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1. Introduction

1.1 History of cardiovascular diseases

1.1.1 History of stroke

Stroke was first described by Hippocrates (460 to 370 BC) in antiquity who called it “apoplexy”, which - in Greek - means "struck down by violence". This was due to the fact that stroke patients developed sudden paralysis, change in well-being and convulsions followed by injuries to the brain. It was known that paralysis was on the opposite side to the wound. Hippocrates also described aphasia for the first time when writing about paralysis of the right arm with loss of speech (Pound et al, 1997; Thompson, 1996).

In 1599 the word “stroke” was used for the first time as a synonym for apoplexy and is a fairly literal translation of the Greek term (Pound et al, 1997).

In the 17th century Johann Jakob Wepfer wrote a monograph on apoplexy. He found out from his autopsy studies that patients who died with apoplexy had bleeding in the brain. He also identified the main arteries supplying the brain, the vertebral and carotid arteries and discovered that apoplexy might be caused by a blockage in one of the brain's blood vessels so that the nutrients supply was disrupted (Thompson, 1996).

Study of the cause, symptoms, and treatment of apoplexy was continued. Finally, at the beginning of the 20th century apoplexy was divided into categories, those caused by obstruction and those caused by haemorrhage and the terms "cerebral disease" emerged (Pound et al, 1997).

1.1.2 History of myocardial infarction

Since the beginning of the 19th century it has been known that coronary thrombosis might be fatal.

In 1901, the German scientist Krehl for the first time reported that coronary thrombosis not always caused death and that there may be complications like ventricular aneurysm and myocardial rupture.

Several years later Obrastov, Strazhesko, and Herrick described the clinical characteristics of acute myocardial infarction. They also established the difference to angina pectoris.

After the find that a myocardial infarction is not necessarily fatal, research on treatment was developed. In 1912 James Herrick established the importance of rest in postinfarction recovery with bed rest up to 6 weeks. Furthermore James Herrick introduced electrocardiography for diagnosis of acute myocardial infarction which is still in use.

In the 1950s Bernard Lown found out that the time of recovery for patients of cardiovascular diseases was cut down by decreasing the time of rest due to reduced risk of deep venous thrombosis and pulmonary embolism (Sarmento-Leite, 2001).

1.2 Global prevalence of cardiovascular diseases

According to the World Health Organisation cardiovascular diseases are the principal cause of death worldwide. In 2005 about 17.5 million people died from cardiovascular disease which is 30% of all global deaths. 7.6 million people died due to heart attacks and 5.7 million due to stroke. Not only in industrialized countries cardiovascular disease is the most common cause of death, about 80% of the globally counted death caused by cardiovascular disease occurred in low- and middle-income countries (WHO, 2007).

Cardiovascular diseases account for about 49% of death in Europe (55% of death in women and 43% of death in men) and 42% in the EU (46% of death in women and 39% of death in men) and is the main cause of death in all countries of Europe except among men in France and San Marino (Petersen et al, 2005).

Cardiovascular diseases account for 36.3% of total mortality in the USA. In 2004 the estimated prevalence of cardiovascular diseases was 37.1% in both sexes, 37.5% in men and 36.6% in women with a mortality rate of 11.0% for both sexes (Rosamond et al, 2007).

If current trends may be continued, by 2015 estimated 20 million people will of from cardiovascular diseases, mainly of heart attacks and strokes (WHO, 2007).

1.3 Cardiovascular diseases – biological background

Atherosclerosis

The basic mechanism of cardiovascular diseases is atherosclerosis. The endothelium regulates the vascular homeostasis which means the balance between vasodilatation and vasoconstriction and exerts anticoagulant, antiplatelet and fibrinolytic properties (Davignoon & Ganz et al, 2004). Endothelial dysfunction, an early marker of atherosclerosis, can be induced by elevated low-density lipoproteins (LDL), free radicals, infectious microorganisms, shear stress, hypertension or toxins after smoking and is associated with decreased nitric oxide synthesis. An inflammatory response plays a major role in the progression of atherosclerosis (Stoll and Benszus, 2006). Oxidized lipoprotein, T-cells and macrophages enter into the vessel wall which leads to enhanced oxidative stress in vascular cells and to an activation of intracellular signalling molecules. T-cells recognize oxidized LDL, heat shock proteins and shared microbial antigens and locally release pro-inflammatory cytokines. Cell adhesion molecules are up-regulated which facilitates the adherence of leukocytes to the dysfunctional endothelium and their transmigration into the vessel wall. The inflammatory response leads to initiation of atherosclerotic plaques formation and to their destabilization. The rupture of plaque causes most acute coronary syndromes like myocardial infarction, unstable angina, and coronary death (Fuster et al, 2005; Stoll, 2006).

Atrial fibrillation

Atrial fibrillation represents an early stage of cardiovascular diseases and indicates increased risk for cardiovascular diseases. During atrial fibrillation the contraction of the atrias is totally uncoordinated resulting from the abnormal electrical impulse. As a result blood is not pumped out completely and can clot. If a blood clot leaves the heart and reaches an artery of the brain, stroke can occur. People with atrial fibrillation have a five time increased risk of stroke (Savelieva et al, 2008; Thews et al, 1999; S199)

Cardiovascular diseases

Cardiovascular diseases (CVDs) are a group of disorders of the heart and blood vessels including coronary heart disease, cerebrovascular disease, peripheral arterial disease, rheumatic heart disease, hypertension, congenital heart disease and heart failure (WHO, 2007).

"Acute coronary syndrome" is the term used for describing patients who present with either acute myocardial infarction or unstable angina (Rosamond et al, 2007). **Coronary heart diseases** are caused by blocking or narrowing of the coronary arteries because of atherosclerotic changes in the blood vessels. Hereby oxygen and nutrient supply of the heart muscle are disrupted. This can cause angina pectoris or a heart attack. In **angina pectoris** the balance of oxygen supply to oxygen use of the heart muscle is destroyed which causes chest pain that can also spread over shoulders and arms. **Stable angina** is exercise induced with no symptoms occurring at rest. **Unstable angina** varies in frequency and severity and can occur during intensive exercise and at rest. In a **myocardial infarction** or **heart attack** the blood flow through a coronary artery is totally blocked and because of this a myocardial ischemia necrosis of an area of the heart muscle occurs. A number of complications can accompany a cardiac infarction like cardiac arrhytmia, mechanic failure of the heart muscle, insufficiency of the mitral valves, aneurysmas and rupture of the heart septum and disruption of the papillar muscle. The location of the infarct scars over. If the scar is spread over a small area only, the heart is able to fully recover. If the scar spreads over a larger area, heart insufficiency can develop (Thews et al, 1999, S209-11).

The **cerebrovascular disease** stroke is caused by a disruption of the blood supply to the brain. An **ischemic stroke** occurs, if arteries are blocked by blood clots or by the gradual build-up of plaque and other fatty deposits. A **hemorrhagic stroke** results from a rupture of a blood vessel in the brain mainly because of hypertension (Thews et al, 1999). The consequences of a cerebrovascular event depend on the location and dilatation of the infarction. Approximately 20-30% of the patients die within the first week, often because of secondary complications

like cerebral oedema, pneumonia, heart insufficiency or infections. Approximately one third of the patients remain in need of care (Thews et al, 1999; S691).

Rheumatic heart disease occurs as a complication of rheumatic fever which is caused mainly by an infection with streptococcal bacteria. It is observed in the development of damage to the heart muscle and weak valvular conditions (Girschik et al, 2008).

A **congenital heart disease** is caused by a malformation of heart structures existing at birth. The most common heart defects are patent ductus arteriosus, the artery which normally closes after birth, atrial and ventricular septal defects which can cause the blood to circulate improperly, valves abnormalities and stenosis of the aorta valve, pulmonal stenosis or coarctation of the aorta (Thews et al, 1999; S207).

Other cardiovascular diseases are aortic aneurysm or dissection, peripheral arterial disease or pulmonary embolism. **Aortic aneurysm** is defined as a local, permanent dilatation and **aortic dissection** is defined as a rupture of the aorta (Thews et al, 1999; S261). A **peripheral arterial disease** is atherosclerosis of the arteries supplying the arms or legs like the iliac, femoral, popliteal and tibial arteries. In **deep venous thrombosis** blood clots occur in the leg veins which can move to the heart or lungs causing **pulmonary embolism**. This effect is capable of causing permanent damage of the affected lung, low oxygen levels in the patient´s blood or damage to other organs caused by lack of oxygen. If the clot is too large, the embolism can be fatal (Thews et al, 1999; S261).

1.4 Cardiovascular risk factors

1.4.1 Metabolic syndrome

An excess of body fat, especially visceral fat is a key factor for developing metabolic syndrome, which is defined as the coexistence of hyperglycaemia, hypertension, hyper- and dyslipidemia and central obesity. The International Diabetes Federation (IDF) has defined the metabolic syndrome as follows (Alberti et al, 2006):

- central obesity defined as waist circumference with ethnicity specific values: ≥94 cm for male Europids and, ≥90 cm for male South Asians, Chinese and Japanese and ≥80 cm for female Europids, South Asians, Chinese and Japanese.

plus any two of the following four factors:

- raised triglycerides ≥150 mg/dL (1.7 mmol/L) or specific treatment for this lipid abnormality.
- reduced HDL (high density lipoprotein) cholesterol of <40 mg/dL (1.03 mmol/L) in males and <50 mg/dL (1.29 mmol/L) in females or specific treatment for this lipid abnormality.
- raised blood pressure: systolic blood pressure ≥130 or diastolic blood pressure ≥85 mm Hg or treatment of previously diagnosed hypertension.
- raised fasting plasma glucose (FPG) ≥100 mg/dL (5.6 mmol/L), or previously diagnosed type 2 diabetes.

The WHO has established the following diagnostic criteria for the metabolic syndrome (Khatib, 2006):

- abdominal obesity: in men waist circumference >102 cm (>40 inches), in women waist circumference >88 cm (>35 inches).
- high levels of triglycerides: at least 150 mg/dL,
- low HDL cholesterol: in men <40 mg/dL, in women <50 mg/dL,
- high blood pressure: at least 130/>85 mmHg
- high fasting glucose: at least 110 mg/dL

According to WHO at least three of the five criteria shown must be met to diagnose metabolic syndrome. Several other components of the metabolic syndrome have been described (e.g. hyperuricaemia, coagulation disorders) but are not considered criteria for its diagnosis (Khatib, 2006)

Cardiovascular diseases are more prevalent among patients with this syndrome (Lakka et al, 2002; Ridker et al, 2003; Howard et al, 2003; McNeill et al, 2005). The risk for coronary heart disease and stroke was increased threefold in subjects with the syndrome. Cardiovascular mortality was significantly increased in subjects with the metabolic syndrome from 2.2 to 12.0 % (Isomaa et al, 2001). It has to be considered that the cardiovascular risk factors have a multiplicative and not an additive effect on the incidence of coronary heart disease (Grundy et al, 2006).

1.4.2 Risk factor obesity

Overweight defined as a BMI (body mass index) between 25 and 29.9 and obesity defined as a BMI over 30 kg/m^2 predispose for higher cardiovascular disease risk.
In the Health Professionals Follow-Up Study, males with a BMI >30 had a 4 times higher risk of cardiovascular mortality than those with a BMI <23.62. In further studies it was shown that cardiovascular risk increases with higher waist circumference. In women a higher risk was reported with waist circumferences >38 inches compared with waist circumferences <30 inches. In further studies it was shown that men with a waist circumference of <38 inches had less cardiovascular risk than men with a circumference of >38 inches (Retelny et, 2008).
Obesity is independently correlated to the risks of developing coronary heart disease, atrial fibrillation, and heart failure. This can be partly explained by the higher prevalence of other cardiovascular risk factors in overweight or obese people like hyper- and dyslipidemia, diabetes type 2 and hypertension. Especially visceral obesity contributes to or causes most other modifiable risk factors, like hypertension and type 2 diabetes mellitus (Zalesin et al, 2008; Retenly et al, 2008). Even modest weight loss (7% to 10% of body weight) results in a decreased fat mass, blood pressure, glucose, low-density lipoprotein, and triglyceride levels (Pritchett et al, 2005).

Obesity can enhance cardiovascular disease through various mechanisms like systemic inflammation, hypercoagulability, and activation of the sympathetic and renin-angiotensin systems (Zalesin et al, 2008). This is caused by the adipose tissues which is an active endocrine organ producing a great variety of hormones and cytokines which are involved in glucose metabolism, lipid metabolism, inflammation, coagulation and blood pressure. Obesity causes an elevated secretion of adipokines which enhance development of diabetes mellitus, metabolic syndrome and atherosclerosis (Hajer et al, 2008).

1.4.3 Risk factor hyper-/ and dyslipidemia

Hyperlipidemia is defined as an increased level of one or more cholesterol fractions and dyslipidemia is defined as an adverse lipoprotein ratio such as an increase of LDL level and triglyceride level and a low HDL level (Thews et al, 1999).

Obesity, especially abdominal obesity, promotes the progression of dyslipidemia like high plasma concentrations of triacylglycerol in the fasted state, low high density lipoprotein cholesterol (HDL) concentrations and higher concentrations of small dense low density lipoproteins (LDL). A low level of body fat is associated with high levels of HDL cholesterol (Hardman et al, 1999).

The ATP III (Adult Treatment Panel III) classifies the LDL-cholesterol levels as follows (NCEP, 2002) according to the proposed risk for developing coronary heart disease:

- <100 mg/dl as optimal,
- 100-129 mg/ml as above optimal,
- 130-159 mg/ml as borderline high,
- 160-189 mg/ml as high,
- ≥190 as very high.

The ATP III (Adult Treatment Panel III) classifies the total-cholesterol levels as follows (NCEP, 2002):

- <200 mg/dl desirable,
- 200-239 mg/ml as borderline high,
- ≥240 as high.

LDL is the major atherogenic lipoprotein, whereas HDL protects against the development of atherosclerosis. One percent decrease in HDL cholesterol is associated with a 2–3 percent increase of a coronary heart disease risk (Gordon et al, 1989). The main mechanism by which cholesterol increases cardiovascular disease risk is its action as a key component in the development of atherosclerosis. Mainly by accumulation of fatty deposits on the inner lining of arteries, cholesterol increases the risks of ischaemic heart disease, ischaemic stroke and other vascular diseases (WHO, 2002).
In several studies the association between serum cholesterol level and cardiovascular diseases was determined. The summary of ten cohort studies shows that there is an association between ischaemic heart disease and the serum cholesterol level which decreases with age. For men a decrease of serum cholesterol concentration of 0.6 mmol/l or about 10% led to a reduction of the risk of ischaemic heart disease of 54% at age 40 years, 39% at age 50 years, 27% at 60 years, 20% at 70 years, and 19% at 80 years. The average reduction of mortality of ischaemic heart disease in three international studies for men aged 55-64 years was 38%. For women the decrease in serum cholesterol concentration led to a similar reduction in the risk of ischaemic heart disease as in men (Law et al, 1994).

1.4.4 Risk factor diabetes

On the contrary to type I diabetes which is characterized by an absolute lack of insulin due to the destruction of the insulin producing beta cells of the pancreas, type II diabetes is characterized by a combination of insulin resistance and an inadequate compensatory insulin secretory response. Insulin resistance is defined as inadequate target organ responsiveness or sensitivity to insulin. As a result,

higher concentrations of insulin are needed to compensate this disturbance which causes a hyperinsulinemia. As a consequence of the high insulin levels, insulin receptors of peripheral tissue are down-regulated. The resulting lack of glucose in the cells is associated with increased blood glucose level. This causes a further enhancement of insulin production of the beta cells. If this condition persists for longer, beta cells become insufficient and are finally unable to produce a sufficient amount of insulin (Thews et al ,1999, p. 515; Expert Committee on the Diagnosis and Classification of Diabetes Mellitus, 2003).

The metabolic stage between normal glucose homeostasis and diabetes is defined as “impaired fasting glucose” or prediabetes and as a fasting blood glucose level of 110 - 126 mg/dl glucose. Diabetic patients have a fasting blood glucose level of 126 mg/dL or greater (Expert Committee on the Diagnosis and Classification of Diabetes Mellitus, 2003).

Diabetes represents a major independent risk factor for cardiovascular disease. In the Framingham study a twofold to threefold increased risk of clinical atherosclerotic disease was shown based on a time period of 20 years (Kannel et al, 1979; NCEP, 2002). Furthermore the 1-year, 28 day and out-of hospital mortality rate after coronary heart disease in diabetic subjects has been found out to be much higher than in non-diabetic men and women (Miettinen et al, 1998).

Besides coronary heart disease and cerebrovascular disease, retinopathy, nephropathy, peripheral neuropathy, peripheral vascular disease and diabetic food are the major complications of diabetes. In developed countries diabetes is one of the leading causes of blindness, renal failure and lower limb amputations (International diabetes federation, 2003).

1.4.5 Risk factor hypertension

Hypertension is defined as a blood pressure ≥140 mmHg systolic or ≥90 mmHg diastolic or current use of antihypertensive medication (Chobanian et al, 2003). Several studies have shown an association of high blood pressure with the risk for cardiovascular diseases (Van den Hoogen et al, 2000; Staessen et al, 1997). Even in subjects with high-normal blood pressure (130–139 mmHg systolic and/or 85–

89 mmHg diastolic) the risk for developing cardiovascular diseases is increased (Vasan et al, 2001).

In men over 50 an elevated systolic blood pressure (SBP) is a more relevant cardiovascular disease risk factor than the diastolic blood pressure (DBP). Starting at 115/75 mmHg, the risk for developing a cardiovascular disease doubles for each increase of 20/10 mmHg. The mortality for an ischemic heart disease and stroke increases linearly from 115 mmHg SBP and 75 mmHg DBP upwards. With an increase of SBP for 20 mmHg or DBP for 10 mmHg mortality doubles. The Framingham Heart Study showed that over a longer period of time blood pressure values between 130–139/85–89 mmHg are associated with a more than twofold increase in relative risk for developing a cardiovascular disease as compared with those with BP levels below 120/80 mmHg (Chobanian et al, 2003).

There are several mechanisms which link hypertension with cardiovascular disease prevalence. Elevated blood pressure favours bleeding of the brain and hereby the development of stroke. Furthermore hypertension enhances the formation of atherosclerotic changes of the vessel walls which can lead to coronary heart diseases or renal insufficiency. In hypertonic stage the heart has to work harder permanently which can cause heart insufficiency (Thews, 1999; S250).

1.4.6 Lifestyle factors

Smoking

Epidemiologic studies have proved that exposure to cigarette smoke is an important risk factor of cardiovascular morbidity and mortality. Several mechanisms are responsibly, including vasomotor dysfunction, changing of the lipid profile, oxidation of low-density lipoprotein cholesterol, modification of prothrombotic effects, including altered platelet function, and deregulation of antithrombotic, prothrombotic, and fibrinolytic mechanisms and inflammation (Cole et al, 2008). Smoking affects all stages of atherosclerosis from endothelial dysfunction to acute clinical events. Free radical-mediated increase of oxidative stress through cigarette smoking seems to play a central role in the development of athero-thrombotic diseases and the initiation of cardiovascular dysfunction. Enhanced by various prothrombotic and antifibrinolytic effects, intravascular

thrombosis is the predominant cause of acute cardiovascular events (Ambrose et al, 2004).

Smoking cessation leads to partial reversion of smoking-induced airway inflammation and endothelial dysfunction in healthy ex-smokers, but not in those with chronic obstructive pulmonary diseases. Furthermore smoking cessation is associated with an improvement of cardiovascular function and a reduction of the risk of primary cardiovascular morbidity and mortality (Gratziou et al, 2009).

Lack of exercise

Lack of exercise is associated with increased risk for developing cardiovascular diseases and diabetes. Conversely, physical activity improves several cardiovascular risk factors such as lowering LDL and triglyceride, increasing HDL levels, improving glucose metabolism and lowering blood pressure (WHO, 2002; Ignarro et al, 2007). Physical training leads to several adaptations in the human body as to a more efficient system for oxygen transfer to the muscle so that unlimited lipid stores can be used instead of the limited carbohydrate reserves (Poirier et al, 2001). Furthermore regular physical activity contributes to weight reduction and hereby decreases the development of dyslipidaemia. One mechanism is the increase of the metabolic capacity for triacylglycerol, maybe through an increased activity of the lipoprotein lipase (Hardman et al, 1999).

Diabetic adults who performed slight exercise (walking $\geq$ 1 mile per day) were able to significantly reduce their all cause mortality and the mortality caused by cardiovascular diseases to less than one-fifth (Smith et al, 2007).

The global prevalence of physical inactivity among adults is estimated to 17% and the estimated prevalence of insufficient activity (which means <2.5 hours per week of moderate activity) ranged from 31% to 51%, with an average of 41%. The WHO estimated physical inactivity to be attributable for about 10–16% of diabetes mellitus, and about 22% of ischaemic heart disease globally (WHO, 2002).

Unhealthy diet

A healthy diet including fruit and vegetables helps to prevent cardiovascular diseases as proved by several studies (He et al, 2006). A recently performed meta-analysis showed that the risk of coronary heart disease is decreased by 4% for each additional portion of fruit and vegetables per day and by 7% for fruit

consumption (Dauchet et al, 2006). Consuming fruits and vegetables is related to a lower prevalence of important cardiovascular risk factors including hypertension, obesity, and type 2 diabetes mellitus. This may be caused by several ingredients as antioxidants or other micronutrients like flavonoids, carotinoids, vitamin C, folic acid or dietary fibers. Furthermore a diet rich in fruits and vegetables has a low dietary glycemic load and energy density (Bazzano et al, 2003). Low fruit and vegetable intake is estimated to be attributable to 31% of ischaemic heart disease and 11% of strokes worldwide. Globally 2.7 million (4.9%) estimated deaths are caused by low fruit and vegetable intake, of which about 85% were from cardiovascular diseases and 15% were from types of cancer (WHO, 2002).

Furthermore the intake of dietary fibers is negatively associated to cardiovascular disease risk, partly explained by their LDL-cholesterol lowering effect (Retenly et al, 2008). The profile of fat intake also has a considerable effect on the risk of developing cardiovascular diseases. High intakes of dietary saturated fatty acids, trans-fatty acids, and cholesterol increase serum total cholesterol and LDL-cholesterol levels in a dose-dependent manner. From these types of fatty acids, trans-fatty acids have the most negative effect on elevating the ratio of serum total cholesterol to HDL-cholesterol. Unsaturated, ω-3 fatty acids like eicosapentanoic acid decreased cardiovascular mortality in animal studies. These fatty acids act by reducing serum triglyceride levels, reducing inflammatory response and favourably affecting platelet function. In the Chicago Western Electric Study the negative association of ω-3 fatty acids consumption and relative risk of death from coronary heart disease was shown (Retenly et al, 2008).

Low socioeconomic status (SES)

There is an inverse relationship of low SES and the risk of developing a cardiovascular disease. In national longitudinal studies in several European countries like Finland, Sweden, Norway, Denmark, England/Wales and Italy lower SES indicated by educational level and occupational class is associated with a higher overall mortality of diseases among men and women. This socioeconomic gap is seen in mortality rates of cardiovascular diseases but also of lung cancer, breast cancer, respiratory diseases and gastrointestinal diseases (Mackenbach et al, 2003).

In another study the relationship of the socioeconomic status with C-reactive protein level (CRP), a non-specific marker of inflammation which is associated to cardiovascular risk was systematically reviewed. It was found out that the CRP levels among adults were inversely associated with the socioeconomic position (Nazawi et al, 2007)

The higher prevalence of cardiovascular disease is associated with a higher prevalence of the risk factors like high blood pressure and diabetes. Furthermore the socioeconomic status might affect the prevalence for cardiovascular diseases through lifestyle factors like higher smoking rates and chronic emotional stress (Kim et al, 2008). Furthermore the utilization of invasive procedures for cardiovascular treatment such as cardiac catheterization, coronary artery bypass graft or percutaneous transluminal coronary angioplasty and use of medications is lower for persons in lower socioeconomic position (Callier et al, 2004; Barnato et al, 2005).

Psychosocial stress

Chronic stress can be defined as a state of disrupted homeostasis which is counteracted by physiologic and behavioural responses which aim to reestablish the challenged body equilibrium, called “adaptive stress response”. The hypothalamic-pituitary-adrenal axis and the autonomic nervous system represent the two main components which regulate the vital functions of the stress system. It is proposed that chronic stress is associated with disruption of the metabolic homeostasis. This could contribute to the development of visceral obesity, type 2 diabetes, atherosclerosis and metabolic syndrome. The mechanism of this correlation is based on the chronic hyperactivation of the hypothalamic-pituitary-adrenal axis under prolonged stress, which favours the accumulation of visceral fat. In addition to this, fat tissue itself causes a chronic inflammatory state by secretion of adipokines by the adipocytes and pro-inflammatory cytokines that contribute to further derangement of the metabolic equilibrium (Kyrou & Tsigos, 2007; Kyrou & Tsigos, 2008).

Several studies investigated the relationship of stress and cardiovascular diseases. In a recent study a high level of trait anger was associated with developing hypertension from prehypertension and incidence of coronary heart disease after adjusting for various covariates. This fact was more predictive for

men. Long-term psychological stress was associated with an increased risk of developing an incident coronary heart disease in men and women (Player et al, 2007). Surtees et al showed a significant association of increased psychological distress like emotional distress with an elevated stroke risk, whereas in this study a major depressive disorder did not influence the incident stroke (Surtees et al, 2008).

A recent review shows that acute stress, chronic stress and particularly the non-adaptive response to stress promote the elevation of blood pressure as the major cardiovascular risk factor. Chronic stress was – as shown in the study - mostly caused by occupational stress indicated by working hours, forms of work organization, the anxiety of keeping the job, the self estimation to be “average or not good at doing the job”. The non-adaptive response to stress was indicated by hopelessness, severe stress and “tension-anxiety” (Sparrenberger et al, 2009).

Interestingly, in a recent study it was found that the association between psychological distress and cardiovascular disease risk can be largely explained by behavioural patterns. In situations of psychological distress people more often tend to smoke, drink alcohol or they become physically inactive (Hamer et al, 2008).

Alcohol consumption

There is an inverse relationship between cardiovascular disease and moderate alcohol consumption which means one drink per day for women and two drinks per day for men. The protective effect of moderate alcohol consumption has been explained by increasing serum HDL cholesterol levels and decreasing aggregation on platelets by lowering levels of fibrinogen and protein tissue-type plasminogen activator. This leads to a reduced rate of coronary artery obstruction (Retenly et al, 2008; Ignarro et al, 2007). Furthermore it was shown that moderate drinking may improve the early outcomes after acute myocardial infarction and prevent sudden cardiac death. A direct effect of ethanol on the ischemic myocardium has been suggested (Ignarro et al, 2007).

1.4.7 Non-modifiable risk factors

Age

The cardiovascular risk increases with increasing age and becomes clinically significant in men in their mid-forties and in women during and after menopause. The main reason of the increase of the risk with age is the progressive accumulation of atherosclerosis which is caused by the cumulative exposure to atherogenic risk factors (NCEP, 2002).

Sex

Women are significantly older than men when suffering from the first myocardial infarction, an effect that effectively contributes to the difference in life expectancy between men and women. The risk of developing a cardiovascular disease in women is about 10 to 15 years delayed in comparison to men (Wilson et al, 1998). The lifetime risk for developing cardiovascular diseases is 50% at age 40 years for men and 30% for women (Lloyd-Jones et al, 1999). This difference can be partly explained by the earlier occurrence of cardiovascular risk factors in men such as dyslipidemia and an elevation of blood pressure (Wilson et al, 1998). It has been observed that cardiovascular risk factors influence the outbreak of cardiovascular disease depending on the gender. Diabetes, HDL blood levels and triglycerides have been found to have a greater impact on the coronary disease risk in women than in men (Roeters van Lennep et al, 2002).

Before menopause cardiovascular disease rarely occurs among women (Lloyd-Jones et al, 1999). This effect can be explained by the protective effect of the female hormones - especially estrogen - which affects the lipid profile and the vascular function (Roeters van Lennep et al, 2002).

Family history

A family history of premature cardiovascular disease is an independent risk factor for developing cardiovascular diseases like a coronary disease (Fischer et al, 2007), myocardial infarction or venous thromboembolism (Braekkan et al, 2008). A familial predisposition is assumed when a myocardial infarction is diagnosed concerning a male first degree relative before his 55th year of life or a female first degree relative before her 65th year of life. The relative risk for cardiovascular

disease in first-degree relatives ranges from two to 12 times to that of the general population and increases with the number of primary relatives affected. For female patients it was shown to be more common than for male patients to have first-degree relatives with coronary artery disease before the age of 65 (Pohjola-Sintonen, 1998; Rissanen et al, 1979). The familial aggregation of cardiovascular disease can be partly explained by the fact that several cardiovascular risk factors are also under genetic control such as blood pressure, lipids and lipoproteins and obesity (Williams et al, 2001).

In a recent study it was found that offsprings of patients suffering from myocardial infarction had decreased postheparin LPL activity associated with an increased postprandial triglyceride-rich lipoproteins and an adverse lipid profile like decreased HDL cholesterol. Those factors may contribute to their increased risk for future coronary events (Lekhal et al, 2008).

Ethnicity

The rate of cardiovascular diseases differs with ethnicity. In a recently performed systematic review non-white ethnicity was associated with elevated C-reactive protein (CRP) levels among adults. Blacks, Hispanics and South Asians had significantly higher levels than Whites (Nazmi et al, 2007). In another recent study the prevalence of stroke among American Indians and African Americans was high with estimated 5.1% and 3.2%, among whites it was 2.5%, and among Asians it was 2.4% (Rosamond et al, 2007).

The prevalence of cardiovascular risk factors varies between individuals of different races. Especially in Hispanic and black people the prevalence of cardiovascular risk factors like diabetes, hypertension and dyslipidemia is high (Clark et al, 2007; Colleran et al, 2007).

1.5 Prevalence of cardiovascular risk factors

1.5.1 Prevalence of obesity

Obesity is a severe world-wide health problem, which has been increasing rapidly over the last decade and has almost reached epidemic proportions by now.

According to the World Health Organization, in 2005 approximately 1.6 billion adults (age ≥ 15 years) were overweight and at least 400 million adults were obese. For 2015 an increase up to approximately 2.3 billion overweight adults and more than 700 million obese persons worldwide has been estimated. This tendency can not only be observed in high income countries, but also in low- and middle income countries (WHO, 2006).

1.5.2 Prevalence of diabetes

The increase in the prevalence of diabetes type 2 is closely related to obesity augmentation. The number of people with diabetes worldwide was estimated as 246 million in 2007 which is a prevalence of diabetes of 5.9% of the adult population (20-79 age group) and has been expected to increase to 380 million people with diabetes in 2025 which is a prevalence of 7.1% of the adult population (International Diabetes Federation, 2006)[a]. Analogue to the obesity prevalence, diabetes has been increasing not only in developed countries, but also in low- and middle income countries. The highest prevalence of diabetes occurs in several countries of the Middle East (United Arab Emirates shows a rate of 19.5 %, Saudi Arabia 16.7 %, Bahrain 15.2%, Kuwait 14.4%, Oman 13.1%, Egypt 11.0%), in certain Pacific countries (up to 30.7%), Mauritius (11.1%) and Mexico (10.6%). Eastern Mediterranean countries have a rate of 9.2% and the North American Region shows 8.4%. The highest absolute number of diabetic people live in India (40.9 million), China (39.8 million), USA (19.2 million), Russia (9.6 million) and Germany (7.4 million) (International Diabetes Federation, 2006).

1.5.3 Prevalence of hypertension

According to an international survey prevalence of hypertension lies between 27.4% in Canada and 55.3 % in Germany with an average of 44.2 % for the six

[a] The mentioned prevalence of diabetes is referred to total diabetes rate because the sources of most countries do not distinguish between type 1 and type 2 diabetes (Wild et al 2004). According to IDF type 2 diabetes accounts to 90-95 % of total diabetes (International Diabetes Federation, 2006).

European countries Italy, Spain, Sweden, England, Finland and Germany (Wolf-Maier et al, 2003). The global prevalence for hypertension was estimated for 1 billion individuals. Furthermore approximately 7.1 million deaths per year are caused by hypertension which is about 13% of total deaths. Suboptimal BP (>115 mmHg SBP) is attributable to 62 percent of cerebrovascular diseases and 49 percent of ischemic heart disease (WHO, 2002).

1.5.4 Prevalence of hyper- and dyslipidemia

In the Multi-Ethnic Study of Atherosclerosis which was performed in USA with Black, White, Hispanic and Chinese men and women between 45 and 84 years 29.3 % of the total population had dyslipidemia. The highest prevalence was found among white men with 36.9 % and the lowest among Chinese women with 21.0 % (Goff et al, 2009). In Germany the average prevalence of hyperlipidemia was estimated to 37.0% in 1998 (Laaser et al, 2005). According to WHO Global InfoBase the estimated prevalence of hyperlipidemia (total cholesterol $\geq$ 240 mg/dl) in certain European countries like Italy, Austria, Netherlands, Finland and United Kingdom ranged from 8.0 to 44.4% in women and 14.0 to 27.1% in men aged between 45-80 years. The increase of the prevalence with age in all mentioned countries is much higher in women than in men (WHO, 2009).
It is estimated that high cholesterol causes 18% of cerebrovascular diseases and 56% of ischemic heart diseases worldwide. Overall this leads to about 4.4 million deaths which are 7.9% of total deaths. In most regions, the proportion of female deaths attributable to cholesterol is slightly higher than that for men (WHO, 2002).

1.6 Measuring the progress of cardiovascular diseases

Several indicators are suitable for measuring the progress of cardiovascular diseases in a subclinical stage like the level of C-reactive protein, the progress of atherosclerosis and myocardial ischemia.

C-reactive protein (CRP)-level

CRP is a sensitive marker for vascular inflammation. Several studies showed a relation between baseline concentration of CRP and future CVD events. In the so-called “Physicians’ Health Study” it was found that healthy men with CRP-levels in the highest quartile had a twofold elevated risk of stroke, a 3-fold elevated risk of myocardial infarction, and a fourfold elevated risk of developing severe peripheral arterial diseases (Greenland et al, 2000).

Subclinical atherosclerotic disease

Subclinical coronary atherosclerosis is associated with the risk for major coronary events (Smith et al, 2000) and can be measured by the following methods: ankle-brachial blood pressure index, carotid intima media thickness (IMT) and coronary calcium.

Ankle-brachial blood pressure index (ABI)

The ABI serves as a measure for lower extremity peripheral arterial disease (PAD). Systolic blood pressure in the brachial, the posterior tibial, and the dorsalis pedis arteries is measured. An ABI of <0.9 is characteristic of PAD which is often associated with other cardiovascular risk factors. Consequently the ABI can be used as a diagnostic test for identification of persons at high risk for coronary heart diseases (Criqui et al, 1992).

Carotid intima media thickness

The extent of carotid atherosclerosis correlates positively with the extent of coronary atherosclerosis. Carotid intima media thickness of the carotid arteries can be measured by carotid sonography (Greenland et al, 2000). Several studies proved that the severity of IMT correlates with risk for coronary events (Chambless et al, 1997).

Coronary calcium

The amount of coronary calcium correlates with coronary plaque burden which indicates subclinical coronary atherosclerosis. Coronary calcium can be measured by electron beam computed tomography (Smith et al, 2000).

Myocardial ischemia

Myocardial ischemia can be tested by exercise electrocardiogram (ECG) testing, myocardial perfusion imaging, and stress echocardiography. A positive exercise ECG in asymptomatic, middle-aged men is associated with a risk for major coronary events whereas it is much less predictive among young adults and middle-aged or older women (NCEP, 2002).

2. Outlook

The aim of this meta-analysis was to provide an overview on the influence of gender, ethnicity and socioeconomic status on the occurrence of the first cardiovascular event, occurrence of recurrent events and long term and short term mortality rates after a cardiovascular event. Furthermore the prevalence of cardiovascular risk factors like hypertension, diabetes, hyperlipidemia, obesity and smoking among a cohort of CVD patients and in cross-sectional analysis of a healthy population should be analysed. It should be elucidated if women are significantly older than men at the incidence of the first cardiovascular event and if they have more cardiovascular risk factors and a higher mortality rate as it was found out in previous literature reviews. Furthermore the influence of ethnicity and the socioeconomic status on the prevalence of cardiovascular risk factors, events and on the mortality rate should be analysed and differentiated between men and women.

3. Methods

3.1 Methods for determining the prevalence of cardiovascular diseases

Differently designed studies were used to investigate the prevalence of cardiovascular diseases. In the first group of studies a cohort which was already affected by a cardiovascular event or a preclinical stage was investigated. These studies were either performed as prospective study with patients admitted to hospital (Bowker et al, 2000; Goto et al, 2007) or retrospective studies with registers or hospital charts that recorded information on CVD events and mortality (Smeeton et al, 2007; Gupta et al, 2002). In the second group of studies a cross sectional analysis was performed which means collection of data at a certain time point within a healthy population (Meigs et al, 2003; MacFadden et al, 2008). In this case the prevalence of cardiovascular risk factor and the occurrence of cardiovascular events over a certain follow-up period were evaluated.

3.2 Literature search

3.2.1 Identification of relevant trials

In the Pubmed database (www.ncbi.nlm.nih.gov/entrez) literature was screened to identify relevant trials which analysed gender, ethnic or socioeconomic differences between occurrence of cardiovascular event, mortality rates or prevalence of cardiovascular risk factors and their influence on developing cardiovascular diseases. Animal studies were excluded. Only abstracts for studies published between 1995 and 2009 in English or German were read for further decision of inclusion.

The following terms were utilised to find relevant trials:

- “cardiovascular disease/ stroke/ myocardial infarct” and “gender/ gender differences”
- “cardiovascular disease/ stroke/ myocardial infarct” and “socioeconomic status/ social differences”
- “cardiovascular disease/ stroke/ myocardial infarct” and “ethnicity/ ethnic differences”

3.2.2 Inclusion criteria

The initial search strategies identified more than 10,000 abstracts with each of the word combinations. To be included in the meta-analysis, studies had to satisfy the following inclusion criteria:

1) human trial
2) listing information about any defined outcome like cardiovascular risk factors, age, morbidity or mortality rate in at least two different subject groups (different gender, ethnicity or SES)
3) hospitalised or former hospitalised patients with a CVD or patients with high progression of arteriosclerosis (or 4)
4) cross sectional analysis of cardiovascular risk factors and prevalence of cardiovascular events
5) performance period of the study mainly after 1990
6) study with an adult cohort, preferably older subjects (>30 years) and not with children or adolescents
7) no studies with further selection criteria of the cohort like inclusion of p. ex. only hyperlipidemic subjects, only hypertensive subjects
8) more than 200 subjects

3.2.3 Definition of outcomes

The cardiovascular outcomes of interest included were the following: myocardial infarct, stroke, angina pectoris, atrial fibrillation or progression of arteriosclerosis. Information on age at the cardiovascular incidence and cardiovascular risk factors like hypertension, diabetes, dyslipidemia, obesity, mean BMI or smoking also were evaluated in the meta-analysis. Further consequences of cardiovascular diseases such as recurrent cardiovascular events, in-hospital mortality rate, short-term or long-term mortality rates were also evaluated if mentioned in the included studies.
The criteria of metabolic syndrome were heterogeneous, some studies used ATPIII criteria (NCEP, 2002) or ATP II criteria (NCEP, 1994) (p.ex. Kawamoto et al, 2007; Lee et al, 2000) and other studies used WHO criteria (p.ex. Marcus et al, 2007; Sodjinou et al, 2008). As criteria within a study were equal, results within a study could be compared, but not results from various studies.

3.3 Evaluation of results

The studies were divided into two different types of studies (see 4.1): study with a cohort already affected by CVD and cross sectional analysis of a primarily healthy population. These studies were further divided into studies dealing with gender, socioeconomic or ethnic differences in CVD morbidity.
Data about age of patients, prevalence of the cardiovascular risk factors hypertension, diabetes, hyper-or dyslipidemia, obesity, mean BMI, smoking rate, in-hospital mortality, 28 to 30 days mortality, 1-year mortality, long-term mortality (2-7 years), recurrent events in study cohorts with CVD were sorted in a table. Data about the prevalence of cardiovascular risk factors like hypertension, diabetes, hyper-or dyslipidemia, obesity, mean BMI, smoking rate, the prevalence of CVD (stroke or myocardial infarct) or a fatal event caused by CVDs from preliminary healthy cohort were also sorted in a table. All information was sorted by gender, socioeconomic status or ethnicity. The associations of gender, ethnicity or SES on the prevalence of risk factors and the cardiovascular morbidity and mortality in healthy subjects or patients were presented in individual graphs (see results section).

4. Results

4.1 Literature search

In a literature search with the terms “cardiovascular disease/stroke/myocardial infarct” and “gender/gender differences” 70 studies which fulfilled the inclusion criteria could be found. With the terms “cardiovascular disease/stroke/myocardial infarct” and “social differences/socioeconomic status/ethnicity“ 30 studies that investigated the influence of socioeconomic status or ethnicity on the prevalence and outcome of cardiovascular diseases were found. From these 30 studies 13 analysed socioeconomic differences and 17 analysed ethnic differences. From these studies 11 studies dealt with gender and socioeconomic differences simultaneously and another 10 studies dealt with gender and ethnic differences simultaneously.

The 78 studies which were included in the meta-analysis and their characteristics like location of the study, sample size, study design, time period, inclusion criteria for subjects, variables, investigated outcome and main results are listed in table1.

53 out of 78 studies analysed a cohort that was already affected by a cardiovascular disease or a preclinical stage. In these studies inclusion criteria was acute coronary syndrome in 41 studies, stroke in 10 studies and atrial fibrillation in two studies.

25 out of 78 studies were cross sectional analysis that evaluated the prevalence of risk factors and the occurrence of cardiovascular morbidity and/or mortality over a certain time period. These two categories of studies were evaluated in separate analysis. The studies were divided into studies dealing with gender, ethnic or socioeconomic influences. The socioeconomic influences were further evaluated according to educational status, occupational status, marital status, residency or general socioeconomic status.

