Published in final edited form as:
Clin Geriatr Med. 2009 November ; 25(4): 563–vii. doi:10.1016/j.cger.2009.07.007.

The Burden of Cardiovascular Disease in the Elderly: Morbidity, Mortality, and Costs

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Synopsis for Table of Contents

Cardiovascular disease (CVD) in older Americans imposes a huge burden in terms of mortality, morbidity, disability, functional decline, and healthcare costs. In light of the projected growth of the population of older adults over the next several decades, the societal burden attributable to CVD will continue to rise. There is thus an enormous opportunity to foster successful aging and to increase functional life years through expanded efforts aimed at CVD prevention. This chapter provides an overview of the epidemiology of CVD in older adults, including an assessment of the impact of CVD on mortality, morbidity, and health care costs.

Introduction

The age structure of the U.S. population is expected to change dramatically over the next several decades with a nearly two-fold increase in the size of the population aged ≥65 years by 2050 [1]. While adults aged 65-84 years accounted for 10.9% of the total population in the year 2000, this proportion is estimated to increase to approximately 16% by 2050. Moreover, it is anticipated that individuals ≥85 years of age will account for 4.3% of the population in the 2050, representing a more than two-fold increase from 2010 [1]. In absolute terms, and considering the projected growth of the overall population, the number of adults aged ≥85 years is estimated to increase from approximately 5.8 million in 2010 to 19 million by 2050, a 228% increase [1]. These projected changes in the U.S. age distribution translate into a significant burden in terms of morbidity, mortality, and costs related to cardiovascular diseases (CVD).

The age-related increase in CVD morbidity and mortality can be appreciated by consideration of the population-based disease-specific incidence and prevalence rates of CVD, including coronary heart disease (CHD), peripheral arterial disease (PAD), heart failure (HF), valvular heart disease, and stroke. Similarly insightful is a review of the associations between age and several measures of subclinical CVD, such as coronary artery calcification and the ankle brachial index (ABI). The impact of CVD on successful aging versus frailty, hospitalization rates, and cost will provide an important additional perspective.

Data presented in this review are derived primarily from population-based epidemiologic studies of community-dwelling U.S. adults, including those focusing on older adults, such as the Cardiovascular Health Study (CHS) [2].

MORBIDITY AND MORTALITY

Cardiovascular Disease

In 2005 CVD was the underlying cause of death in 864,480 of the approximately 2.5 million total deaths in the U.S., and adults aged ≥65 years accounted for 82% of all deaths attributable to CVD (Figure 1). In terms of morbidity, an estimated 80 million Americans have at least one form of CVD, and nearly one-half of these are aged ≥60 years [3], reflecting a marked increase in the incidence and prevalence of CVD with advancing age. The prevalence of CVD, including hypertension, CHD, HF, and stroke, increases from about 40% in men and women 40-59 years of age, to 70-75% in persons 60-79 years of age, and to 79-86% among those aged 80 years or older (Figure 2) [3]. Similarly, the incidence of CVD, including CHD, HF, and stroke or intracerebral hemorrhage, increases from 4-10 per 1,000 person-years in adults aged 45-54 years to 65-75 per 1,000 person-years in adults aged 85-94 years (Figure 3) [3,4].

Coronary Heart Disease

CHD accounts for more than half of all CVD-related deaths. In 2005, CHD was the primary cause of 445,687 deaths, of which nearly 82% were in individuals aged ≥65 years [3]. The prevalence of CHD increases markedly with age in both men and women (Figure 4) [3]. Similarly, the incidence of CHD increases with age among older adults, irrespective of race or gender (Figures 5 and 6) [5]. Even at the age of 70 years, the lifetime risk of a first CHD event is 34.9% in men and 24.2% in women [6].

Myocardial Infarction

Prevalence—The prevalence of myocardial infarction (MI) increases with age, and there is nearly a seven-fold higher prevalence among individuals age 65-74 years relative to those age 35-44 [7]. The pattern of age-related increase in MI prevalence extends into the oldest age groups, and the magnitude is greater in women. In CHS, MI prevalence increased from 9.7% in women aged 65-69 years to nearly 18% in those aged ≥85 years, representing an increase of nearly two-fold [8].

Incidence—Nearly one-half million persons aged ≥75 years are diagnosed with an MI each year, accounting for more than one-third of all MIs in the U.S. Relative to individuals 35-44 years old, men and women 65-74 years old have an approximately ten-fold greater MI incidence rate. This represents an increase from approximately 1.0 to nearly 10 per 1,000 person-years in men and from 0.3-0.7 to 5.1-7.2 per 1,000 person-years in women [3]. Data from CHS indicate that the age-related increase in MI incidence continues into the oldest age groups, with 2-3 fold increases in persons ≥80 years of age compared to those age 65-69 (Figures 7 and 8) [5].

Prognosis—MI in the elderly is associated with poor short- and long-term prognosis in terms of both morbidity and mortality [3,9]. The proportion of patients ≥70 years with recurrent MI, stroke, or HF within 5 years following a first MI is 1.5 to 3-fold greater than in those aged 40-69 years. Likewise, the proportion of individuals aged ≥70 years that die within one year following a first MI is 2 to 3-fold higher than in those aged 40-69 years [3].

Heart Failure

In 2005, HF, which is predominantly a disorder of the elderly, was the primary cause of approximately 59,000 deaths and was listed as a primary or contributory cause of death on nearly 300,000 U.S. death certificates [3,10].

Prevalence—The aging of the population in combination with improved survival in patients with CVD, particularly CHD and hypertension, has led to an increase in both the prevalence and incidence of HF. HF is relatively uncommon in individuals age 20-39 (0.1-0.2%), but the prevalence increases progressively with age to 5-10% in persons age 60-79 years and 12-14% in those ≥80 years [3]. In CHS, the prevalence of HF increased from 12% in men and 6% in women 65-69 years of age to 18% in men and 14% in women age 85 or older [8].

Incidence—Older adults without HF have an approximately 1 in 5 lifetime risk for developing HF [11]. At age 80, men without HF have a 20.2% risk for developing HF, which is close to the 21.0% lifetime risk for 40 year old men. However, relative to younger adults, the short-term risk of HF is much greater in the elderly. For example, the 5-year risk of incident HF for an 80 year old person is about 8%, whereas the risk for a 40 year old is only 0.2% (i.e., a 40-fold difference).

In the CHS, the 10-year incidence of HF increased by up to 6-fold across age strata [5], with similar increases in men and women and in Caucasians and African-Americans (Figures 9 and 10). In both Caucasians and African-Americans, men had a higher 10 year incidence of HF than women. While the overall incidence rate of HF was higher in Caucasian men than in African-American men, the reverse was true in women.

