cholesterol but still have higher rates of CHD. However, smoking, hypertension, and diabetes are strongly associated with CHD among SAs. SAs in the UK and Canada suffer a high prevalence of impaired glucose tolerance (IGT), central obesity, elevated triglycerides, and low HDL cholesterol, and NIDDM at rates 4 to 5 times higher than in Europeans (19% versus 4% by age 55 years). High rates of diabetes has been reported among SAs in the UK (10% to 19%), Trinidad (21%), Fiji (25%), South Africa (22%), Mauritius (20%), and Canada (10%). By contrast, the prevalence of diabetes in rural India is 2% to 3% and approximately 8% in urban areas. In addition, there is increasing evidence that elevations in blood glucose even in the nondiabetic range increases CHD risk among SAs. SAs have elevated levels of Lp(a), a lipoprotein which is genetically mediated and associated with increased atherosclerosis, thrombogenesis, and clinical events. Recent studies have confirmed that SAs also have higher levels of homocysteine, fibrinogen, and plasminogen activator inhibitor (PAI-1), all of which could increase the risk for thrombosis. Although the degree of subclinical atherosclerosis is related to clinical events, it appears that SAs have a higher propensity for clinical events compared with Europeans or Chinese, even after adjusting for all known risk factors and the degree of atherosclerosis (Figure 2). This probably suggests the po-
tential for greater plaque rupture and thrombotic events among SAs.

Geographic Variations
Marked increases in both CHD prevalence and risk factors is observed in urban India compared with rural settings. A recent overview of prevalence surveys conducted over 2 decades in India reported a 9-fold increase of CHD in urban centers, compared with a 2-fold increase in CHD rates among rural populations. This increase in CHD rates in urban areas is associated with an increase in the prevalence of lipid and glucose abnormalities as well as hypertension and obesity. By contrast, the rates of tobacco smoking are higher in rural compared with urban populations. (Although these studies used somewhat different methods of sampling and varying definitions for CHD, collectively, they suggest that there is likely a real increase in CHD; however, the magnitude of the increase remains uncertain).

Migration Patterns
SAs in the UK have higher risk factor levels compared with their siblings living in India (BMI, 27 versus 23 kg/m²; systolic BP, 144 versus 137 mm Hg; total cholesterol, 6.3 versus 5.0 mmol/L; lower HDL cholesterol, 1.14 versus 1.27 mmol/L; and higher fasting glucose, 5.4 versus 4.6 mmol/L). Therefore, adverse changes in CVD risk factors and disease rates are observed when South Asians adopt an urban lifestyle whether they live in India or abroad.

Hispanics
The term Hispanic includes Americans of Cuban, Mexican, and Puerto Rican descent. There are approximately 35.3 million Mexican-Americans living in the US, and they comprise approximately 12.5% of the US population. CVD is the leading cause of death among Hispanic males (28%) and females (34%). Although earlier studies suggested that the age-adjusted mortality rates for major CVD among Mexican-Americans (28.8 and 26.6 per 100 000 men and women, respectively) were lower than those of African-Americans (40.5 and 39.6, respectively) and whites (30.0 and 23.8 per 100 000), recent data from the Corpus Christi Heart Project, reported a greater incidence of myocardial infarction (MI) in Mexican-Americans compared with non-Hispanic whites. The age-adjusted MI incidence was higher by 1.25 and 1.52 among Mexican-American men and women compared with non-Hispanic whites, with greater MI case-fatality rate among Mexican-Americans than non-Hispanic whites.

Under the age of 60 years, Hispanics have a significantly elevated CBVD death rate compared with non-Hispanic whites (32 versus 19 and 23 versus 18 per 100 000 in men and women, respectively). However, in older age categories the CBVD rate in Hispanics is substantially lower than whites (589 versus 765 and 535 versus 847, respectively). Although declines in CHD and CBVD mortality have occurred in Mexican-Americans over the past 20 years, this decline has been less than that which has occurred among non-Hispanic whites.

Risk Factors
Mexican Americans suffer a high prevalence of conventional CVD risk factors such as smoking (42.5% in men and 23.8% in women), hypertension (17% and 14%, respectively), low HDL cholesterol (<0.90 mmol/L: 15.2% men, 5% women), elevated cholesterol (total cholesterol ≥6.2 mmol/L: 16.6% men and 16.5% women), diabetes (24%), physical inactivity (39%), and obesity (BMI>85th percentile, 30% men, 39% women).