Table1: Studies included in the meta-analysis

Reference	Country	Sample size (n)	Study design	Time period	Inclusion criteria for subjects	Variables	Outcomes investigated	Main results
Abdul-Rahim et al, 2001	West Bank	992	cross-sectional study	1996-1998		gender, urban-rural residency	risk factors	Dyslipidemia and overall obesity were more prevalent in the urban population.
Aguado-Romeo et al, 2007	Spain	46007	retrospective study	2000-2003	acute coronary syndrome	gender	mortality	Mortality rate in women was higher even after adjusting for age and comorbidities.
Alfredsson et al, 2007	Sweden	53781	prospective study	1998-2002	non-ST-elevation coronary syndrome	gender	risk factors, mortality	Women were older, had more likely hypertension and diabetes; age adjusted mortality did not differ significantly.
Berger et al, 2006	USA	4284	prospective study	1998-1999	percutaneous coronary intervention	gender	risk factors, mortality	Women were older, had a higher prevalence of diabetes and hyper-tension and a higher unadjusted mortality rate.

Bouguerra et al, 2006	Tunisia	2927	cross-sectional study	1995-1996		gender	risk factors	The prevalence of metabolic syndrome was higher among women and urban residents and increased with age.
Bowker et al, 2000	UK	1064	prospective study	1995-1996	myocardial infarct or myocardial ischemia	gender	age, risk factor, mortality	Women with acute coronary syndrome were older and suffered from more comorbidities.
Bravata et al, 2005	USA	11163	cross-sectional study			ethnicity, gender	stroke risk factors	Blacks had a higher prevalence of hyper-tension, diabetes and higher C-reactive protein levels; whites had lower HDL levels.
Chang et al, 2003	Canada	22967 8441	retrospective study	1993-2000	acute myocardial infarct unstable angina	gender	risk factors, mortality	Women were older, had more comorbidities and higher mortality rates.
Cheng et al, 2004	Taiwan	1032	prospective study	1993-2002	acute myocardial infarct	gender	risk factors, mortality	Women were older and had more often hyper-tension and diabetes.

Dagres et al, 2007	Europe	5333	prospective study	2004-2005	atrial fibrillation	gender	risk factors	Women were older and had a higher rate of comorbidities.
Deurenberg-Yap et al, 2001	Singapore	4723	cross-sectional study	1998		ethnicity, gender	risk factors	The risk factor profile differed with ethnicity and was less among Chinese.
Dragano et al, 2007	Germany	11554	cross-sectional study	2000-2003		Socioeconomic status	risk factors	Smoking and obesity were more common in deprived neighbourhoods in Germany; in the Czech Republic associations were only observed for smoking.
European Group for the study of Insulin Resistance (EGIR), 2002	Europe	17563	cross-sectional study	1990-1997		gender	risk factors	The prevalence of metabolic syndrome increased with age and was higher among men at a given age.

Elkoustaf et al, 2006	USA	1197	retrospective study	2001-2004	non-ST-elevation coronary syndrome	gender	risk factors, mortality	Women were older, had more often hypertension and obesity; in-hospital mortality rate did not differ between sexes.
Engström et al, 2001	Sweden	3540	prospective study	1989-1998	stroke	socio-economic status, gender	risk factors, stroke prevalence	The prevalence of stroke was higher among people with low socioeconomic status.
Fabijanic et al, 2006	Croatia	3382	prospective study	1990-1999	myocardial infarct	gender	risk factors, mortality	Women with myocardial infarct were older, had more comorbidities and a higher unadjusted mortality rate.
Freedman et al, 2005	USA	1180	cross-sectional study			gender, ethnicity	risk factors	In families enriched for members with type 2 diabetes, African American had higher carotid artery intima media thickness and conventional risk factors than whites.

Galobardes et al, 2003	Switzerland	8194	cross-sectional study	1993-2000		occupational level, gender	risk factors	Smoking, obesity and high blood pressure were more prevalent among persons with low socioeconomic position.
Gargano et al, 2007	USA	373	prospective study		stroke survivors	gender	quality of life, risk factors	Women patients were older and had a higher prevalence of diabetes and hypertension; women stroke survivors had a lower recovery and a poorer quality of life.
Gargano et al, 2008	USA	2566	prospective study	2002	acute stroke or transient ischemic attack	gender	risk factors, mortality	Women were older and more likely had hypertension.
Gerber et al, 2006	USA	1104	prospective study	1990-1998	myocardial infarct	gender	risk factors, recurrent events	Women were older, had more comorbidities and had more recurrent events.
Gerward et al, 2006	Sweden	5533	prospective study	1996-2005	acute myocardial infarct	gender, socio-economic status	mortality	Rates of survival from myocardial infarct were inversely related to socioeconomic status.

Glaser et al, 2006	USA	3462 1457	prospective study prospective study	1997-2002 1997-2003	coronary syndrome stable angina	gender gender	risk factors, mortality risk factors, mortality	Women were older, had more comorbidities and had a higher one-year mortality rate.
Goto et al, 2007	Japan	720	prospective study	1995-2004	stroke after coronary artery bypass	gender	age, risk factor	Women were older and had higher rates of hypertension; men had higher rates of hyperlipidemia.
Griffith et al, 2005	UK	698	prospective study	1994-2000	myocardial infarct	gender	risk factors, mortality	Women were older and had more likely hypertension and diabetes; mortality was higher among women.
Gupta et al, 2002	Canada	1106	retrospective study	1994-1999	acute myocardial infarct	country origin	risk factors, mortality, recurrent events	The mortality rate after myocardial infarct was similar between South Asians and non-South Asians; South Asians had a lower BMI, more likely diabetes and less likely hyperlipidemia

Hajat et al, 2001	UK	1198	prospective study	1995-1998	stroke	ethnicity	risk factors	The prevalence of diabetes and hypertension was higher among black than white stroke patients.
Harwell et al, 2005	USA and Canada		cross-sectional study	1996-2000		ethnicity, gender	heart disease and stroke death	The mortality rate from cardiovascular diseases was higher in Indians than in whites.
Heer et al, 2006	Germany	6358	prospective study	2000-2002	non-ST-elevation coronary syndrome	gender	risk factors, mortality	Women were older, had more comorbidities; there was no difference in age-adjusted mortality.
Hirakawa et al, 2006	Japan	1336	retrospective study	1995-1997	acute myocardial infarct	gender	risk factors, mortality	Women were older, had more comorbidities and a higher in-hospital mortality rate.
Hirakawa et al, 2007	Japan	2614	prospective study	2001-2003	acute myocardial infarct, undergoing percutaneous coronary intervention	gender	risk factors, mortality	Women were older and had higher rates of hypertension and in-hospital mortality; after adjusting for age, rate did not differ significantly.

Hochmann et al, 1997	USA	1473	prospective study		acute coronary syndrome	gender	risk factors	Women were older and had a higher incidence of diabetes and hyper-tension.
Hochmann et al, 1999	New Zealand, Australia, USA, Belgium	12142	prospective study		acute myocardial infarct with or without ST-elevation, unstalbe angina	gender	risk factors, mortality	Women were older than men and had higher rates of diabetes, hypertension, and a higher 30 days-mortality rate.
Holroyd-Leduc, 2000	Canada	44832	retrospective study	1993-1996	acute stroke	gender	risk factors, mortality	Male stroke patients were more likely to suffer from diabetes, female patients were more likely to suffer from hypertension; the one year mortality rate was lower in women.
Ikeda et al, 2007	Japan	94062	cross-sectional study	1988-1999		gender, marital status	risk factors, incidence of CVD	Single status was associated with a higher mortality rate from CVD in both sexes; divorce and widowhood elevated the mortality rate only in men.

Kapral et al, 2002	Canada	38945	retrospective study	1994-1997	stroke	gender socioeconomic differences	risk factors, mortality	Mortality decreased with higher socioeconomic status; diabetes was more and hypertension less prevalent among lower socioeconomic groups.
Kaul et al, 2005	Canada	1871	prospective study	1998-2001	coronary artery disease; undergoing cardiac catherizaiton	ethnicity, gender	risk factors	Among blacks there was a higher incidence of hypertension and diabetes.
Kawamoto et al, 2007	Japan	868	cross-sectional study	1996-2006		gender	intima media thickness, risk factors	The intima media thickness was significantly higher in patients with metabolic syndrome
Koek et al, 2006	Netherland	21565	retrospective study	1995	acute myocardial infarct	gender	mortality	Women were older, had a higher prevalence of diabetes; mortality was higher in women; age adjusted 28-day mortality was equal and 5 years mortality was reversed.

Koek et al, 2007	Netherland	2018 19547	retrospective study	1999-2004	myocardial infarct + diabetes myocardial infarct	gender	mortality (28 days, 5 years)	Patients simultaneously suffering from myocardial infarct and diabetes have a higher short-time and long-time mortality risk.
Kuper et al, 2007	UK	49259	cross-sectional study	1991-2002		education	risk factor, incidence of stroke	There was a strong gradient in risk of stroke by years of education.
Lee et al, 2000	Taiwan	3602	cross-sectional study	1990-1995	cardiovascular diseases	gender	risk factors	White-collar workers more likely had dyslipidemia and diabetes and had a slightly lower risk for stroke and sudden death. The risk of sudden death was higher for men than for women.
Lundblad et al, 2008	Sweden	11763	retrospective study	1985-2004	myocardial events	gender	myocardial infarct, 28d-mortality	The proportion of events in men to women was 3:1 in 2004.

MacFadden et al, 2008	UK	22486	cross-sectional study	1993-2006	myocardial infarct	gender, age	mortality, risk factors	Social status was associated with higher incidence of CVDs, which was decreased after adjusting for smoking; the effect of SES was higher in men.
MacIntyre et al, 2001	UK	201114	retrospective study	1986-1995	myocardial infarct	gender, age	mortality, risk factors	Men had a lower 30-day mortality rate, but were more likely to die before hospitalisation.
Maksimovic et al, 2008	Serbia	657	prospective study	2006-2007	carotid atherosclerotic disease	gender, SES	risk factors	Low and medium educational level was associated with increased triglycerides and CRP levels.
Markus et al, 2007	UK	1200	prospective study	1999-2005	stroke including recurrent stroke	ethnicity	prevalence of stroke, risk factors	Black stroke patients were younger and had a higher prevalence of risk factors.

Matsui et al, 2002	Japan	482	retrospective study	1995-1996	acute myocardial infarct	gender	risk factors, mortality	Women were older, had a higher prevalence of diabetes and hyper-tension and a higher mortality rate.
Meigs et al, 2003	USA	5961	cross-sectional study	1991-1996		gender, ethnicity	risk factors	Mexican Americans had a higher prevalence of risk factors, especially women.
Mendez et al, 2003	Jamaica	2082	cross-sectional study	1993-1998		gender, socioeconomic status	risk factors	The prevalence of obesity and hypertension was higher in women.
Milcent et al, 2007	France	74389	retrospective study	1999	myocardial infarct	gender		Women were older and had a higher rate of in-hospital mortality.
Misra et al, 2001	India	532	cross-sectional study	1998		gender	risk factors	The prevalence of cardiovascular risk factors was high in an urban slum population of Dehli with nearly no gender differences.

Ordunez et al, 2005	Cuba	1667	cross-sectional study	2001-2002		gender, ethnicity	risk factors	There was no difference in blood pressure in men from different ethnicity; women with a lower educational level had an increased CVD risk.
Perers et al, 2005	Sweden	1744	prospective study	1995-1999	acute coronary syndrome	gender	risk factors, mortality	Women were older, had more comorbidities and had slightly higher in-hospital mortality.
Pitsavos et al, 2003	Greece	3042	cross-sectional study	2001-2002		gender	risk factors	The prevalence of cardiovascular risk factors was higher among men.
Qureshi et al, 2006	USA	547	prospective study	2002	stroke	ethnicity, gender	risk factors, mortality	African American women had the highest mortality rate after stroke
Radovanovic et al, 2007	Switzerland	20290	prospective study	1997-2006	acute coronary syndrome	gender	risk factors, mortality	Women were older, had more comorbidities and a higher mortality rate.
Reina et al, 2007	Spain	6209	prospective study	2000-2001	myocardial infarct	gender	risk factors, mortality	Women were older, had more comorbidities and a higher mortality rate.

Rosvall et al, 2000	Sweden	4176	cross-sectional study	1992-1994		socioeconomic status, gender	risk factors, carotid IMT	An association of educational level, occupational status, and thicker IMT in women and low occupational status with a thicker IMT in men was found.
Sanderson et al, 2007	USA	616	retrospective study	1996-2006	cardiac rehabilitation	ethnicity	risk factors	Blacks had a higher prevalence of risk factors.
Santos et al, 2008	Portugal	1962	cross-sectional study			socioeconomic status, gender	risk factors	Metabolic syndrome was more frequent in women and the prevalence increased with low social class in women but not significantly in men.
Schreiner et al, 2001	Finland	4900	retrospective study	1983-1992	coronary events	gender	risk factors, recurrent events	Men were far more likely to have a fatal recurrent event than women; women had a higher prevalence of risk factors.

Setoguchi et al, 2008	USA	1625	retrospective study	2000-2001	myocardial infarct	gender	risk factors, mortality	Women with MI were older, had a higher BMI and diabetes prevalence; men suffered from a higher mortality rate.
Shaw et al, 2008	USA	375886	prospective study	2000-2002	stable angina; elective, diagnostic coronary angiography	gender and ethnicity	prevalence of acute coronary syndrome, risk factors, in-hospital mortality	Blacks had the highest prevalence of hypertension; Asians had the highest prevalence of hyperlipidemia; native Americans had the highest prevalence of diabetes; in-hospital mortality rate was highest among native Americans and Asians.
		450329	prospective study	2000-2002	acute myocardial infarct or unstable angina	gender and ethnicity	risk factors, age	
Shen et al, 2007	USA	18867	retrospective study	1995-2000	atrial fribrillation	ethnicity	risk factors, coronary heart disease	Blacks had the highest prevalence of risk factors.
Singh et al, 2008	USA	10981	retrospective study	1996-2004	PCI; myocardial infarct or unstable angina	gender	risk factors, mortality rate, recurrent CVD	There was no gender difference in 30 days or 1 year mortality rate.

Singh-Manoux et al, 2008	France	5363	prospective study	1991-2004	coronary heart disease	social status	risk factor, incidence of CVDs	Low SES was associated with more risk factors and a higher prevalence of coronary heart diseases.
Slater et al, 2003	USA	4617	prospective study		percutaneous coronary intervention	ethnicity	risk factors, mortality	Blacks, Hispanics and Asians were younger than whites when undergoing PCI and had a higher prevalence of risk factors.
Smeeton et al, 2007	UK	566	retrospective study	1995-2004	stroke	ethnicity	risk factors	White stroke patients were older and smoked more often; blacks had a higher prevalence of cardiovascular risk factors.
Sodjinou et al, 2008	Benin	200	cross-sectional study			gender	risk factors	Female sex and urban residency was positively associated with cardiovascular risk factors.

Theres et al, 2004	Germany	5133	retrospective study	1999-2002	acute myocardial infarct	gender	risk factors, mortality	Women were older, had more likely diabetes and hypertension and a higher in-hospital mortality rates.
Thursten et al, 2005	USA	6913	cross-sectional study	1971-1993		gender	risk factors, coronary heart disease events	The incidence of coronary heart disease was higher among men; cardiovascular risk factors were more prevalent among women
U.K. Prospective Diabetes Study Group, 1998	UK	4974	prospective study	1977-1991	diabetes	gender	ethnicity, gender	Afro-Caribbean subjects with diabetes had a lower risk for MI than whites, whereas South Asians did not have a risk different from that of whites.
Vaccarino et al, 2003	USA	1113	prospective study	1999-2001	patients undergoing a coronary artery bypass graft	gender	risk factors, mortality	Women were older and had more risk factors.

Venketa-subramanian et al, 2005	Singapore	14903	cross-sectional study	2001-2003		ethnicity, gender	stroke prevalence	Stroke was most prevalent among Chinese men and lowest among Malay women.
Victor et al, 2004	USA	2971	cross-sectional study	2000-2002		gender, ethnicity	risk factors	Cardiovascular risk factors were most frequent among black women.
Xu et al, 2008	China	29340	cross-sectional study	2000-2001		gender, socioeconomic status	risk factors, stroke prevalence	An elevated prevalence of stroke was associated with an increasing level of socioeconomic status like family average income.
Zaliunas et al, 2008	Lithuania	2756	prospective study	2000-2005	patients with myocardial infarct or unstable angina	gender	risk factors	Men more often had increased triglyceride concentrations and women more often had too low HDL levels.

4.2 Gender and cardiovascular diseases

The number of male patients who were affected by a cardiovascular event or a subclinical atherosclerotic stage was higher in 41 studies (Figure 1) (Aguado-Romeo et al, 2007; Alfredsson et al, 2006; Berger et al, 2006; Chang et al, 2003; Cheng et al, 2004; Dagres et al, 2007; Elkoustaf et al, 2006; Engström et al, 2001; Fabijanik et al, 2005; Gerber et al, 2006; Glaser et al, 2005; Griffith et al, 2002; Gupta et al, 2002; Hajat et al, 2001; Heer et al, 2006; Hirakawa et al, 2006; Hirakawa et al, 2007; Hochmann et al, 1997; Hochmann et al, 1999; Kapral et al, 2002; Kaul et al, 2005; Koek et al, 2007; Lundblad et al, 2008; MacIntyre et al, 2002; Matsui et al, 2002; Perers et al, 2005; Qureshi et al, 2005; Radovanovic et al, 2007; Reina et al, 2007; Sanderson et al, 2007; Schreiner et al, 2001; Setoguchi et al, 2008; Shaw et al, 2008; Shen et al, 2007; Singh et al, 2008; Slater et al, 2003; Smeeton et al, 2007; Theres et al, 2004; Vaccarino et al, 2003; Zaliiunas et al, 2008) and the number of female patients was higher in five studies (Figure 1) (Bowker et al, 2000; Gargano et al, 2007; Gargano et al, 2008; Holroyd-Leduc et al, 2000;Setoguchi et al, 2008). In 34 of those studies the inclusion criteria was acute coronary syndrome, in 10 studies it was stroke and in 2 studies atrial fibrillation.

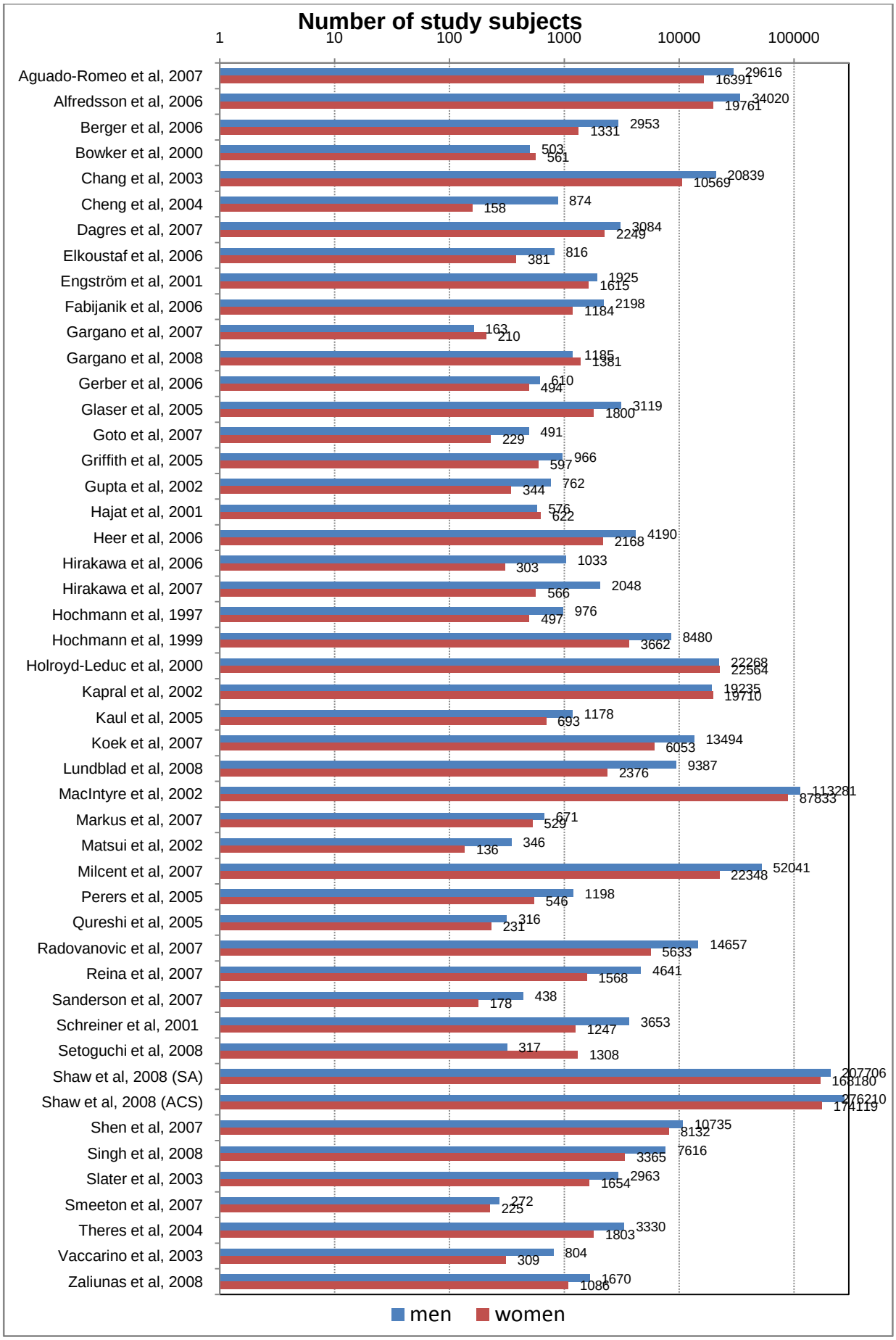

Figure 1: Number of study subjects with a cardiovascular event

4.2.1 Gender difference in age at the incidence of a cardiovascular diseases

30 studies listed the mean age of people who suffered from a cardiovascular diseases or a subclinical cardiovascular disease. 27 studies analysed subjects with any form of acute coronary syndrome (Alfredsson et al, 2006; Berger et al, 2006; Bowker et al, 2000; Chang et al, 2003; Cheng et al, 2004; Elkoustaf et al, 2006; Fabijanik et al, 2005; Gerber et al, 2006; Griffith et al, 2002; Heer et al, 2006; Hirakawa et al, 2006; Hirakawa et al, 2007; Hochmann et al, 1997; Hochmann et al, 1999; Koek et al, 2006; Koek et al, 2007; Lundblad et al, 2008; MacIntyre et al, 2002; Matsui et al, 2002; Perers et al, 2005; Radovanovic et al, 2007; Reina et al, 2007; Setoguchi et al, 2008; Shaw et al, 2008; Singh et al, 2008; Vaccarino et al, 2003; Zaliiunas et al, 2008), two studies analysed stroke patients (Gargano et al, 2008; Goto et al, 2007) and one study analysed patients with atrial fibrillation (Dagres et al, 2007). In all 30 studies women were older than men (Figure 2). The age difference ranged from only one year (Lundbland et al, 2008) to 9 years (Gerber et al, 2006).

MacIntyre et al (2002) differentiated between patients who reached hospital alive and patients who did not survive to reach hospital admission. In both groups women were older than men. The mean age was 64.3 years in men and 71.6 years in women among patients who were admitted to hospital and 71.1 years in men and 77.7 years in women among the patients who died before reaching hospital.

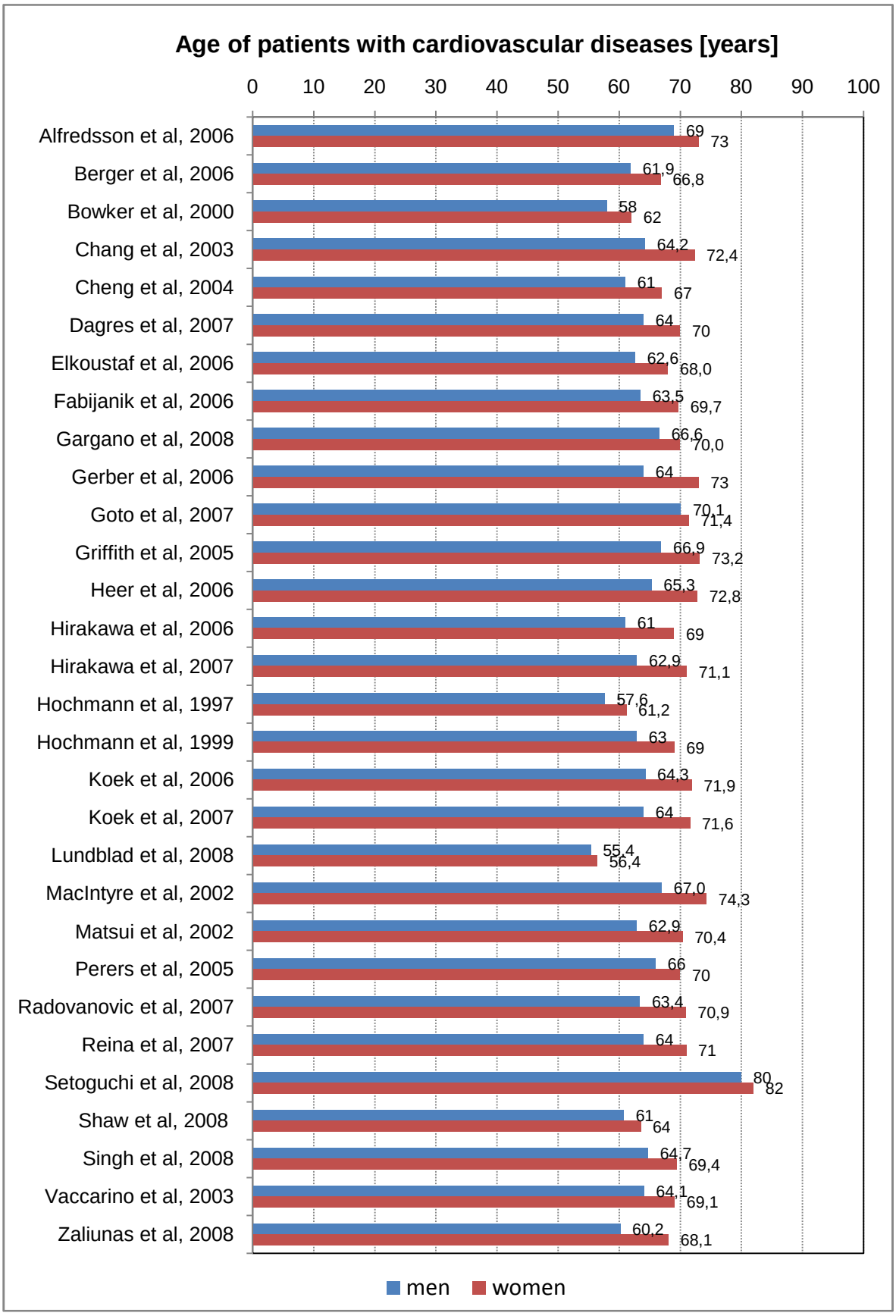

Figure 2: Age of patients at the incidence of a cardiovascular event

Four studies divided the study subjects into age groups (Figure 3). In three studies the proportion of men was higher below 50 or 55 years (Gargano et, 2008; Mac Intyre et al, 2002; Milcent et al, 2007). One study reported a similar proportion of men and women below an age of 45 years (Quresi et al, 2005). In three studies the percentage of men in the age group from 55 to 65 years or 45 to 65 years was higher (Mac Intyre et al, 2002; Milcent et al, 2007 and Qureshi et al, 2005). Two studies reported that between 65 and 75 years the percentage of male and female CVD patients was approximately the same (Milcent et al, 2007; Mac Intyre et al). Only in one study the proportion of male and female patients was approximately the same from 50 to 80 years of age (Gargano et al, 2008). In three studies the percentage of the more than 75 and 80 years old CVD patients was higher in women than in men (Gargano et al, 2008; MacIntyre et al, 2002; Milcent et al, 2007; Theres et al, 2004). A greater percentage of women than men had a CVD incidence at an age above 65 years in one study (Glaser et al, 2006).

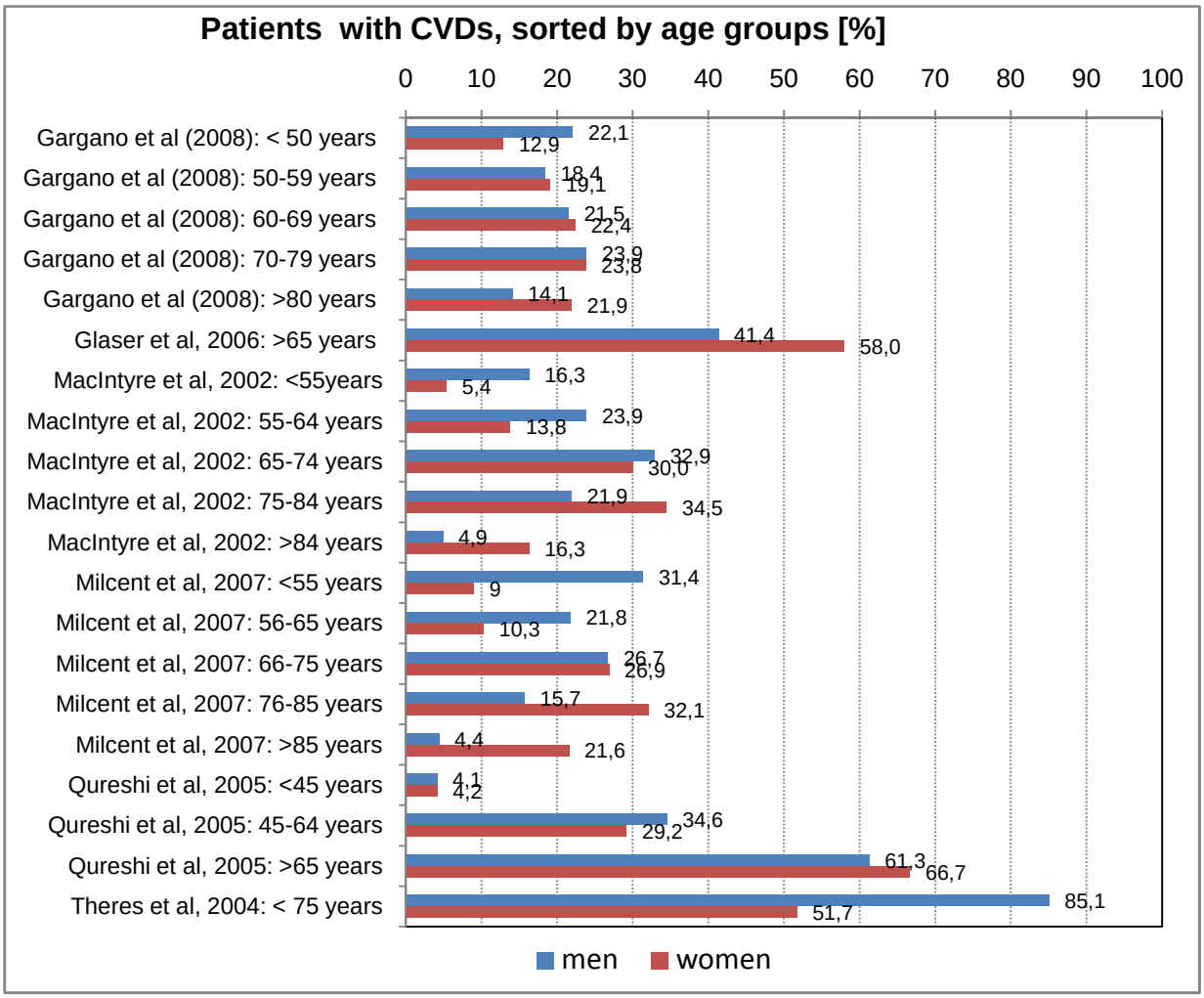

Figure 3: Cardiovascular disease patients, sorted by age groups

4.2.2 Gender difference in the prevalence of diabetes among CVD patients

33 studies reported the prevalence of diabetes in male and female CVD patients (Figure 4). In 29 of the 33 evaluated studies the prevalence of diabetes was higher among women (Alfredsson et al, 2006; Berger et al, 2006; Bowker et al, 2000; Chang et al, 2003; Cheng et al, 2004; Dagres et a, 2007; Fabijanik et al, 2005; Gargano et al, 2007; Gerber et al, 2006; Glaser et al, 2006; Goto et al, 2007; Griffith et al, 2005; Heer et al, 2006; Hirakawa et al, 2006; Hochmann et al, 1997; Hochmann et al, 1999; Koek et al, 2006; Matsui et al, 2002; Milcent et al, 2007; Perers et al, 2005; Qureshi et al, 2005; Radovanovic et al, 2007; Reina et al, 2007; Schreiner et al, 2001; Setoguchi et al, 2008; Singh et al, 2008; Theres et al, 2004; Vaccarino et al, 2003; Zaliiunas et al, 2008). In two studies the prevalence was higher among men (Elkoustaf et al, 2006; Holroyd-Leduc, 2000) and in two studies the prevalence in both sexes was approximately the same (Hirakawa et al, 2007; Gargano et al, 2008).

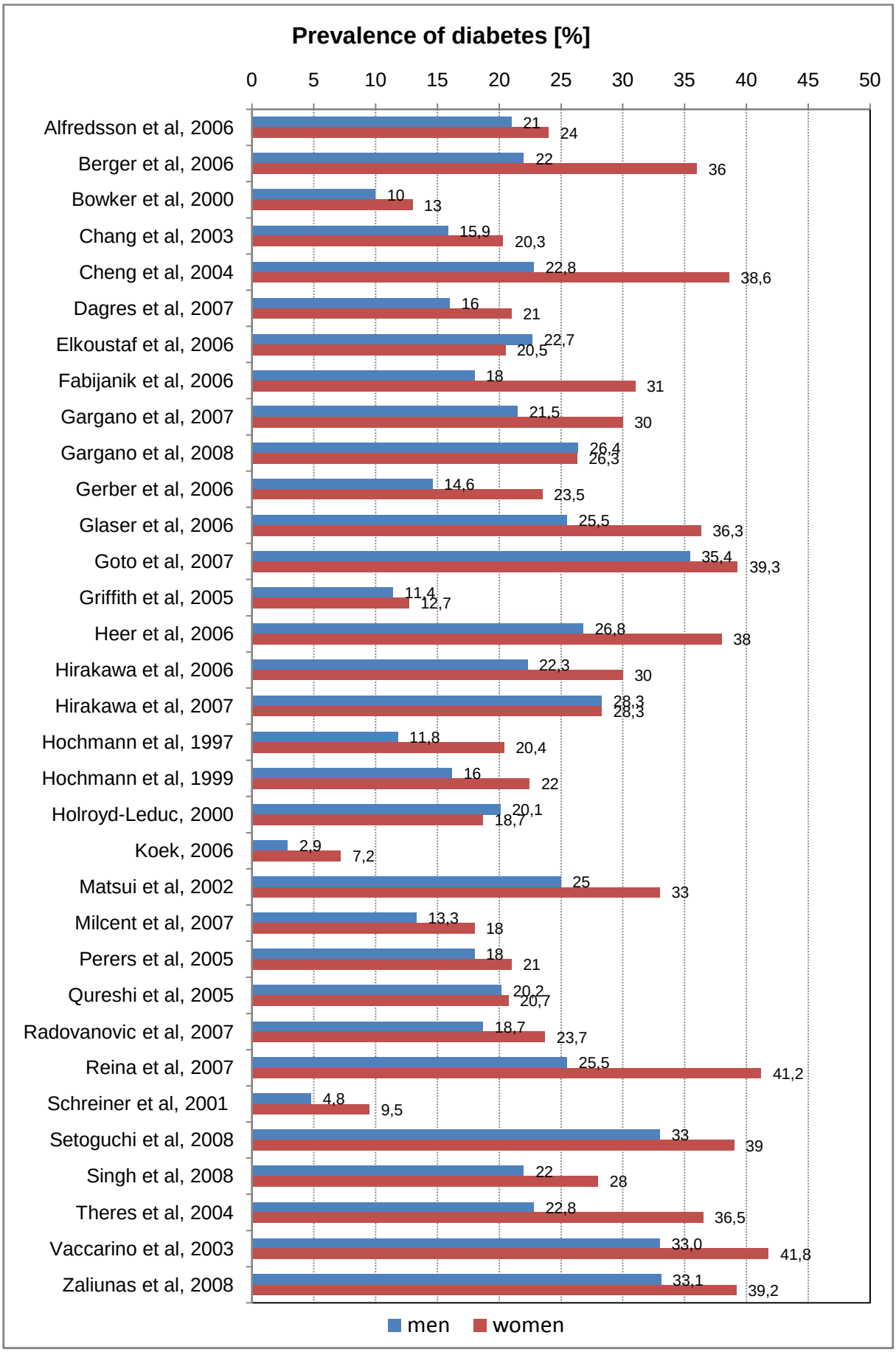

Figure 4: Prevalence of diabetes among patients with cardiovascular diseases

4.2.3 Gender difference in the prevalence of hypertension among CVD patients

In figure 5 the prevalence of hypertension among CVD patients is shown. 32 studies gave information about the prevalence of hypertension in men and women. In all studies the prevalence of hypertension was higher among women (Alfredsson et al, 2006; Berger et al, 2006; Bowker et al, 2000; Chang et al, 2003; Cheng et al, 2004; Dagres et al, 2007; Elkoustaf et al, 2006; Fabijanik et al, 2005; Gargano et al, 2007; Gargano et al, 2008; Gerber et al, 2006; Glaser et al, 2006; Goto et al, 2007; Griffith et al, 2005; Heer et al, 2006; Hirakawa et al, 2006; Hirakawa et al, 2007; Hochmann et al, 1997; Hochmann et al, 1999; Holroyd-Leduc et al, 2000; Matsui et al, 2002; Milcent et al, 2007; Perers et al, 2005; Qureshi et al, 2005; Radovanovic et al, 2007; Reina et al, 2007; Schreiner et al, 2001; Setoguchi et al, 2008; Singh et al, 2008; Theres et al, 2004; Vaccarino et al, 2003; Zaliiunas et al, 2008). In most studies the gender difference was significant, only in some studies there was an only slight difference in the prevalence of hypertension like the study of Zaliunas et al (2008).

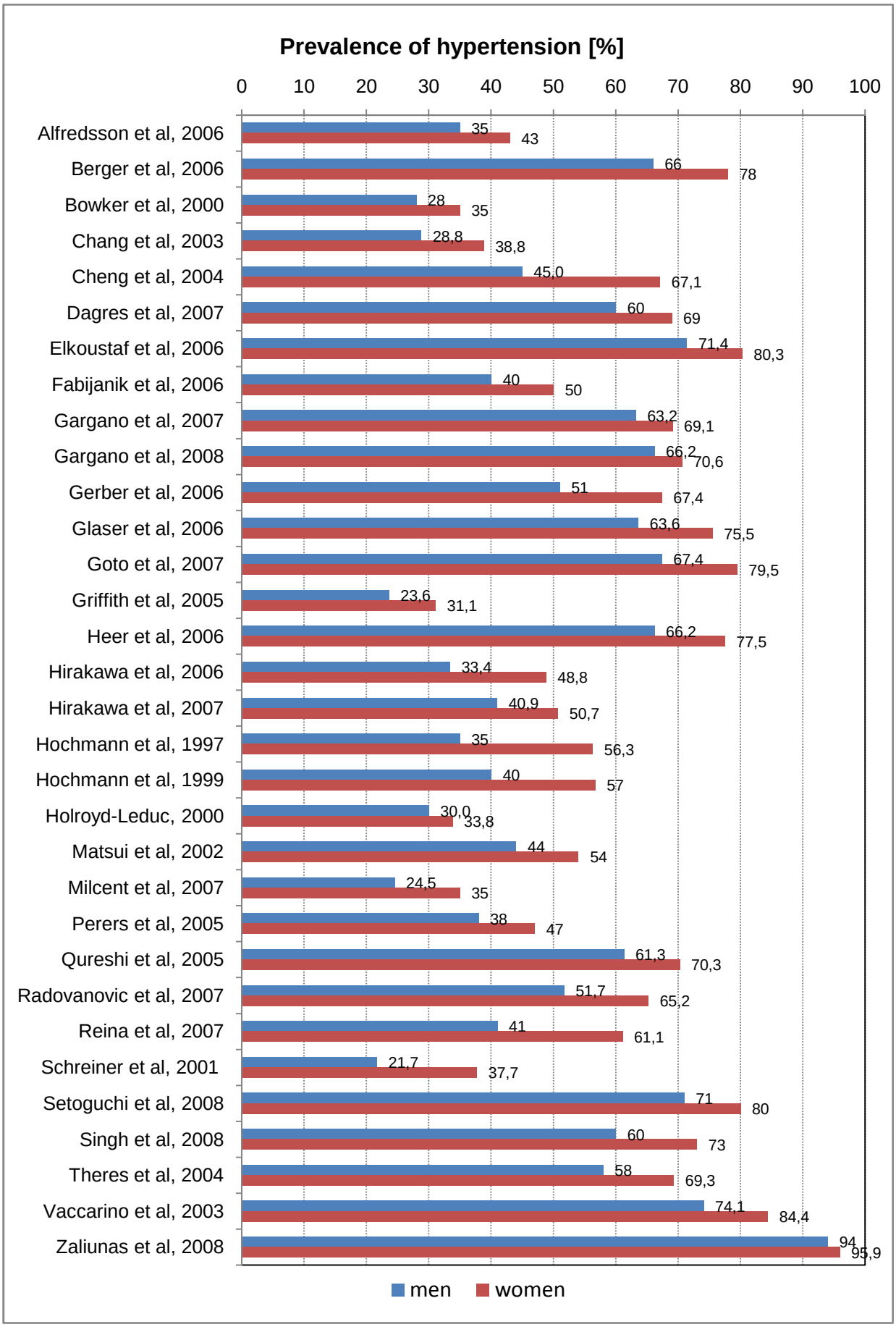

Figure 5: Prevalence of hypertension among patients with cardiovascular diseases

4.2.4 Gender difference in the prevalence of hyper-/dyslipidemia among CVD patients

21 studies reported the prevalence of hyperlipidemia. In nine studies the prevalence of hyper- or dyslipidemia was higher among men (Chang et al, 2003; Cheng et al, 2004; Gargano et al, 2008; Heer et al, 2006; Hirakawa et al, 2006; Qureshi et al, 2005; Radovanovic et al, 2007; Theres et al, 2004; Zaliunas et al, 2008), whereas in 12 studies the prevalence was higher among women (Elkoustaf et al, 2006; Fabijanik et al, 2006; Gerber et al, 2006; Glaser et al, 2006; Goto et al, 2007; Hirakawa et al, 2007; Hochmann et al, 1999; Matsui et al, 2002; Perers et al, 2005; Reina et al, 2007; Singh et al, 2008; Vaccarino et al, 2003) (Figure 6).