Stroke

Stroke is the third leading cause of death and a leading cause of long-term disability in the U.S. While the prevalence of stroke is below 3% in adults aged 20-59 years, it increases to approximately 8% by age 60-79 years, and reaches 13-17% among persons aged ≥80 years [3].

The overall 10-year incidence of stroke in CHS ranged from 13.7-14.7 per 1,000 person-years [5]. Notably, after age 75 the 10-year incidence of stroke tended to be higher in women than in men. Stroke incidence rates also increased two- to five-fold across age groups (Figures 11 and 12) [5].

Peripheral Arterial Disease

PAD is a significant predictor of cardiovascular and overall mortality. In addition, PAD is associated with limitations in physical function and with reduced health-related quality of life [12,13]. PAD, diagnosed by an ankle brachial index (ABI) <0.9, was present in 12.4% of 5,084 CHS participants [14]. In CHS, the prevalence of an ABI <0.9 among men without clinical CVD increased almost 3-fold from age 65-69 to age ≥85, reaching approximately 30% in the latter age group. In women, the increase in prevalence of PAD with age was even more striking, with nearly 40% of women ≥85 having an abnormal ABI, representing an 8-fold increase relative to the 65-69 year age group.

Valvular Heart Disease

Cardiac calcification—Cardiac calcification, a marker of increased CVD risk, is commonly detected in the elderly [15,16]. For example, a necropsy study of 490 patients aged ≥80 years found that 91% had calcified deposits involving the coronary arteries, aortic valve cusps, mitral valve annulus, and/or the left ventricular papillary muscles [17].

Mitral Annular Calcification—Mitral annular calcification (MAC), a degenerative condition of the mitral valve support ring, has been shown to be independently associated with 1.5- to two-fold increases in the risk of stroke and other CVD events, as well as CVD- and all-cause mortality [18,19]. The prevalence of MAC increases with age. In the CHS, the overall prevalence of MAC was 42%, increasing from approximately 35% in 65-74 year olds to nearly

60% by age ≥85 years [15]. Using different criteria for diagnosing MAC, the Framingham Heart Study reported an overall prevalence of 2.8% among 5694 adults. However, the prevalence of MAC increased with age in both genders, reaching 6.0% in men and 22.4% in women ≥80 years of age [20].

Aortic Valve Thickening and Calcification—Calcification of the aortic valve is a common finding in advanced age. In one study, calcification was present in 53% of adults over the age of 55 years, and the proportion increased with advancing age, from 28% at age 55-71 years to 75% in individuals aged 85-86 years [21]. In addition, the prevalence of severe aortic valve calcification increased from 7% in 55-71 year-olds to 19% in persons aged 85-86 years.

Aortic valve sclerosis, defined as increased echogenicity and leaflet thickness without restriction of leaflet motion, is associated with an approximately 50% increase in the risk of CVD death and incident MI [22]. Aortic valve sclerosis was present in 26% of CHS participants, increasing from 20% in 65-74 year-olds, to 35% in 75-84 year-olds, and to 48% in those aged ≥85 years [23].

Aortic Stenosis—In 2005, diseases of the heart valves accounted for 93,000 hospital discharges and nearly 21,000 deaths, of which approximately 13,000 were due to aortic valve disease [3]. In CHS, the prevalence of aortic stenosis (AS), defined as an increased systolic velocity across the aortic valve (≥2.5 m/s by Doppler echocardiography), increased from 1.3% in participants aged 65-74 years, to 2.4% in those age 75-84, and to 4% among those ≥85 years [24].

The Helsinki Ageing Study reported the prevalence of moderate or severe AS among 197 participants aged 75-76 years, 155 participants aged 80-81 years, and 124 participants aged 85-86 years [21]. Moderate and severe AS were defined as calculated aortic valve areas ≤1.2 cm^2 and ≤0.8 cm^2, respectively. The overall prevalence rates of moderate and severe AS were 4.8% and 2.9%. The prevalence of at least moderate AS increased from 2.5% in subjects aged 75-76 years, to 3.9% in 80-81 year-olds, and to 8.1% by age 85-86. Prevalence rates for severe AS for these age categories were 0.5%, 2.6%, and 5.6%, respectively.

Valvular Regurgitation—In the Framingham Heart Study, the prevalence of valvular regurgitation involving the mitral, tricuspid, and aortic valves was determined in participants aged 26 to 83 years using Doppler echocardiography [25]. In men, the prevalence of at least mild severity mitral regurgitation increased more than 4-fold from 8.9% in subjects aged 26-39 years to 39.3% in those aged 70-83 years. The prevalence of at least mild tricuspid regurgitation increased from 13.0% in participants aged 26-39 years to 27.3% in those aged 70-83 years. Similarly, the prevalence of aortic valve regurgitation increased from 0% in 26-39 year-olds to 14.4% in 70-83 year-olds. In women, the prevalence of at least mild mitral, tricuspid, and aortic valve regurgitation in those aged 26-39 years was 9.7%, 14.4%, and 0%, respectively. By ages 70-83 years, prevalence rates increased to 23.6%, 29.5%, and 16.9%, respectively. The age-related increase in prevalence of valvular heart disease has also been confirmed by a pooled analysis of echocardiographic data from 11,911 participants in three epidemiologic studies representing various age groups, including the Coronary Artery Risk Development in Young Adults (CARDIA) study, Atherosclerosis Risk in Communities (ARIC) study, and the Cardiovascular Health Study [26].

In contrast to most other forms of valvular heart disease, the prevalence of mitral valve prolapse (MVP) has not been observed to vary significantly with age [27]. Among 3491 Framingham Heart Study participants with a mean age of 54.7 years (range: 26 to 84 years), the overall prevalence of MVP was 2.4%. MVP prevalence rates were similar across age decades from 30 to 80 years.

Electrocardiographic Abnormalities and Arrhythmias

Resting Electrocardiogram—Abnormalities on the resting electrocardiogram (ECG) are quite common in older adults. Evaluation of ECGs from 5,150 CHS participants revealed that the overall prevalence of any ECG abnormality was 28.7% [28]. Prevalence rates of specific ECG abnormalities were 8.7% for ventricular conduction defects, 5.3% for first-degree atrioventricular block, 3.2% for AF, 6.3% for isolated major ST-T wave abnormalities, 4.2% for left ventricular hypertrophy, and 5.2% for major Q/QS waves.

The prevalence of ECG abnormalities in men and women with known coronary artery disease (CAD) and hypertension (HTN) was 44.5% and 31.3%, respectively. In comparison, the prevalence of ECG abnormalities in men and women free of CAD and HTN was lower at 25.0% and 14.3%. In men free of CAD and HTN, the prevalence of ECG abnormalities increased from 16.0% in those aged 65-69 years, to 27.5% by age 75-79 years, and 45.9% by age ≥85 years. Likewise, in women free of CAD and HTN, the prevalence of ECG abnormalities increased from 10.5% at age 65-69 years, to 20.2% by age 75-79 years, and 31.6% by age ≥85 years.