Prevention
Programs to decrease obesity and promote physical activity are needed to reduce the rate of glucose intolerance in this group. Furthermore, Mexican-Americans are less likely to receive treatment for diabetes, hypercholesterolemia, and hypertension compared with non-Hispanic whites.

Aboriginal Populations
The rates of chronic degenerative diseases such as CVD, diabetes, cancer, and mental illness are increasing among Aboriginal peoples. These trends parallel the epidemiological transition that is occurring in other developing populations throughout the world.

Disease Burden
Mortality rates for CVD among aboriginal populations had been reported to be lower than people of European ancestry; however, CHD is the leading cause of death in North American Indians and Alaskan Natives. The Strong Heart Study, which was initiated in 1988, studied 4549 American Natives aged 45 to 74 years from 13 tribes in the Southern US. The prevalence estimates of definite MI in those aged 45 to 74 years was 2.8% in men without diabetes and 5.3% in men with diabetes, and 0.4% in women without diabetes and 1.4% in women with diabetes. In the US, the CBVD mortality rates under the age of 65 years is similar in Native Americans and white Americans, and substantially lower than rates in African Americans.

In Canada, CVD is the leading cause of death among Aboriginal peoples. Although the CHD mortality rates among Aboriginal and Canadian males are similar, the CHD...
mortality among Aboriginal women is 61% higher compared with Canadian women. In addition, the stroke mortality rate is 44% and 93% higher among Aboriginal men and women, respectively, compared with the general Canadian population.52 However, all the above data are based on studies conducted 10 or more years ago. A recent prevalence study in Canada indicates a 2.5-fold higher rate of CVD among aboriginal peoples compared with Canadians of European origin.53

Temporal Trends
As more Aboriginal people give up their traditional lifestyles and adopt “urban” lifestyles, the prevalence of CVD and its risk factors will likely increase. Comparing Canadian data from 1979 to 1983 to data from 1984 to 1985 reveals a 25% decline in CHD among Native men, but a 5% increase among Native women.52 In the US, the age-adjusted rates of CBVD mortality declined by about 20% between 1980 and 1990 in Native Americans, which is similar to the 26% decline in white Americans.50

Risk Factors
The common CHD risk factors among Aboriginal men and women include diabetes, obesity, and low HDL-cholesterol. The prevalence of cigarette smoking is high, with wide variations between reserves.54 The prevalence of diabetes in the Strong Heart Study was 48% in the group aged 45 to 64 years compared with approximately 5.5% in the US general population. The prevalence of obesity ranged from 26% to 41%, with an average BMI of 31 and waist-hip ratio of 0.97 in men. By contrast, the prevalence of hypertension and elevated cholesterol among Natives appears to be lower than the general US population.

In a Canadian study, Aboriginal people had a higher prevalence of CVD, atherosclerosis, glucose abnormalities, obesity, and poverty compared with European Canadians. There is a clear inverse relationship between higher incomes and lower rates of risk factors and CVD. However, at each income level, aboriginals had higher risk factors and CVD compared with European Canadians.53

Geographic Variations
There are important regional and intertribal differences in CVD risk factors and disease rates,49,50,54 but most of the current data on CVD have come from Natives living on reserves, and little is known about the risk factor profiles among city-dwelling Natives. There are only very limited data regarding CVD among Aboriginal populations outside North America. One study in Chile, among the Mapuche Indians indicated substantially lower rates of obesity, diabetes, hypertension, or hyperlipidemia compared with the North American Aboriginal populations.55

Prevention
In order to develop strategies for prevention of CVD in Aboriginal populations, more research is required relating psychosocial factors with CVD. There are higher rates of poverty, social isolation, hopelessness, and lack of empowerment, and addressing these issues is key to a culturally sensitive and effective prevention strategy.

Blacks of African Origin
CVD rates among blacks in Africa are relatively low when compared with the rates in most western countries. However, among blacks in the US, the rates of CVD are comparable or higher than the rates among whites in the US.