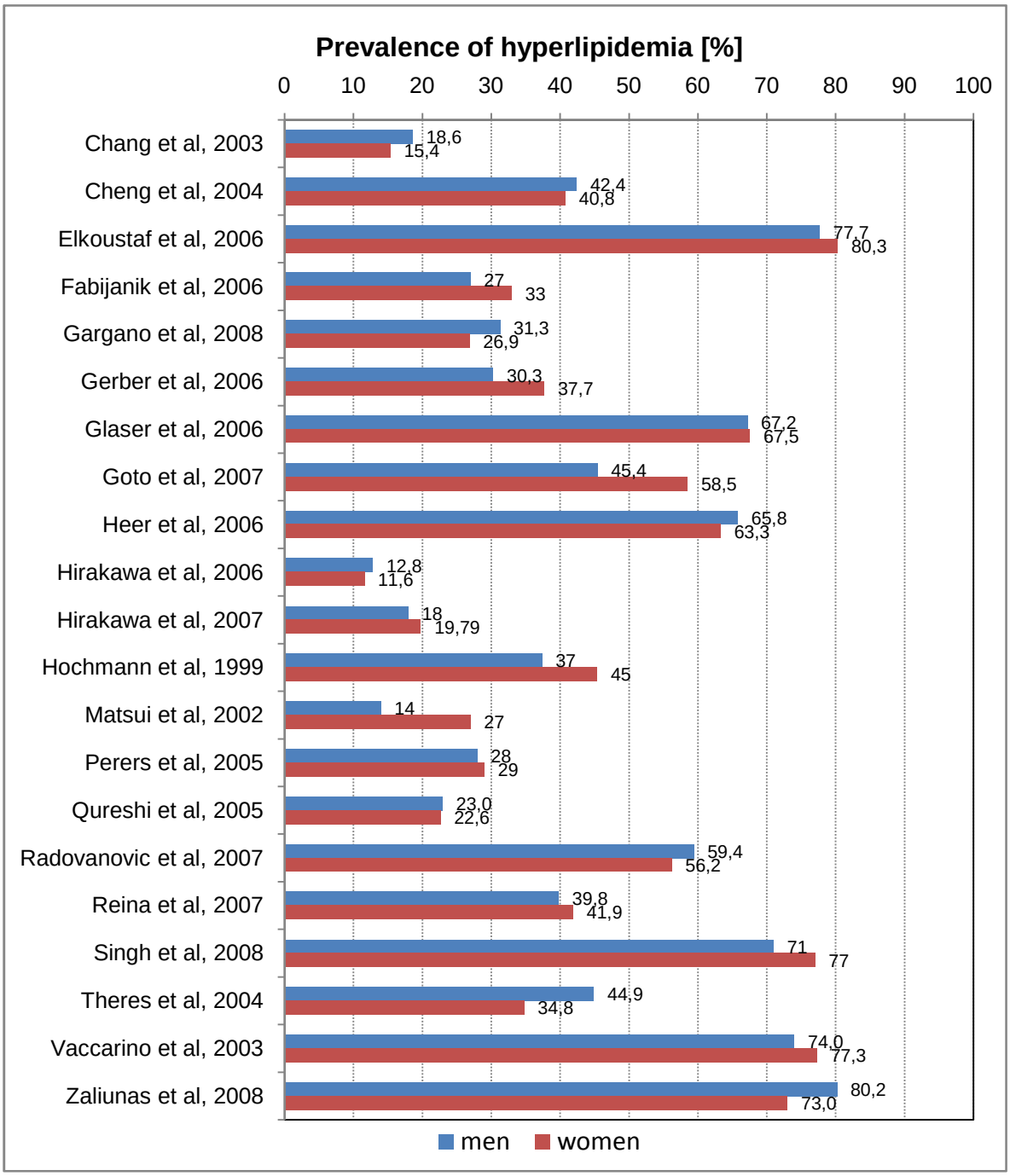

Figure 6: Prevalence of hyperlipidemia among patients with cardiovascular diseases

4.2.5 Gender difference in the prevalence of obesity among CVD patients

7 studies reported the prevalence of obesity among patients with a cardiovascular disease and 4 studies reported the mean BMI of study subjects (Figure 7 and 8). The prevalence of obesity was higher among men in three studies (Gerber et al, 2006; Radovanovic et al, 2007; Zaliunas et al, 2008) and higher among women in 4 studies (Heer et al, 2006; Setoguchi et al, 2008; Theres et al, 2004; Vaccarino et

al, 2003). The mean BMI was slightly higher among women in 2 studies (Berger et al, 2006; Schreiner et al, 2001), about the same in one study (Singh et al, 2008) and higher among men in one study (Hirakawa et al, 2007).

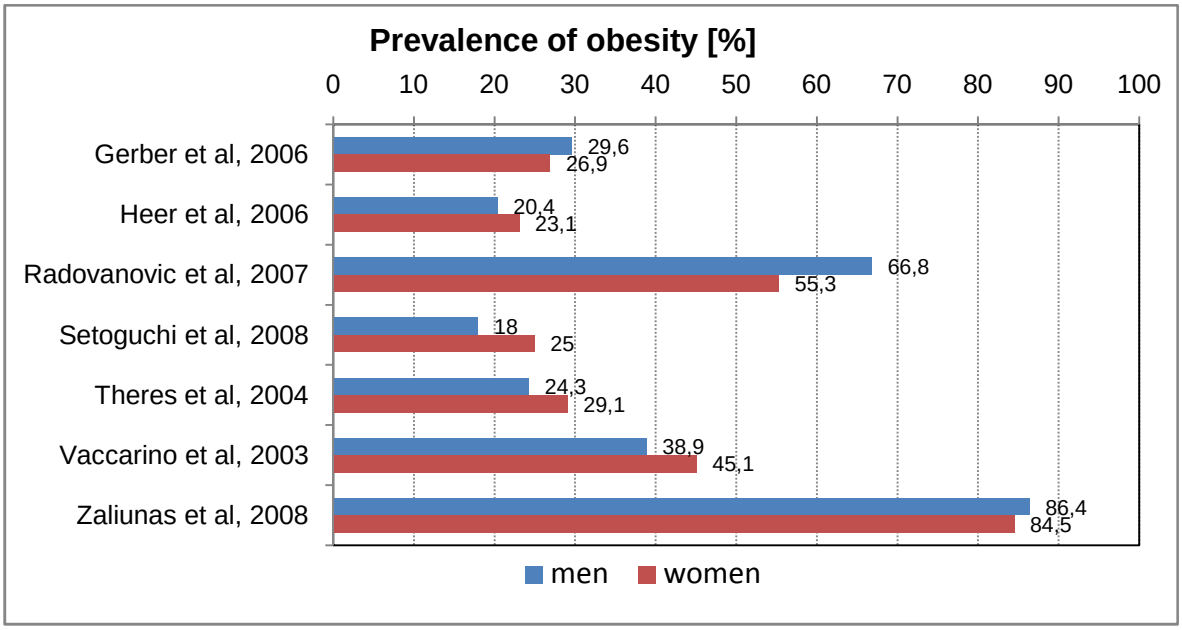

Figure 7: Prevalence of obesity among patients with cardiovascular diseases

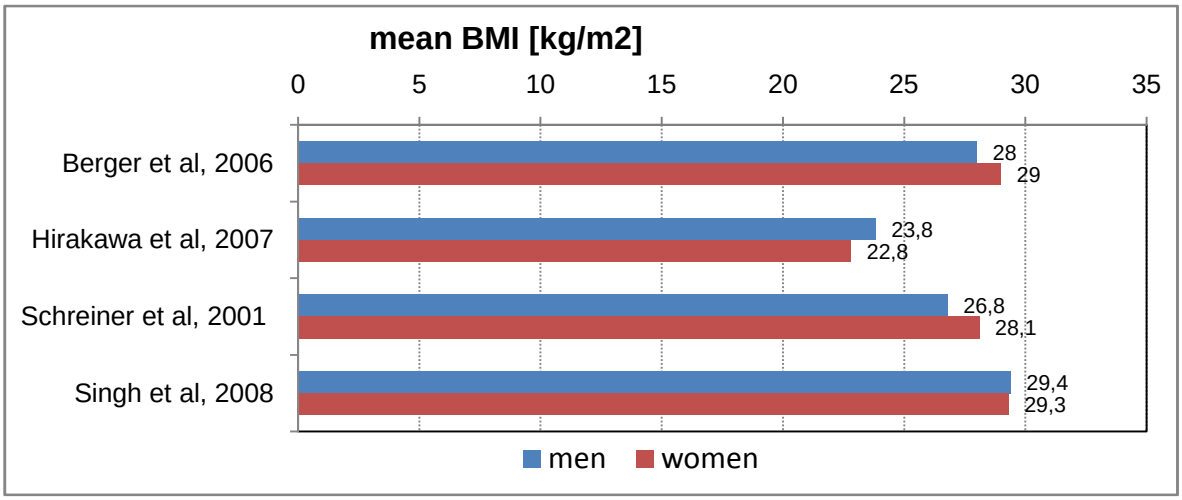

Figure 8: Mean BMI of patients with cardiovascular diseases

4.2.6 Gender difference in the prevalence of smoking among CVD patients

27 studies gave information on the gender difference in smoking prevalence. In all studies the prevalence of smoking was higher in men than in women (Alfredsson er al, 2006; Berger et al, 2006; Bowker et al, 2000; Cheng et al, 2004; Elkoustaf et

al, 2006; Fabijanik et al, 2005; Gargano et al, 2007; Gargano et al, 2008; Gerber et al, 2006; Glaser et al, 2006; Goto et al, 2007; Griffith et al, 2005; Heer et al, 2006; Hirakawa et al, 2006; Hirakawa et al, 2007; Hochmann et al, 1997; Hochmann et al, 1999; Matsui et al, 2002; Milcent et al, 2007; Perers et al, 2005; Qureshi et al, 2005; Radovanovic et al, 2007; Reina et al, 2007; Schreiner et al, 2001; Setoguchi et al, 2008; Singh et al, 2008; Theres et al, 2004; Vaccarino et al, 2003) (Figure 9). Interestingly, the smoking habits differed only slightly in some studies of certain European countries or the USA (p. ex. Alfredsson et al, 2006; Elkoustaf et al, 2006; Milcent et al, 2007; Singh et al, 2008). In other European studies the difference was higher like in the two German studies where more than twice as much men were smokers compared to women (Heer et al, 2006; Theres et al, 2004). The difference in Europe was highest in the Croatian study (Fabijanik et al, 2006), the Spanish study (Reina et al, 2007) and the Finish study (Schreiner et al, 2001) with about 3 times more male smokers than female. The highest gender difference was found in Asian countries like Taiwan (Cheng et al, 2004) where smoking prevalence was about 13 times higher in men than in women and Japan where smoking prevalence was 3 to 4 times higher among women than among men (Goto et al, 2007; Hirakawa et al, 2006; Hirakawa et al, 2007; Matsui et al, 2002).

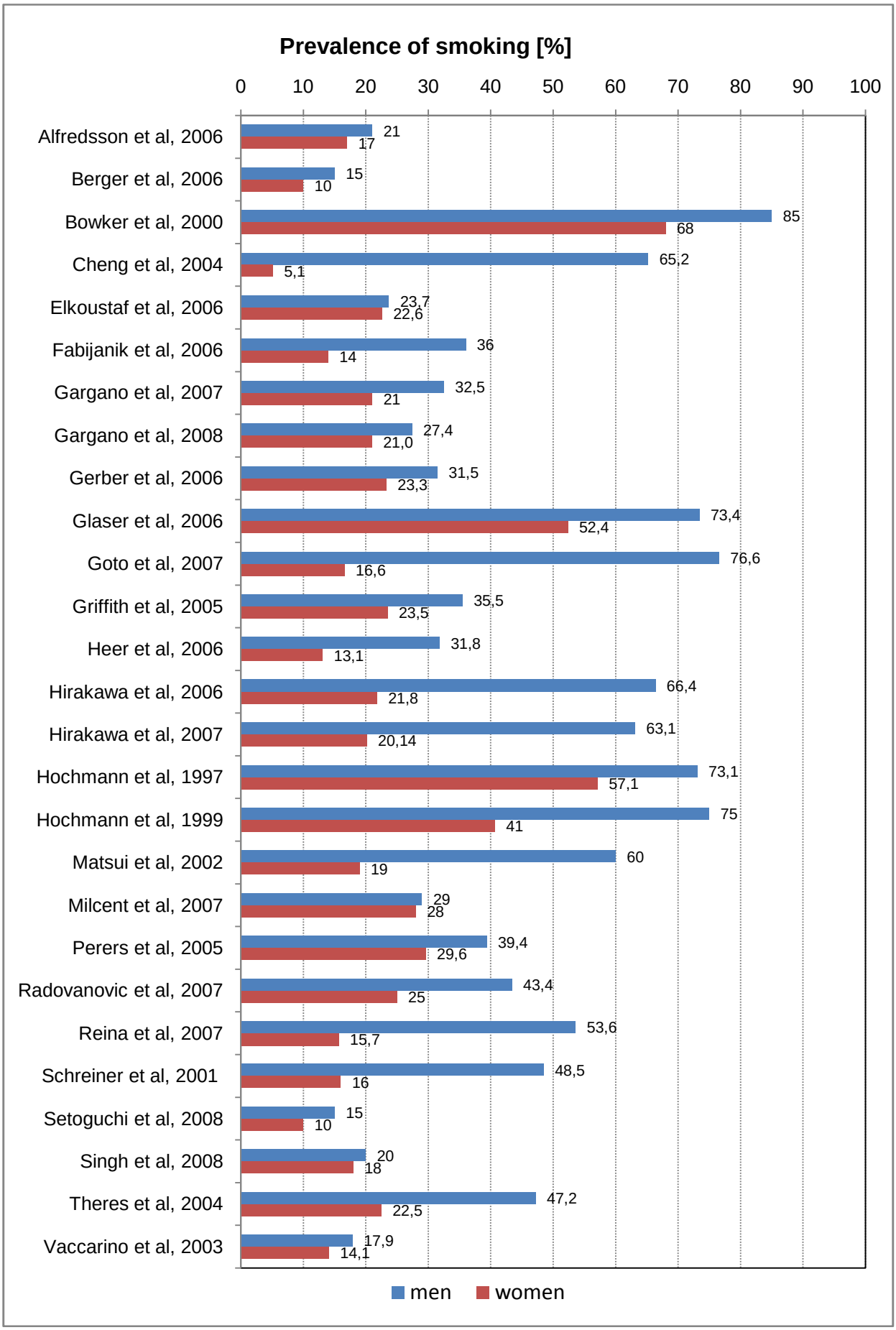

Figure 9: Prevalence of smoking among patients with cardiovascular diseases

4.2.7 Gender difference in the prevalence of recurrent events

In two studies the prevalence of recurrent events within 30 days was slightly higher in men than in women (Figure 10) (Qureshi et al, 2005; Singh et al, 2008). In two other studies the occurrence of recurrent events within one year was higher in women (Figure 11) (Gerber et al, 2008; Singh et al, 2008). In the study of Glaser et al (2008) recurrent events among stable angina patients were more prevalent in women and among coronary syndrome patients more prevalent in men.

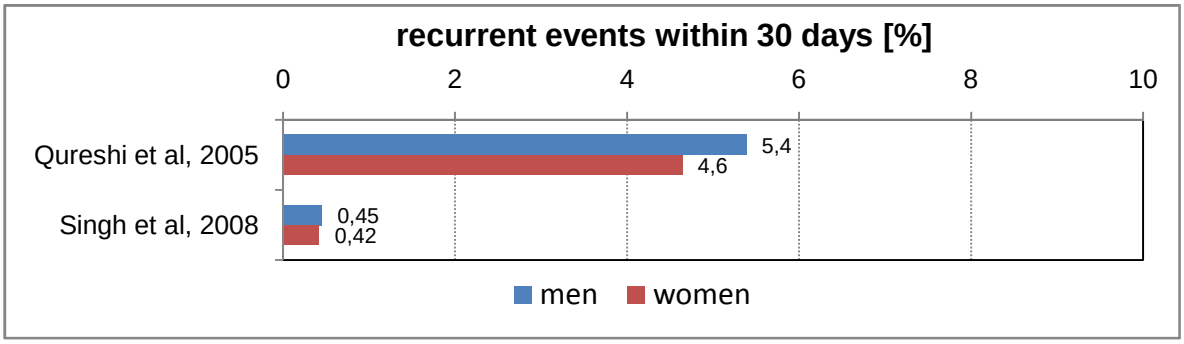

Figure 10: recurrent events [%] within 30 days among male and female patients with cardiovascular diseases

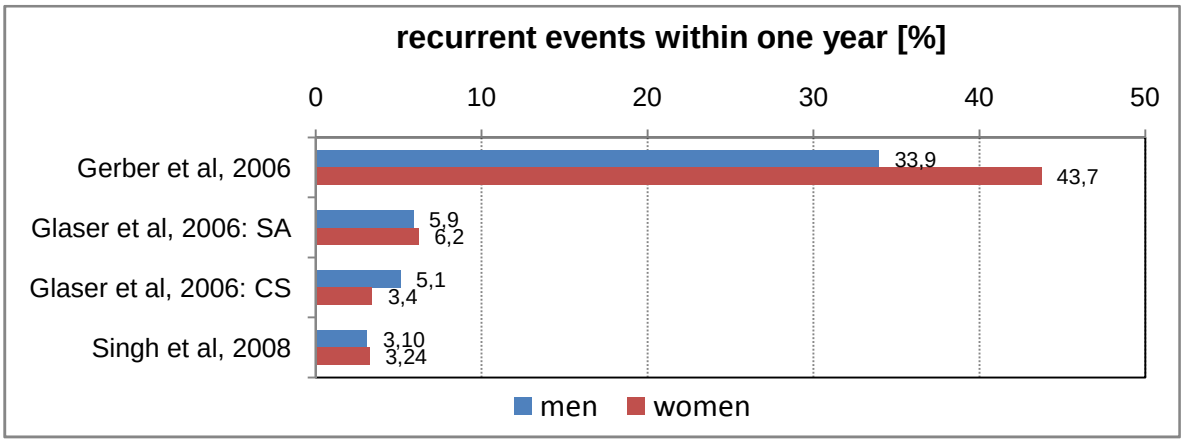

Figure 11: recurrent events [%] within one year among male and female patients with cardiovascular diseases

4.2.8 Gender difference in the mortality from a CVD

In several studies the gender difference in in-hospital, short-term (28-days) and long-term mortality rate (1-year to 5 years) was analysed (Figure 12-14). In-hospital-mortality rate was reported by 16 studies (Figure 12), one study

differentiated according to age groups. In 11 out of 16 studies women had a higher in-hospital mortality rate (Aguado-Romeo et al, 2007; Alfredsson et al, 2006; Gargano et al, 2008; Heer et al, 2006; Hirakawa et al, 2006; Hirakawa et al, 2007; Milcent et al, 2007; Perers et al, 2005; Radovanovic et al, 2007; Singh et al, 2008; Theres et al, 2004), in 4 studies men had a higher rate (Bowker et al, 2000; Elkoustaf et al, 2006; Fabijanik et al, 2006; Setoguchi et al, 2008) and in one study the rate was about the same in both sexese (Berger et al, 2006). Fabijanik et al (2006) reported a higher mortality rate among men in patients between 45 and 64 years and a higher mortality rate among women in patients above 65 years. There were nearly no fatal outcomes in patients younger than 45 years.

Several studies adjusted the in-hospital mortality rate to various variables. As a consequence gender difference in in-hospital mortality was diminished in two studies after adjustment for age (Milcent et al, 2007; Fabijanik et al, 2006) or other baseline factors like hypertension, diabetes, hypercholesterolemia, smoking or the AMI type (Fabijanik et al, 2006) or after adjustment for age, comorbidities and interventions (Milcent et al, 2007). In seven studies gender difference in in-hospital mortality disappeared after adjustment for age (Alfredsson et al, 2006; Heer et al, 2006; Radovanovic et al, 2007), after adjustment for age, several comorbidities and cardiovascular risk factors (Hirakawa et al, 2006; Hirakawa et al, 2007; Radovanovic et al, 2007; Theres et al, 2004), after adjustment for selected hospital procedures, complications, secondary prevention measures and outcomes (Gargano et al, 2008).

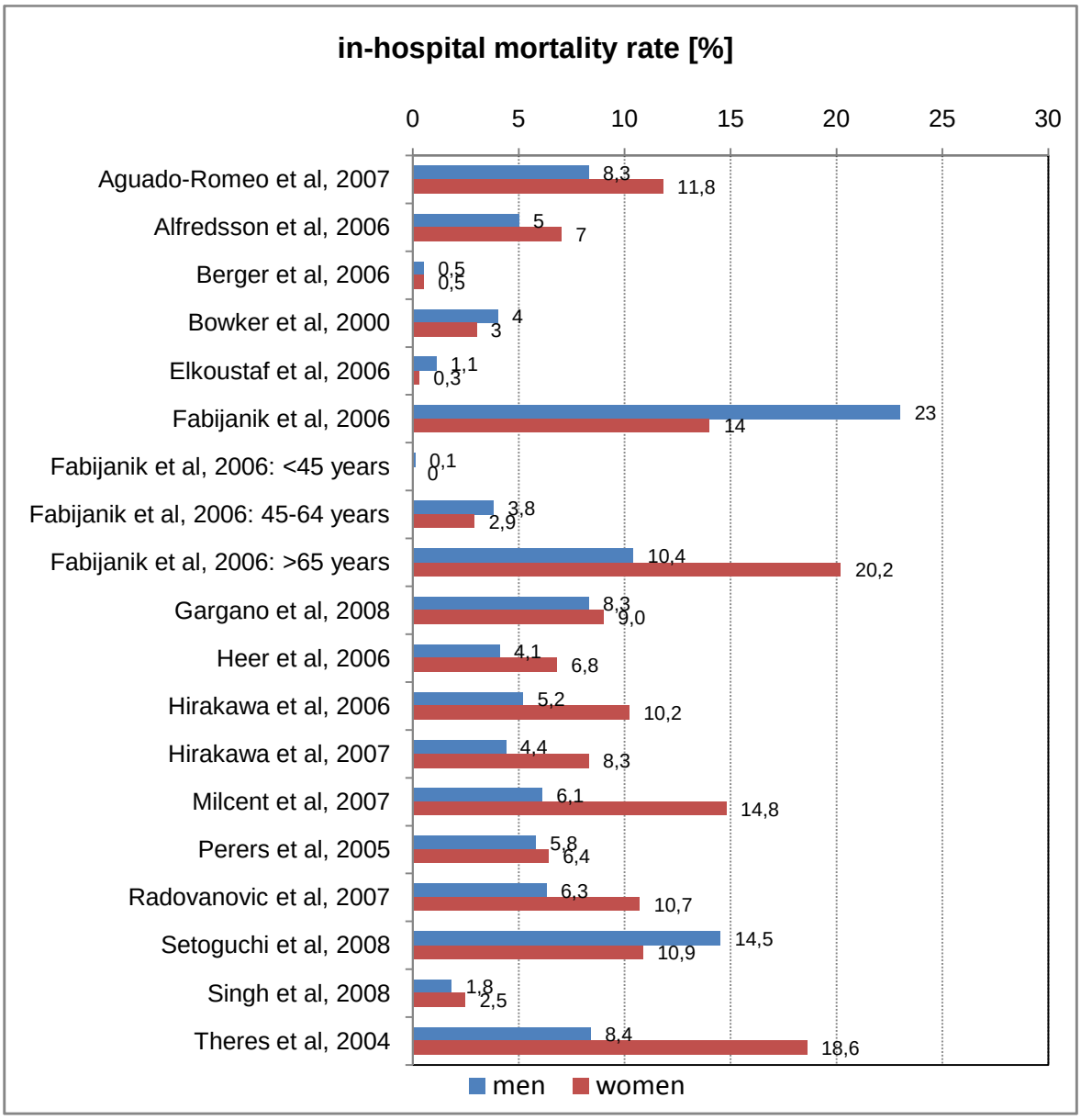

Figure 12: in-hospital mortality rate [%] among male and female patients with cardiovascular diseases

11 studies evaluated the 28 or 30 days-mortality rate (Figure 13). In 8 studies the 28 or 30 days-mortality rate was higher among women (Alfredsson et al, 2006; Chang et al, 2003; Griffith et al, 2005; Koek et al, 2007; MacIntyre et al, 2002; Matsui et al, 2002; Reina et al, 2007; Singh et al, 2008), whereas in 3 studies the rate was higher among men (Holroyd-Leduc et al,2000; Lundblad et al, 2008; Setoguchi et al, 2008). Chang et al (2003) differentiated between patients with acute myocardial infarct and unstable angina. Mortality rate was higher among female AMI patients, but lower among female patients with unstable angina. Holroyd-Leduc et al (2000) differentiated according to age groups. In the group of

the patients younger than 65 years women were affected by a slightly higher mortality rate, in all other age groups men had a higher rate. Koek et al (2007) evaluated the mortality of patients with a myocardial infarct with and without diabetes. Among both groups the mortality was higher in women. Lundblad et al (2008) showed the mortality rate of patients with their first myocardial infarct and patients with a recurrent infarct which was in both groups higher in men. MacIntyre et al (2002) differentiated into subject groups that reached hospital alive or did not. In both groups women had the higher mortality rate after 28 days.

Three studies adjusted the mortality rate to various variables. As a consequence gender differences were diminished in one study after adjustment for age and various variables (Reina et al, 2007) or disappeared in two studies after adjustment for age (Alfredsson et al, 2006) or after adjustment for age, smoking, comorbidity, previous vascular diseases, diabetes, hypertension, and social deprivation (Griffith et al, 2005).

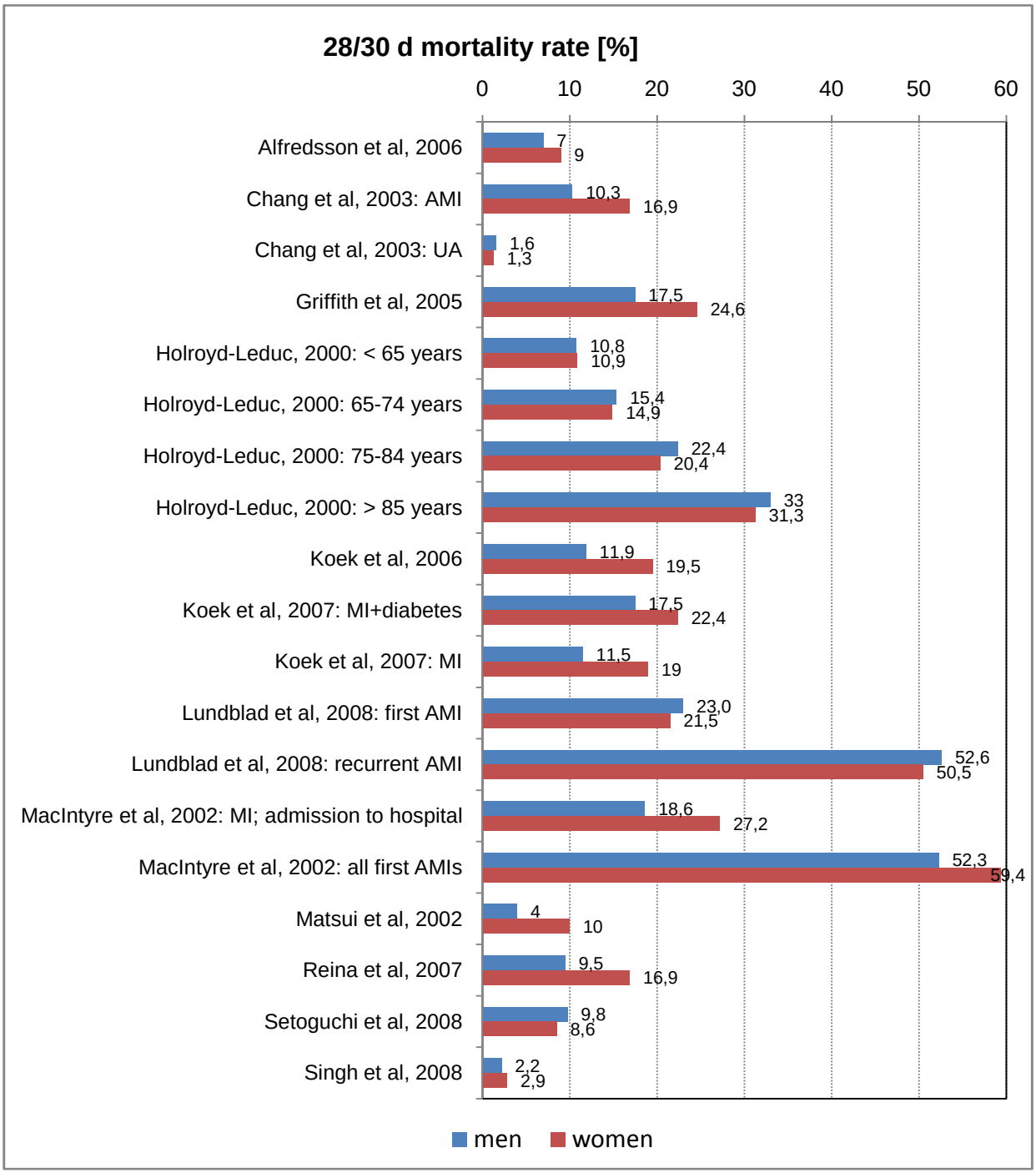

Figure 13: 28/30 day-mortality rate [%] among male and female patients with cardiovascular diseases

Nine studies reported the 1-year-mortality rate (Figure 14). In four studies women were affected by a higher 1-year-mortality rate (Alfredsson et al, 2006; Chang et al, 2003; Koek et al, 2005; Reina et al, 2007) whereas in 3 studies men had a higher 1-year mortality rate (Gargano et al, 2008; Holroyd-Leduc et al, 2000 and Setoguchi et al, 2008). Singh et al (2008) reported a similar 1-year-mortality rate in both sexes. Glaser et al (2006) reported a higher 1-year-mortality rate for men with

coronary syndrome and a lower mortality rate for men with stable angina. Koek et al (2006) found out that the mortality rate of myocardial infarct patients with and without diabetes was higher among women. Holroyd-Leduc et al (2000) differentiated the mortality rate according to age groups. Mortality rate was higher for men in all age groups except for the patients younger than 65 years.

One study adjusted the one-year-mortality rate to age which was higher in men (Alfredsson et al, 2006).

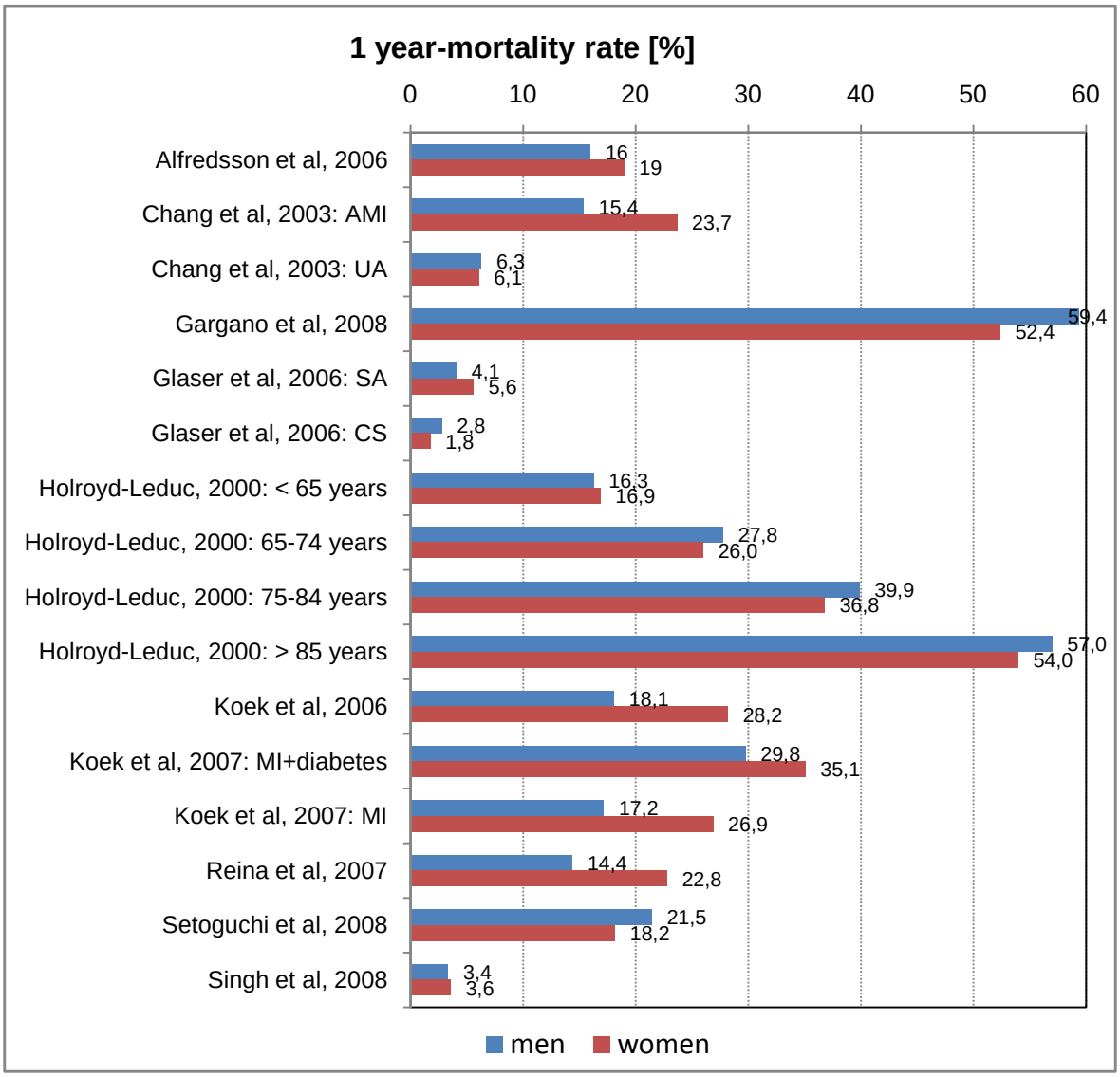

Figure 14: 1-year--mortality rate [%] among male and female patients with cardiovascular diseases

Six studies reported the long-term mortality rate. In all studies the 3 to 7 years mortality rate was higher among women (Berger et al, 2006, Chang et al, 2003; Cheng et al, 2004; Griffith et al, 2005; Koek et al, 2006; Setoguchi et al, 2008).

Several studies adjusted the mortality rate to various variables. As a consequence gender difference disappeared after adjustment for age, smoking, comorbidities, previous vascular disease, diabetes, hypertension, and social deprivation (Griffith et al, 2005). In the study of Chang et al (2003) the hazard ratios for 5-years mortality in women versus men were 0.81 after unstable angina and 0.99 after acute myocardial infarct after adjustment for baseline characteristics and revascularization. In the study of Berger et al (2006) the 3-years-mortality-rate adjusted to comorbidities was lower in women than in men.

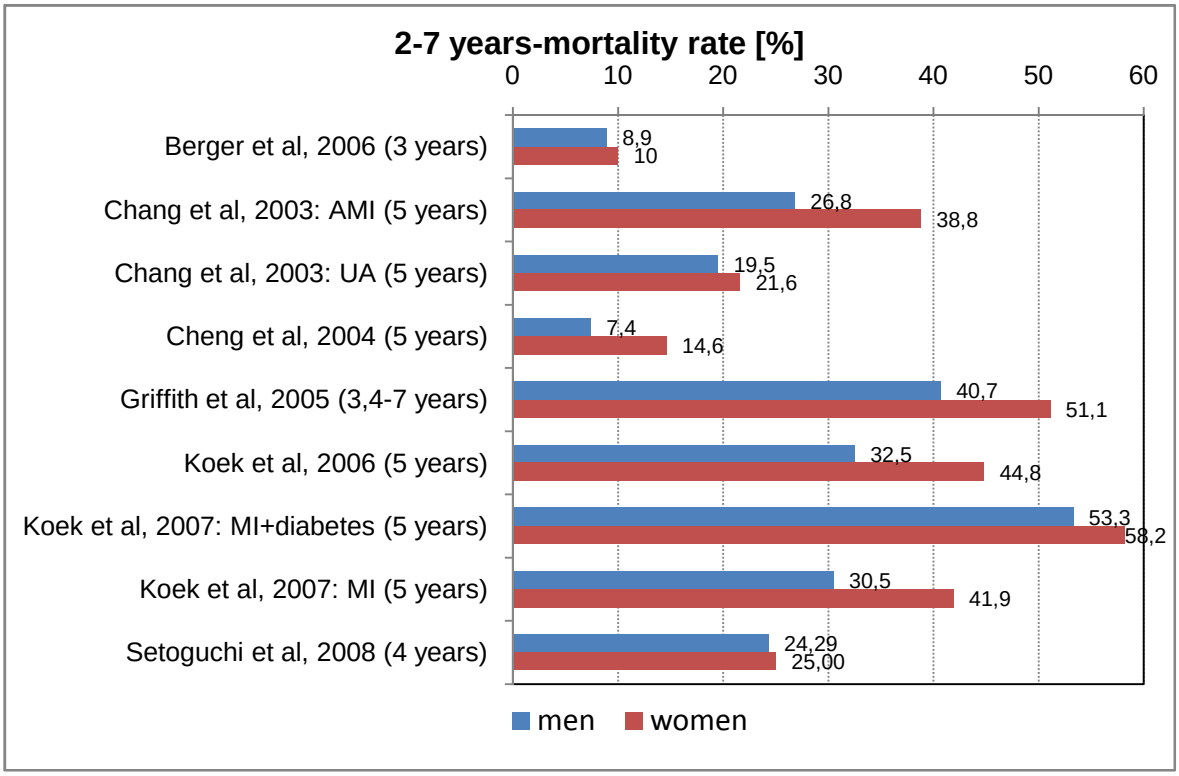

Figure 15: 2-7 year-mortality rate [%] among male and female patients with cardiovascular diseases

4.3 Ethnicity and cardiovascular diseases

11 studies analysed the characteristics of people with cardiovascular diseases depending on ethnicity.

4.3.1 Ethnicity and difference in age of CVD patients

Nine studies gave information on the age of CVD patients from different ethnicity (Figure 16). In all eight studies which compared age of black and white patients, white CVD patients were older than black (Hajat et al, 2002; Kaul et al, 2005; Markus et al, 2007; Sanderson et al, 2007; Shaw et al, 2008; Shen et al, 2007; Slater et al, 2003; Smeeton et al, 2007). Three of those studies compared stroke patients and six compared patients with any form of coronary syndrome or the preclinical stage, atrial fibrillation.

Two studies compared black African and black Caribbean stroke patients. In both studies black Caribbean stroke patients were much older (Smeeton et al, 2007; Markus et al, 2007).

Asian CVD patients had a similar age as white CVD patients in two studies (Shaw et al, 2008; Gupta et al, 2002) and were younger in two studies (Shen et al, 2007; Slater et al, 2003).

Hispanics were younger than whites and Asians in three studies (Shen et al, 2007; Slater et al, 2003; Shaw et al, 2008) and older than blacks in two studies (Slater et al, 2003; Shaw et al, 2008), but younger than blacks in one study (Shen et al, 2007).

Native American patients with acute coronary syndrome and stable angina were younger than whites, Asians, Hispanics and blacks. White, Asian, Hispanic, black and Native American women with stable angina were older than men from the same ethnicity (Shaw et al, 2008).