Ambulatory Electrocardiogram

Twenty-four hour ambulatory electrocardiography was performed in 1,372 CHS participants and revealed that supraventricular ectopic beats and minor supraventricular arrhythmias were extremely common, occurring in approximately 97% of older adults [29]. Similarly, ventricular ectopic activity was present in 82% of the CHS population. Frequent ectopic beats, defined as ≥15 beats per hour, were recorded in nearly half of men and women and were more commonly of supraventricular origin. Supraventricular arrhythmias were observed in 57.1% and 55.5% of men and women, respectively. There was an age-related increase in the prevalence of supraventricular arrhythmias, such that by age ≥80 years more than three-quarters of subjects manifested supraventricular arrhythmias. Supraventricular tachycardia (SVT) of at least 3 beats was seen in 47.7% of men and 49.9% women. Ventricular arrhythmias were observed in 28.5% of men and 15.6% of women. Prevalence rates for ventricular tachycardia, defined as ≥3 consecutive complexes, were 13% and 4.3% in men and women, respectively. Conversely, serious arrhythmias, such as sustained ventricular tachycardia (≥15 complexes) and complete atrioventicular block, were rarely detected (≤0.5%) in CHS participants.

Atrial Fibrillation

Prevalence—In 2005, atrial fibrillation (AF) was estimated to affect 2.2 million Americans, but it is projected that by 2050 the number of individuals with AF will exceed 10 million, primarily due to population aging [3,30]. In CHS, the overall prevalence rates of AF in men and women were 6.2% and 4.8%, respectively [31]. The prevalence of AF varied by CVD status such that the prevalence in women with clinical CVD was 8.7%, compared to 4.5% in those with subclinical CVD, and 1.1% in women without evidence for CVD. The prevalence of AF in men was 9.4% in those with clinical CVD, 4.7% in those with subclinical CVD, and 2.7% in those without CVD. Regardless of CVD status, the overall prevalence of AF increased with age, from 5.9% in men and 2.8% in women aged 65-69 years, to 8.0% in men and 6.7% in women aged ≥80 years.

Incidence—The lifetime risk for AF in persons without HF or MI is approximately 15% at age 40 as well as at age 80 [32]. Overall incidence rates of AF in CHS men and women were 26.4 and 14.1 per 1,000 person-years, respectively [33]. There is an age-associated increase in the incidence of AF in both genders, such that the incidence increases from 12.3 per 1000 person-years in men aged 65-69 years to 58.7 per 1,000 person-years by age ≥80 years. Similarly, the incidence in women increases from 10.9 per 1,000 person-years in the 65-69 year age group to 25.1 per 1,000 person-years in women aged ≥80 years.

FRAILTY and SUCCESSFUL AGING

CVD is the second leading cause of disability among older adults (after arthritis), and it is an important cause of a decline in self-reported health. Certain features of aging are in part a reflection of not only clinical but also subclinical atherosclerotic burden. As with clinical CVD, the burden of subclinical CVD, evidenced by low ABI or high coronary artery calcium score, increases progressively with age in both men and women [34-37].

Data from the CHS also implicate CVD, both clinical and subclinical, as contributing to dementia and functional decline, manifested by loss of independence and the ability to perform routine activities of daily living. Further, there is a growing body of evidence linking CVD with frailty, a clinical syndrome associated with marked loss of physiologic reserve and an increased risk for disability, institutionalization, and death [38]. In CHS, for example, compared to people 65 years of age or older with a normal ABI (i.e., ≥ 0.9), those with an ABI < 0.8 had a 3.5-fold increased risk of frailty [38]. Viewed another way, the presence of subclinical CVD among participants in CHS was associated with a loss of approximately 6.5 years of “successful” life (i.e. with good health and function) in women and 5.6 years in men [39].

MORTALITY

In the U.S., CVD accounts for more deaths than any other major cause, and CHD and stroke account for approximately two-thirds of CVD deaths [3]. The remaining CVD deaths are due to HF (7%), high blood pressure (7%), diseases of the arteries (4%), and miscellaneous causes (14%) [3]. As noted earlier, in 2005 approximately 80% of the 864,000 CVD deaths occurred in individuals aged ≥65 years and nearly 40% occurred in persons aged ≥85 years [3]. Furthermore, mortality rates from CHD, HF, and stroke are nearly 2-fold higher in the 75-84 year age group compared to the 65-74 year age group [40].

In 2004, 48% of all deaths in Americans aged ≥85 years were ascribed to CVD, compared to only 20% in those aged 35-44 years [40]. Among women, more than 200,000 of the 454,613 total CVD deaths occurred in the ≥85 year age group. In men, approximately 100,000 of the 409,867 total CVD deaths were in those ≥85 years [3]. Thus, CVD exacts an exceptionally high toll in the very elderly, particularly among women.

HOSPITALIZATIONS

CVD accounted for 6.2 million hospital discharges in 2006, more than any other disease category [3]. Approximately 75% of admissions for HF occur in people 65 years of age or older, with more than half occurring in people age 75 or older. Persons over age 65 also account for more than 60% of admissions for acute MI and 75% of admissions for heart rhythm disorders. Likewise, in 2006, persons aged ≥65 years accounted for more than half of hospital discharges listing a major cardiac-related procedure as the principal procedure for the hospitalization. More specifically, persons aged ≥65 years accounted for 85% of pacemaker insertions, 61% of implantable defibrillators, 53% of coronary bypass operations, 51% of percutaneous coronary interventions, 60% of cardiac valve procedures, and 75% of endarterectomies [41].

COSTS

In 2009, the cost of CVD and stroke, including direct and indirect costs, is expected to exceed \$475 billion (Figure 13), making CVD the most expensive disease category in the U.S. [3]. Direct costs, including hospital, nursing home, professional fees, drugs and other costs, will total more than \$313 billion dollars. Indirect costs, including costs arising from disability and loss of productivity, will approach $161.5 billion. CHD accounts for the largest proportion of the total cost burden at approximately $165.4 billion, followed by hypertensive disease at $73.4 billion, stroke at $68.9 billion, and HF at $37.2 billion.

In light of the high prevalence rates and substantial morbidity associated with CVD among older adults, it is not surprising that the costs attributable to CVD in the elderly are extremely high. Most of the total expenditures for circulatory diseases, nearly three-quarters, are for persons aged ≥65 years [42]. In addition, approximately one-quarter of all personal health care expenditures are for diseases of the circulatory system, and this proportion increases with age such that by age 85 circulatory diseases account for about one-third of all personal health care expenses [42]. Moreover, with the growth in size of the older adult population in the U.S., it has been projected that, expenditures for the treatment of heart disease will increase 46% by 2025 relative to 1999 [43].