Africa
Disease Burden
CVD mortality data from countries in the Sub-Saharan African region (SSA) are limited, as only 1.1% of all deaths are registered with a central agency.28 Data from other sources such as sample-registries and small-scale population studies indicate that the burden from CHD in 1990 was 4.5 million DALY, and that the CHD mortality was 41/100 000.28 These rates are considerably lower than those of whites who live in Africa, as well as the rates in most western countries, which are on average 4 to 5 times higher.28 Even so, in SSA, the proportional mortality rate from CVD accounts for 10% of all deaths, and CHD accounts for 3% of all deaths.28 Furthermore, the CHD case-fatality rates may be higher in SSA compared with western countries perhaps due to the limited access to health care.

Risk Factors
The prevalence of most conventional risk factors for CHD, with the exception of hypertension (and perhaps smoking among urban areas), is lower among blacks compared with other groups within Africa, and the world.56,57 Among Tanzanians (35 to 64 years), the prevalence of smoking was 37% among men and 4% among women, the mean BMI was 21 and 22, the mean blood pressure was 126/79 and 125/79 mm Hg, and the mean serum cholesterol was 4.1 and 4.3 mmol/L in men and women, respectively.57 When compared with other developing and developed countries, the Tanzanian risk factor profile was more favorable, with the exception of smoking among men. Furthermore, the prevalence of multiple risk factors for CHD was low, as 65% of the population has no identifiable risk factors, 30% had a single risk factor, and only 5% had at least two risk factors, compared with 50%, 40%, and 10%, respectively, in the US.57

Geographic Variations
In most urban and virtually all rural regions of SSA, the prevalence of traditional CVD risk factors among blacks is low. However, with urbanization, an increase in conventional cardiovascular risk factors and CHD rates is anticipated.58 In South Africa, the rapid migration of blacks to urban centers has led to increased poverty, obesity, hypertension, and elevated cholesterol. This pattern of increasing risk factors with higher rates of urbanization is likely to affect most of SSA.

Prevention
Lessons learned from other regions in the world should be used to develop an aggressive strategy of primordial prevention. This could include control of cigarette smoking by
increasing the price of cigarettes and anti-tobacco campaigns, promoting traditional dietary patterns, reducing salt consumption and BP, and promoting regular physical activity, especially among urban populations.

Western Indies

**Disease Burden**

In Trinidad, data from 1989 reveal that the age-adjusted incidence of CHD in people of African origin was 6.8 and 5.4 per 1000 person years among men and women, respectively. The rates among black men approximated those of European descent (6.8 versus 6.5/1000 person years at risk), whereas the rates among black women were higher (5.4 versus 2.9/1000).59

**Risk Factors**

The most prevalent and influential risk factor is hypertension. In Trinidad, the prevalence of hypertension was 33%, diabetes 8.1%, and smoking 39%.59 The mean HDL cholesterol was 1.03 and 1.30 mmol/L; the mean LDL cholesterol was 4.04 and 4.11 mmol/L in men and women, respectively.

United States

African-Americans are the largest nonwhite population in the US and represent 12.9% of the population.

**Disease Burden**

CVD is the leading cause of death among African-Americans. Although the CHD mortality rate in African-American men is similar to that among white men (224 versus 236/100 000), it is higher among African-American women (160 versus 140/100 000).41 Sudden cardiac death is more common among African-Americans.60 In addition, the CBVD mortality rate is substantially higher among African American men (89 versus 62/100 000) and women (76 versus 58/100 000) compared with whites.41

**Temporal Trends**

Since the 1960s, CV mortality has been declining among Americans of all races.61,62 However, since the mid 1970s, the rate of decline has slowed down among African Americans,58,63 leading to a widening disparity in CVD death rates between blacks and whites.