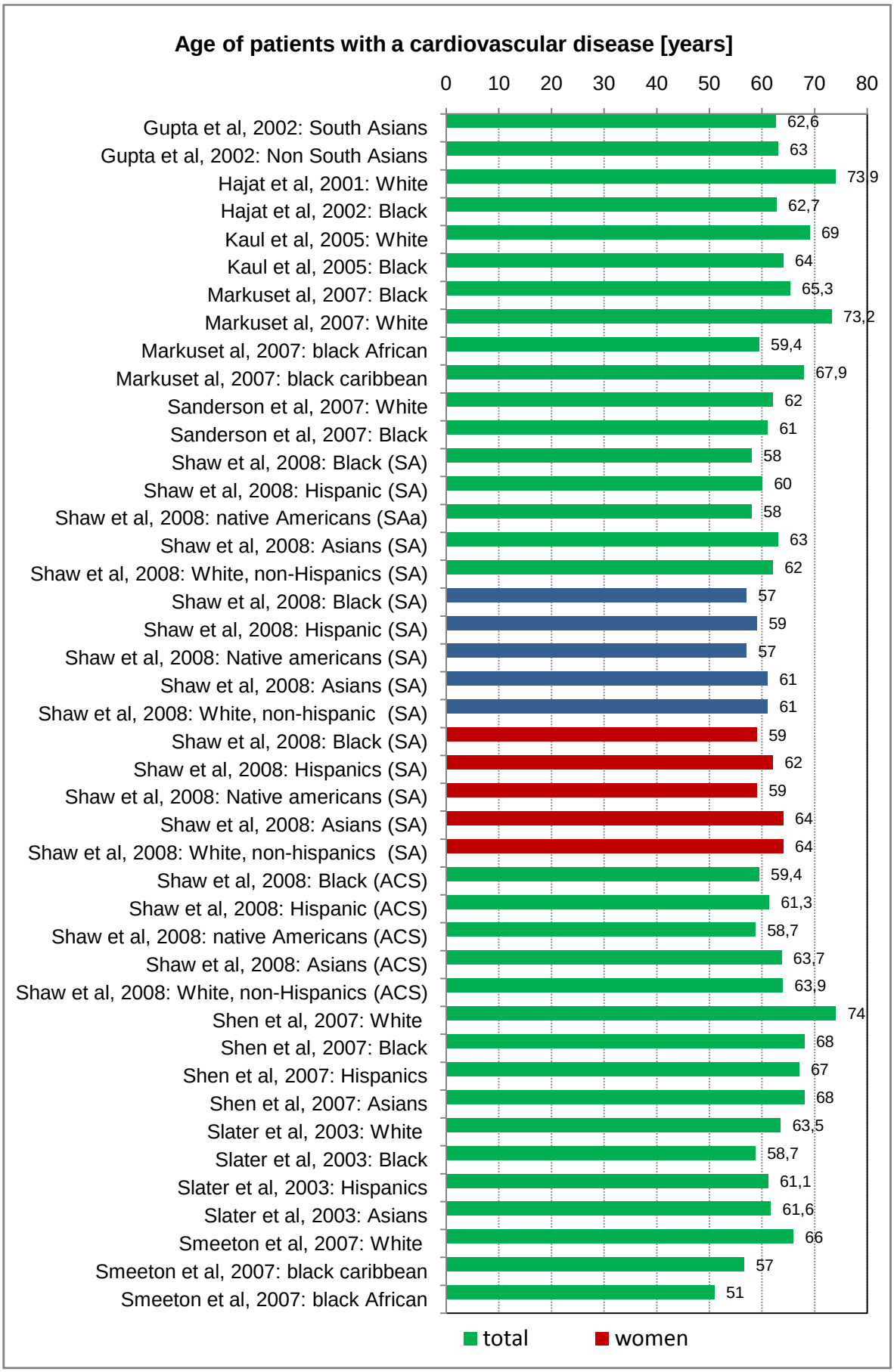

Figure 16: Age of patients with cardiovascular diseases from different ethnicity

One studies sorted stroke patients by age groups (Figure 17). More whites were older than 65 years than blacks at incidence of stroke. More women were older than 65 years at their first stroke than men among black and white patients (Qureshi et al, 2005).

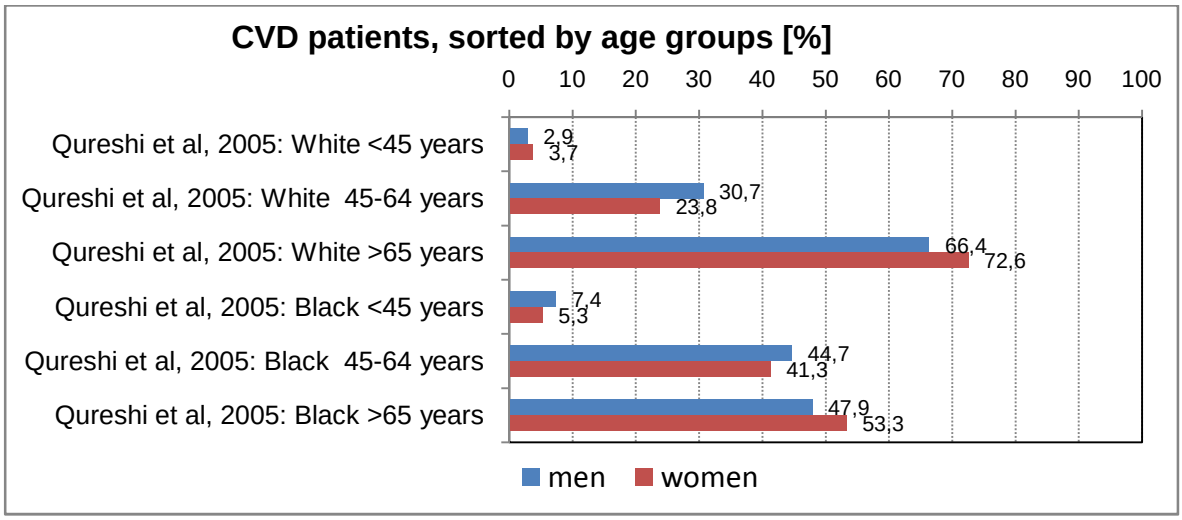

Figure 17: Age of patients with cardiovascular diseases from different ethnicity

4.3.2 Ethnicity and prevalence of diabetes among CVD patients

Nine studies analysed the prevalence of diabetes in patients from different ethnicity who had a cardiovascular disease (Figure 18). The prevalence of diabetes was higher in blacks than in whites in eight studies (Hajat et al, 2002; Kaul et al, 2005; Markus et al, 2007; Sanderson et al, 2007; Shaw et al, 2008; Shen et al, 2007; Slater et al, 2003; Smeeton et al, 2007). In one study black Caribbean had a higher prevalence of diabetes (Markus et al, 2007) and in one study black Africans had a higher prevalence (Smeeton et a, 2007). Four studies showed a higher occurrence of diabetes in Asians than in whites (Gupta et al, 2002; Shaw et al, 2008; Shen et al, 2007; Slater et al, 2003). Hispanics had more likely diabetes than blacks, Asians and whites as showed in three studies (Shaw et al, 2008; Shen et al, 2007; Slater et al, 2003). Among Native Americans diabetes was most prevalent (Shaw et al, 2008).

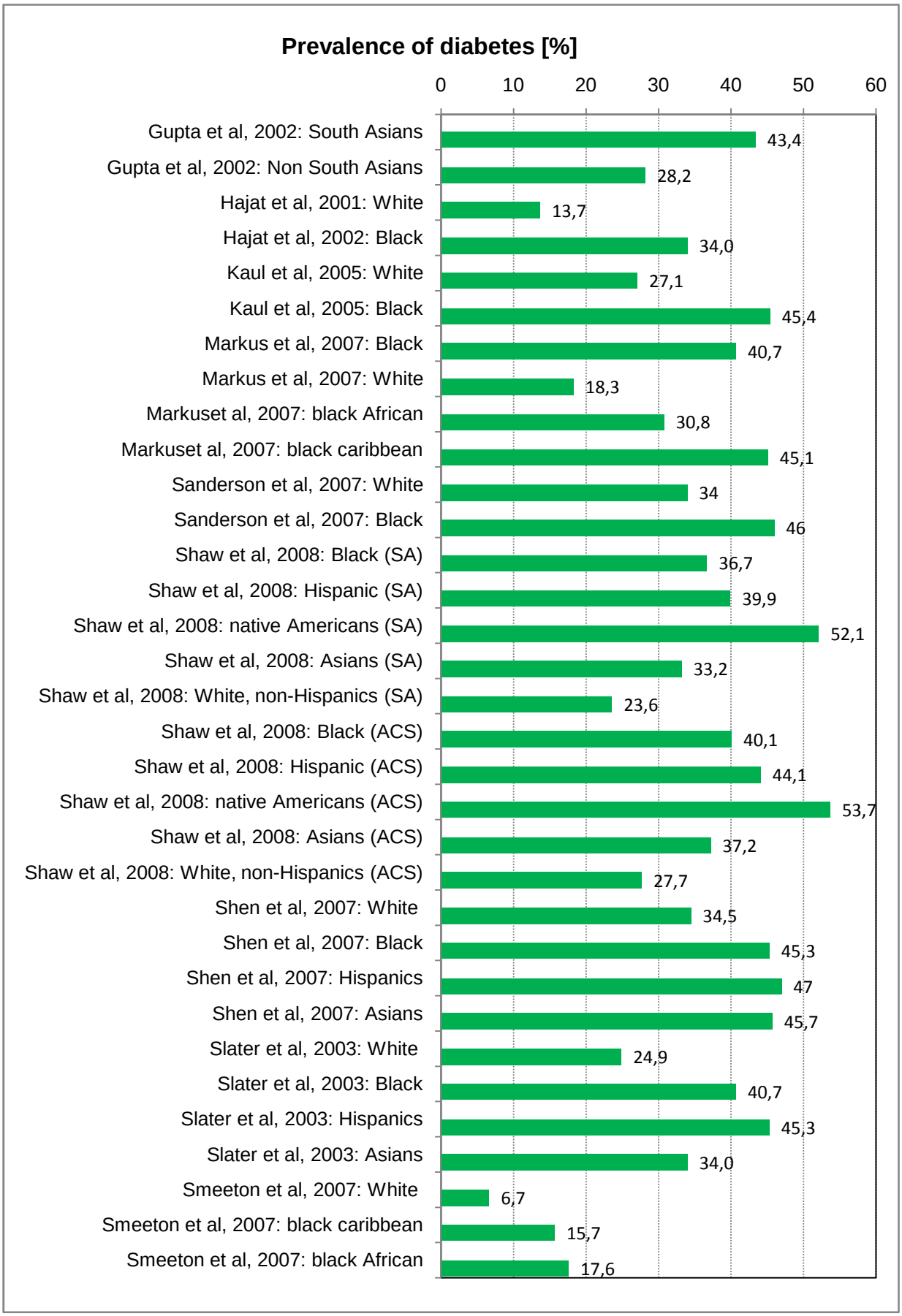

Figure 18: Prevalence of diabetes among patients with cardiovascular diseases from different ethnicity

4.3.3 Ethnicity and prevalence of hypertension among CVD patients

Nine studies analysed the prevalence of hypertension in patients from different ethnicity who suffered from a cardiovascular disease (Figure 19). The prevalence of hypertension was higher in blacks than in whites as shown in eight studies (Hajat et al, 2002; Kaul et al, 2005; Markus et al, 2007; Sanderson et al, 2007; Shaw et al, 2008; Shen et al, 2007; Slater et al, 2003; Smeeton et al, 2007). In one study black Caribbeans had a higher prevalence of hypertension (Markus et al, 2007) and in one study black Africans had a higher prevalence (Smeeton et a, 2007). Hypertension was more prevalent in Asians than in whites as reported by four studies (Gupta et al, 2002; Shaw et al, 2008; Shen et al, 2007; Slater et al, 2003). Hispanics had more likely hypertension than blacks, Asians and whites as showed in three studies (Shaw et al, 2008; Shen et al, 2007; Slater et al, 2003). Among Native Americans hypertension was most prevalent (Shaw et al, 2008).

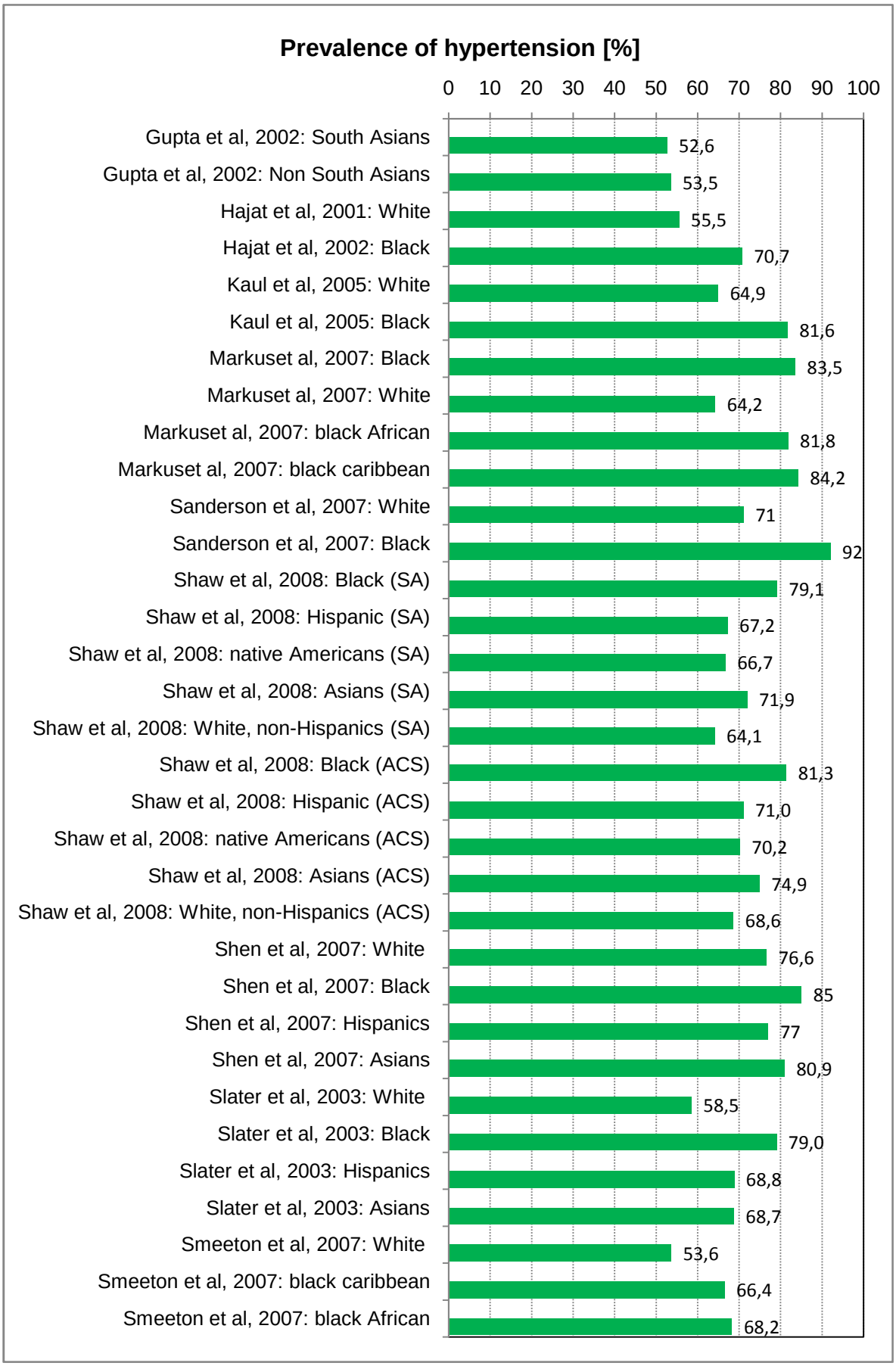

Figure 19: Prevalence of hypertension among patients with cardiovascular diseases from different ethnicity

4.3.4 Ethnicity and prevalence of hyper-/dyslipidemia among CVD patients

Six studies analysed the prevalence of hyper- or dyslipidemia in patients from different ethnicity who had a cardiovascular disease (Figure 20). In three studies the prevalence of hyper- or dyslipidemia was lower in black than in white patients (Kaul et al, 2005; Shaw et al, 2008; Slater et al, 2003), whereas the prevalence was about the same in the study of Sanderson et al (2007) and higher than in whites in the study of Markus et al (2007). Black Caribbean had a similar prevalence hyper- or dyslipidemia as black Africans (Markus et al, 2007). In Asians hyper- or dyslipidemia was less prevalent in Asians than in whites as reported in one study (Gupta et al, 2002). Shaw et al (2008) showed a higher prevalence of hyper- or dyslipidemia among Asian stable angina patients and a lower prevalence among acute coronary syndrome patients. Hispanics had more likely hyper- or dyslipidemia than blacks and less likely than Asians and whites as showed in two studies (Shaw et al, 2008; Slater et al, 2003). Among Native Americans hyper- or dyslipidemia was more prevalent than among blacks and Hispanics and less prevalent than among Asians and whites (Shaw et al, 2008).

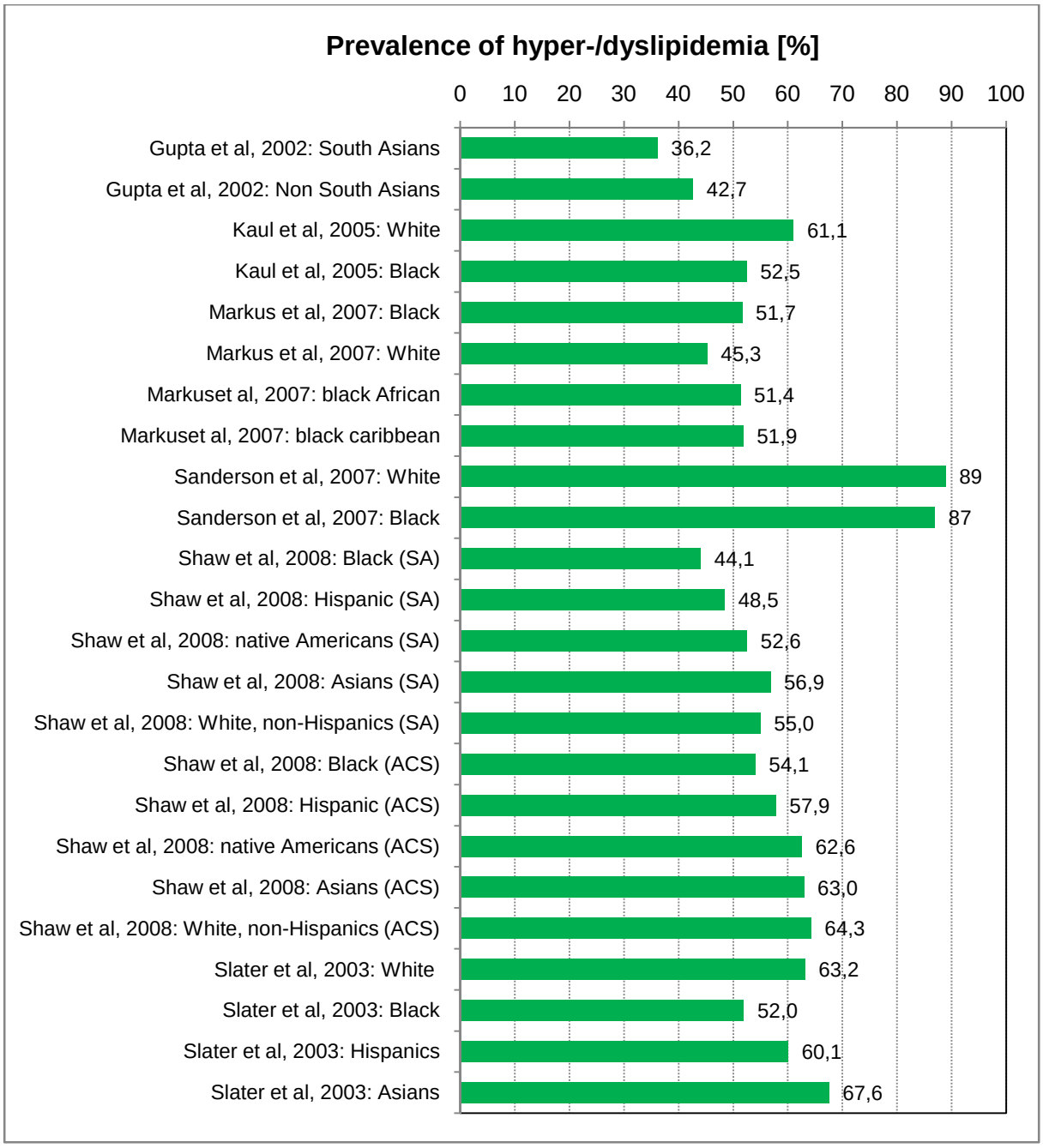

Figure 20: Prevalence of hyper-/dyslipidemia among patients with cardiovascular diseases from different ethnicity

4.3.5 Ethnicity and prevalence of obesity among CVD patients

Two studies reported the prevalence of obesity among CVD patients (Figure 21). In both studies more blacks were obese than whites and more black Caribbean were obese than black Africans (Markus et al, 2007).

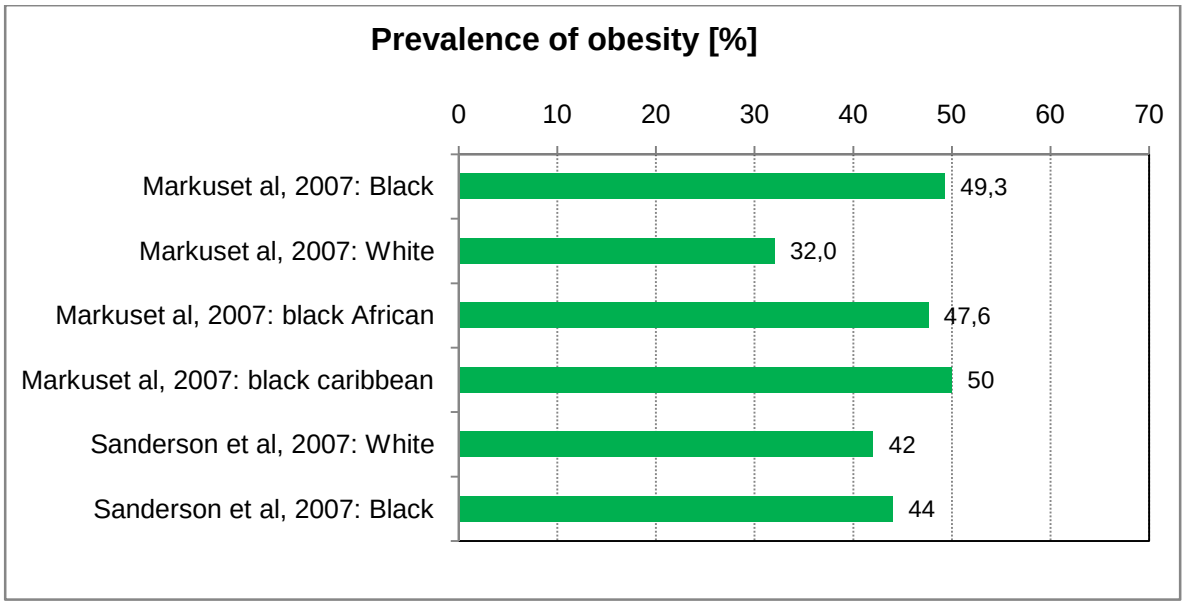

Figure 21: Prevalence of obesity among patients with cardiovascular diseases from different ethnicity

Three studies reported the mean BMI of CVD patients (Figure 22). Asian patients had the lowest BMI as shown in two studies (Gupta et al, 2002; Shaw et al, 2008). Blacks had a higher BMI than whites which was shown in two studies (Kaul et al, 2005; Shaw et al, 2008). Shaw et al (2008) reported a higher BMI of Hispanics compared to Asians and whites and a lower BMI than blacks and Native Americans.

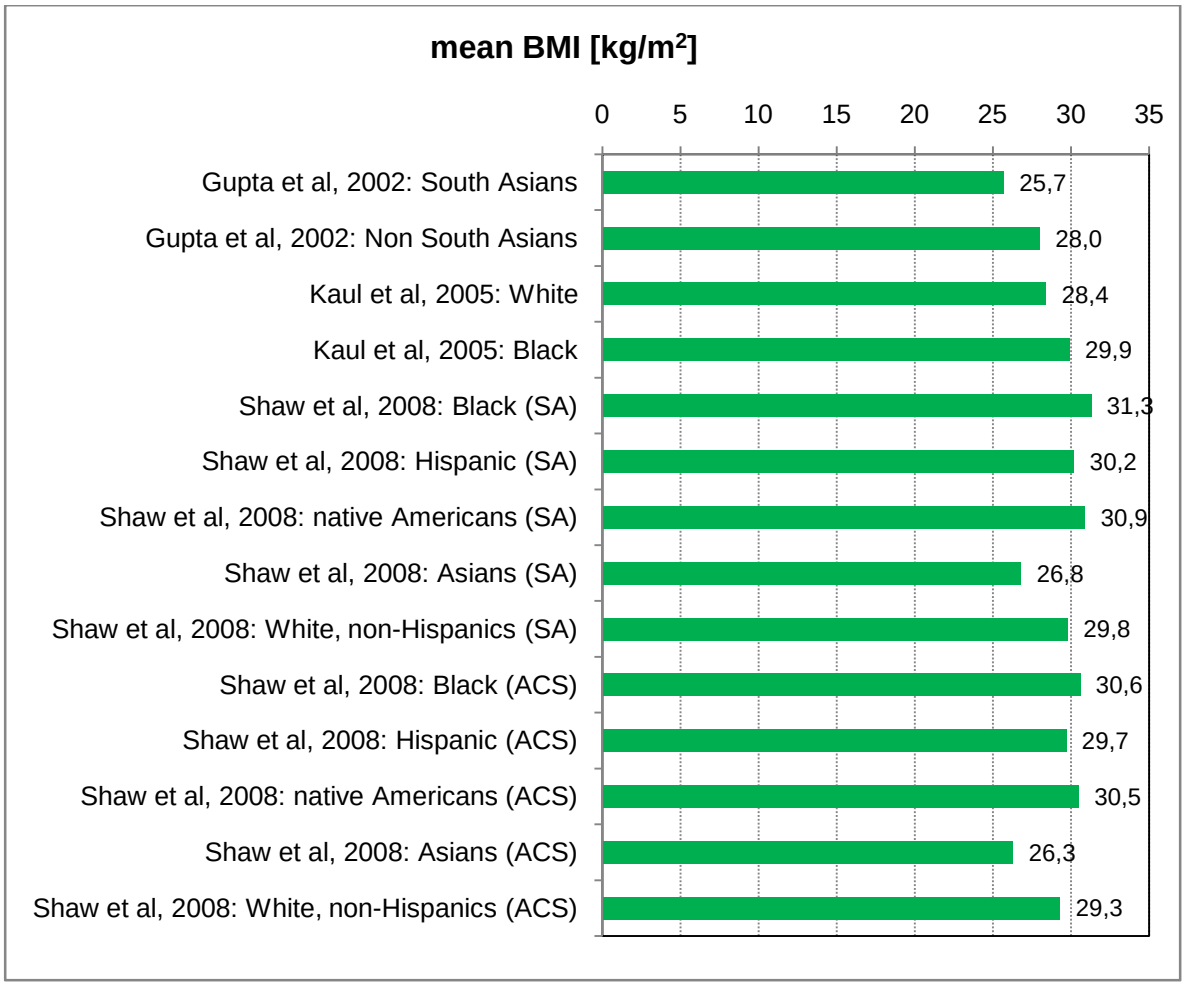

Figure 22: Mean BMI among patients with cardiovascular diseases from different ethnicity

4.3.6 Ethnicity and prevalence of smoking among CVD patients

Eight studies reported the prevalence of smoking among CVD patients from different ethnicity (Figure 23). Four studies showed that more black patients smoked than white patients (Kaul et al, 2005; Sanderson et al, 2007; Shaw et al, 2008; Slater et al, 2003), whereas in three studies less blacks smoked compared to whites (Hajat et al, 2001; Markus et al, 2007; Smeeton et al, 2007). In all three studies Asians smoked less than whites (Gupta et al, 2002; Shaw et al, 2008; Slater et al, 2003). Less Hispanic CVD patients than white and black were smokers and more than Asians (Shaw et al, 2008; Slater et al, 2003). Among Native American patients with stable angina or coronary syndrome smoking was most common compared to patients from other ethnicities (Shaw et al, 2008).

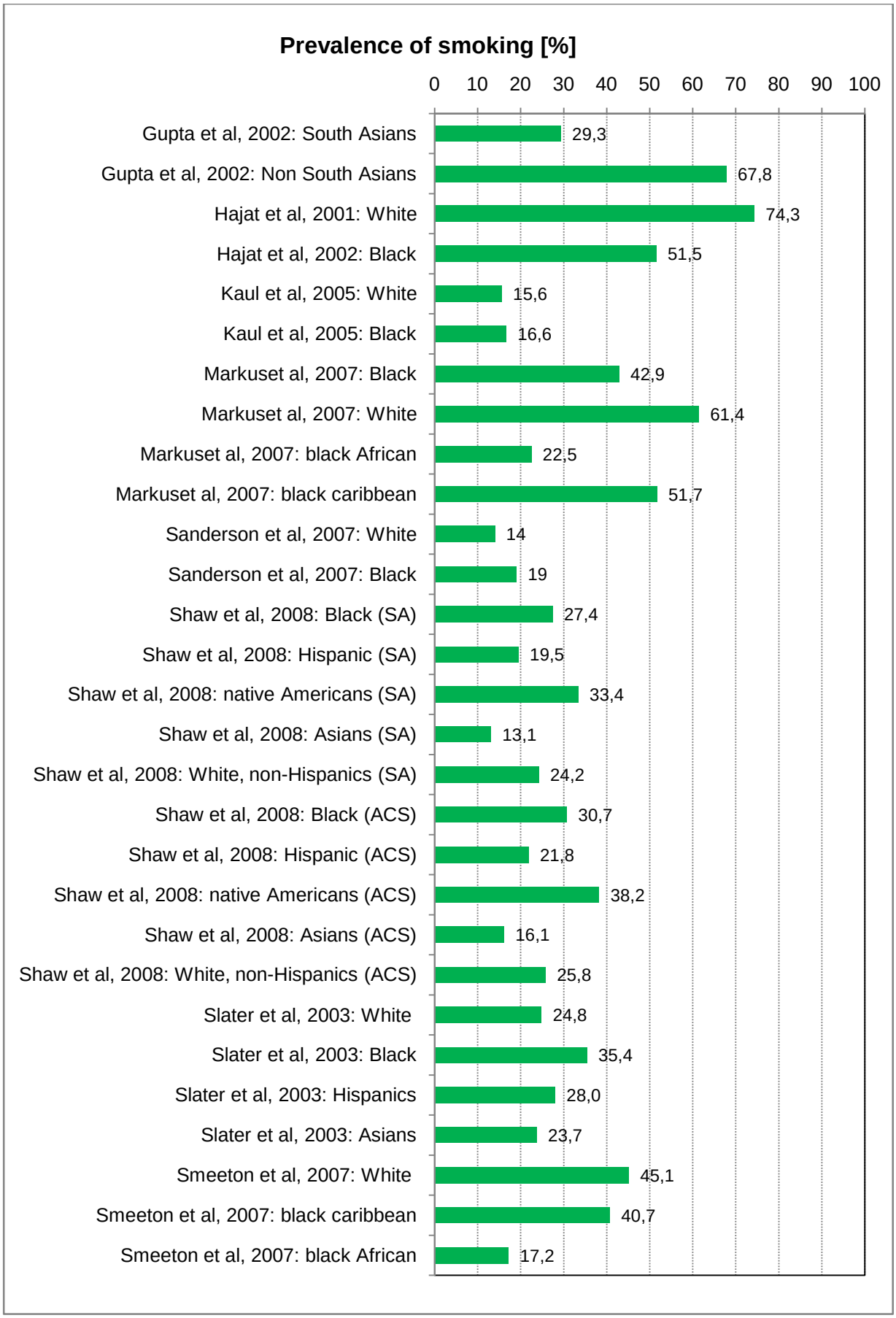

Figure 23: Prevalence of smoking among patients with cardiovascular diseases from different ethnicity

4.3.7 Ethnicity and prevalence of recurrent events

In the study of Qureshi et al (2005) black men had the highest rate of recurrent events, followed by white women and white men (Figure 24). Black women had the lowest rate. In another study South Asians had a higher rate of recurrent events than non South Asians (Gupta et al, 2002).

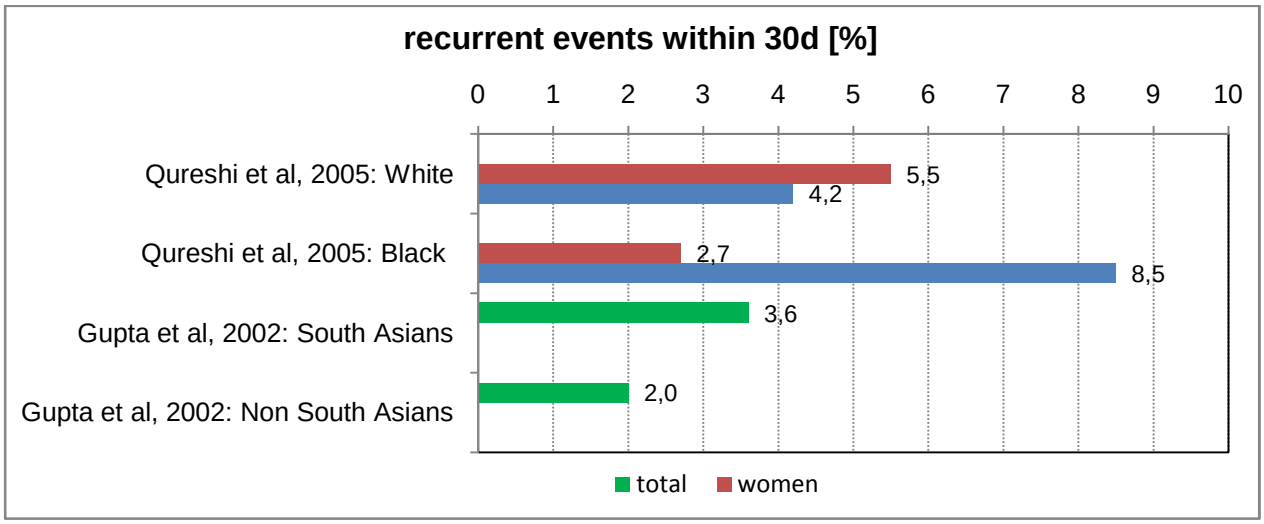

Figure 24: recurrent events within 30 days [%], among patients with cardiovascular diseases from different ethnicity

4.3.8 Ethnicity and mortality rate among CVD patients

The in-hospital-mortality rate was evaluated in three studies (Figure 25). In two studies black CVD patients had a lower in-hospital-mortality rate than whites, which was significant in one study (Slater et al, 2003) and only slightly in the other study (Shaw et al, 2008). Asians had a slightly higher in-hospital-mortality rate than whites in two studies (Gupta et al, 2002; Shaw et al, 2008) and a slightly lower mortality rate than whites in one study (Slater et al, 2003). Hispanics were affected by a slightly higher rate than whites in one study (Shaw et al, 2008) and by a lower rate in the other study (Slater et al, 2003). Furthermore Hispanics had a slightly higher mortality rate than blacks in the two studies and a slightly lower rate than Asians (Shaw et al, 2008; Slater et al, 2003). Native Americans with acute coronary syndrome had the lowest in-hospital mortality rate compared to whites, blacks, Hispanics and Asians (Shaw et al, 2008).

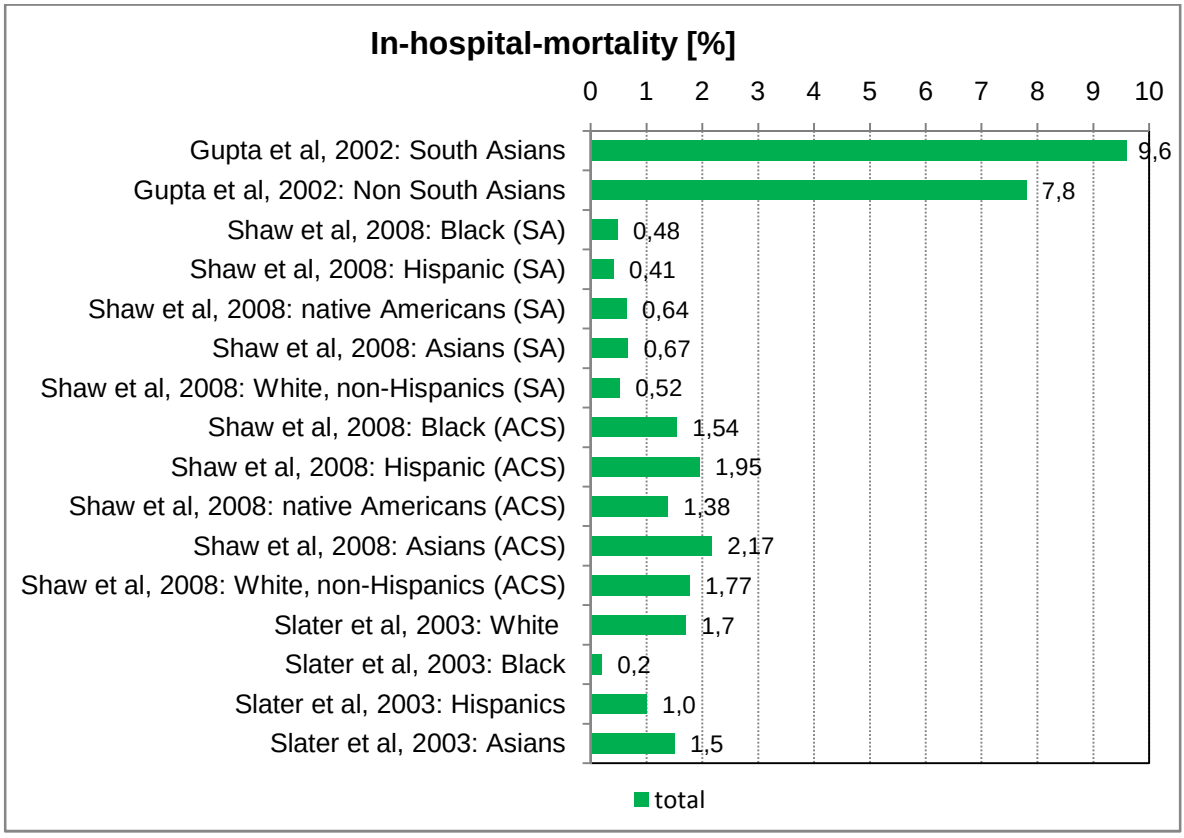

Figure 25: In-hospital-mortality rate of patients with cardiovascular diseases from different ethnicity

One-year-mortality rate was evaluated in two studies (Figure 26). In one study black CVD patients had a slightly lower one-year-mortality rate than white patients (Slater et al, 2003). In the other study black women had a higher mortality rate than white women, whereas black men had a slightly lower mortality rate than white men (Qureshi et al, 2005). Asians had a higher 1-year-mortality rate than whites in the studies of Slater et al (2003). In the same study Hispanics were affected by a slightly higher rate than whites and blacks and a slightly lower rate than Asians (Slater et al, 2003).

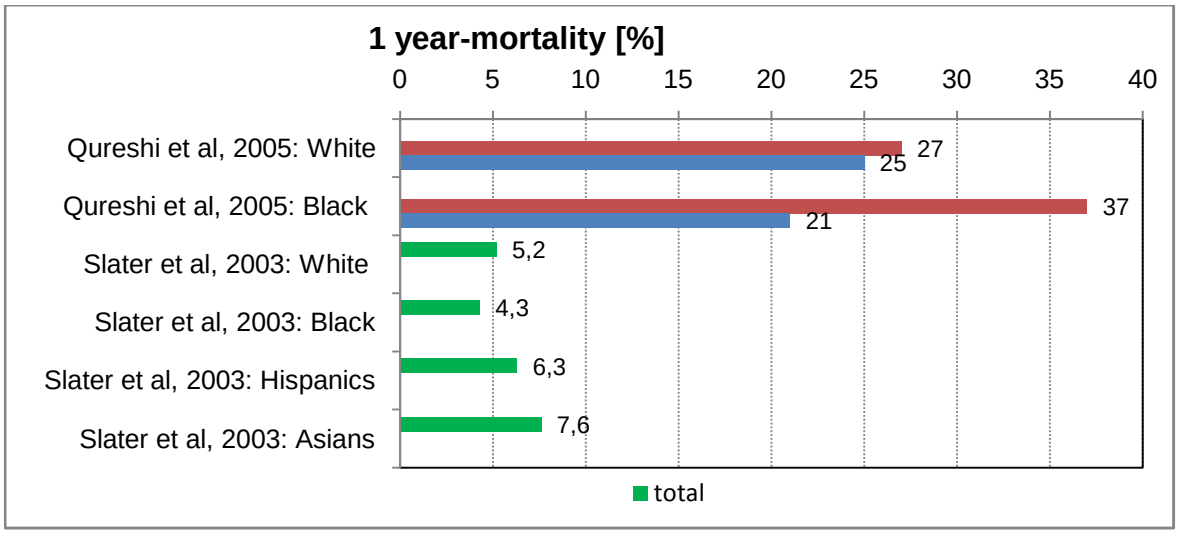

Figure 26: 1-year-mortality rate of patients with cardiovascular diseases from different ethnicity

The two-years-mortality rate was only evaluated by one study (Figure 27) (Slater et al, 2003). Asians were affected by the lowest rate and blacks by the highest rate. Hispanics had a higher two-years mortality rate than whites.

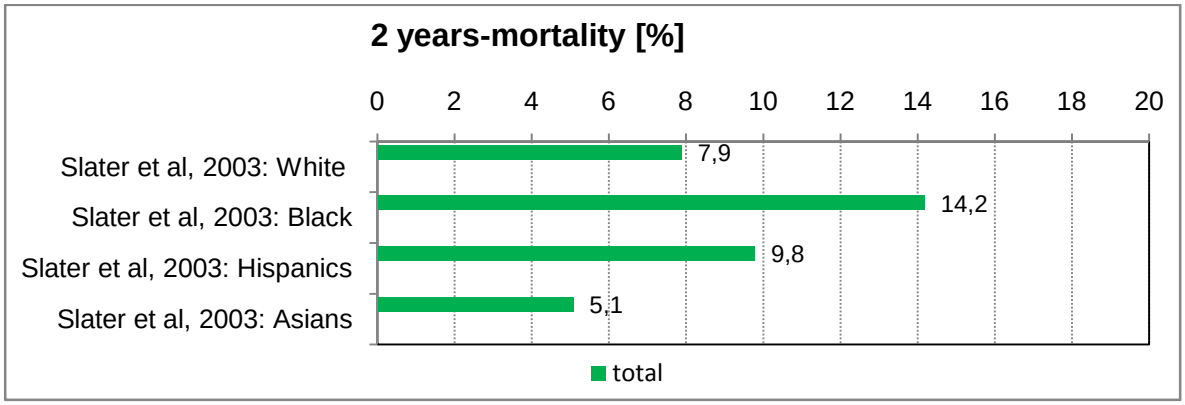

Figure 27: 2-years-mortality rate of patients with cardiovascular diseases from different ethnicity

4.4 Cardiovascular diseases and socioeconomic status

4.4.1 Influence of socioeconomic status on the age of CVD patients

Two studies gave information on age of CVD patients from different socioeconomic classes (Figure 28). Age did not differ significantly in one study which sorted patients according to income quintile (5=highest income and 1=lowest income) (Kapral et al, 2002). Among patients sorted by educational level, those defined as having “medium educational level” were significantly younger (Maksimovic et al, 2008).