SUMMARY

CVD in older Americans imposes a huge burden in terms of mortality, morbidity, disability, functional decline, and healthcare costs. There is thus an enormous opportunity to foster successful aging and to increase functional life years through expanded efforts aimed at CVD prevention. It follows that active life expectancy, rather than survival alone, should be included as a pivotal outcome in clinical trials involving older adults.

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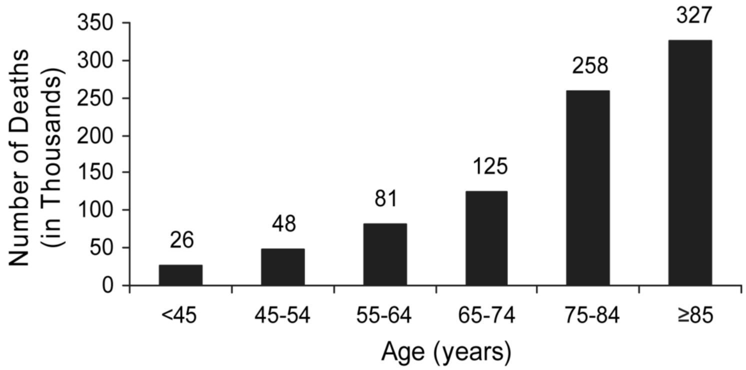

Figure 1.

Number of Deaths (in thousands) due to Cardiovascular Diseases by Age in 2005
Source: Heart Disease and Stroke Statistics-2009 Update. From NCHS. Available at: www.myamericanheart.org.

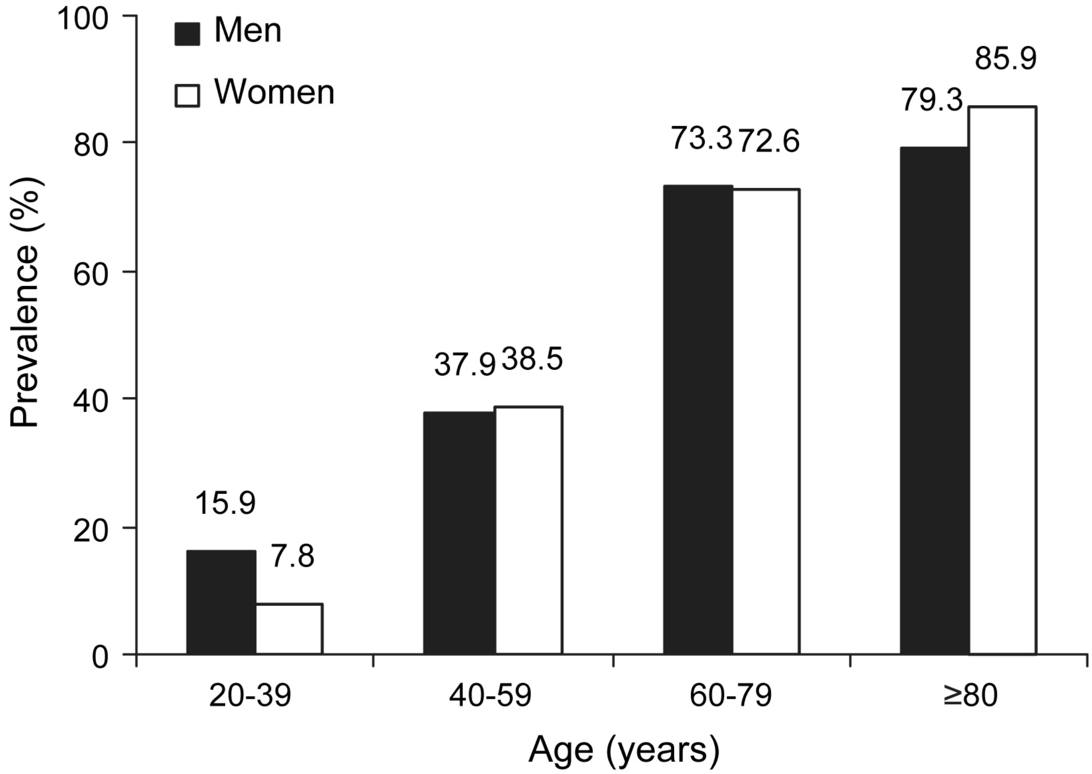

Figure 2.
Prevalence of Cardiovascular disease in adults aged 20 years and older by age and sex
Cardiovascular disease includes coronary heart disease, heart failure, stroke and hypertension.
Source: Heart Disease and Stroke Statistics-2009 Update. From NHANES 2005-2006.
Available at: www.myamericanheart.org.