**Geographical Variations**

Early investigators noted high stroke mortality rates among black Americans in the southeastern coastal states. By late 1980s, this “stroke belt” had dissipated in the south eastern coastal areas and shifted to the Midwest regions of the Mississippi and Ohio river valleys.64 CHD mortality has shown a similar westward shift to the so called coronary valley.65 The increased CVD mortality among blacks has been mainly confined to the southern states (Mississippi River valley). Although changes in regional profile of risk factors, local environment, and migration pattern may have played a role, recent economic shifts in these areas may be the principal reason for changes in disease rates.64 Whereas southeastern coastal areas have undergone considerable economic development, the more westwardly regions have not kept pace.65 In Mississippi, one of the most economically and educationally disadvantaged US states, CVD mortality has risen among African Americans over the past two decades while among whites there has been a decline.66 Similar patterns are also observed in the Northeast and the Midwest.67

**Risk Factors**

Compared with whites, African-Americans develop hypertension at an earlier age. The reason for black-white differences in hypertension prevalence likely involves a complex interaction between environmental response to diet, stress, and a potential genetic/physiological difference in sodium/potassium excretion. Serum cholesterol levels are similar among African-Americans compared with white Americans, but the former group has higher HDL cholesterol levels, despite having more diabetes. Cigarette smoking rates are similar among African-Americans compared with whites (eg, 32.3% of men, 22.3% of women versus 27.3% of men and 23.9% of women). Obesity is an emerging problem especially in women, with approximately 21% of African-American men and 38% of women having a BMI >30, compared with 21% and 23% of white American men and women, respectively. Approximately 33% of African-American men and 43% of women report no leisure time physical activity compared with 25% and 28% among white American men and women, respectively. Furthermore, the prevalence of diabetes in African-Americans is higher than in whites (7.6% in African American men and 9.5% in women compared with 5.4% and 4.7% in white men and women).41 However, even after consideration of differences in conventional risk factors, socioeconomic factors that affect access to health care likely play a role in the slower decline in CVD rates observed among blacks.

**Prevention**

Special efforts at detection, prevention, and treatment of hypertension (which is the dominant CVD risk factor) through lifestyle changes and appropriate pharmacological therapy are necessary. In the US, the lower socioeconomic status of blacks probably contributes to the higher disease burden because of less awareness and access to prevention and treatment modalities. Therefore, strategies that are culturally sensitive to the African American blacks and targeted at those in the lower socioeconomic subset are required.

**General Prevention Strategies: From Epidemiological Evidence to Prevention Program**

The previous sections emphasize some general points: first, that atherothrombotic CVD is a global problem that affects every ethnic group; second, that as societies undergo “urbanization,” the risk factor levels for CVD increase; third, conscious efforts at the societal level (through changes in legislation or social policies) and at the individual level (through risk factor modification and use of evidence based treatments) can prevent or reverse the adverse consequences of urbanization, as demonstrated by the marked declines in CVD rates in many countries; fourth, even though there may be variations in genetic susceptibility among different ethnic groups, the common environmental and risk factors usually play a dominant role in the development of clinical disease in all ethnic groups. It is therefore likely that lessons learned
regarding prevention from one region or a particular ethnic group are likely to be relevant to another region or ethnic group, with appropriate modifications that take into account genetic susceptibility, as well as social, economic, and cultural factors.

Two complementary strategies that are usually advocated for primary prevention are the "population approach" and "high-risk approach." In the former, community wide interventions seek to modify behaviors and thereby influence the distribution of risk factors in the population. Even modest changes in risk factors are expected to contribute to a substantial reduction in the cumulative population risk of CVD because of the large number of people affected. The high risk strategy, on the other hand, seeks to identify the few individuals who are at high risk, either because of marked elevation of single or multiple risk factors; targeted behavioral or pharmacological interventions follow. The population strategy aims to reduce the burden of disease in the whole community while conferring small benefits to each individual. The high-risk strategy, on the other hand, provides large benefits to the few individuals who are most vulnerable but the benefits to the whole community may be relatively limited because the beneficiaries are few.

The promise of the population approach has, however, not been adequately delivered by several community-based randomized intervention trials targeting multiple risk factors. Therefore, the scientific basis for developing community-based program similar to those undertaken during the 1970s and 1980s has been questioned. This view contrasts with the reported success of the North Karelia program, the lifestyle program in Mauritius, and the delayed benefits observed in the MRfit trial. Projects evaluating the benefits of the population approach face several methodological problems. First, although the numbers of individuals in these studies are relatively large, because communities and not individuals are the sampling units, the number of communities compared are small, which dramatically reduces statistical power. Second, only a small impact of the intervention on risk factors is possible because of inefficient delivery of the intervention, "contamination" of the control population who tend to partially adopt the intervention package, and declining disease rates overall, all of which reduce statistical power. Therefore, more research is needed into the determinants of risk factors at societal levels and how they can be modified more effectively through governmental or social policies. Based on the currently available data (chiefly from individual level interventions and observations correlating declines in CHD to declines in risk factors), it would still be prudent to advocate policy changes and community level programs that control tobacco, reduce obesity, increase physical activity, and promote a healthy diet.