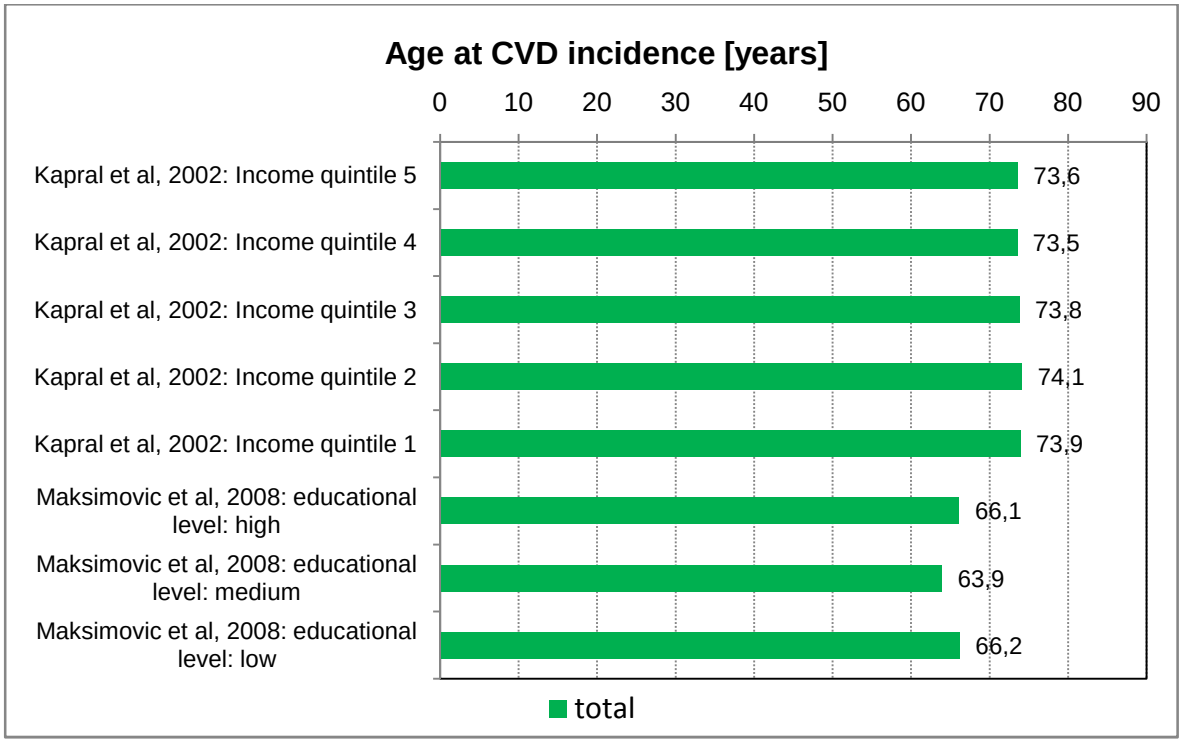

Figure 28: Age of patients at the incidence of a cardiovascular event

4.4.2 Prevalence of cardiovascular risk factors among patients with CVD from different socioeconomic status

The prevalence of diabetes in CVD patients from different SES was evaluated by three studies (Figure 29). In the first study the prevalence of diabetes increased with lower SES in both sexes. Only among men the prevalence of diabetes was higher in patients from medium SES compared to those from low SES (Engström

et al, 2001). In the second study the prevalence of diabetes was higher in the lower income groups. Interestingly it was similar in the first and the fourth income group (Kapral et al, 2002). In the study of Maksimovic et al (2008) medium educational level was associated with the highest diabetes rate.

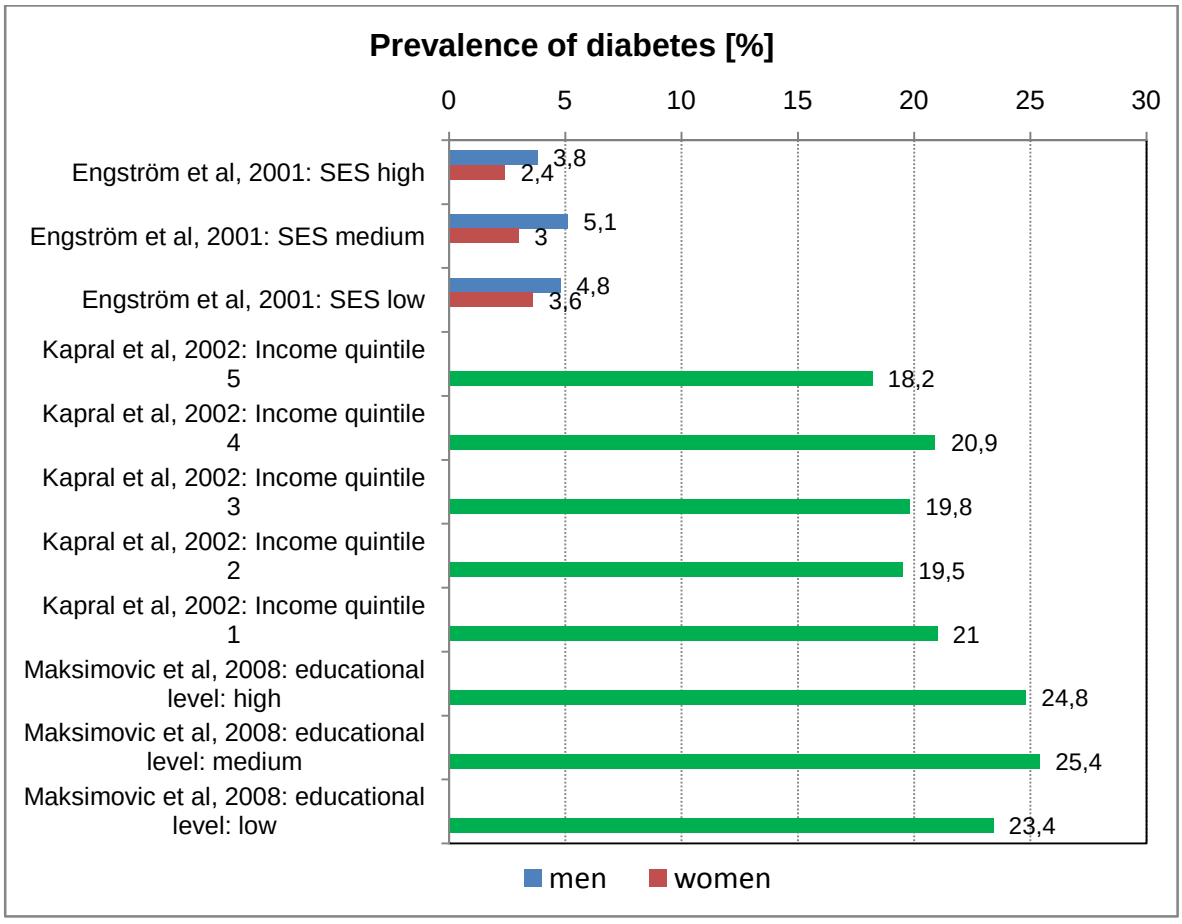

Figure 29: Prevalence of diabetes among patients with cardiovascular diseases from different socioeconomic status

The prevalence of hypertension among CVD patients from different SES was evaluated in three studies (Figure 30). In one study it was slightly higher among women from low SES compared to women from medium or high SES whereas the difference was more significant among men from low SES compared to men from high SES. Interestingly, men from medium SES had a lower prevalence of hypertension than men from high SES (Engström et al, 2001). In the study of Kapral et al (2002) patients were divided into income quintiles with quintile 5 representing the highest income. Patients from income quintile 4 had the highest prevalence of hypertension and those from income quintile 2 had the lowest prevalence. So in this study high income is positively correlated with a high

prevalence of hypertension. In the third study the prevalence of hypertension is more prevalent among patients with low educational level compared to patients with a medium or a high level (Maksimovic et al, 2008).

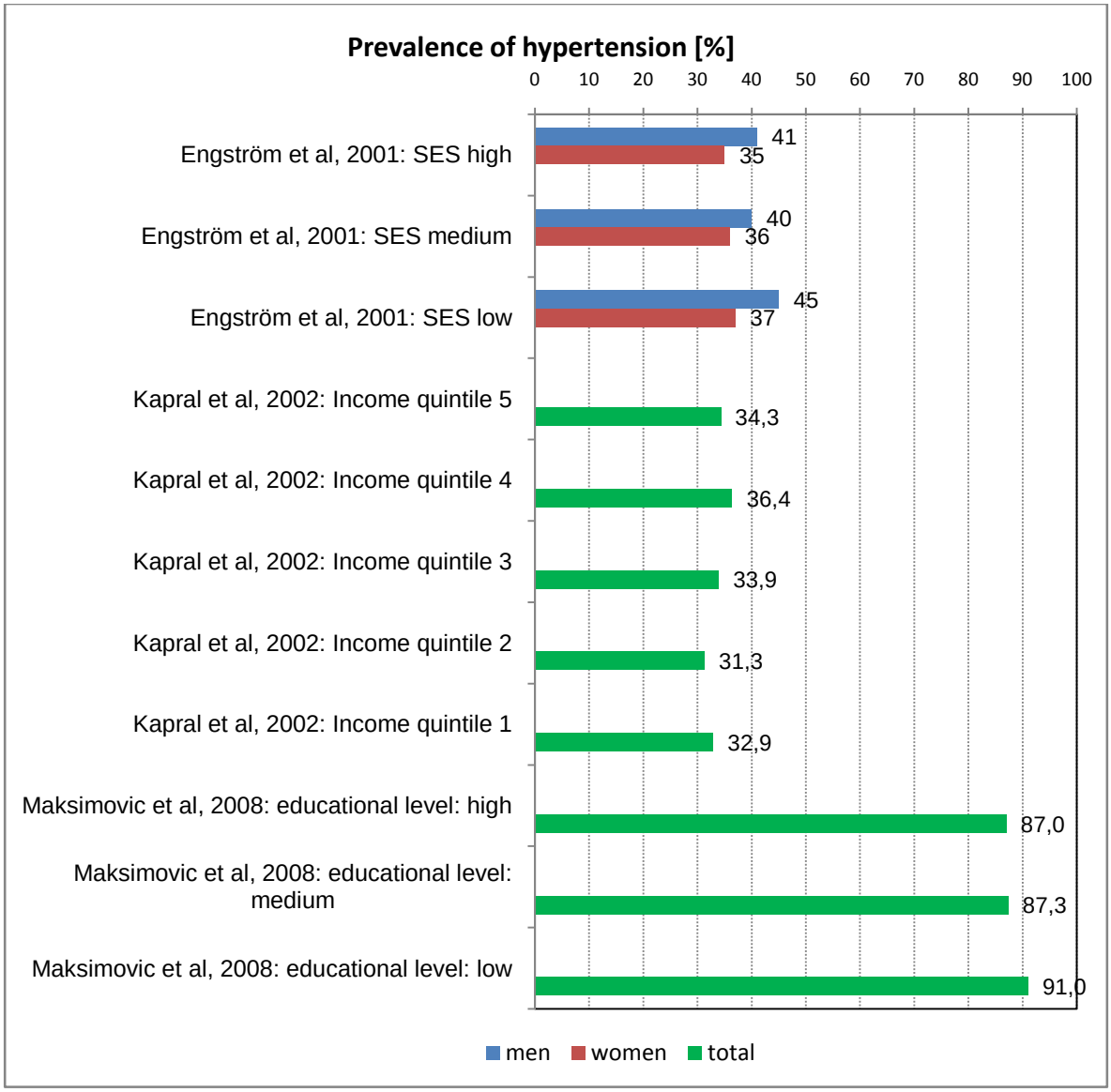

Figure 30: Prevalence of hypertension among patients with cardiovascular diseases from different socioeconomic status

The prevalence of hyper-or dyslipidemia was only evaluated in one study where patients with a medium educational level had the highest prevalence and those with a high educational level had the lowest prevalence (Figuer 31) (Maksimovic et al, 2008).

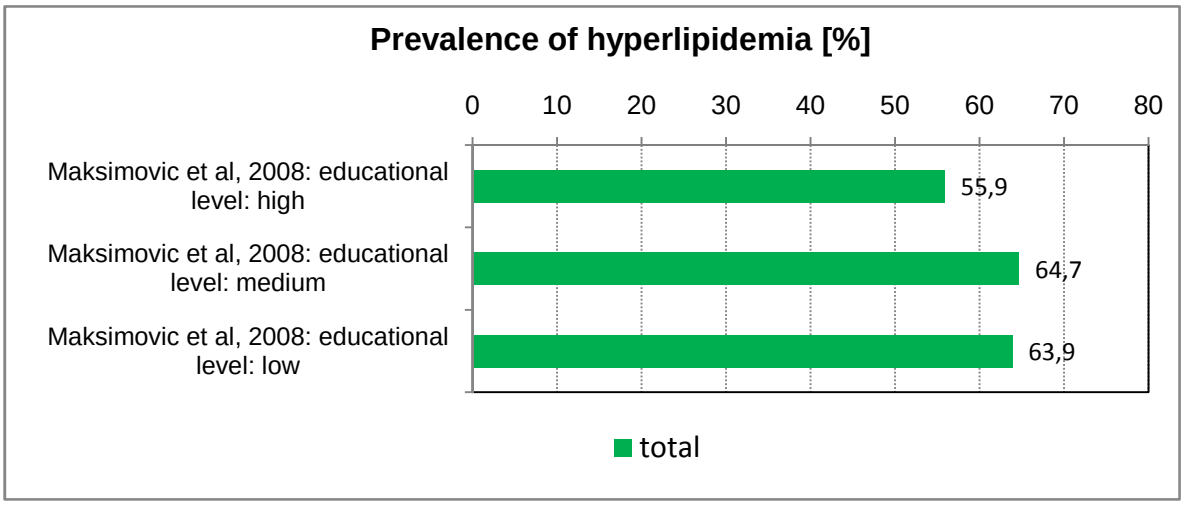

Figure 31: Prevalence of hyper-/dyslipidemia among patients with cardiovascular diseases from different socioeconomic status

The prevalence of obesity was evaluated in three studies (Figure 32). In all three studies the prevalence of obesity was highest in the lowest social class which was defined by SES or income level in two studies and educational level in one study (Engström et al, 2001; Kapral et, 2002; Maksimovic et al, 2008). Interestingly, patients with a medium educational level had a lower prevalence of obesity than patients with high educational level (Maksimovic et al, 2008). In the study of Engström et al (2001), women from medium SES had a lower occurrence of obesity than women from high SES.

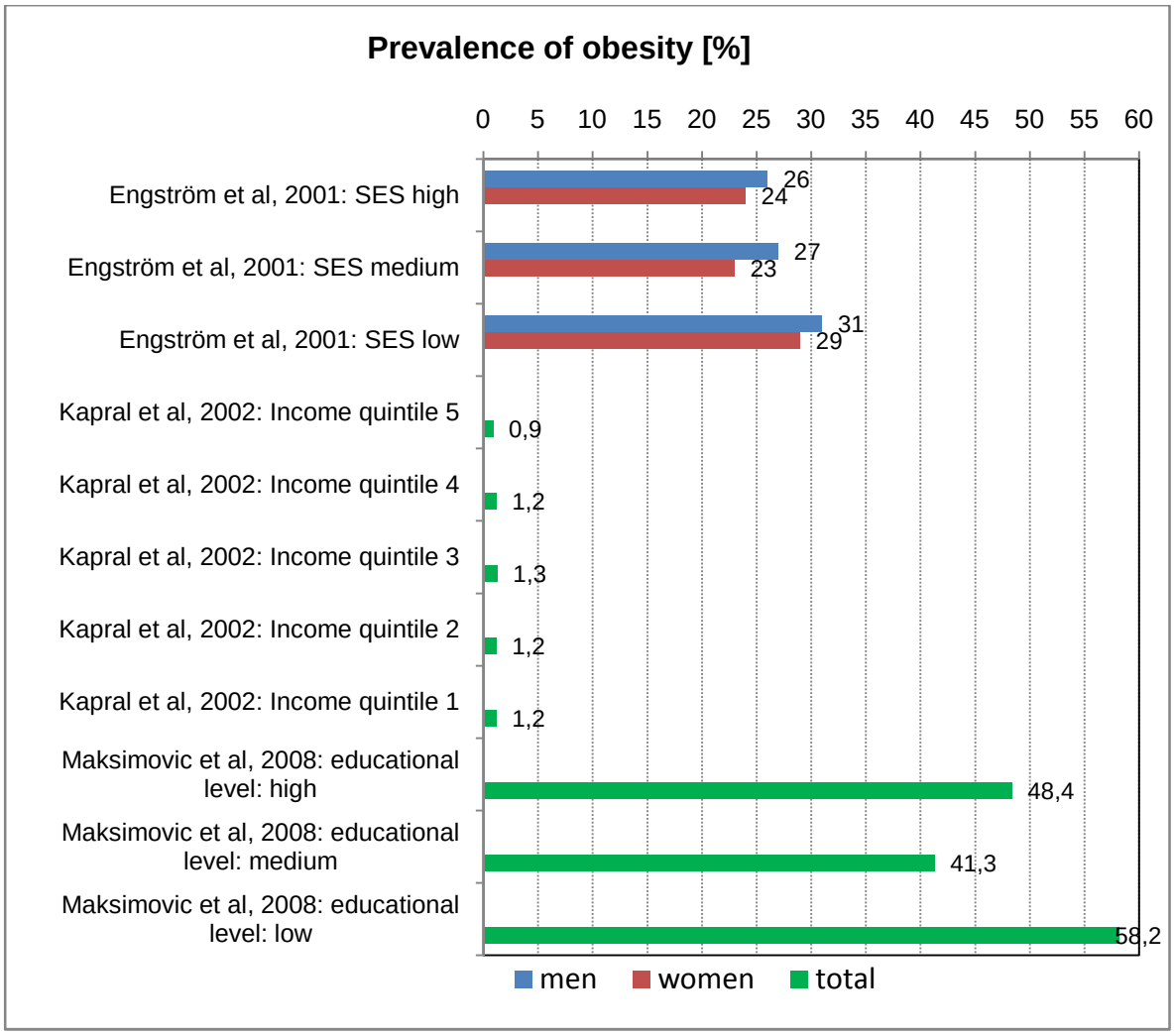

Figure 32: Prevalence of obesity among patients with cardiovascular diseases from different socioeconomic status

Two studies reported the prevalence of smoking among CVD patients from different socioeconomic status (Figure 33). In one study which divided patients into three categories according to SES, those from the lowest class had the highest smoking rate (Engström et al, 2001). The second study found the highest smoking rate among patients with medium educational level (Maksimovic et al, 2008).

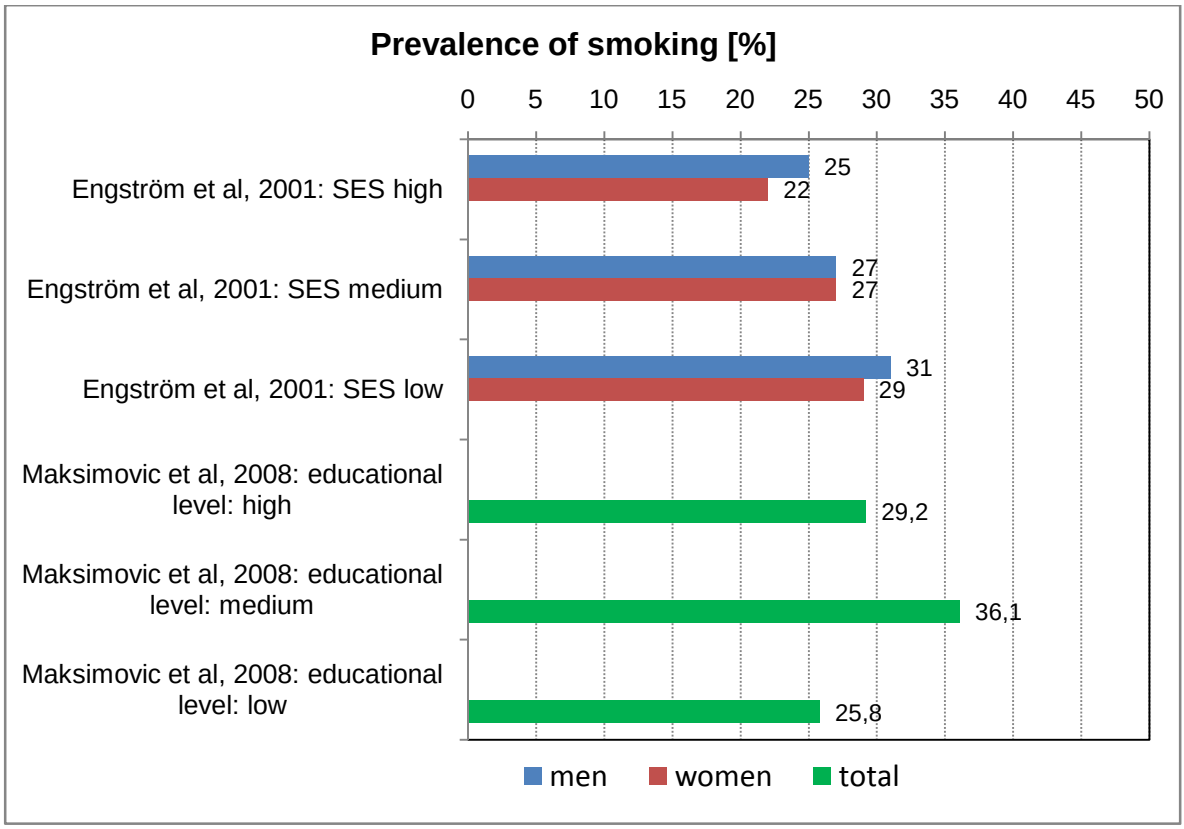

Figure 33: Prevalence of smoking among patients with cardiovascular diseases from different socioeconomic status

4.4.3 Mortality rate among patients with CVD from different socioeconomic status

The 28 or 30 days mortality rate was higher in lower socioeconomic groups as reported by two studies (Figure 34) (Gerward et al, 2006; Kapral et al, 2002). Exceptions were female patients from middle SES which had a lower mortality rate than female patients from high or low SES. In the middle SES group women had an even lower mortality rate than men, whereas in all other SES groups men had a lower rate (Gerward et al, 2006).

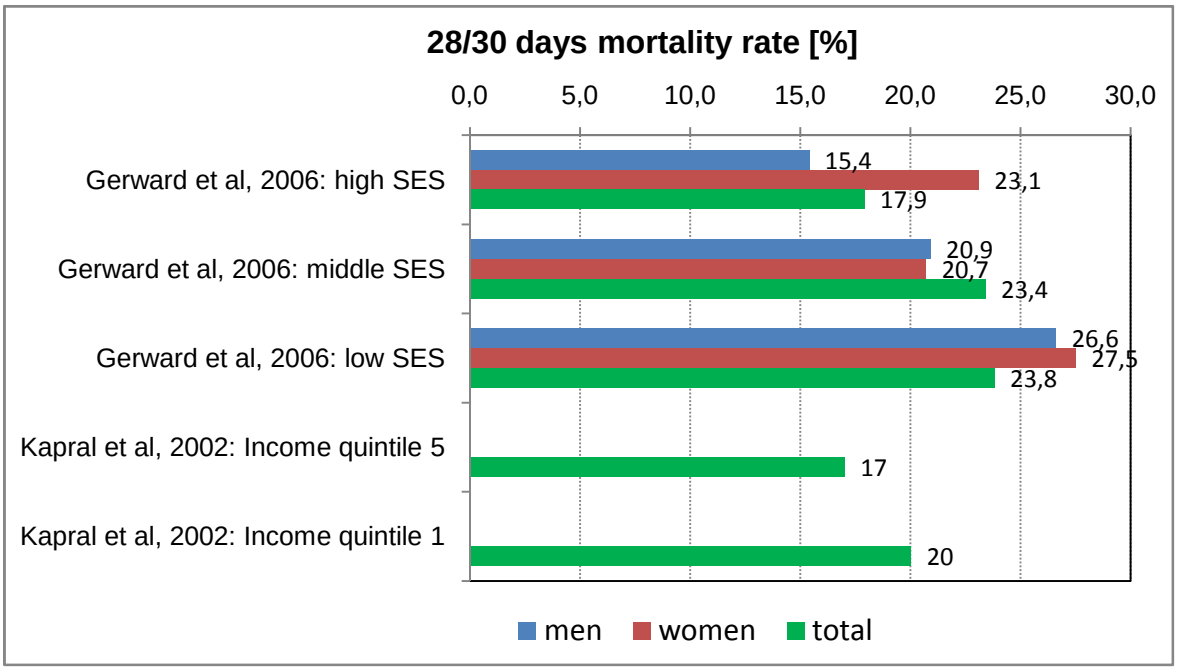

Figure 34: 28/30 days mortality rate among patients with cardiovascular diseases from different socioeconomic status

The 1-year-mortality rate was reported by only one study in which it was significantly higher in the lowest income group compared to the highest income group (Figure 35) (Kapral et al, 2002).

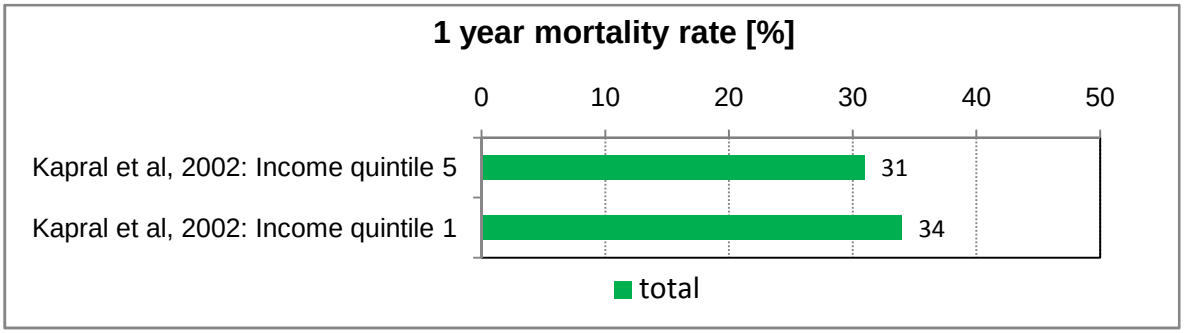

Figure 35: 1-year-mortality rate among patients with cardiovascular diseases from different socioeconomic status

4.5 Gender and prevalence of cardiovascular risk factors

4.5.1 Gender difference in prevalence of diabetes

17 studies evaluated the gender difference in the prevalence of diabetes in cross-sectional analysis (Figure 36). Some studies compared men and women from all age groups and some studies sorted according to different age groups.

In the studies which analysed all age groups, women had a higher occurrence of diabetes than men in three studies (Abdul-Rahim et al, 2001; Deurenberg et al, 2001 and Thursten et al, 2005), the same occurrence as men in one study (Lee et al, 2000) and a lower occurrence than men in four studies (Rosvall et al, 2000; Sodjinou et al, 2008; Meigs et al, 2003; Pitsavos et al, 2003). The studies with a higher prevalence of diabetes among women were performed in West-Bank, Singapore and the USA whereas the studies with a higher prevalence among men were performed in Europe, USA or Africa. The study with no gender difference in occurrence of diabetes was performed in Taiwan.

In all four studies which investigated a sample younger than 40 years, men had a higher prevalence of diabetes than women (DESIR study, Barilla study, MORGEN study, VIVA study in EGIR, 2002). In the sample groups aged 40 to 55 years, five studies reported a higher diabetes rate among men (DESIR study, Ely study; Barilla follow-up study, Barilla study, VIVA study in EGIR et al, 2002), one study reported a lower rate (Goodinge study in EGIR, 2002) and one study a similar rate (MORGEN study in EGIR, 2002). In a sample group aged more than 55 years in five studies men more likely had diabetes than women (DESIR study, Goodinge study, Ely study; Glostrup study MORGEN study in EGIR et al, 2002) and in one study it was reverse (VIVA study in EGIR, 2002). All those studies with a significantly higher prevalence of diabetes among men in all age groups were performed in Europe.

In one study the prevalence of diabetes in different age groups of Tunisian people was analysed. This study showed a higher rate of diabetes in men than in women aged 20-29 years and 40-49 years and a higher rate in women in all other age groups (Bouguerra et al, 2005).

Generally there was an increase in the prevalence of diabetes with age among men and women in all studies.

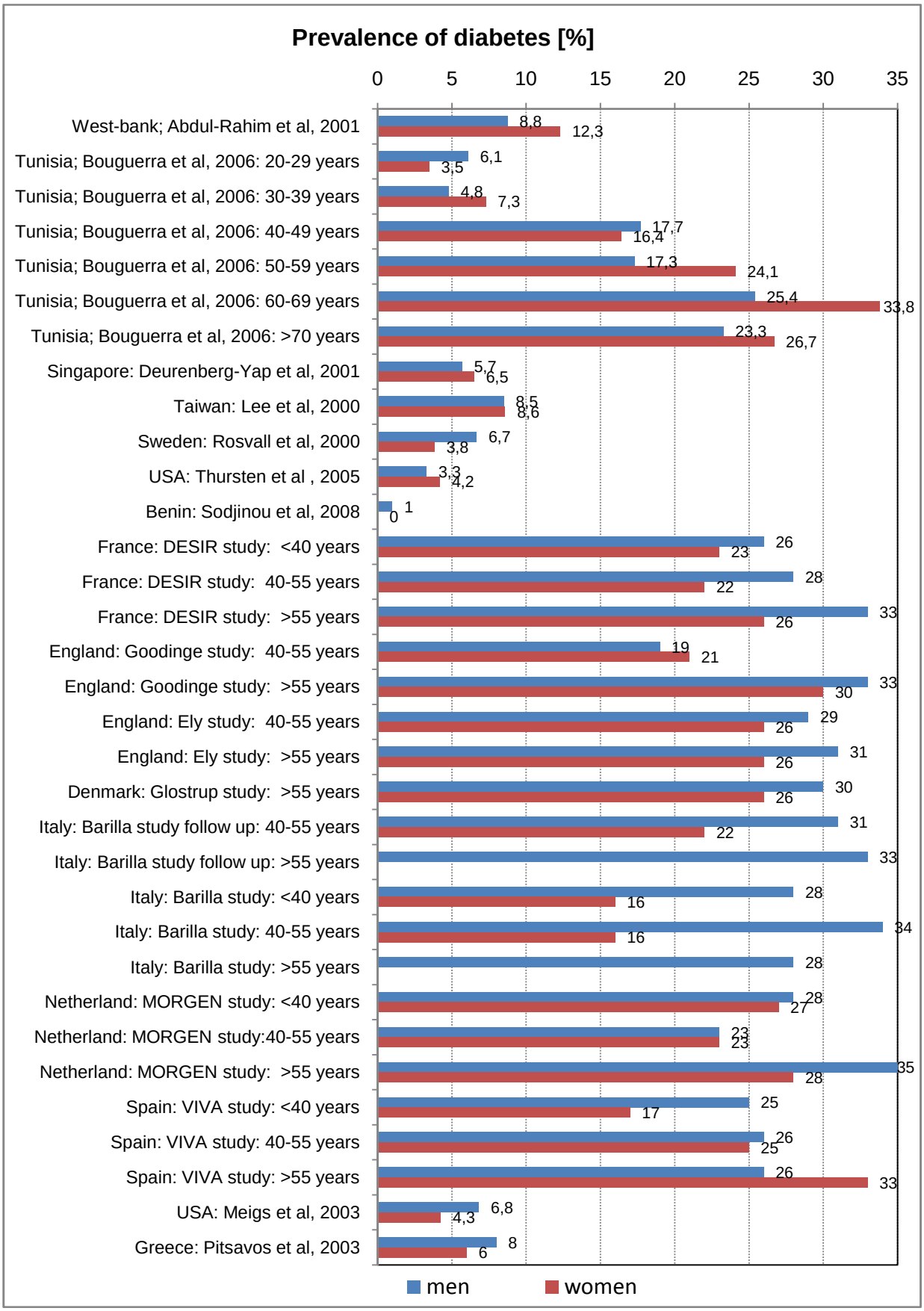

Figure 36: Prevalence of diabetes, depending on gender; the DESIR study, Goodinge study, Ely study, Gostrup study, Barilla study, MORGEN study and VIVA study were summarised in EGIR et al 2002).

4.5.2 Gender difference in prevalence of hypertension

20 studies evaluated the gender difference in the prevalence of hypertension in cross-sectional analysis. Some studies compared men and women from all age groups and some studies sorted according to different age groups (Figure 37).

In the studies which summarized all age groups, women more likely had hypertension than men in three studies (Lee et al, 2000; Sodjinou et al, 2008; Thursten et al, 2005), the same occurrence as men in one study (Abdul-Rahim et al, 2001) and a lower occurrence than men in seven studies (Deurenberg-Yap et al, 2001; Galobardes et al, 2003; Ordunez et al, 2005; Rosvall et al, 2000; Meigs et al, 2003; Pitsavos et al, 2003; Santos et al, 2008). The studies with a higher prevalence of hypertension among women were performed in Taiwan, Benin and the USA whereas the studies with a higher prevalence among men were performed in Singapore, Europe, USA or Cuba. The study with no gender difference in occurrence of hypertension was performed in West-Bank.

In all four European studies which investigated a cohort younger than 40 years, men had a higher prevalence of hypertension than women (DESIR study, Barilla study, MORGEN study, VIVA study in EGIR, 2002). Five studies reported a higher hypertension rate among men in a cohort aged 40 to 55 years, (DESIR study, Ely study; Barilla follow-up study, Barilla study, MORGEN study in EGIR et al, 2002), one study reported a lower rate (VIVA study in EGIR, 2002) and one study reported a similar rate (Goodinge study in EGIR, 2002). Three studies showed that in a cohort aged more than 55 years hypertension was more prevalent among men than among women (DESIR study, Glostrup study MORGEN study in EGIR et al, 2002). In one study the prevalence was similar (Ely study) and in two studies the prevalence was higher in women (Goodinge study, VIVA study in EGIR, 2002).

In one study the prevalence of hypertension in different age groups of Tunisian people was investigated. This study showed a higher rate of hypertension in men than in women aged 20-29 years and a higher rate in women in all other age groups (Bouguerra et al, 2005).

Generally there was an increase in the prevalence of hypertension with age among men and women in all studies.

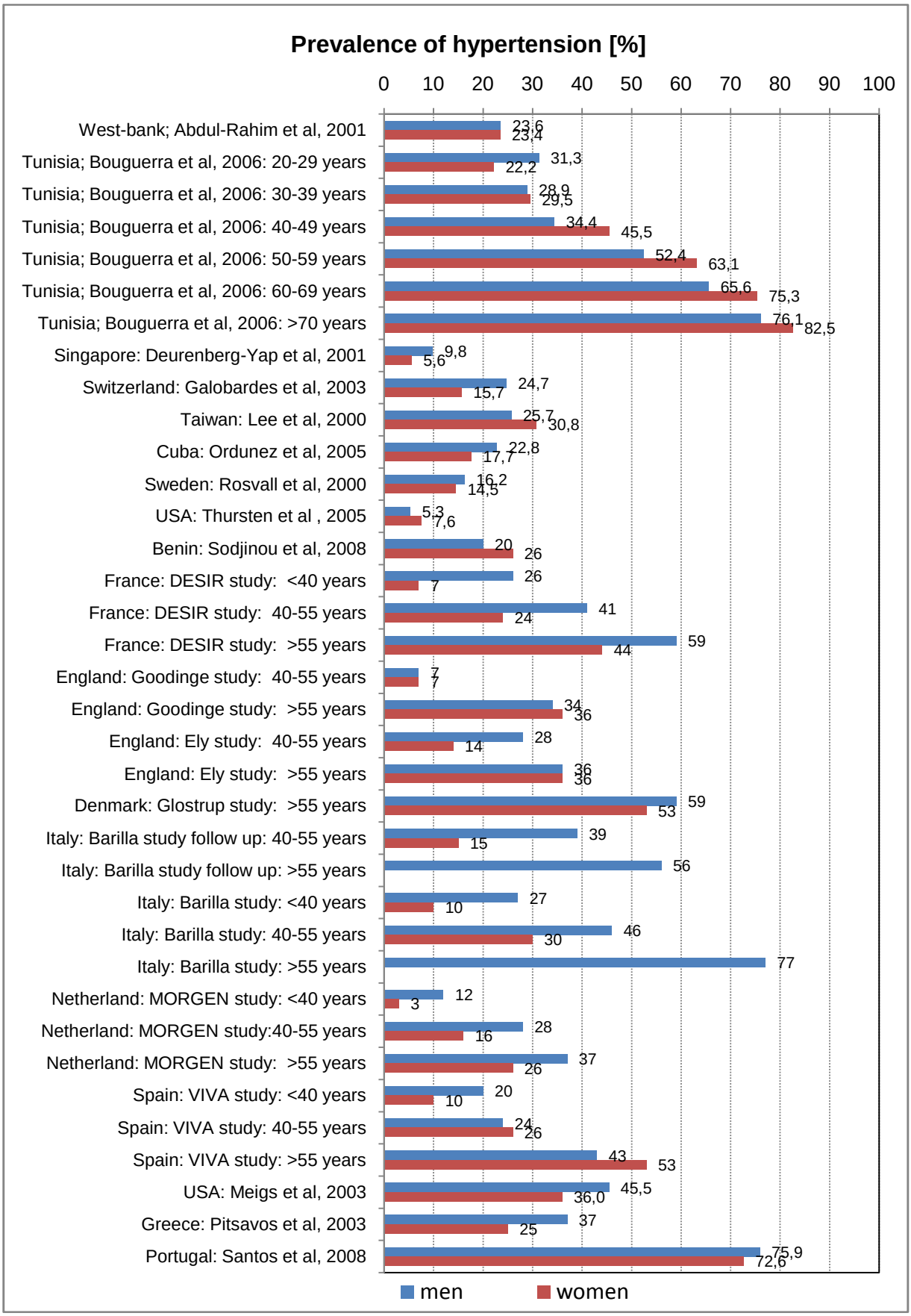

Figure 37: Prevalence of hypertension, depending on gender; the DESIR study, Goodinge study, Ely study, Gostrup study, Barilla study, MORGEN study and VIVA study were summarised in EGIR et al 2002).

4.5.3 Gender difference in prevalence of hyper-/dyslipidemia

18 studies evaluated the gender difference in the prevalence of hyper- or dyslipidemia in cross-sectional analysis. Some studies compared men and women from all age groups and some studies sorted according to different age groups (Figure 38).

In the studies which analysed all age groups, women had a higher occurrence of hyper- or dyslipidemia than men in three studies (Lee et al, 2000; Sodjinou et al, 2008; Santos et al, 2008) and a lower occurrence than men in six studies (Deurenberg-Yap et al, 2001; Galobardes et al, 2003; Meigs et al, 2003; Pitsavos et al, 2003; Rosvall et al, 2000; Abdul-Rahim et al, 2001). The studies with a higher prevalence of hyper- or dyslipidemia among women were performed in Taiwan, Benin and Portugal whereas the studies with a higher prevalence among men were performed in Singapore, Europe, USA or Benin.

In all four European studies which gave information on a cohort younger than 40 years, men had a higher prevalence of hyper- or dyslipidemia than women (DESIR study, Barilla study, MORGEN study, VIVA study in EGIR, 2002). In the subject groups aged 40 to 55 years all seven studies reported a higher hyper- or dyslipidemia rate among men (DESIR study, Ely study; Barilla follow-up study, Barilla study, MORGEN study, VIVA study; Goodinge study in EGIR et al, 2002). In four studies in a cohort aged more than 55 years men more likely had hyper- or dyslipidemia than women (DESIR study, Glostrup study MORGEN study, VIVA study in EGIR et al, 2002), in one study the prevalence was similar (Goodinge study) and in one study it was reverse (Ely study in EGIR, 2002).

In one study the prevalence of hyper- or dyslipidemia in different age groups of Tunisian people was analysed. This study showed a higher rate of hyper- or dyslipidemia in men than in women aged 30-49 years and a higher rate in women in all other age groups (Bouguerra et al, 2005).

Generally there was an increase in the prevalence of hyper- or dyslipidemia with age among men and women in all studies.

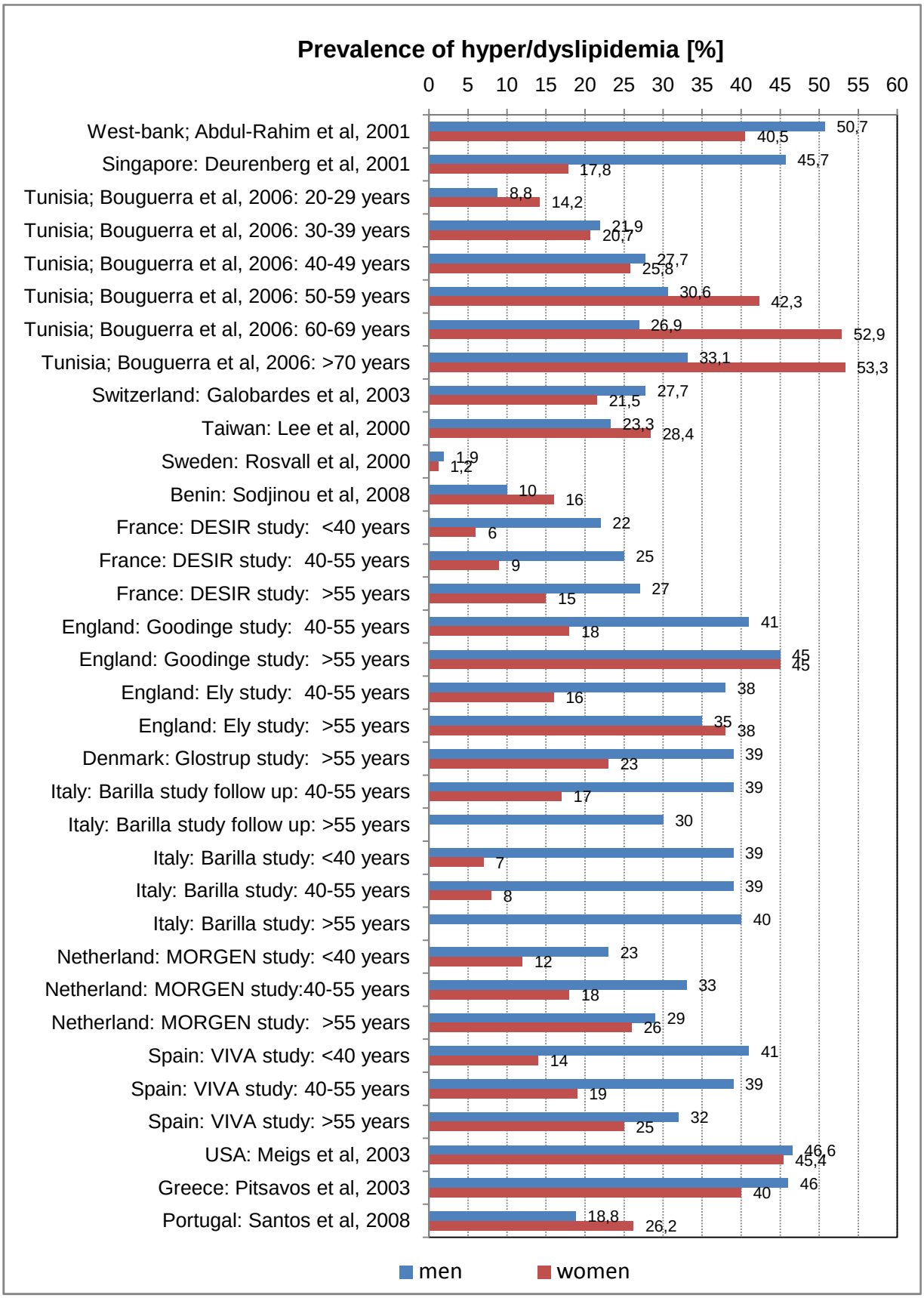

Figure 38: Prevalence of hyper-/dyslipidemia, depending on gender; the DESIR study, Goodinge study, Ely study, Gostrup study, Barilla study, MORGEN study and VIVA study were summarised in EGIR et al 2002).