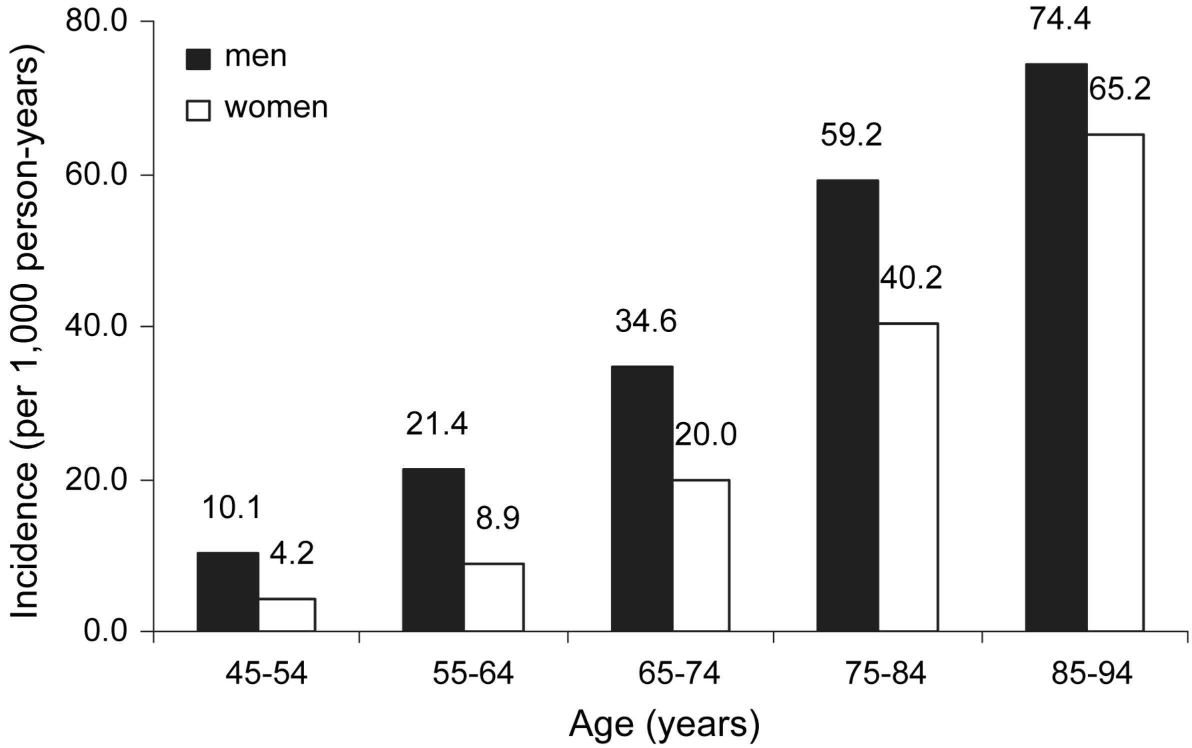

Figure 3.
Incidence of Cardiovascular disease in adults aged 45 years and older by age and sex Cardiovascular disease includes coronary heart disease, heart failure, and stroke or intracerebral hemorrhage. From NHLBI-FHS: 1980-2003. Source: Heart Disease and Stroke Statistics-2009 Update. Available at: www.myamericanheart.org.

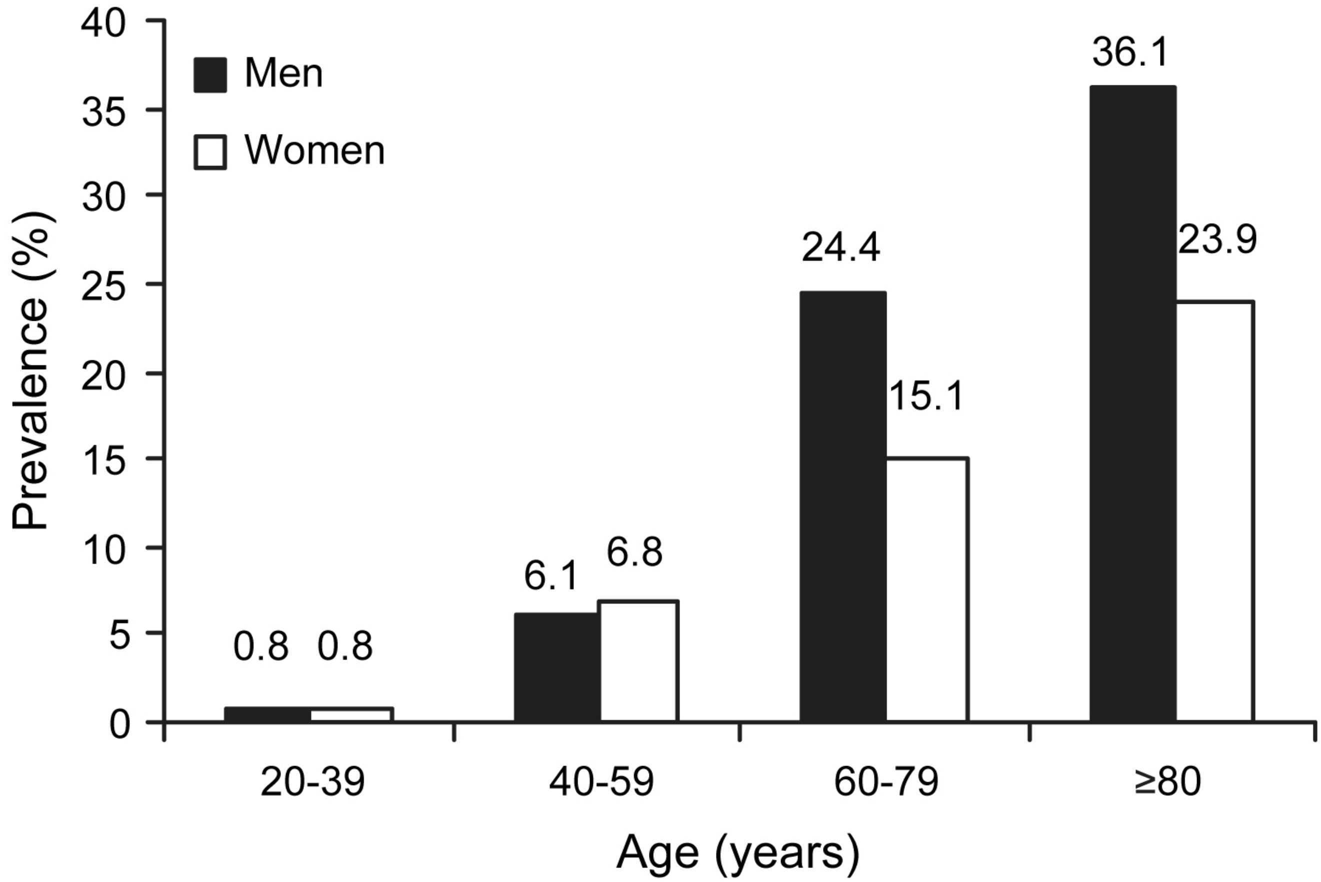

Figure 4.
Prevalence of Coronary Heart Disease in adults aged 20 years and older by age and sex
Source: Heart Disease and Stroke Statistics-2009 Update. From NHANES: 2005-2006.
Available at: www.myamericanheart.org.