By contrast, the high risk approach has yielded clear proof of efficacy, whether for lifestyle interventions or for pharmacological interventions (eg, trials of statins, aspirin, or ACE inhibitors). However, it must be recognized that the majority of CVD arise from the large segments of the population who exhibit average levels of risk factors and are, therefore, at modest risk. Hence, the high risk approach, which reduces the risk in a limited number of individuals, needs to be complemented by a more embracing risk reduction approach which addresses the larger population attributable risk.

The clinical trials for secondary prevention have also contributed substantially to documenting the importance of modifying risk factors. By demonstrating reductions in major cardiovascular events from interventions aimed at specific risk factors (like cholesterol, blood pressure, or mediators of thrombogenesis) or involving dietary regimes (like...
fish\textsuperscript{79} or the Mediterranean diet\textsuperscript{80}), they have reinforced the belief that risk factors and protective factors are critical to the prevention of cardiovascular disease. By progressively lowering the thresholds for such clinical interventions, the clinical norms have come closer to the prevention norms. Thus, it is no longer surprising to see clinical guidelines advocating LDL cholesterol target levels lower than 130 mg/dL (or below 100 mg/dL in those with clinical disease) or identifying the optimal blood pressure as lower than 140/80 mm Hg in otherwise healthy individuals or 120/80 mm Hg in high risk individuals (eg, diabetics). Therefore, there is considerable overlap between a population approach and a high risk approach to prevention.

Because risk factors track from early childhood to adulthood and old age, and subclinical atherosclerosis occurs even in children if they have elevated risk factors, preventive strategies should start as early as possible. Because lifelong pharmacological treatment is not desirable except in a few very high risk children, this would emphasize further the need for community level prevention with special focus on the family as the unit in a high risk strategy. If the Barker hypotheses\textsuperscript{81} is true, prevention of CVD may start with ensuring that the maternal risk factors are controlled and intrauterine nutrition is appropriate. This suggests an intergenerational approach to prevention, which requires both a community wide population strategy and a targeted high risk individual strategy that would be applicable across the entire life span of individuals (Figures 3 and 4).

Summary

Over the 20th century, most countries in the world have experienced great transitions in social structures, economics, politics, education, and home environments. This has resulted in a shift from agricultural and rural societies to industrial and urban societies in the first 3 quarters of the 20th century, with a further shift in the last quarter to information-based societies. These social and economic transitions have resulted in major changes in population demography, industrial structure, income levels, expenditure patterns, education levels, family structures, eating habits, and physical activity. These changes have markedly increased CV risk factors and disease rates.

CVD is a major global health problem, with the majority of the burden occurring in developing countries. Most of our knowledge about prevention and treatment derives from studies conducted in developed countries and predominantly among white populations. Therefore, there is an urgent need to establish appropriate research studies, increase awareness of the CVD burden, and develop preventive strategies in developing countries. In the meantime, as it is likely that most risk factors will be of some importance in all ethnic populations in the world, prevention and treatment strategies that have been proven to be effective in developed countries should be adapted for developing countries. These strategies should include approaches to prevent the development of risk factors in the population as a whole by changes in social and governmental policy as well as approaches that can be applied to high risk individuals. Some approaches are relatively low cost and readily applicable (eg, promoting physical activity, use of aspirin, or angiotensin-converting enzyme inhibitors in high risk subjects and controlling blood pressure using thiazides or beta-blockers), whereas others may only be applicable to relatively affluent sections of some societies (eg, statins or coronary artery bypass graft surgery). Therefore, both population-level and individual-level strategies should be tailored to each country, community, and socioeconomic stratum (Figure 4). Translating our current knowledge of CVD prevention into effective implementation could be expected to substantially blunt or even reverse the current and future global epidemic of CVD.

Acknowledgments

We acknowledge that this article largely focuses on atherothrombotic cardiovascular diseases. We have not covered the topics of valvular heart disease, Chagas disease, or heart failure, all of which remain significant global health problems.

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