4.5.4 Gender difference in prevalence of obesity

17 studies evaluated the gender difference in the prevalence of obesity in cross-sectional analysis. Some studies compared men and women from all age groups and some studies sorted according to different age groups (Figure 39).

In the studies which analysed all age groups, women had a higher occurrence of obesity than men in six studies (Sodjinou et al, 2008; Santos et al, 2008; Meigs et al, 2003; Deurenberg-Yap et al, 2001; Ordunez et al, 2005; Abdul-Rahim et al, 2001) and a lower occurrence than men in two studies (Galobardes et al, 2003; Pitsavos et al, 2003). The studies with a higher prevalence of obesity in men were performed in Europe and the studies with a higher prevalence in women were performed in Benin, Europe, USA, Singapore, Cuba, Tunisia and West-Bank.

In three European studies which investigated a subject group younger than 40 years, men had a higher prevalence of obesity than women (DESIR study, MORGEN study, VIVA study in EGIR, 2002) and in one study women had a higher prevalence of obesity than men (Barilla study in EGIR, 2002). In the subject groups aged 40 to 55 years four studies reported a higher obesity rate among men (DESIR study, MORGEN study, Ely study, VIVA study in EGIR et al, 2002) and three studies a higher obesity rate among women (Goodinge study, Barilla study, Barilla follow-up study in EGIR et al, 2002). In a sample group aged more than 55 years in four studies men more likely had obesity than women (DESIR study, Eli study, MORGEN study, VIVA study in EGIR et al, 2002) whereas in one study it was reverse (Goodinge study in EGIR, 2002).

In one study the prevalence of obesity in different age groups of Tunisian people was analysed. This study showed a higher rate of obesity in women in all age groups (Bouguerra et al, 2005).

Generally there was a trend of increasing prevalence of obesity with age among men and women in all studies.

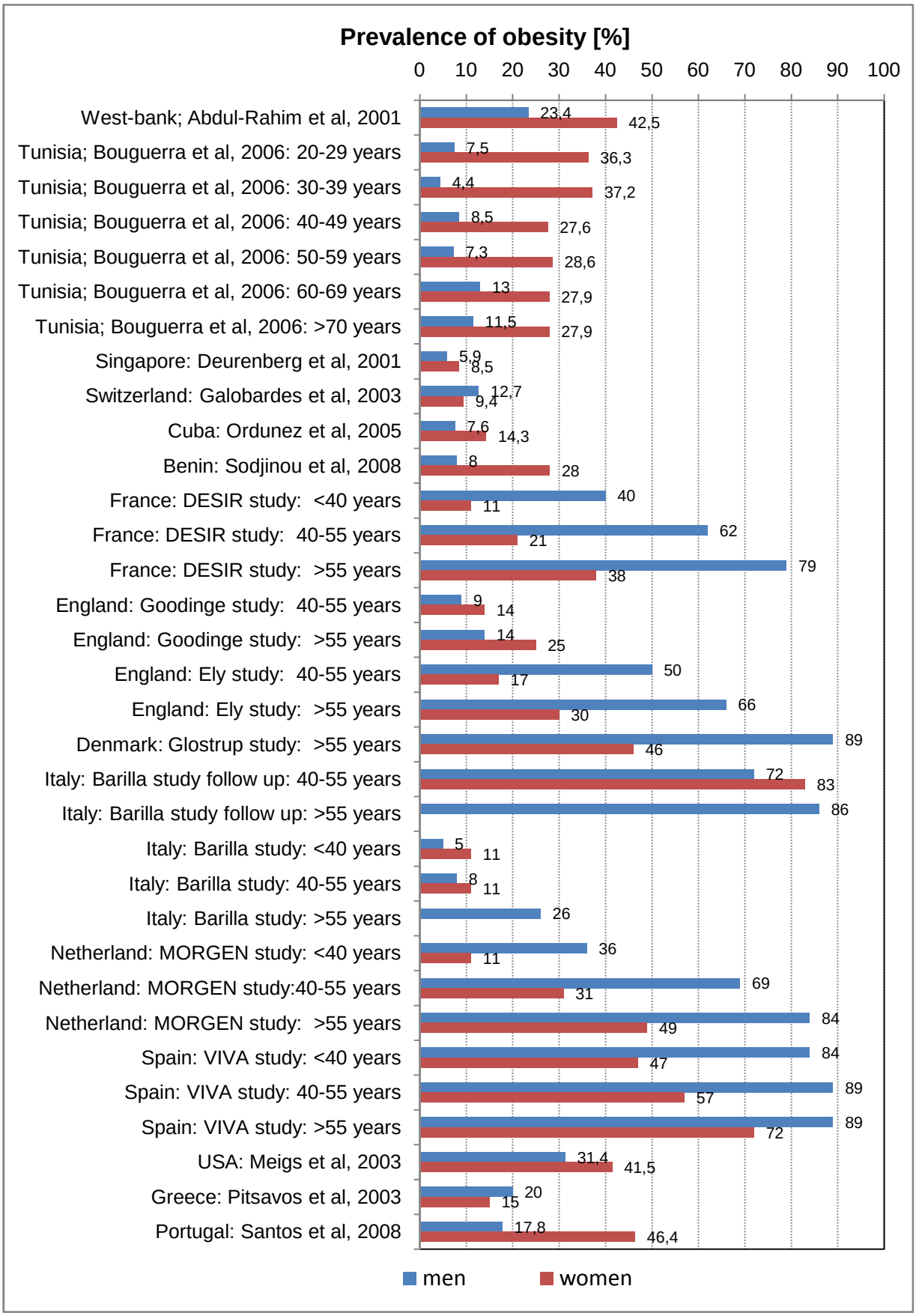

Figure 39: Prevalence of obesity, depending on gender; the DESIR study, Goodinge study, Ely study, Gostrup study, Barilla study, MORGEN study and VIVA study were summarized in EGIR et al 2002).

The mean BMI of both sexes was reported in seven studies (Figure 40). In five of them a higher BMI was found among men (Deurenberg et al, 2001; Galobardes et al, 2003; Pitsavos et al, 2003; Rosvall et al, 2000; Thursten et al, 2005) whereas only in two studies women had a higher BMI than men (Lee et al, 2000; Ordunez et al, 2005). These two studies were performed in Taiwan and Cuba whereas the studies with a higher male BMI were performed in Europe, in the USA or Singapore. The mean BMI of women in the study performed in Benin is higher than the BMI of all men and women of the other studies (Sodjinou et al, 2008).

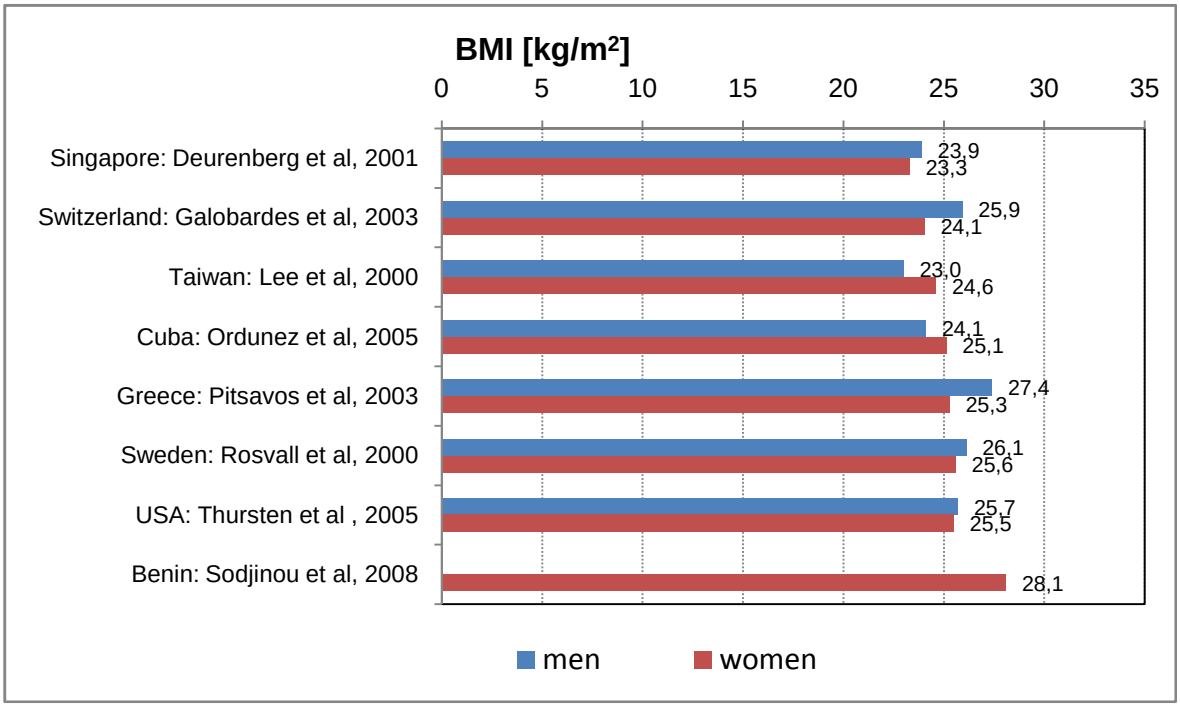

Figure 40: Mean BMI, depending on gender

4.5.5 Gender difference in prevalence of smoking

Six studies reported the percentage of smokers among both sexes (Figure 41). In all studies more men smoked than women (Galobardes et al, 2003; Lee et al, 2000; Ordunez et al, 2005; Rosvall et al, 2000; Thursten et al, 2005; Sodjinou et al, 2008). The difference in smoking rate was much smaller in European countries and the USA compared to the study in Taiwan and the study in Benin where the smoking rate among men was 14 or 22 times higher than among women (Lee et al, 2000; Sodjinou et al, 2008).

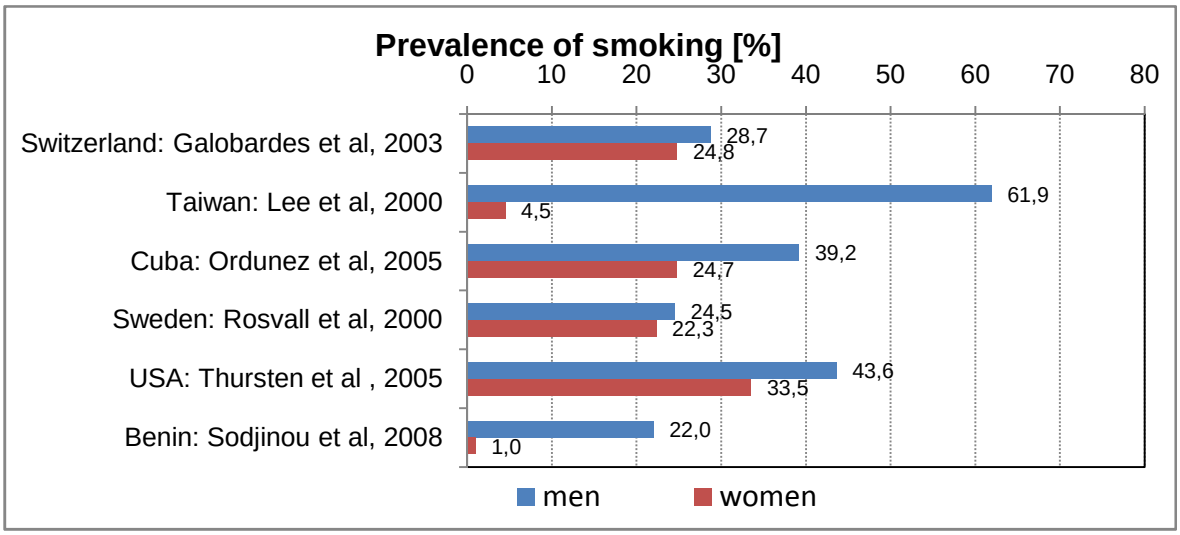

Figure 41: Prevalence of smoking, depending on gender

4.5.6 Gender difference in prevalence of cardiovascular events

The prevalence of stroke was higher in men in two studies (Freedman et al, 2005; Venketasubramanian et al, 2005) and the same among men and women in one study (Lee et al, 2000) (Figure 42).

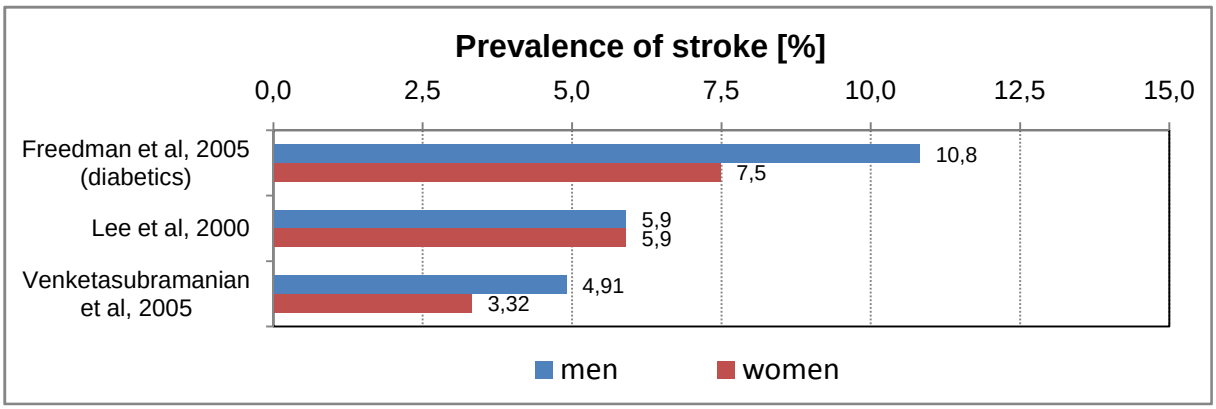

Figure 42: Prevalence of stroke, depending on gender

The prevalence of myocardial infarct was higher among men in all four studies which analysed the gender difference in the prevalence of myocardial infarct (Freedman et al, 2005; Pitsavos et al, 2003; Sodjinou et al, 2008; U.K. Prospective Study Group, 2000) (Figure 43).

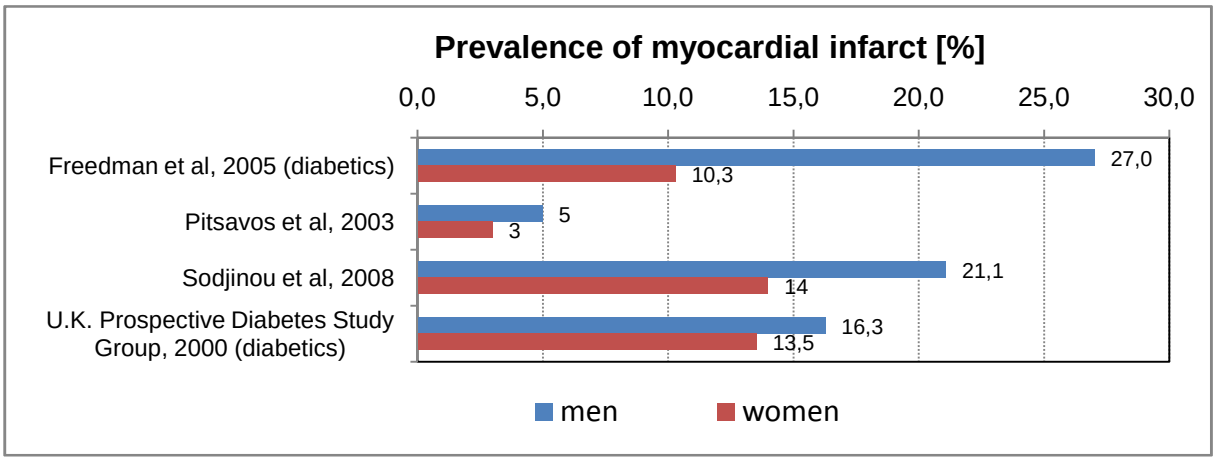

Figure 43: Prevalence of myocardial infarct, depending on gender

4.5.7 Gender difference in cardiovascular mortality

In the two studies which reported the gender difference of cardiovascular mortality the rate was significantly higher among men (Lee et al, 2000; U.K. Prospective Study Group, 2000) (Figure 44).

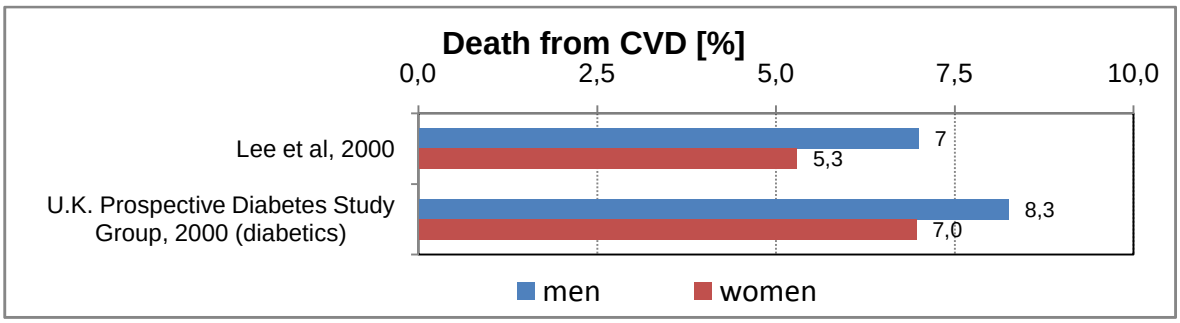

Figure 44: Mortality rate from cardiovascular diseases, depending on gender

4.6 Ethnicity and prevalence of cardiovascular risk factors

4.6.1 Ethnicity and prevalence of diabetes

Five studies reported the prevalence of diabetes among people from different ethnicity (Figure 45). In two studies blacks less likely had diabetes than whites (Bravata et al, 2005; Ordunez et al, 2005) whereas in one study a higher prevalence was found among blacks especially among black women. One study showed that diabetes was more prevalent among Hispanics than among non-Hispanic whites (Meigs et al, 2003). In the study which was performed in the multi-ethnic Singapore Chinese had the lowest prevalence of diabetes followed by Malay and Indians had the highest rate (Deurenberg-Yap et al, 2001).

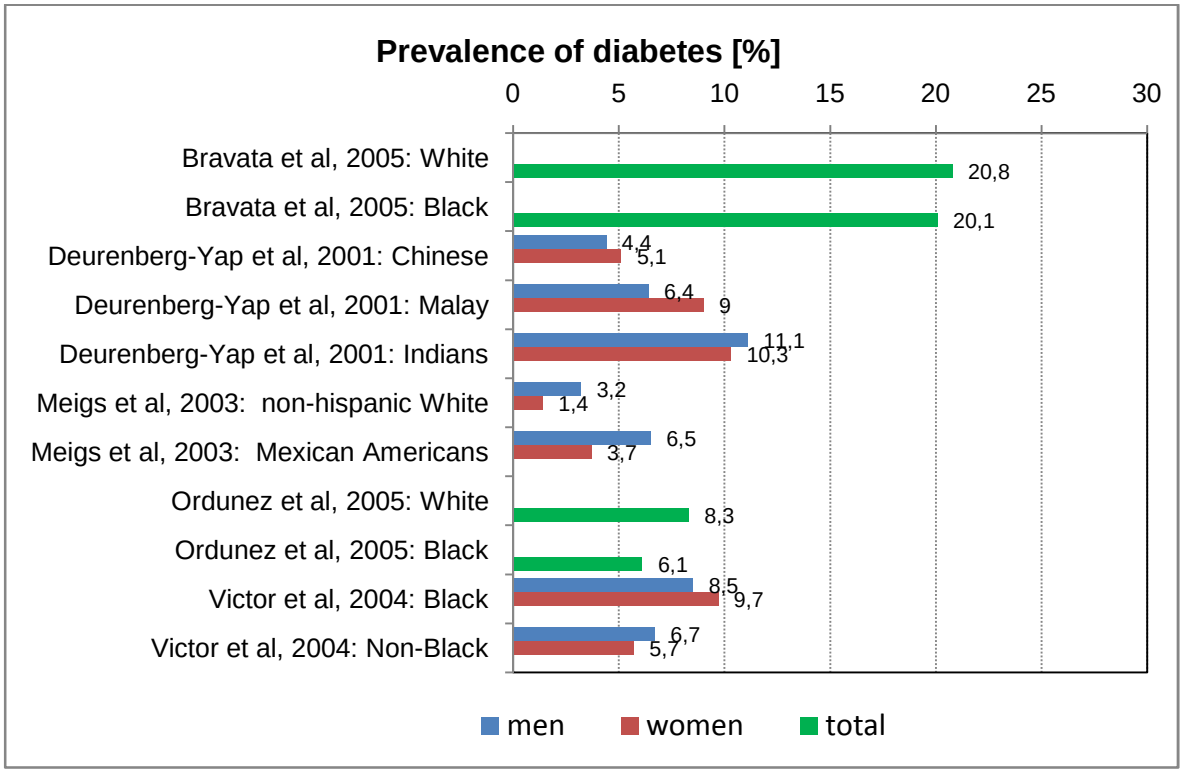

Figure 45: Prevalence of diabetes, depending on ethnicity

4.6.2 Ethnicity and prevalence of hypertension

In five studies the prevalence of hypertension in a multi-ethnic group was compared (Figure 46). Whites more likely had hypertension than blacks in two

studies (Bravata et al, 2005; Ordunez et al, 2005) and less likely had hypertension in one study with the highest rate among black women (Victor et al, 2004). Among Hispanics hypertension was more prevalent than among non-Hispanic whites in both sexes as shown in one study (Meigs et al, 2003). In the study of Deurenberg-Yap et al (2001) the highest rate of hypertension was reported for Malay and no significant difference was found between Indians and Chinese. Men from every ethnicity more likely had hypertension than women except black women.

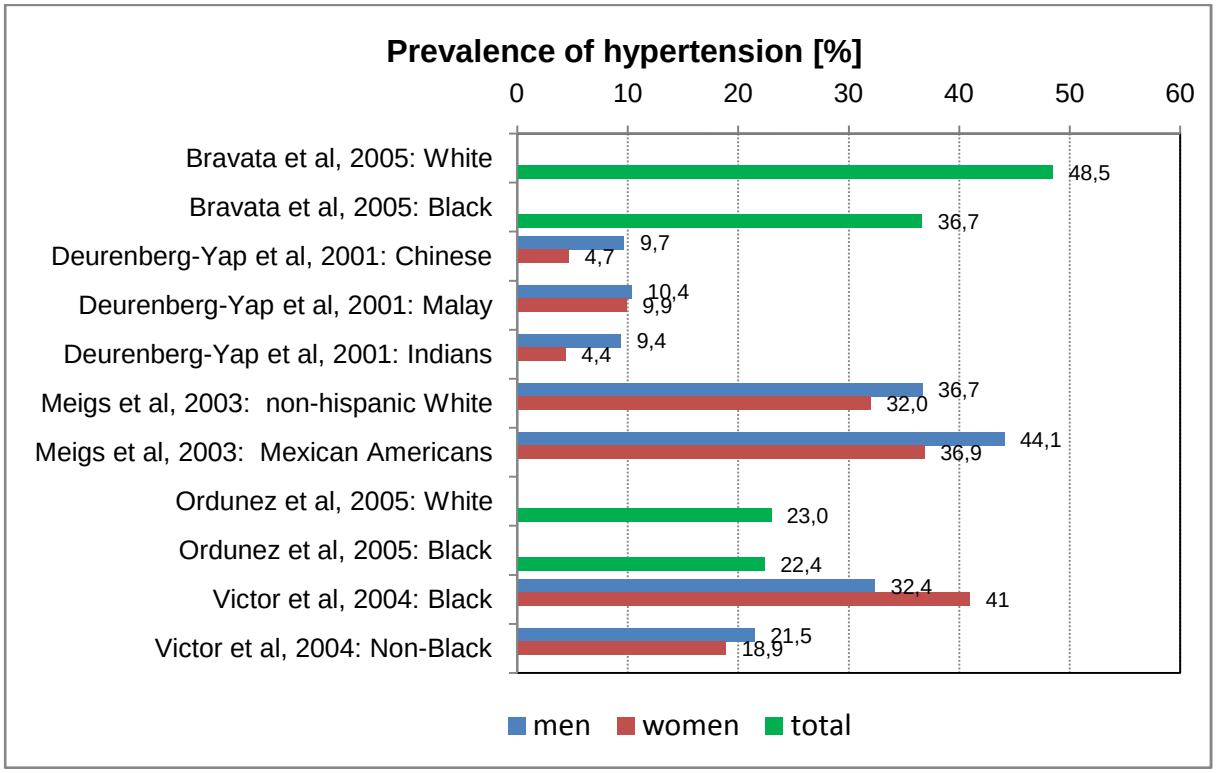

Figure 46: Prevalence of hypertension, depending on ethnicity

4.6.3 Ethnicity and prevalence of hyper-/dyslipidemia

Two studies reported the prevalence of hyper- or dyslipidemia in a multi-ethnic group (Figure 47). The first study which was performed in Singapore reported a higher prevalence among Indians than among Malays and the lowest prevalence among Chinese with a much higher prevalence among men in all ethnic groups (Deurenberg-Yap et al, 2001). The second study showed a higher prevalence of hyperlipidemia among Mexican American women than among non-Hispanic white women. In the male group the correlation was reverse with a slightly higher rate of hyperlipidemia among white men than black men (Meigs et al, 2003).

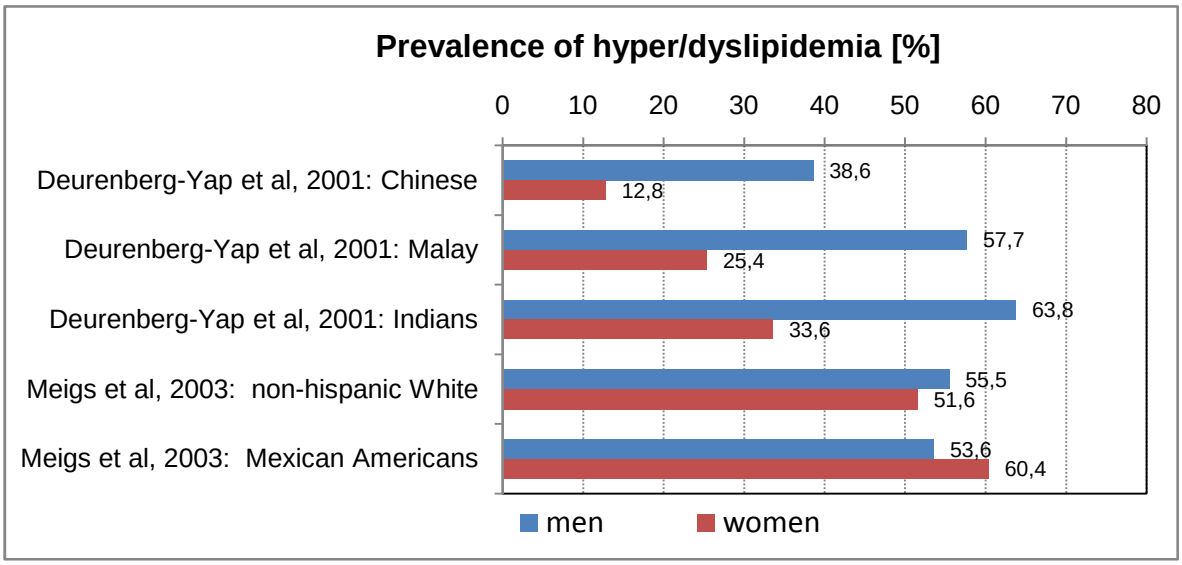

Figure 47: Prevalence of hyper-/dyslipidemia, depending on ethnicity

4.6.4 Ethnicity and prevalence of obesity

Two studies reported the prevalence of obesity in a multi-ethnic group (Figure 48). The first study which was performed in Singapore reported a higher prevalence among Malays than among Indians and the lowest prevalence among Chinese with a higher prevalence among women in Malay and Indians and a higher prevalence among men in Chinese (Deurenberg-Yap et al, 2001). The second study reported a higher prevalence of obesity among Mexican American women than among non-Hispanic white women. Among men this relationship was reverse with a slightly higher prevalence of obesity among white men (Meigs et al, 2003).

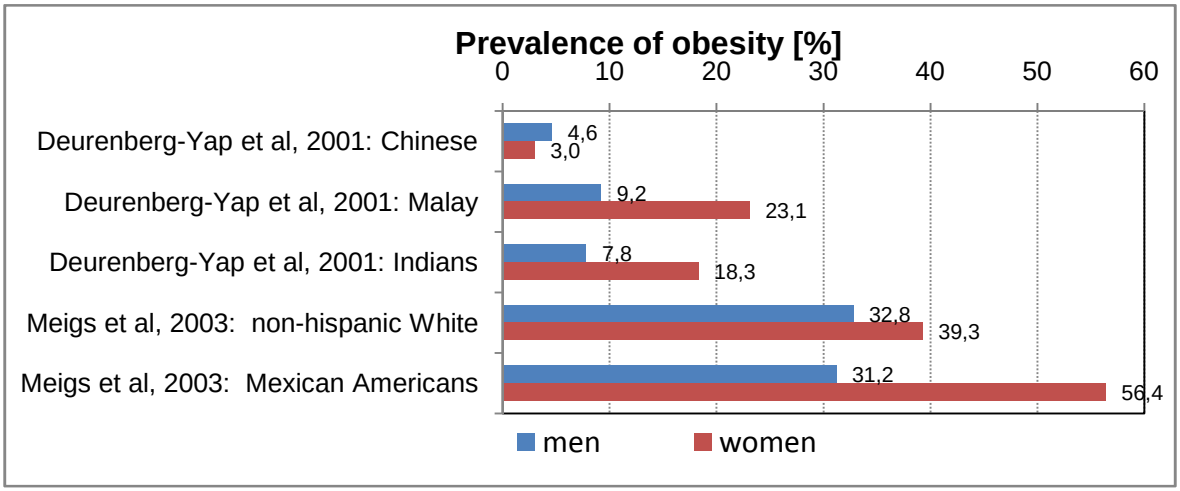

Figure 48: Prevalence of obesity, depending on ethnicity

Three studies compared the average BMI in a multi-ethnic sample-group (Figure 49). In one study blacks had a higher mean BMI than whites (Victor et al, 2004) whereas in the second study there was no significant difference between blacks and whites (Ordunez et al, 2005). In both studies black women had a higher BMI than black men which was not the case among whites where BMI was the same in both sexes in one study and slightly higher in women in the other study. Deurenberg-Yap et al (2001) reported the lowest BMI among Chinese men and women, the approximately same BMI among Malay and Indian men and a higher BMI in Malay women than in Indian women.

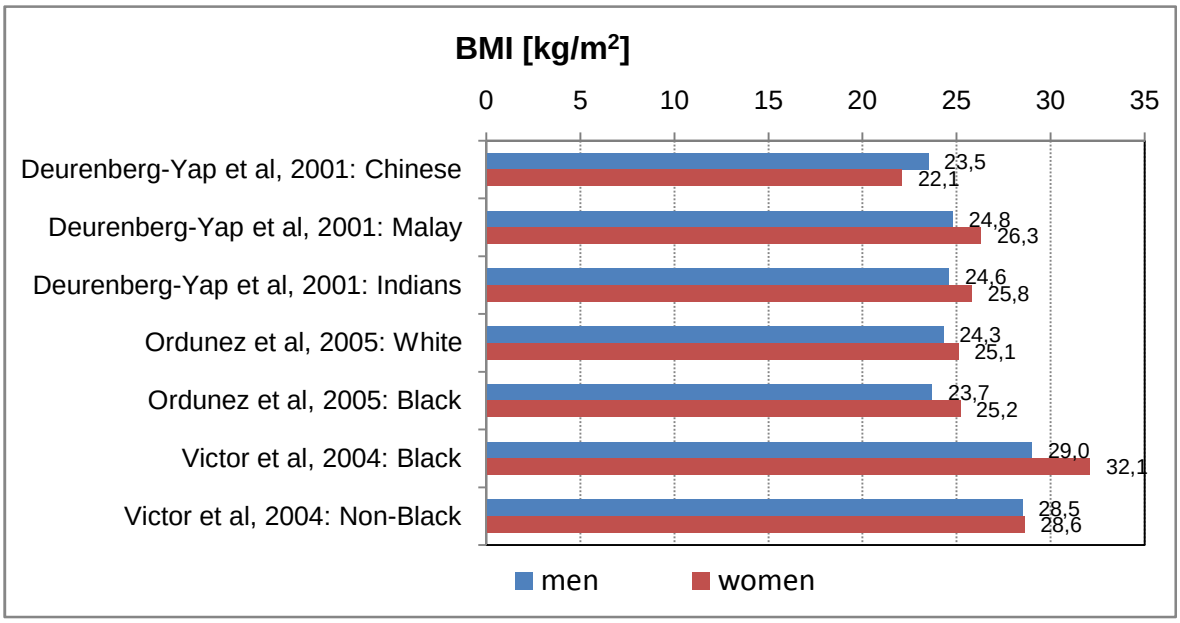

Figure 49: Mean BMI, depending on ethnicity

4.6.5 Ethnicity and prevalence of smoking

The prevalence of smoking among people from different ethnicity was reported in two studies (Figure 50). In the first study whites smoked more often than blacks (Bravata et al, 2005) whereas in the second study white men smoked more often than black men and white women smoked less often than black women (Ordunez et al, 2005).

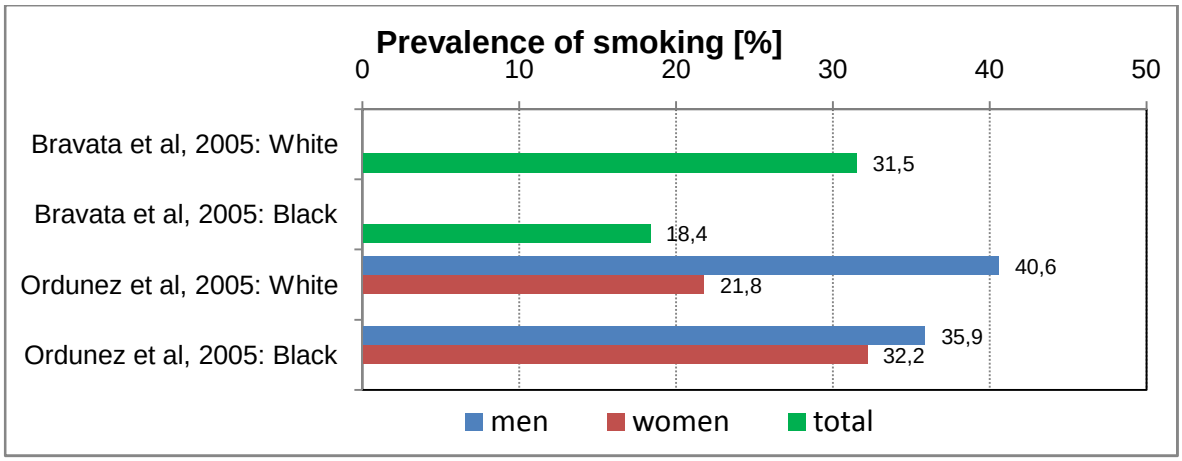

Figure 50: Prevalence of smoking, depending on ethnicity

4.6.6 Ethnicity and prevalence of cardiovascular events

In three studies the prevalence of stroke in a certain time period among people from different ethnicity was reported (Figure 51). In two studies whites had a higher rate than blacks (Bravata et al, 2005; Freedman et al, 2005), especially diabetic men (Freedman et al, 2005). In a study performed in Singapore stroke was most prevalent among Chinese and less prevalent among Indians regarding both sexes (Venketasubramanian et al, 2005). This trend was mainly caused by the male prevalence of stroke whereas among women there was nearly no difference between Malay and Indian women.

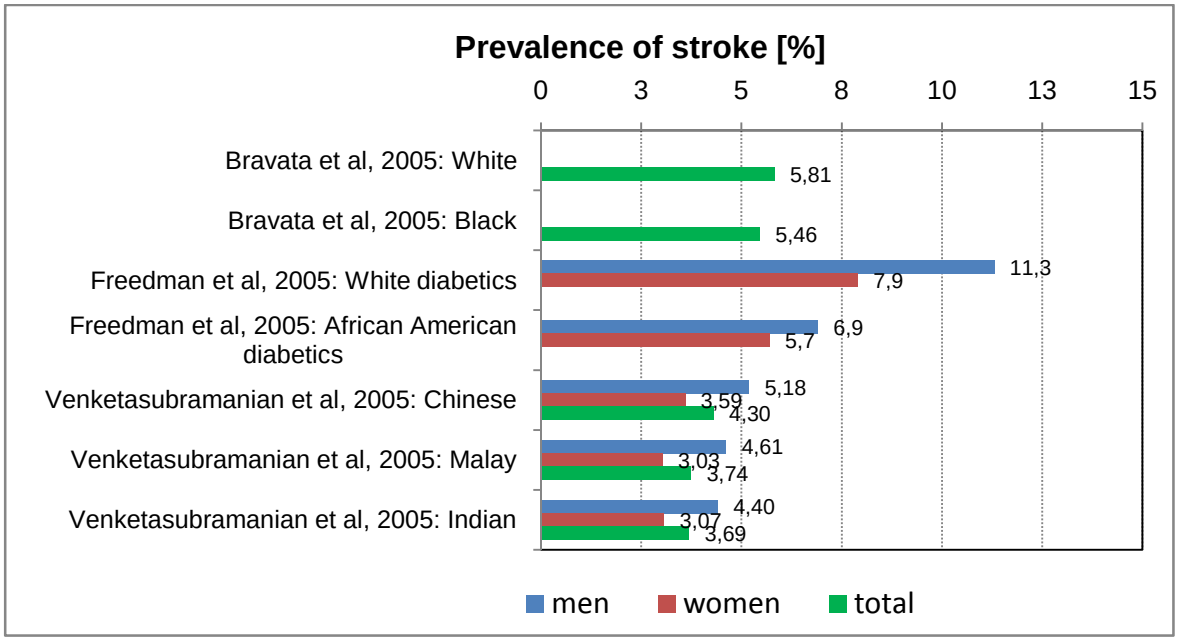

Figure 51: Prevalence of stroke, depending on ethnicity

The prevelance of myocardial infarct among people from different ethnicity was tested in three studies (Figure 52). In one study the prevalence of MI was higher among blacks (Bravata et al, 2005) than among whites and in two studies with diabetic patients it was reverse (Freedman et al, 2005; UK Prospective Diabetes Study Group, 2000). Interestingly in one study the prevalence of myocardial infarct in black women exceeded the prevalence of black men (Freedman et al, 2005) wherease it was contrary among white diabetic patients and among all patients of the second study with a higher prevalence among men. South Asian diabetic patients more likely were affected by a myocardial infarct than blacks and less likely were affected than whites (UK Prospective Diabetes Study Group, 2000).