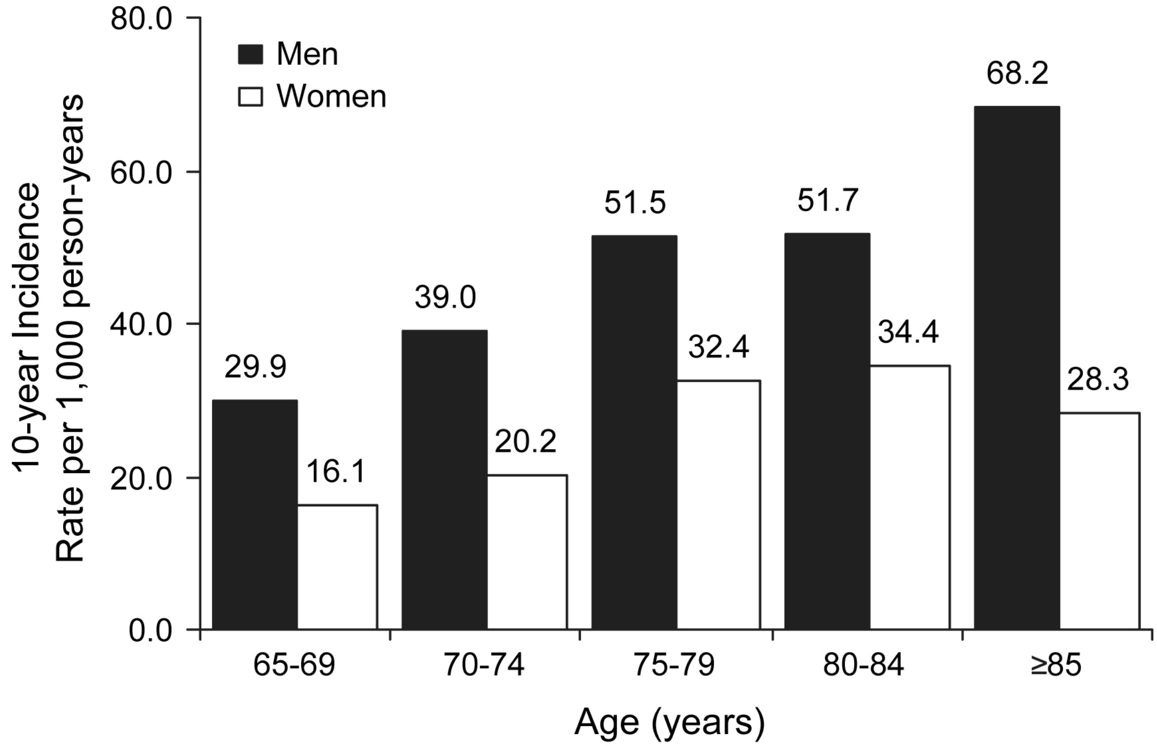

Figure 5.
10-Year Incidence Rate for Coronary Heart Disease in Caucasians by Age and Gender in the Cardiovascular Health Study
Source: Arnold AM, Psaty BM, Kuller LH, et al. *J Am Geriatr Soc*. Feb 2005;53(2):211-218 [5].

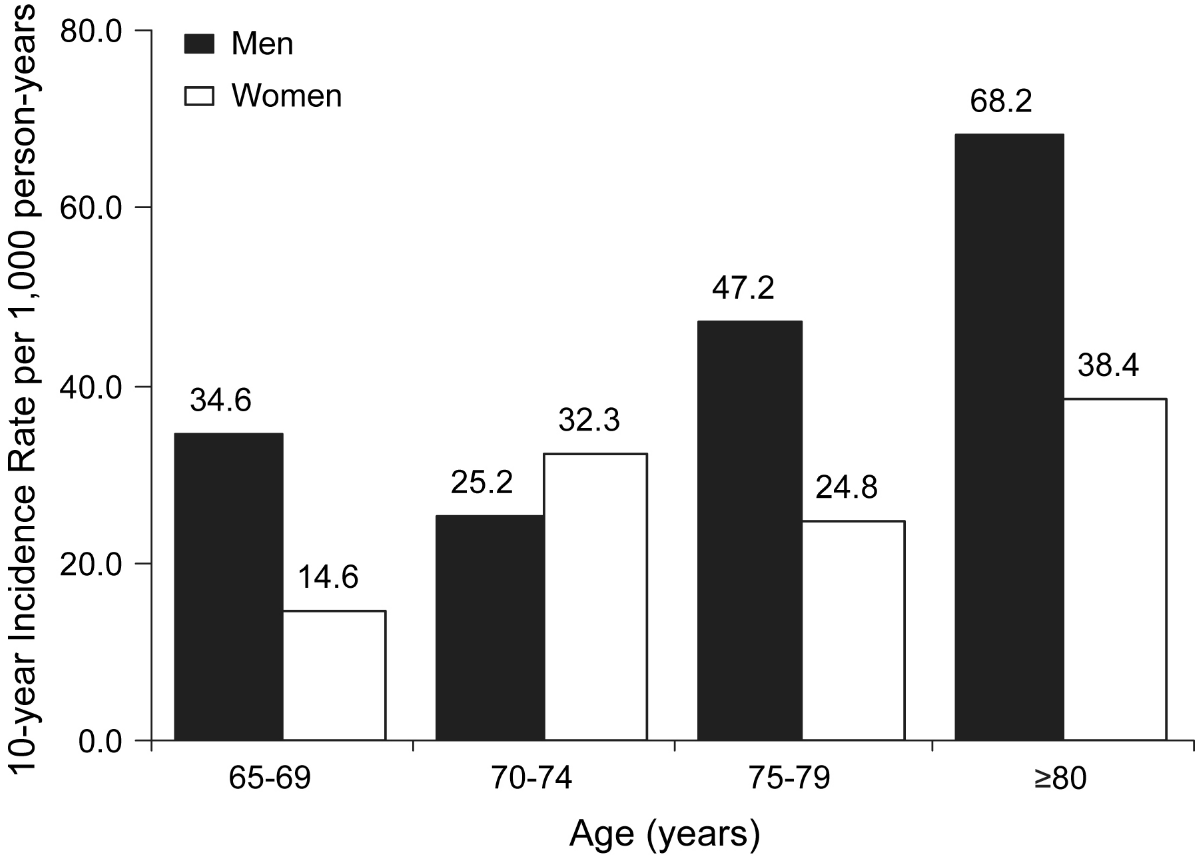

Figure 6.
10-Year Incidence Rate for Coronary Heart Disease in African Americans by Age and Gender in the Cardiovascular Health Study
Source: Arnold AM, Psaty BM, Kuller LH, et al. *J Am Geriatr Soc*. Feb 2005;53(2):211-218 [5].

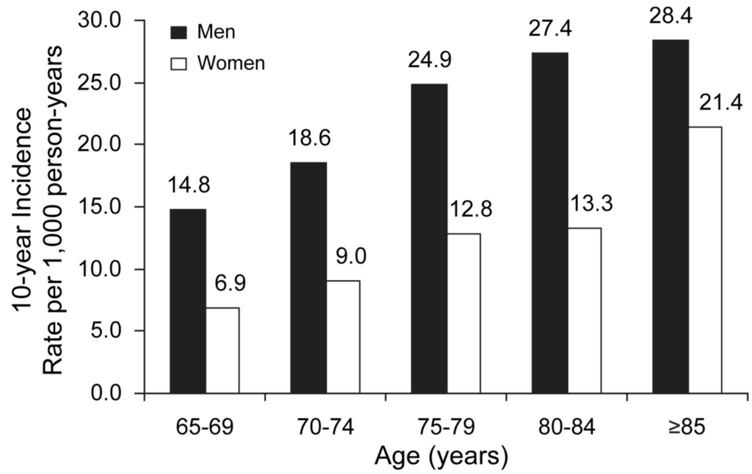

Figure 7.
10-Year Incidence Rate for Myocardial Infarction in Caucasians by Age and Gender in the Cardiovascular Health Study
Source: Arnold AM, Psaty BM, Kuller LH, et al. *J Am Geriatr Soc*. Feb 2005;53(2):211-218 [5].