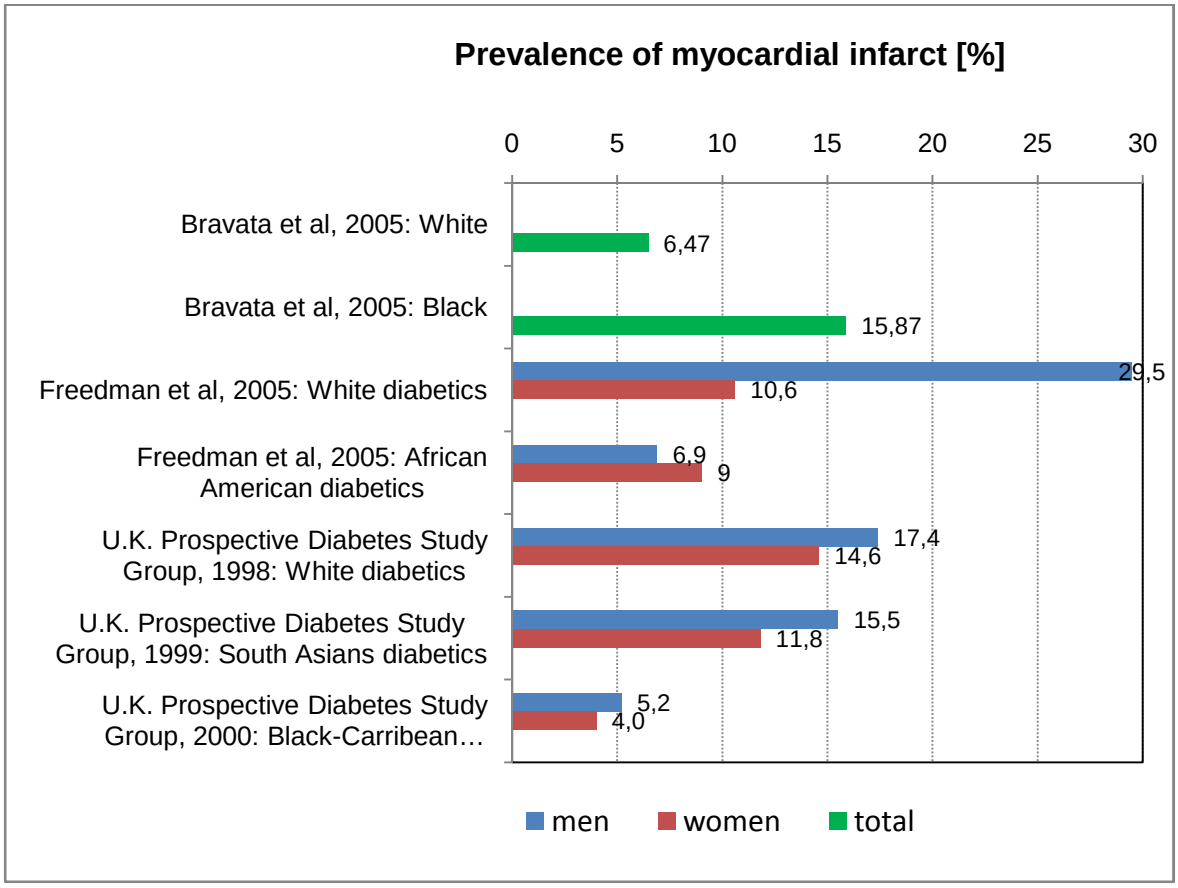

Figure 52: Prevalence of myocardial infarct, depending on ethnicity

4.6.7 Ethnicity and prevalence of cardiovascular mortality

In the only study which reported the mortality rate from stroke, American Indian men and women were affected by a higher rate than whites (Figure 53) (Harwell et al, 2008).

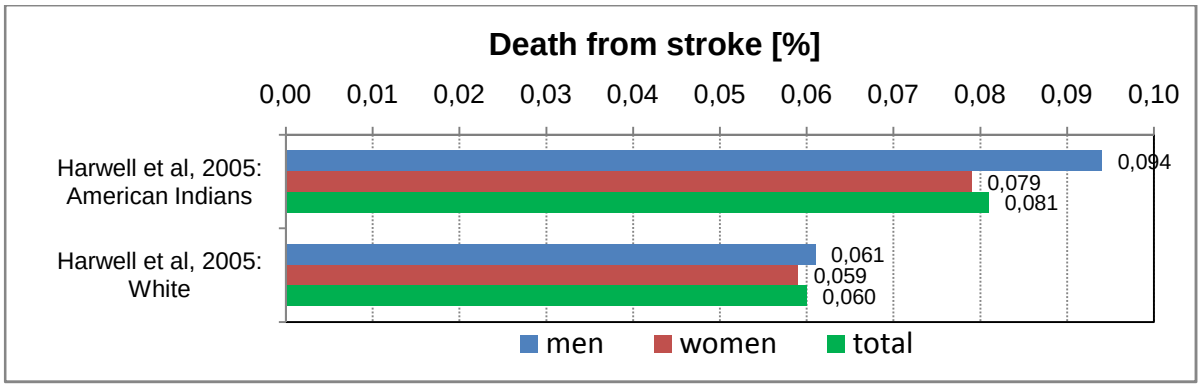

Figure 53: Mortality rate from stroke, depending on ethnicity

In two studies the influence of ethnicity on mortality rate from myocardial infarct was analysed (Figure 54). One study showed that American Indian men and women had a higher mortality rate from myocardial infarct (Harwell et al, 2005). In the second study white diabetic patients had the highest mortality rate from MI, followed by South Asian diabetics and the black Carribean diabetics (UK Prospective Diabetes Study Group, 2000).

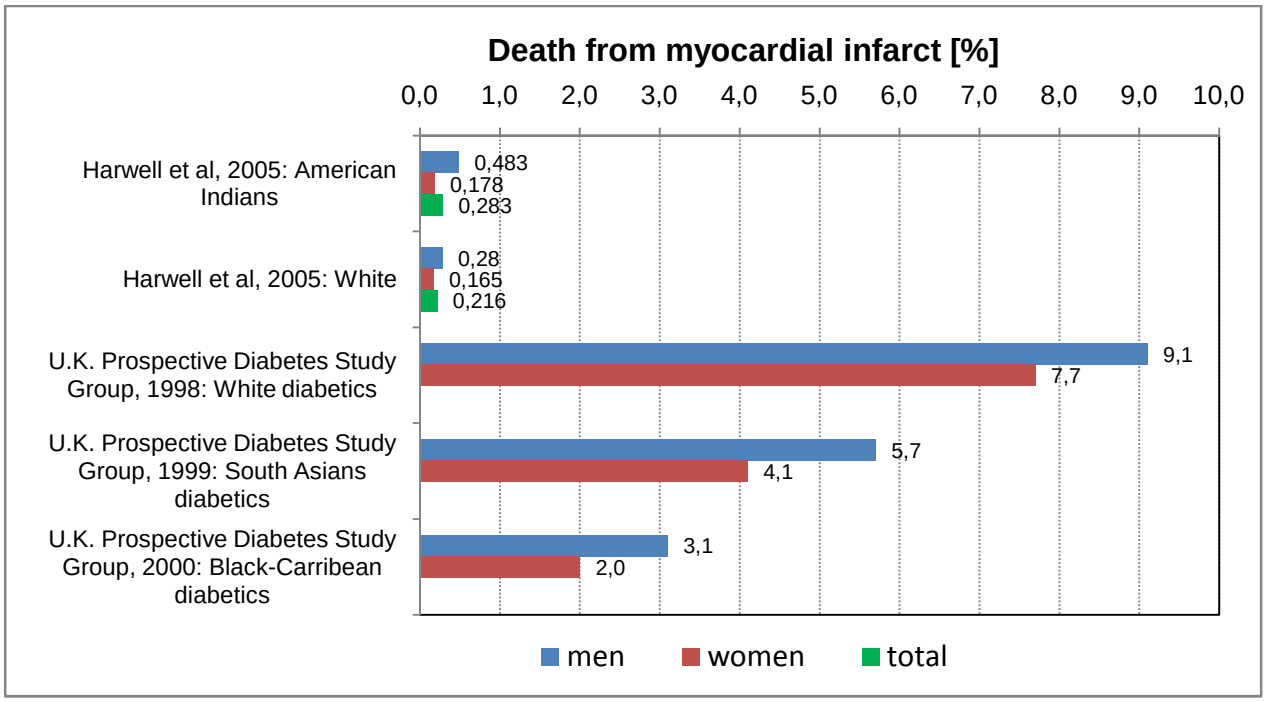

Figure 54: Mortality rate from myocardial infarct, depending on ethnicity

4.7 Socioeconomic status and prevalence of cardiovascular risk factors

4.7.1 Socioeconomic status and prevalence of diabetes

In two studies the prevalence of diabetes significantly increased with low occupational status in women (Figure 55) (Galobardes et al, 2003; Rosvall et al, 2000). There was no trend depending on occupational status in the study of Galobardes et al (2003). In the study of Rosvall et al (2000) low occupational level was associated with a high diabetes rate with exception of the group from the highest occupational level which had a very high diabetes rate. In the study of Singh-Manoux et al (2008) a socioeconomic gradient of the diabetes rate was found. In the Chinese study of Xu et al (2008) high family income was associated with a high diabetes rate.

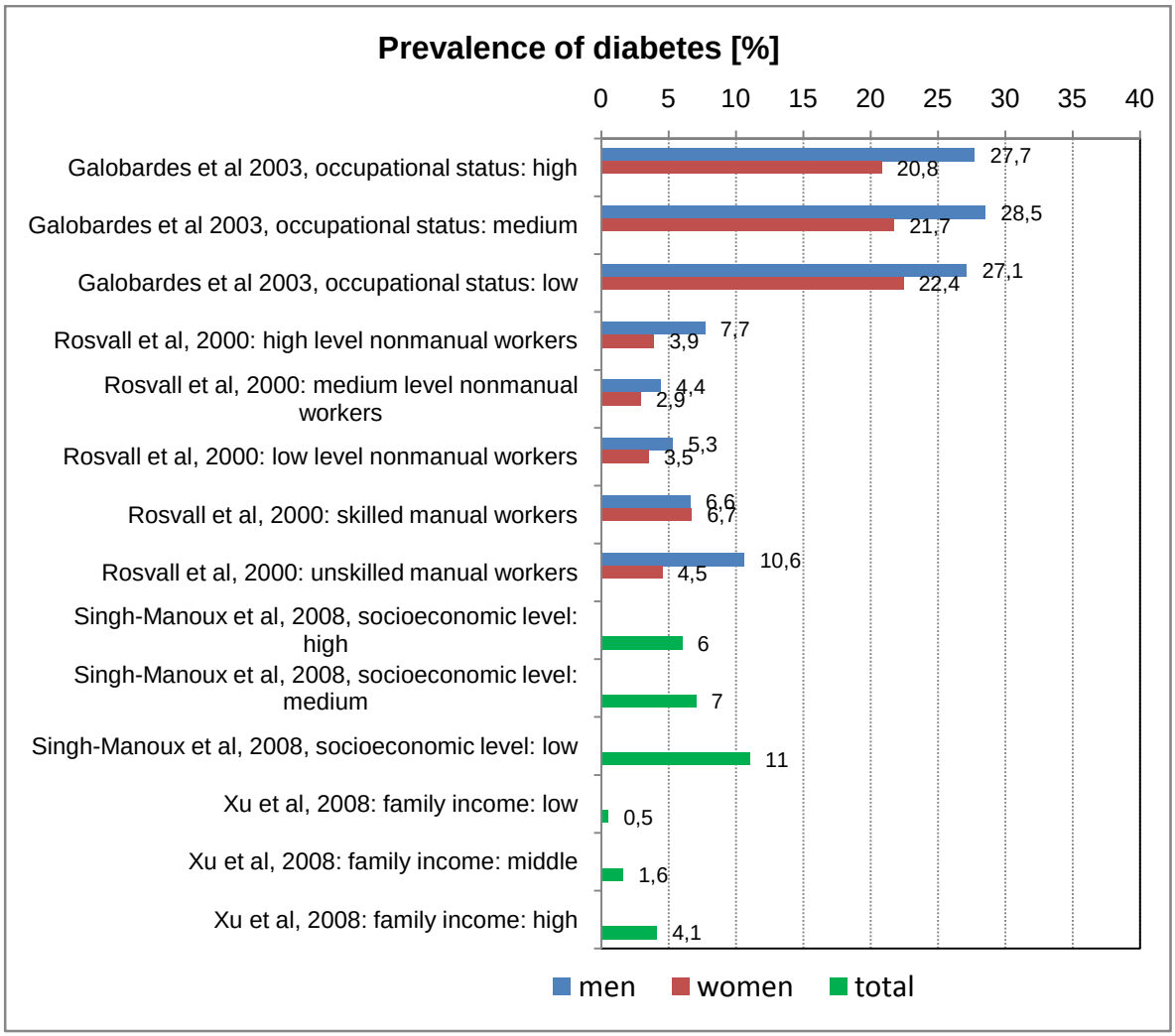

Figure 55: Prevalence of diabetes, depending on occupational status, SES or family income

Among women the duration of education is negatively associated with the prevalence of diabetes as shown in two studies (Figure 56) (Kuper et al, 2007; Rosvall et al, 2000). Rosvall et al (2000) showed that men with the lowest educational level had the highest diabetes rate, and men with medium educational level had the lowest diabetes rate.

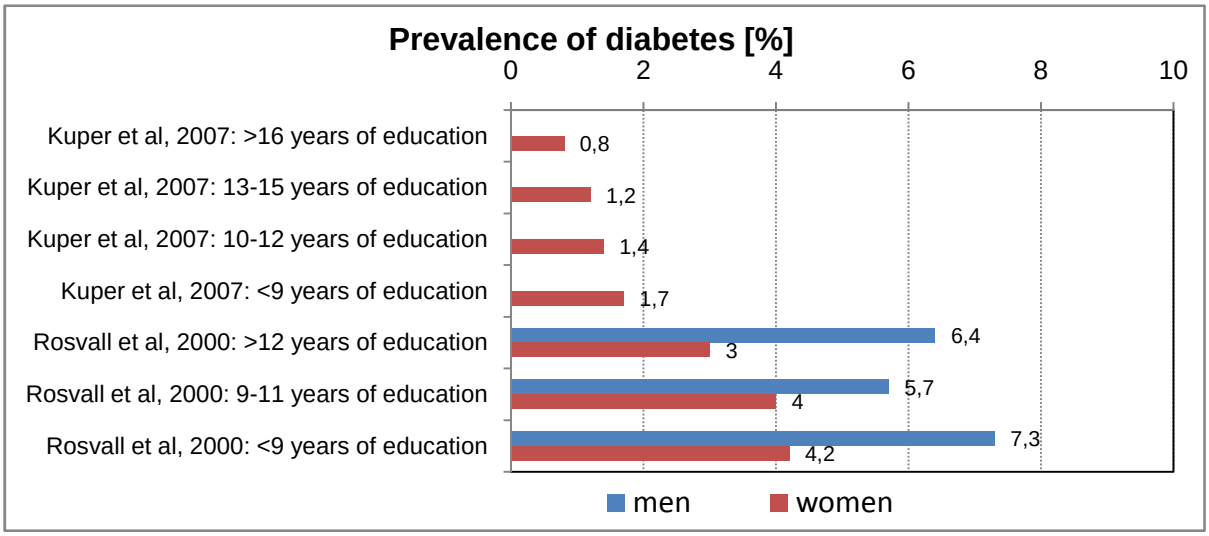

Figure 56: Prevalence of diabetes, depending on educational status

Urban residents more likely had diabetes than rural residents as it was shown in two studies (Figure 57) (Abdul-Rahim et al, 2001; Bouguerra et al, 2006), except male urban residents in the study of Abdul-Rahim et al (2001) who had a lower diabetes rate than male rural residents.

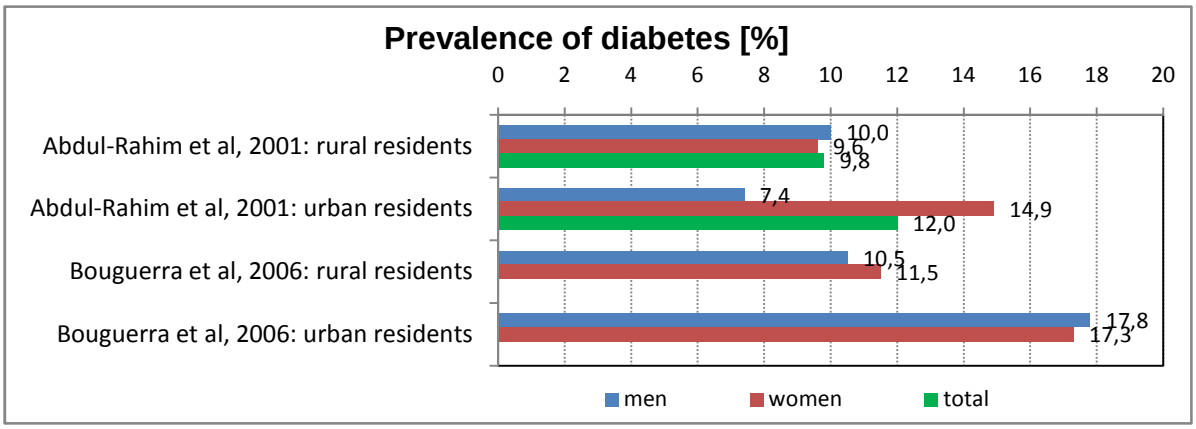

Figure 57: Prevalence of diabetes, depending on residency

The study of Ikeda et al (2007) analysed the dependence of the marital status on the prevalence of diabetes (Figure 58). Among single, divorced and widowed

women the diabetes rate did not differ significantly. The lowest rate was found among married women. This profile was different among men where the prevalence was lowest in the single group and highest in the divorced group. There was no significant difference among married and widowed men.

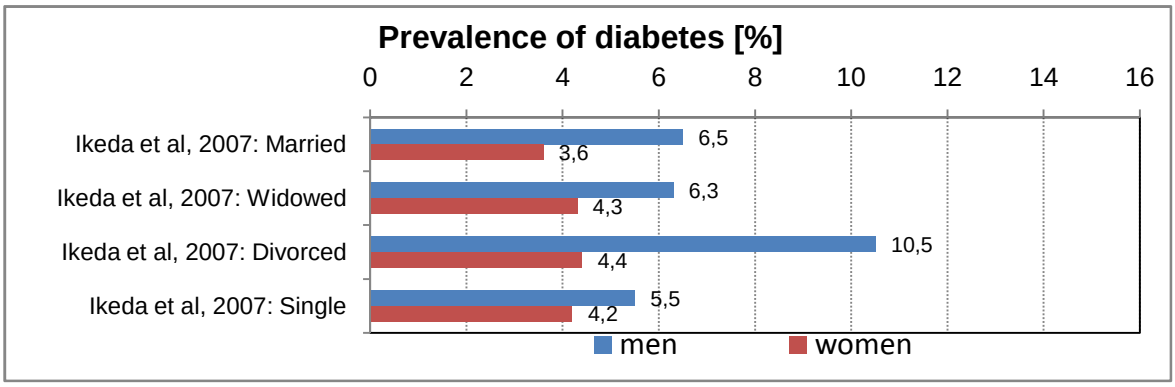

Figure 58: Prevalence of diabetes, depending on marital status

4.7.2 Socioeconomic status and prevalence of hypertension

Four studies analysed the influence of SES indicated by various parameters on the prevalence of hypertension (Figure 59). In all four studies there was an association between a low SES and a higher prevalence of hypertension. SES was indicated by neighbourhood unemployment (with Quartile I defined as the lowest unemployment and Quartile IV defined as the highest unemployment in the study of Dragano et al, 2007). A significant correlation between high unemployment and high prevalence of hypertension was shown in both countries, Germany and the Czech Republic. In the Czech Republic the prevalence of hypertension was generally higher than in Germany. The second tested parameter, neighbourhood overcrowding, did not significantly influence the prevalence of hypertension in both countries with exception of the Quartile I (defined as no overcrowding) in which a slightly lower prevalence of hypertension was found in Germany compared to the other classes. In the study of Santos et al (2008) there was a significant trend in increasing prevalence of hypertension from the highest social class (Class I) to the lowest class (class V) and the unemployed class. The same trend could also be seen in the study of Singh-Manoux et al (2008). Only in the study of Xu et al (2008) the influence of low family income on a high prevalence of hypertension was not as significant.

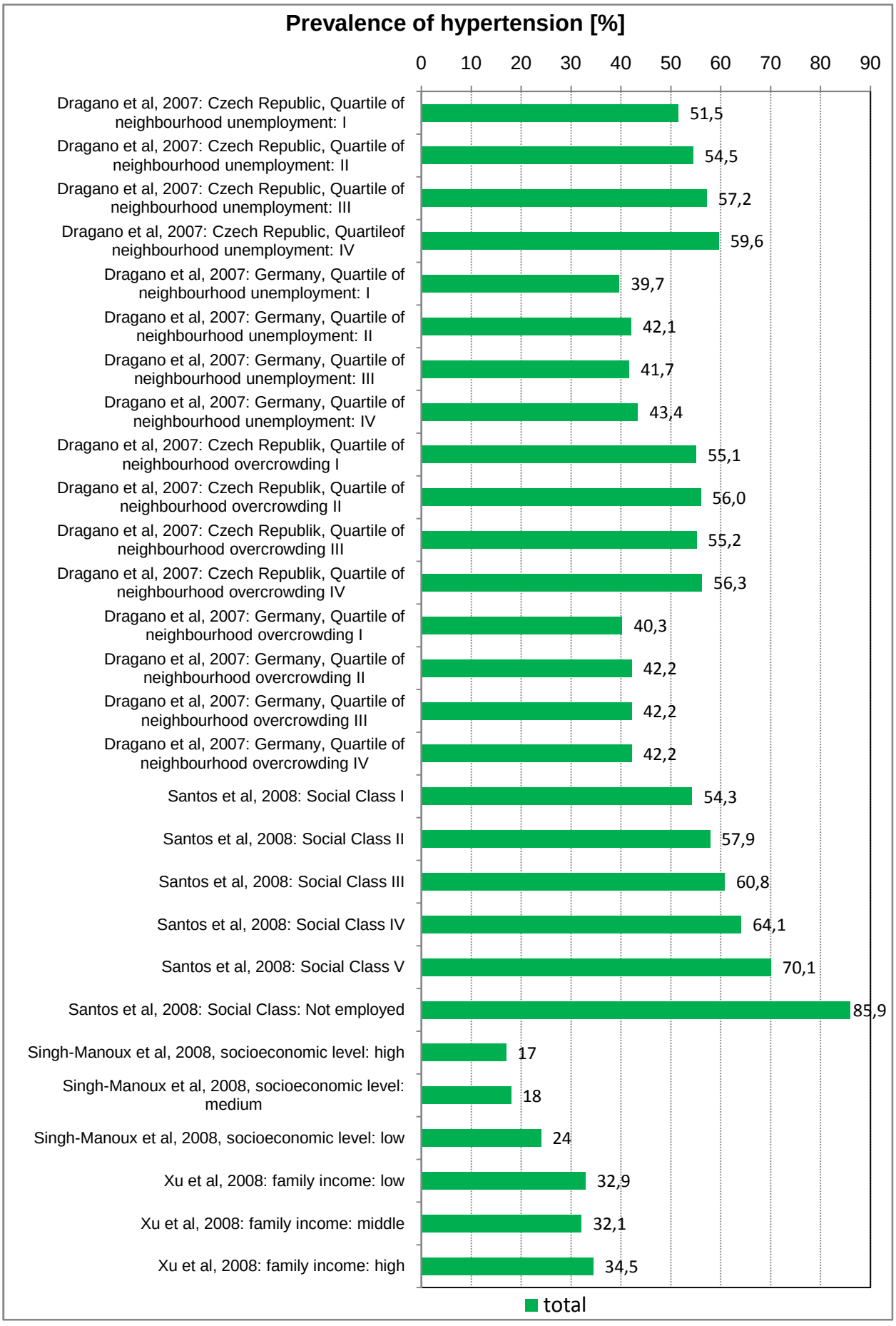

Figure 59: Prevalence of hypertension, depending on SES

Three studies evaluated the association of occupational status and hypertension (Figure 60). In two of them a lower occupational status was associated with a higher occurrence of hypertension (Galobardes et al, 2003; Rosvall et al, 2000). In the study of Santos et al (2008) active persons had a significantly lower prevalence of hypertension than unempoyed and retired persons or housewives.

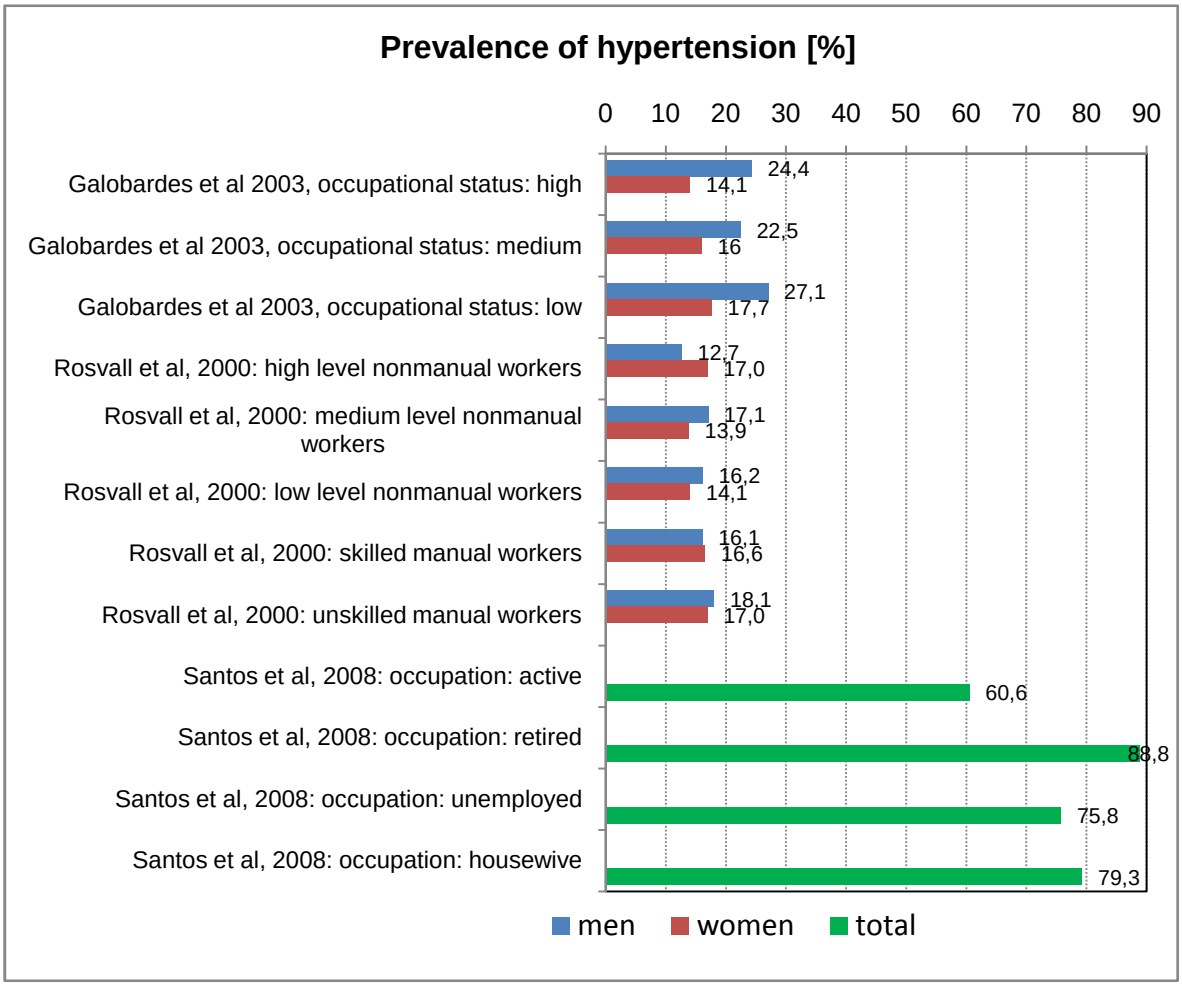

Figure 60: Prevalence of hypertension, depending on occupational status

Three studies analysed the influence of educational status on the prevalence of hypertension. In all three studies a significant association between a low duration of education and a high rate of hypertension was found (Figure 61) (Kuper et al, 2007; Santos et al, 2008). The only exception were the men with high education level in the study of Rosvall et al (2000) who had a higher rate than men with medium or low education level.

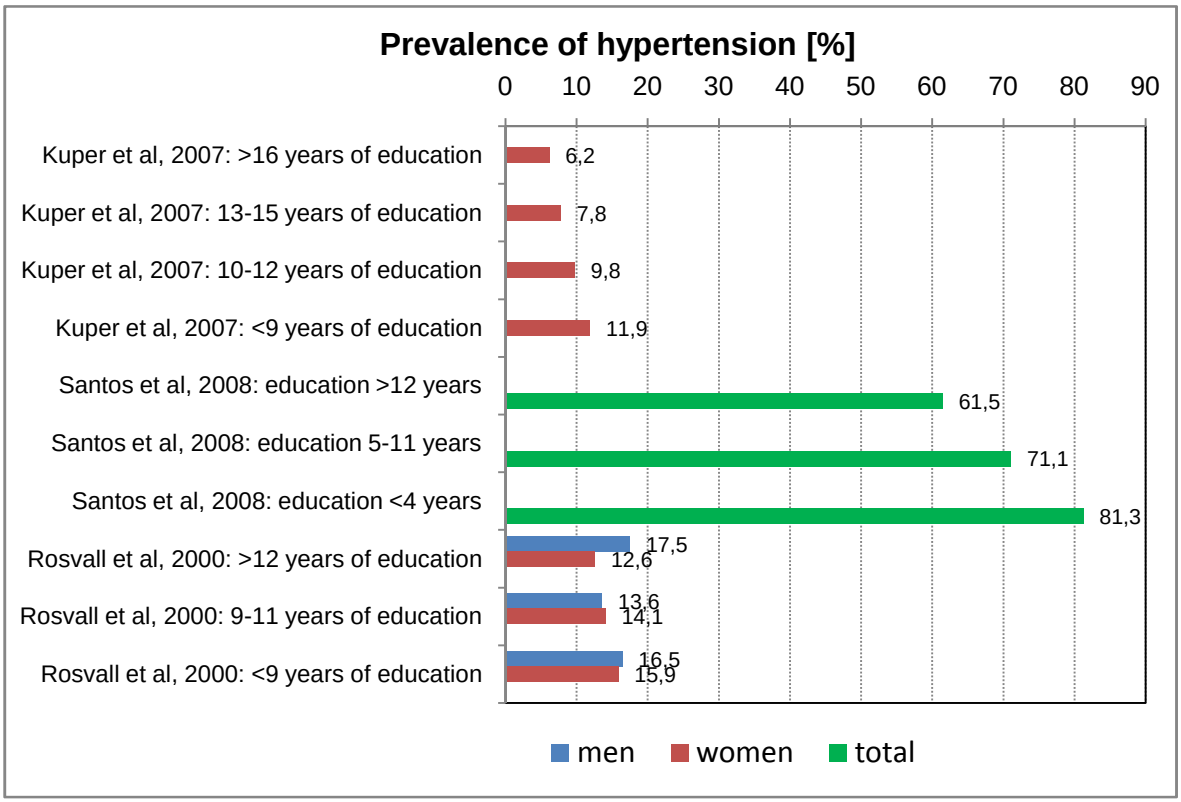

Figure 61: Prevalence of hypertension, depending on educational status

The prevalence of hypertension was slightly higher among male and female urban residents than among rural residents in the study of Bouguerra et al (2006) (Figure 62). This relationship was inverse in the study of Abdul-Rahim et al (2001), especially among men.

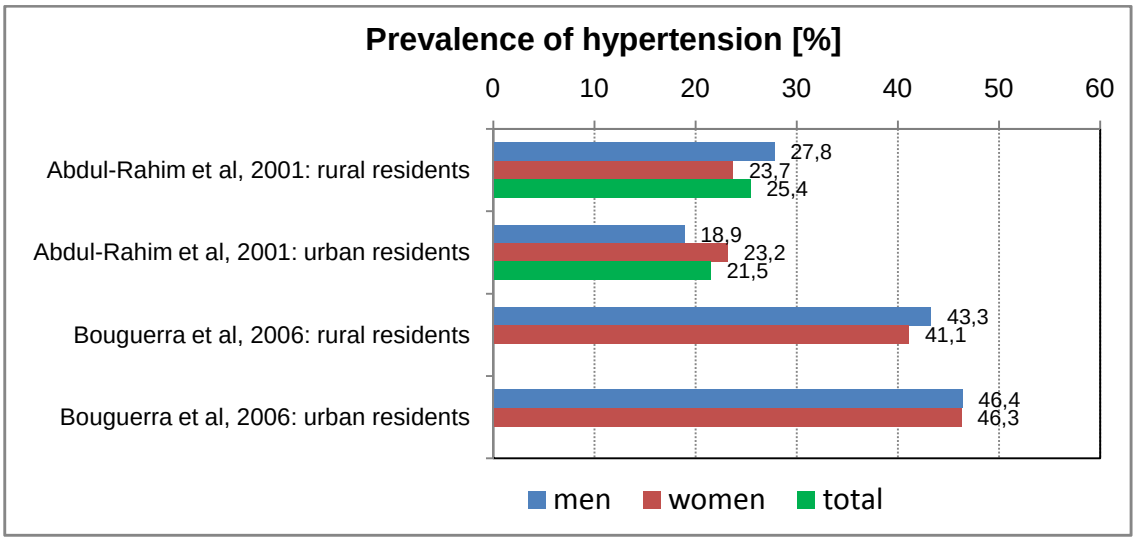

Figure 62: Prevalence of hypertension, depending on residency

In two studies the association of the prevalence of hypertension with marital status was analysed (Figure 63). In the study of Santos et al (2008) hypertension was more prevalent in the married group than in the not married group. Ikeda et al (2007) found the highest occurrence of hypertension among widowed women followed by married and divorced women. This profile differed among men where the highest rate was found among the divorced group, followed by the married and widowed group. Single men and women had the lowest hypertension rate.

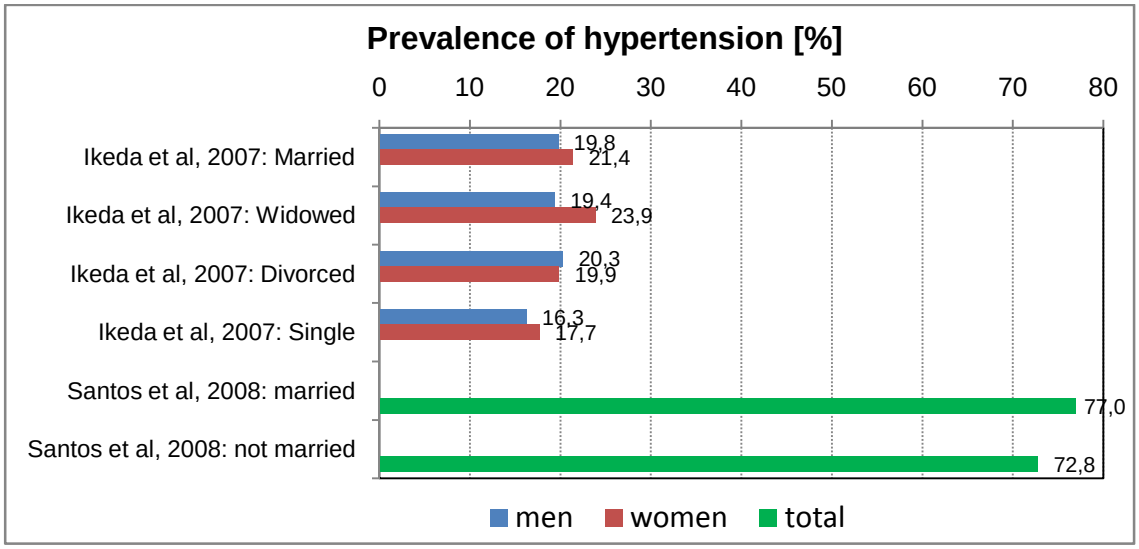

Figure 63: Prevalence of hypertension, depending on marital status

4.7.3 Socioeconomic status and prevalence of hyper-/dyslipidemia

Three studies analysed the influence of occupational status on the prevalence of hyper- or dyslipidemia (Figure 64). In the study of Rosvall et al (2000) a slight trend with a lower prevalence among higher occupational status was shown with exception of the medium class which has the lowest prevalence. In the study of Santos et al (2008) people from the highest socioeconomic class (Social class I) had the lowest prevalence of hyperlipidemia, interestingly followed by the lowest class (Social class V) whereas “Social class II” had the highest prevalence of hyperlipidemia. Furthermore in this study hyperlipidemia was most prevalent among housewives and less prevalent among the retired group. In the study of Singh-Manoux et al (2008) there was no significant difference in occurrence of hyper-or dyslipidemia between people from different SES.

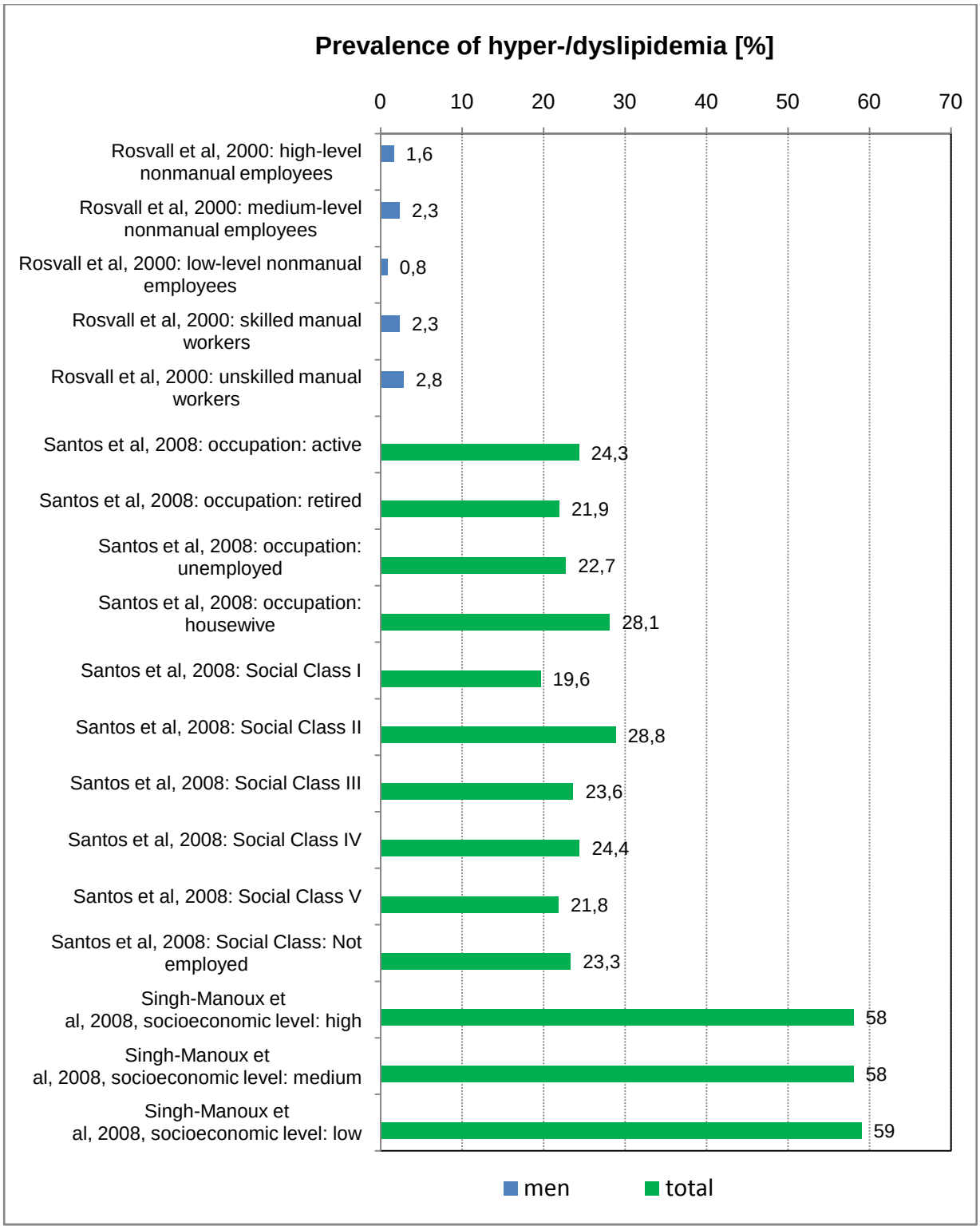

Figure 64: Prevalence of hyper-/dyslipidemia, depending on occupational status

Two studies analysed the influence of educational status on hyper- or dyslipidemia (Figure 65). In both studies the prevalence of hyperlipidemia increased with lower educational status (Rosvall et al, 2000; Santos et al, 2008). This trend was not so significant in the study of Rosvall et al (2000) in which women with medium

education had the highest rate and men with medium education had the lowest rate.

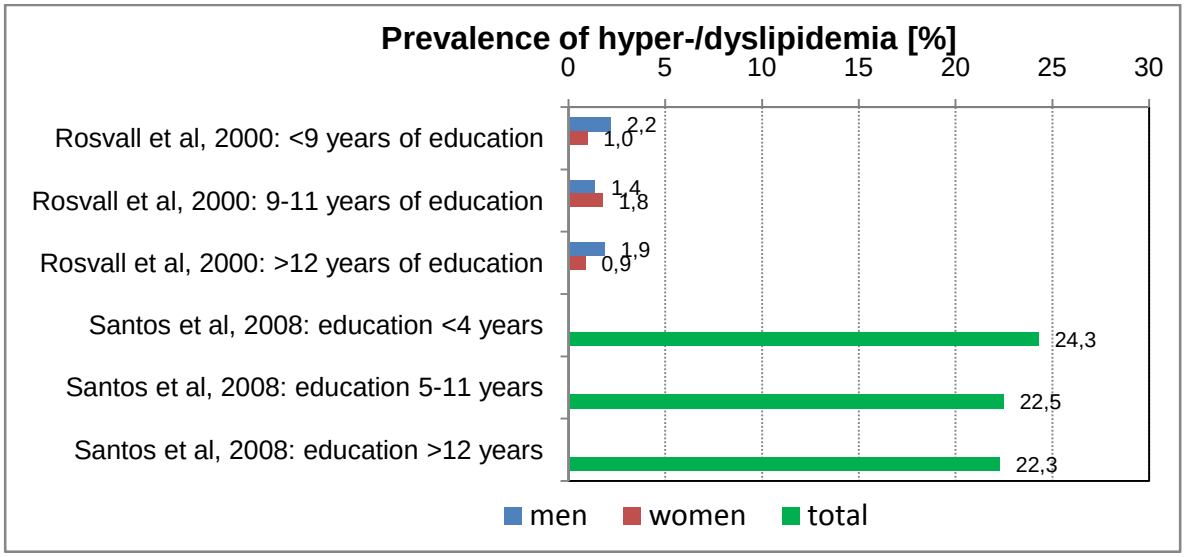

Figure 65: Prevalence of hyper-/dyslipidemia, depending on educational status

The prevalence of hyper- or dyslipidemia was higher among urban residents than among rural residents as reported in two studies (Abdul-Rahim et al, 2001; Bouguerra et al, 2006). This trend was shown in men and women (Figure 66).