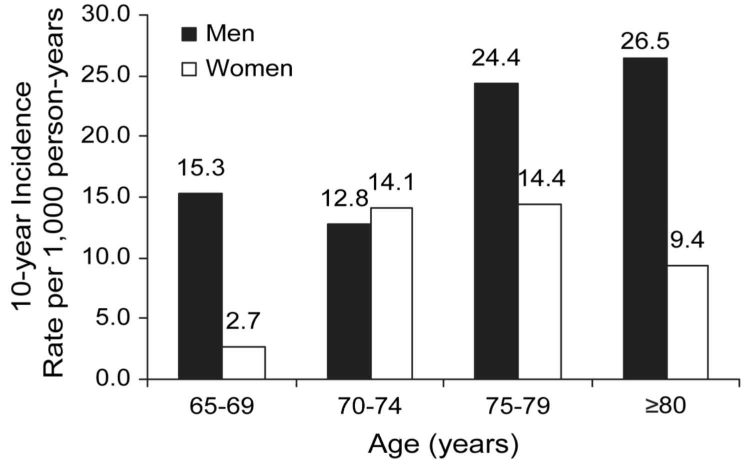

Figure 8.
10-Year Incidence Rate for Myocardial Infarction in African Americans by Age and Gender in the Cardiovascular Health Study
Source: Arnold AM, Psaty BM, Kuller LH, et al. *J Am Geriatr Soc*. Feb 2005;53(2):211-218 [5].

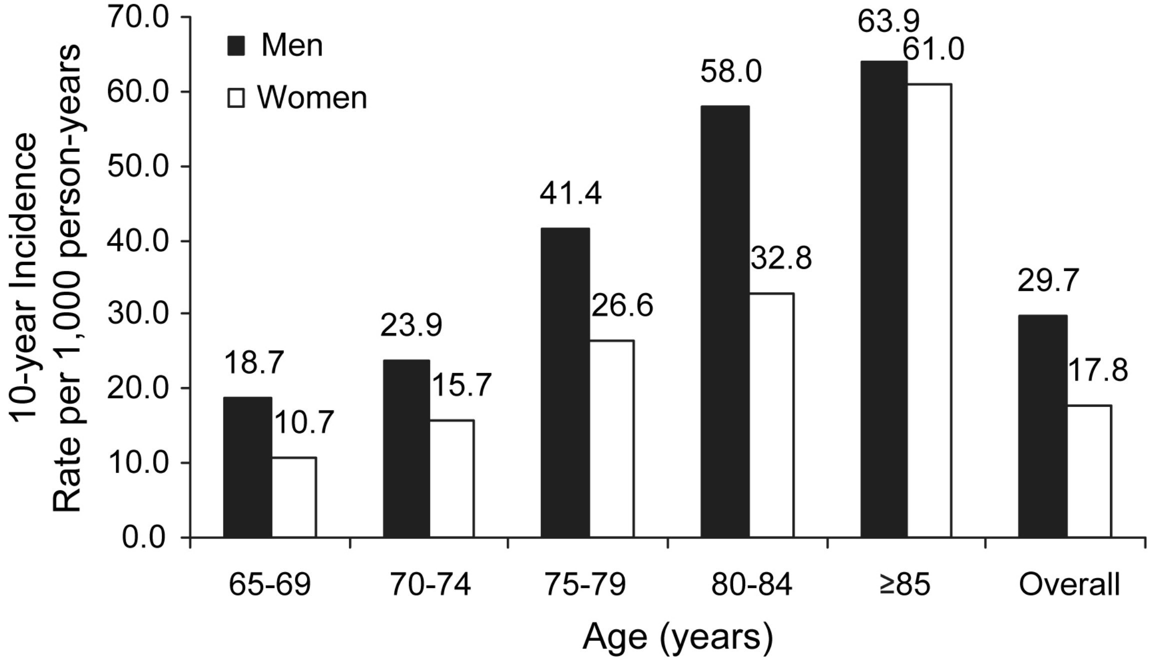

Figure 9.
10-Year Incidence Rate for Congestive Heart Failure in Caucasians by Age and Gender in the Cardiovascular Health Study
Source: Arnold AM, Psaty BM, Kuller LH, et al. *J Am Geriatr Soc*. Feb 2005;53(2):211-218 [5].

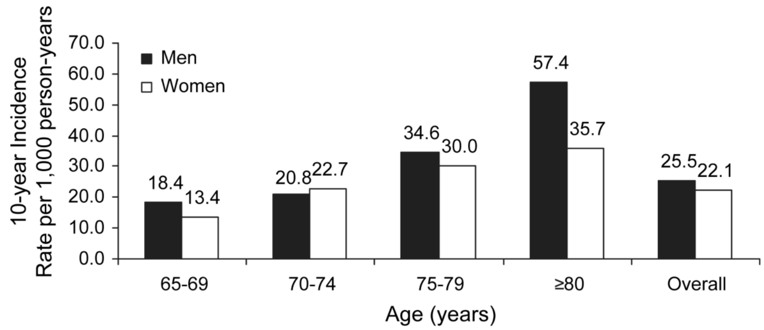

Figure 10.

10-Year Incidence Rate for Congestive Heart Failure in African Americans by Age and Gender in the Cardiovascular Health Study

Source: Arnold AM, Psaty BM, Kuller LH, et al. *J Am Geriatr Soc.* Feb 2005;53(2):211-218 [5].

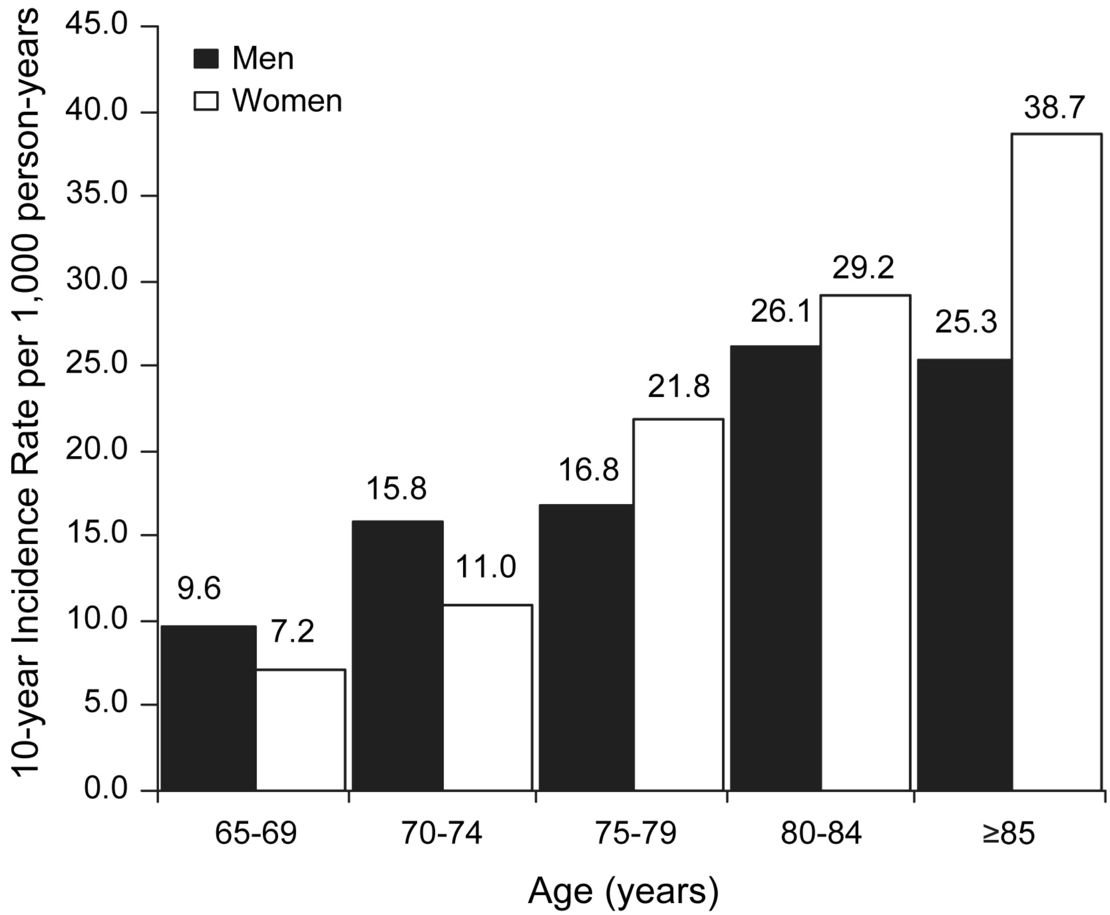

Figure 11.
10-Year Incidence Rate for Stroke in Caucasians by Age and Gender in the Cardiovascular Health Study
Source: Arnold AM, Psaty BM, Kuller LH, et al. *J Am Geriatr Soc*. Feb 2005;53(2):211-218 [5].

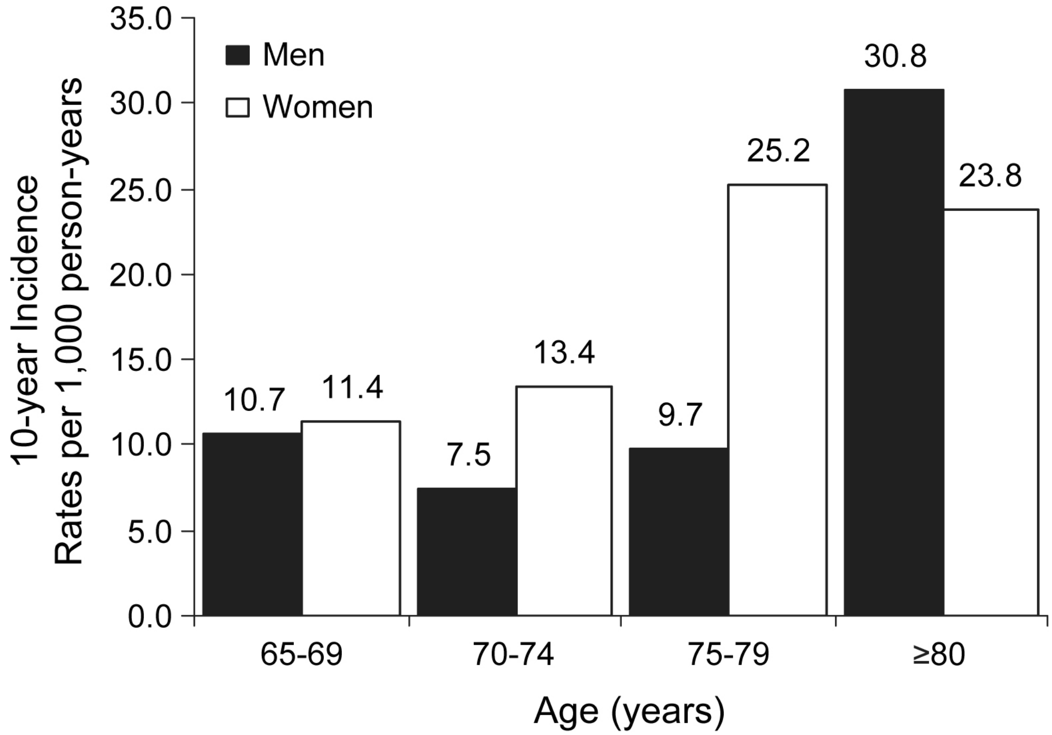

Figure 12.
10-Year Incidence Rate for Stroke in African Americans by Age and Gender in the Cardiovascular Health Study
Source: Arnold AM, Psaty BM, Kuller LH, et al. *J Am Geriatr Soc*. Feb 2005;53(2):211-218 [5].

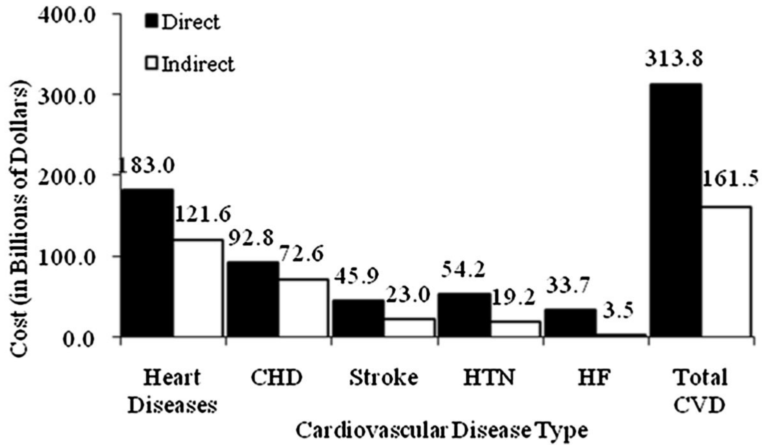

Figure 13.

Estimated Direct and Indirect Costs in Billions of Dollars of Cardiovascular Disease and Stroke Heart Disease category includes coronary heart disease, heart failure, stroke and part of hypertensive disease, cardiac dysrhythmias, rheumatic heart disease, cardiomyopathy, pulmonary heart disease, and other or ill-defined “heart” disease.

Source: Heart Disease and Stroke Statistics-2009 Update. Available at: www.myamericanheart.org.