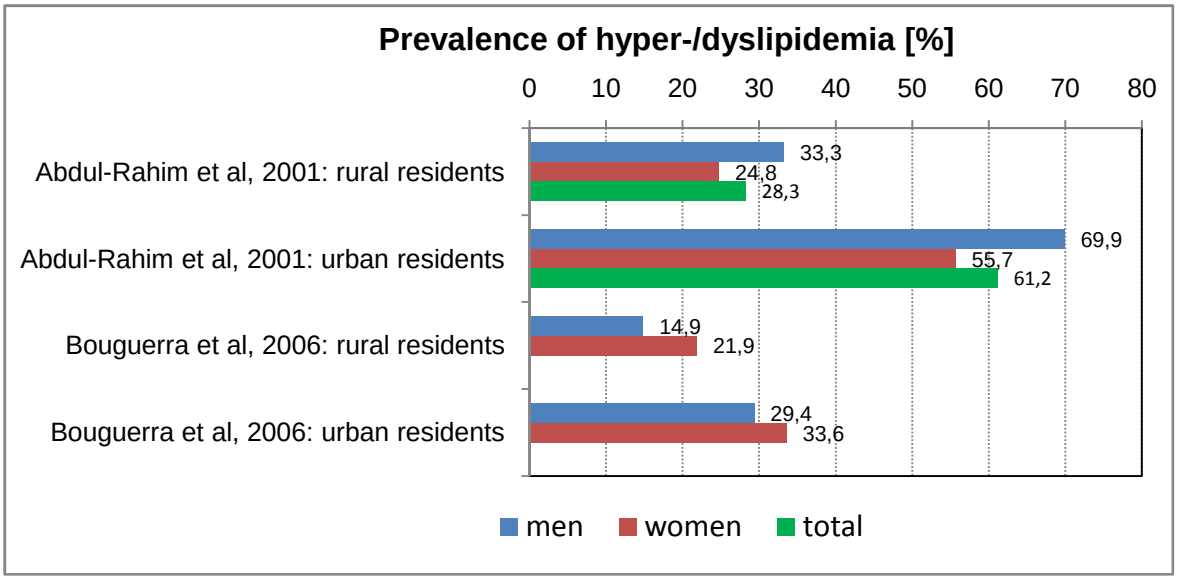

Figure 66: Prevalence of hyper-/dyslipidemia, depending on residency

In the study of Santos et al (2008) hyper- or dyslipidemia was more prevalent among the married than among the not married group (Figure 67).

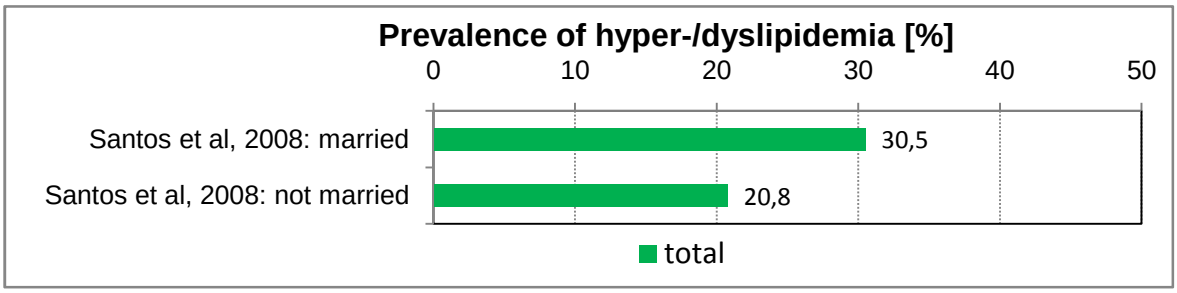

Figure 67: Prevalence of hyper-/dyslipidemia, depending on marital status

4.7.4 Socioeconomic status and prevalence of obesity

Three studies analysed the differences of the prevalence of obesity in different socioeconomic classes (Figure 68). In all three studies a lower socioeconomic status was associated with a higher prevalence of obesity. In the study of Dragano et al (2007) a positive correlation of high neighbourhood unemployment (Quartile I was the group with the lowest unemployment and Quartile IV was the group with the highest unemployment) with a higher prevalence of obesity was shown in two different countries, Germany and the Czech Republic. The association was stronger in Germany. The second parameter tested in this study, neighbourhood overcrowding (Quartile I defined as no overcrowding and Quartile IV defined as the highest overcrowding) did not have an influence of obesity in the Czech Republic, whereas a higher neighbourhood overcrowding was associated with a higher prevalence of obesity in Germany. In the study of Galobardes et al (2008) a lower occupational class was associated with a higher obesity rate. This correlation was higher among women. In the third study (Santos et al, 2008) the occurence of obesity increased with low social class (Class V defined as the lowest class). Obesity was most prevalent among housewives. Retired or unemployed people were more likely obese than active people.

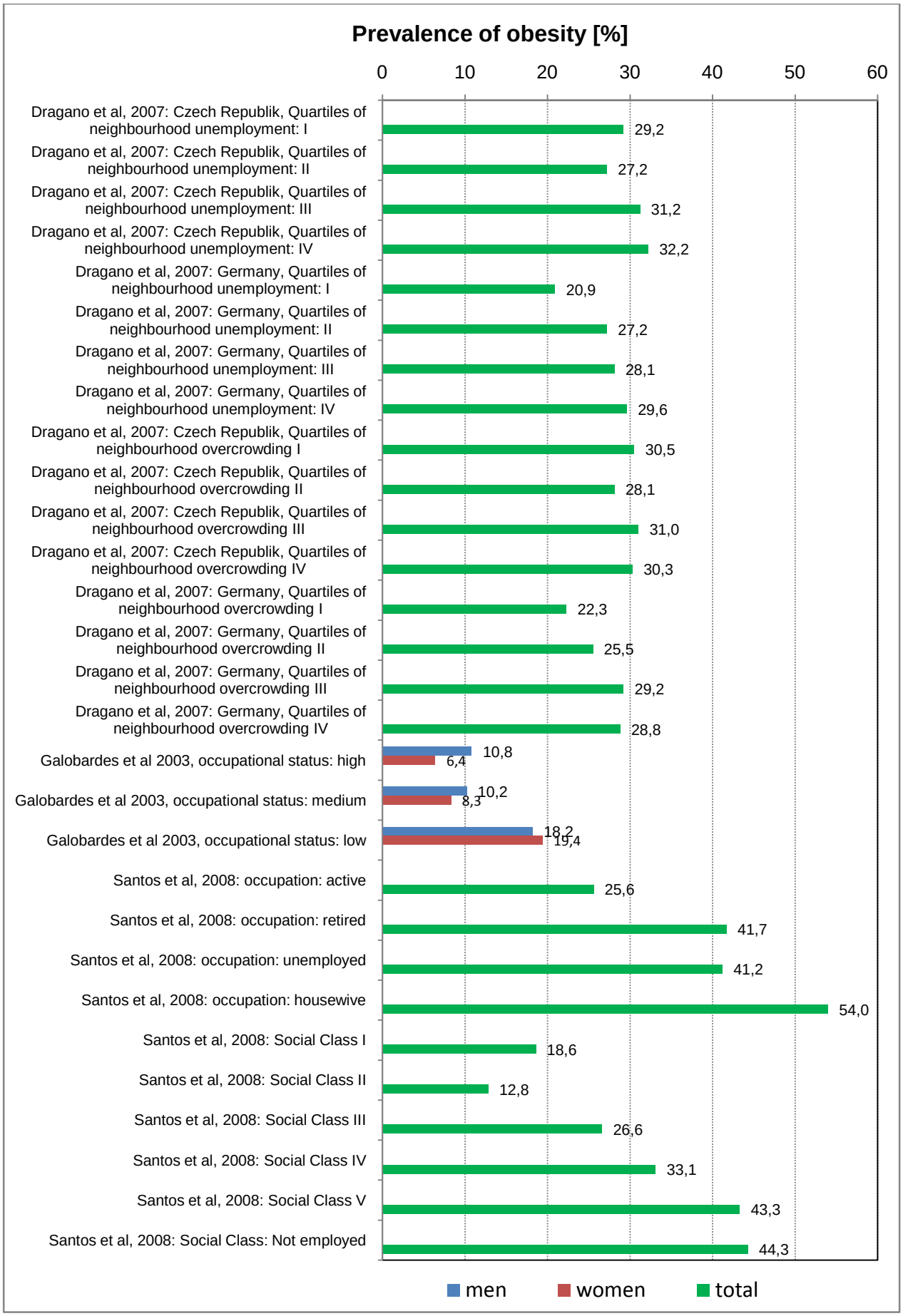

Figure 68: Prevalence of obesity, depending on occupational status

In two studies the prevalence of obesity was higher among urban than rural residents in both sexes (Abduhl-Rahim et al, 2001; Bouguerra et al, 2006) (Figure 69). Furthermore in these two studies performed in West-Bank and Tunisia, women were more likely obese than men.

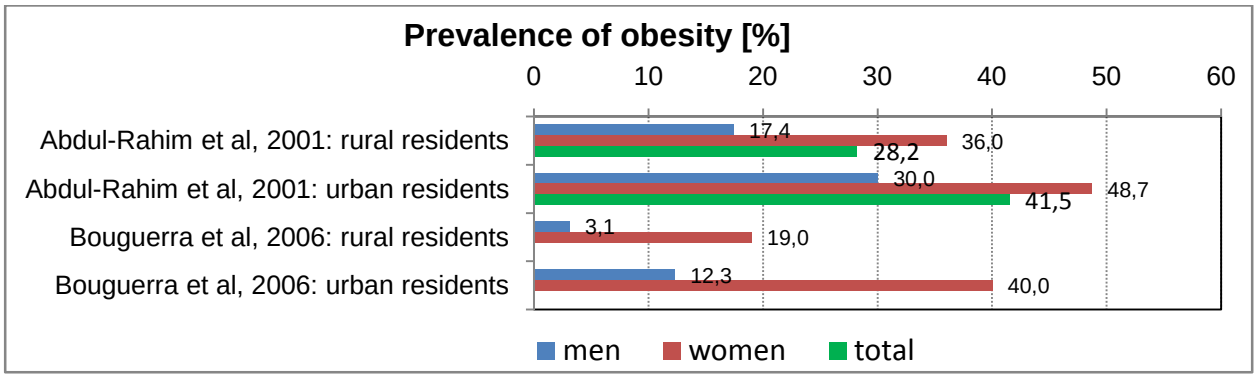

Figure 69: Prevalence of obesity, depending on urban or rural residency

In the study of Santos et al (2008) married people were more likely obese than not married people (Figure 70).

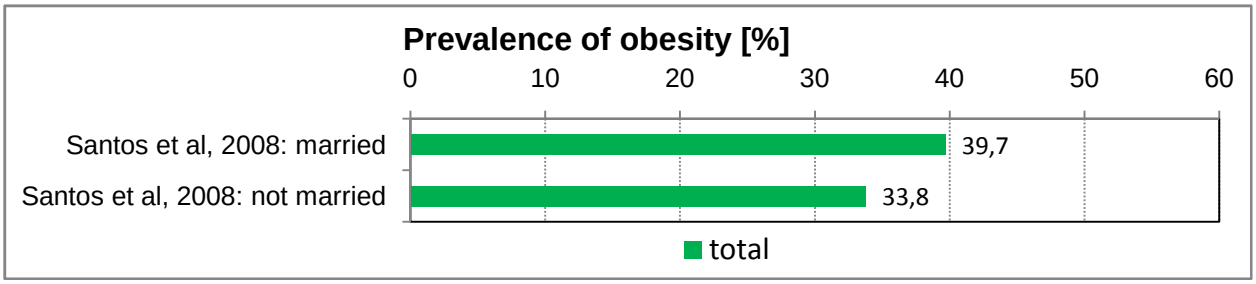

Figure 70: Prevalence of obesity, depending on marital status

In the only study which analysed the association of obesity rate with educational status, people with the shortest education duration were more likely obese then those with a higher education duration (Santos et al, 2008) (Figure 71).

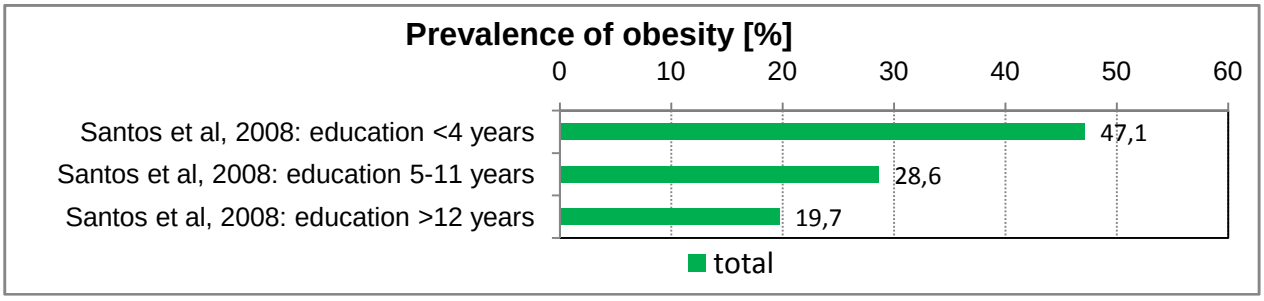

Figure 71: Prevalence of obesity, depending on educational duration

The association of mean BMI and occupational status was analysed in three studies. In all three studies there was a significant association between low occupational status and higher BMI among women (Figure 72)(Galobardes et al, 2003; MacFadden et al, 2008; Rosvall et al, 2000). This trend was not as significant among men.

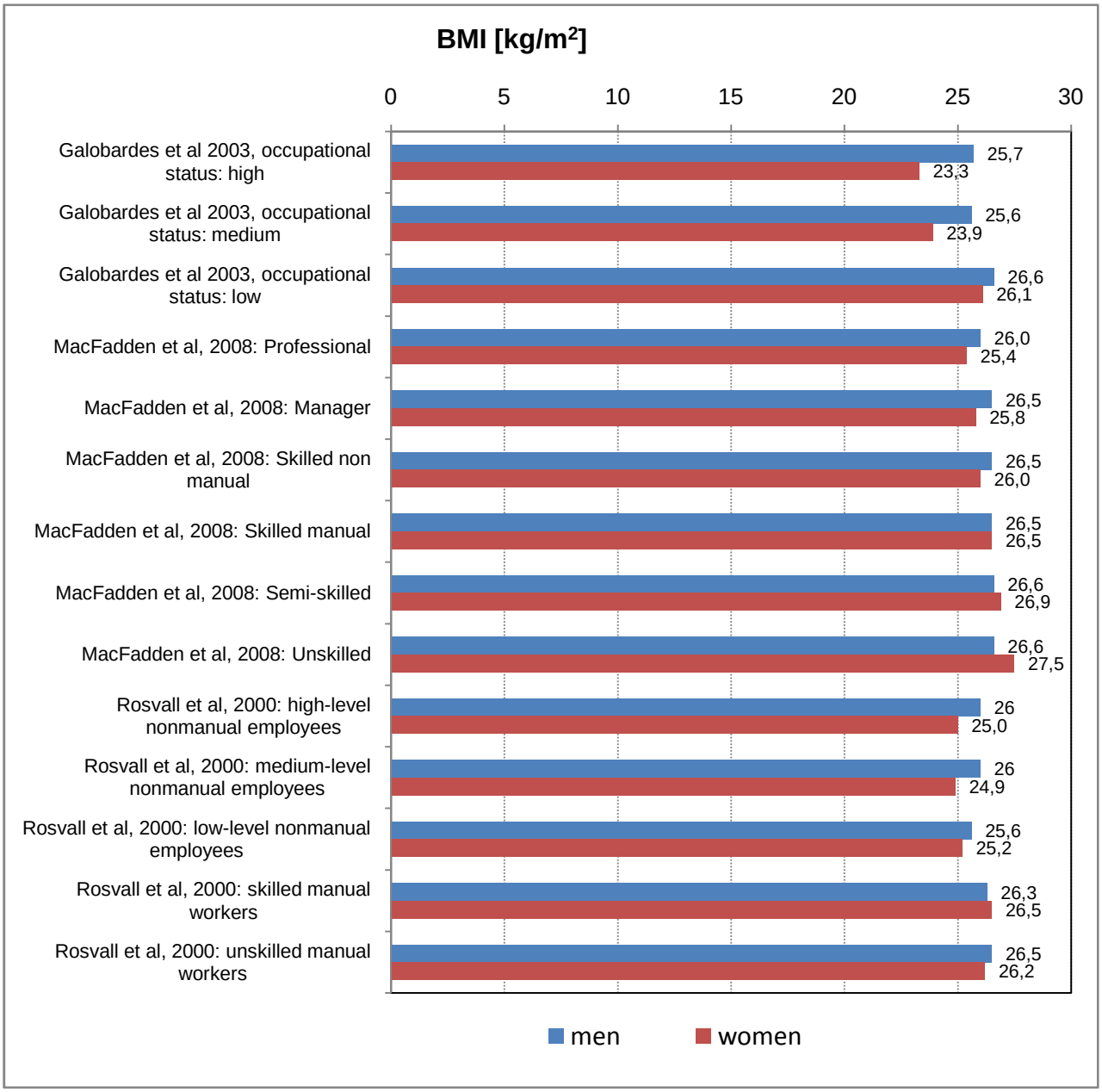

Figure 72: Mean BMI, depending on occupational status

In the study of Ikeda et al (2007) the mean BMI of married, widowed and divorced men and women did not differ significantly (Figure 73). The BMI was lowest

among single men and women and slightely lower in the divorced group as in the widowed and married group of both sexes.

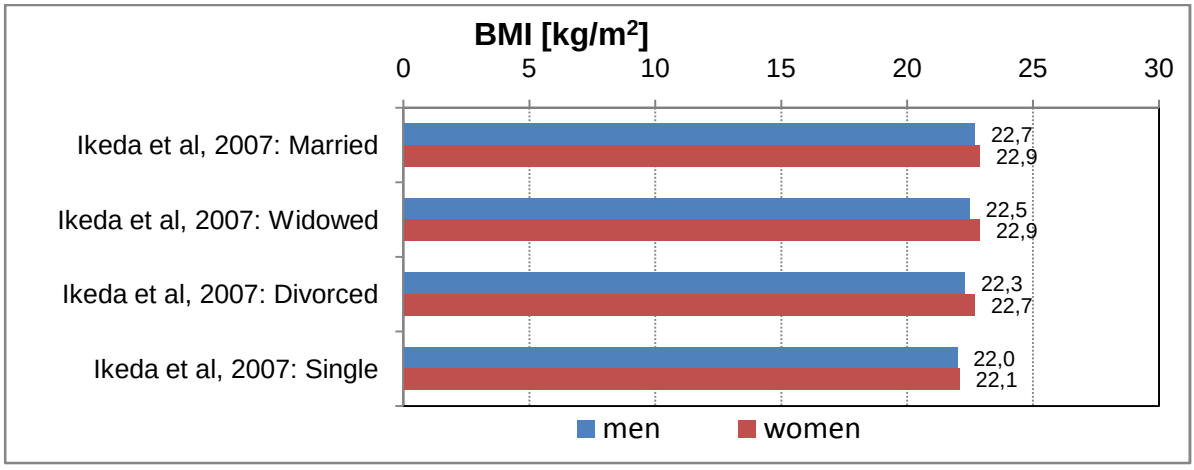

Figure 73: Mean BMI, depending on marital status

In three studies the association of mean BMI and educational level was analysed. In all three studies a low duration of education was related to a higher BMI (Figure 74). This trend was more significant in one study (Kuper et al, 2007) and only slightly in two studies (MacFadden et al, 2008; Rosvall et al, 2000). The only exception were men in the study of MacFadden et al (2008) among who BMI did not differ with educational level.

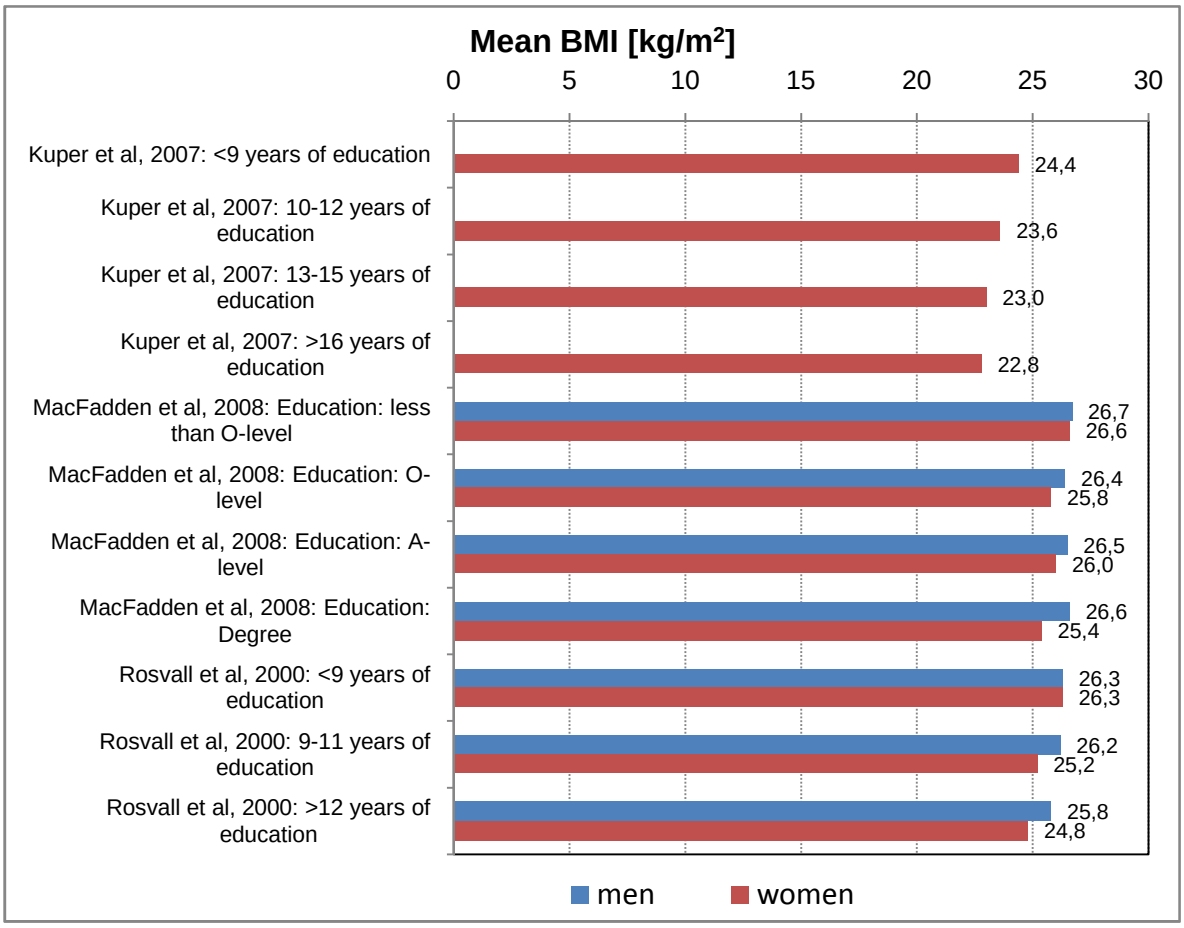

Figure 74: Mean BMI, depending on educational status

4.7.5 Socioeconomic status and prevalence of smoking

Six studies analysed the smoking rate depending on SES (Figure 75). In all the studies smoking rate was higher among the groups from lower SES. Three studies showed a correlation of low occupational status with a higher prevalence of smoking. This association was higher among men than among women (Galobardes et a, 2003; MacFadden et al, 2008; Rosvall et al, 2000). The study of Singh-Manoux (2008) showed a significant association of low SES with a high smoking rate and the study of Xu et al (2008) showed an association of a high family income with a high smoking rate. In the study of Dragano et al (2007) the neighbourhood unemployment with Quartile IV defined as the highest unemployment and Quartile I defined as the lowest unemployment was positively correlated with the smoking rate in Germany and in the Czech Republic. The second parameter, neighbourhood overcrowding also was positively correlated with the smoking rate in both countries.

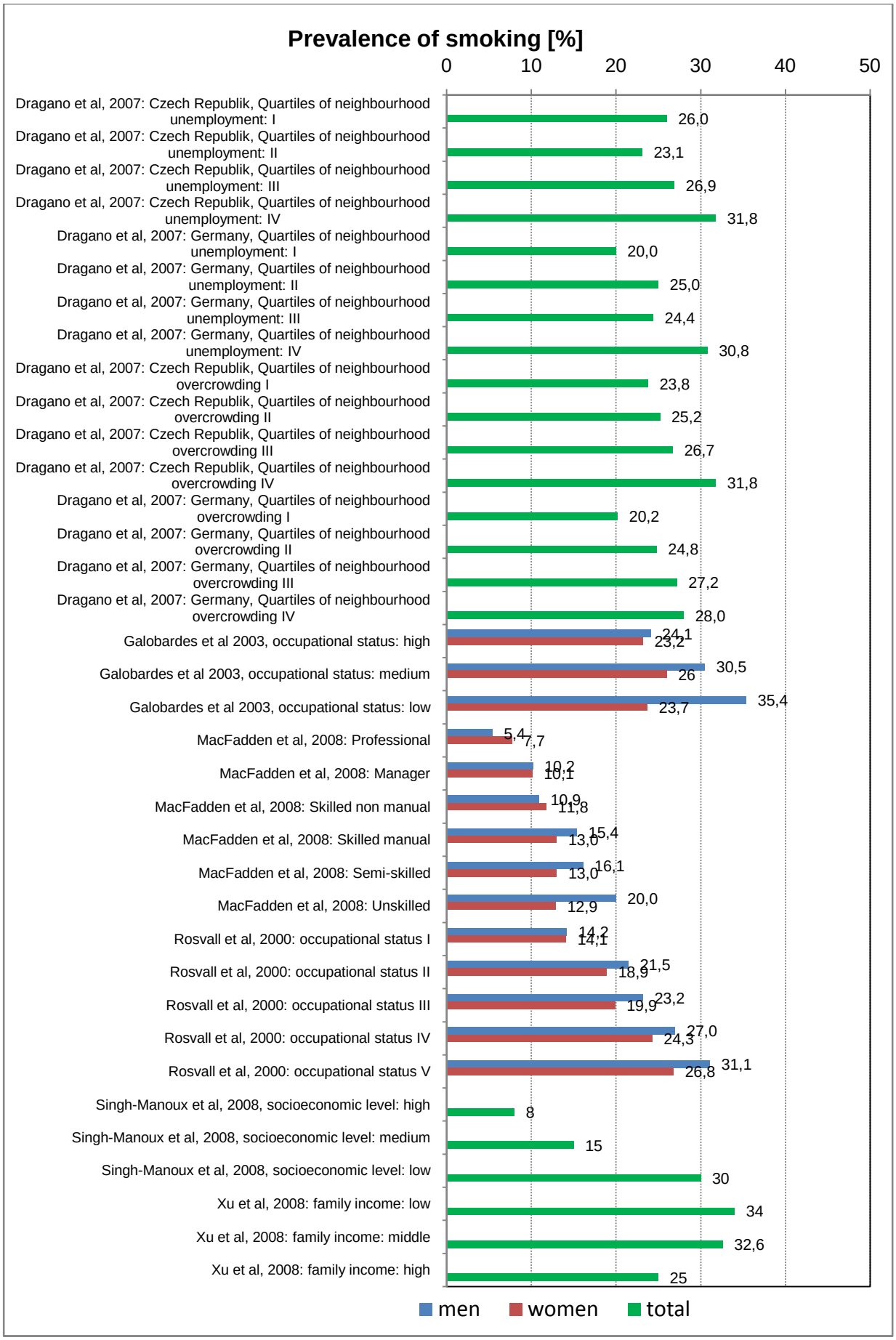

Figure 75: Smoking rate, depending on SES or occupational class

In the study of Ikeda et al (2007) the association of smoking rate and marital status was analysed (Figure 76). Men had a much higher smoking rate than women. Among both sexes the rate was highest in divorced people and lowest in married people. Widowed men more likely were smokers than single men whereas this was reverse for women.

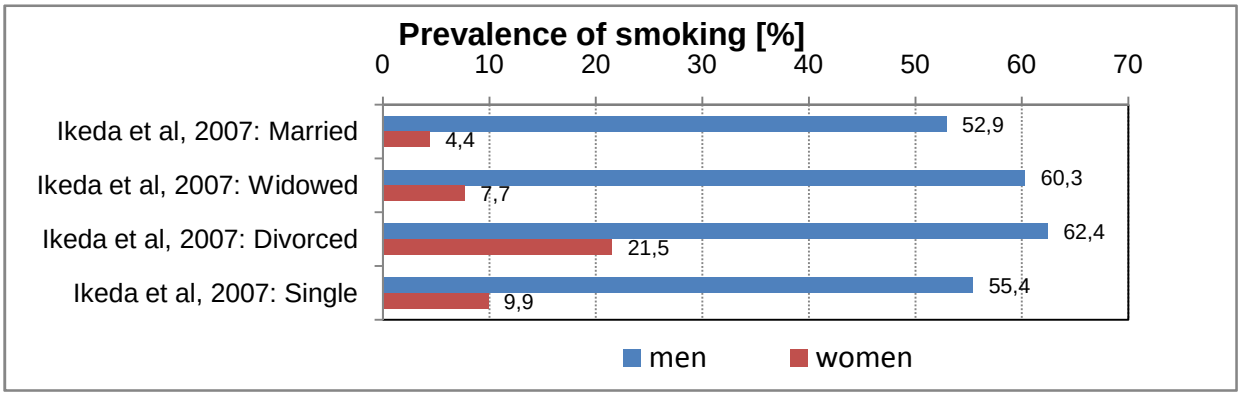

Figure 76: Smoking rate, depending on marital status

In three studies an association of low educational status with high smoking rate in men and women was shown (Figure 77) (Kuper et al, 2007; MacFadden et al, 2008; Rosvall et al, 2008).

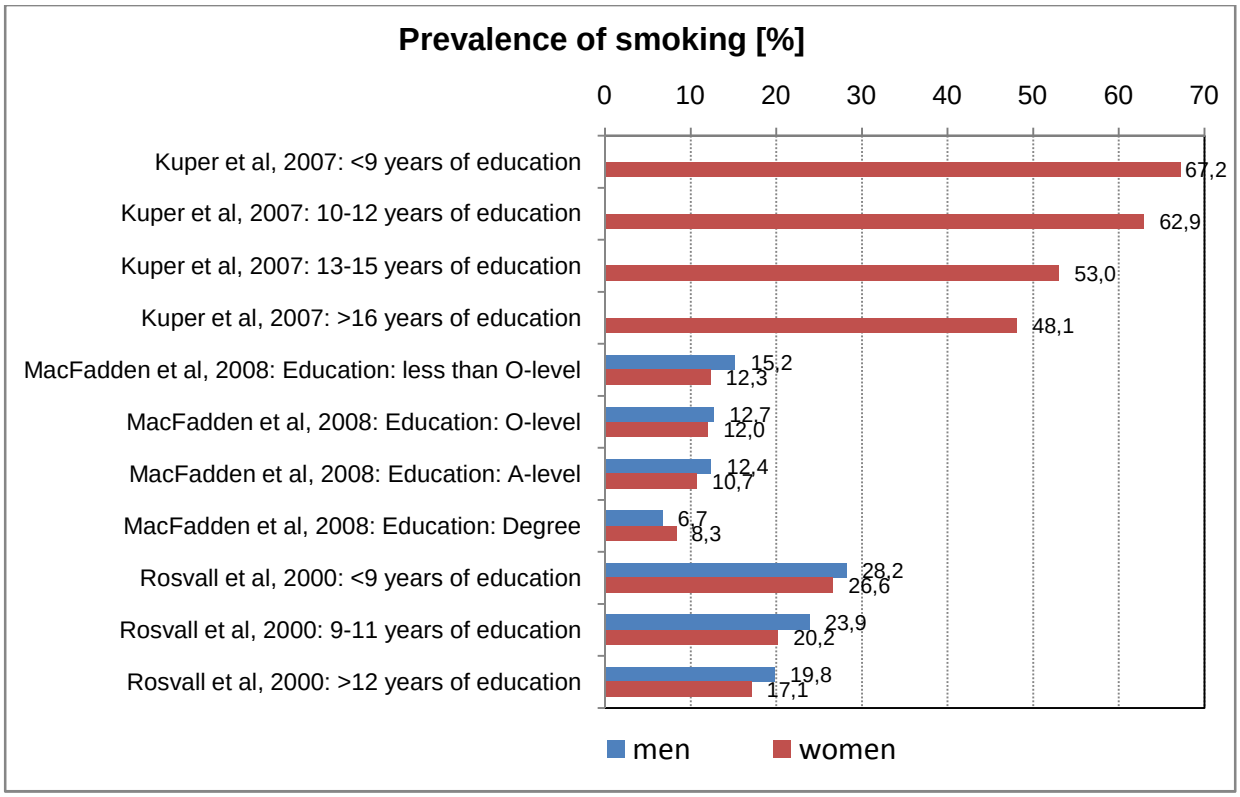

Figure 77: Smoking rate, depending on educational status

4.7.6 Socioeconomic status and prevalence of cardiovascular events

Three studies analysed the association of SES with various parameters indicating for socioeconomic status (Figure 78). In all studies low SES correlated with a higher prevalence of stroke. In three of these studies family income (Xu et al, 2008), occupation (Xu et al, 2008) or general SES were analysed (Engström et al, 2001); and in two studies educational status was analysed (Kuper et al, 2007; Xu et al, 2008). In one study urban residency correlated with a higher prevalence of stroke compared to rural residency (Xu et al, 2008).

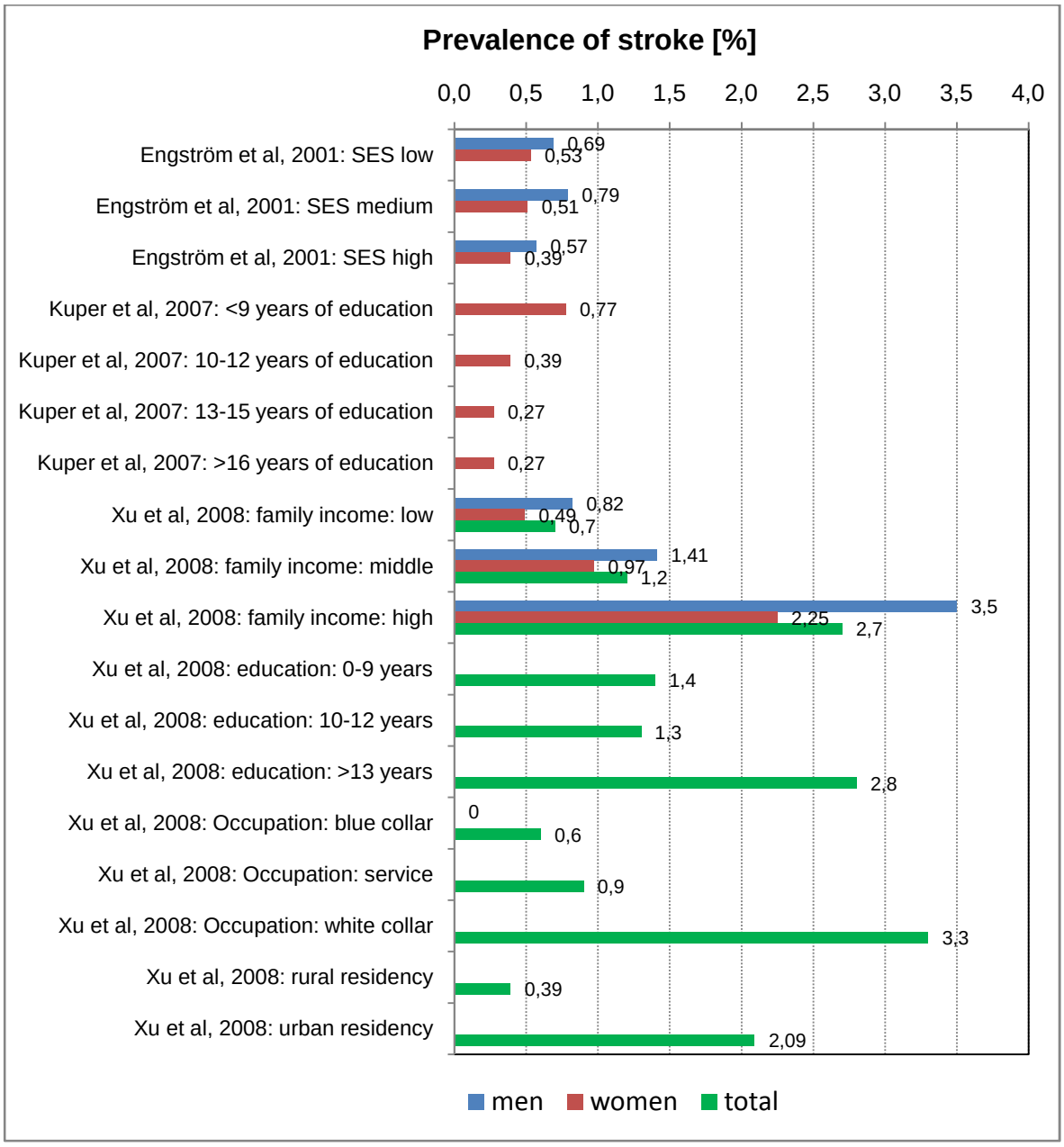

Figure 78: Prevalence of stroke, depending on SES, duration of education and residency

In the study of MacFadden et al (2008) low professional and low educational status was associated with a higher prevalence of CVD (Figure 79). This trend was more significant among men.

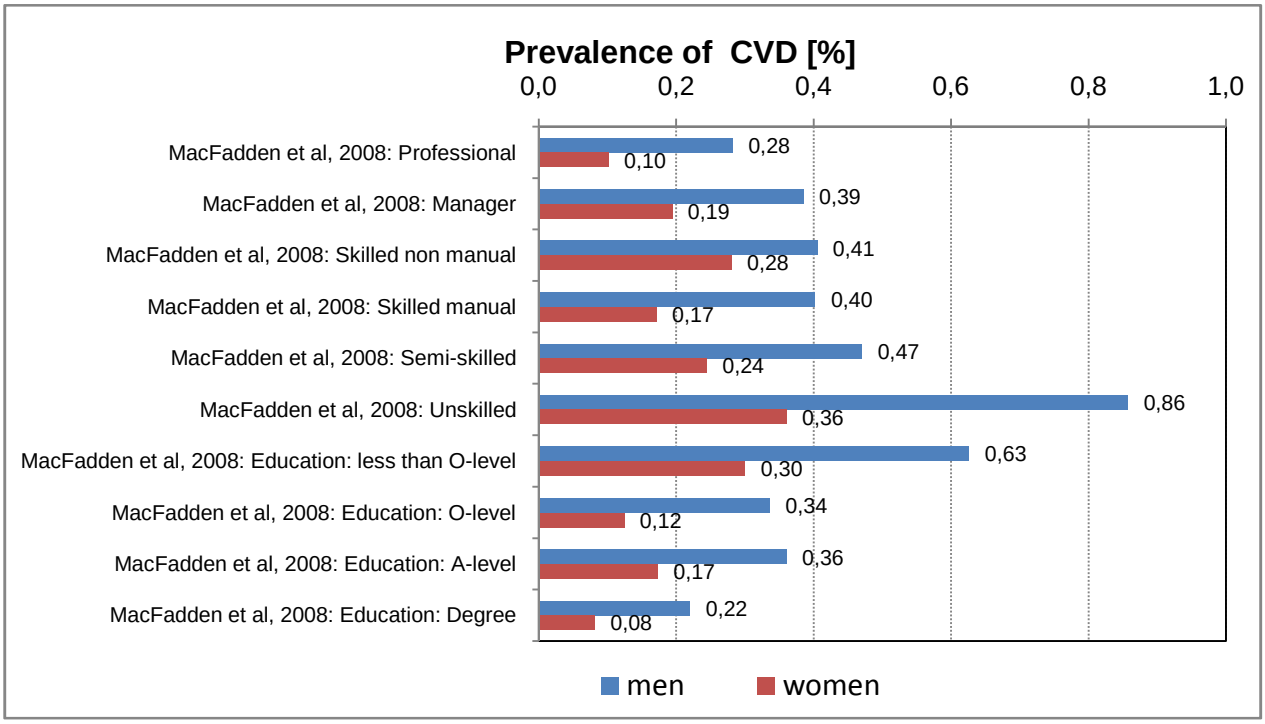

Figure 79: Prevalence of cardiovascular diseases, depending on profession and education

In the study of Singh-Manoux et al (2008) the prevalence of coronary heart diseases was associated with low SES (Figure 80).

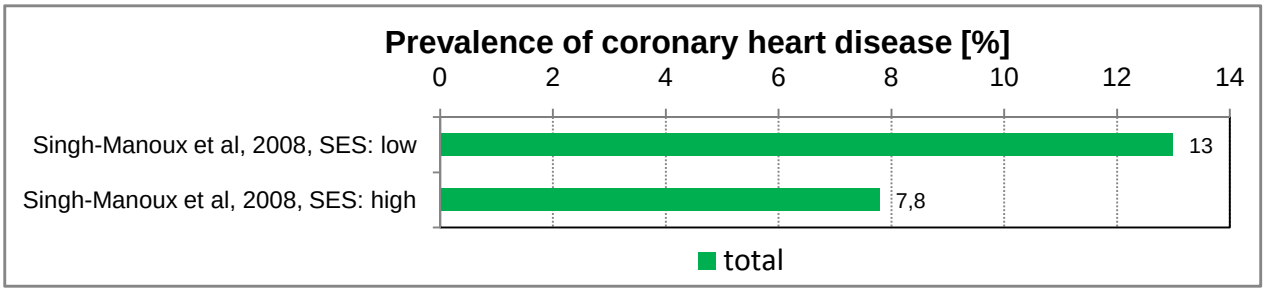

Figure 80: Prevalence of coronary heart diseases, depending on SES

4.7.7 Socioeconomic status and cardiovascular mortality

One study reported the mortality rate from various cardiovascular diseases depending on marital status (Figure 81) (Ikeda et al, 2007). The mortality rate from

stroke was highest among widowed men. Interestingly in both sexes, the single group was affected by the lowest mortality rate. Married women had a lower mortality rate than divorced and widowed women whereas married men had a higher rate than divorced men. In all groups a higher mortality rate was reported among men.

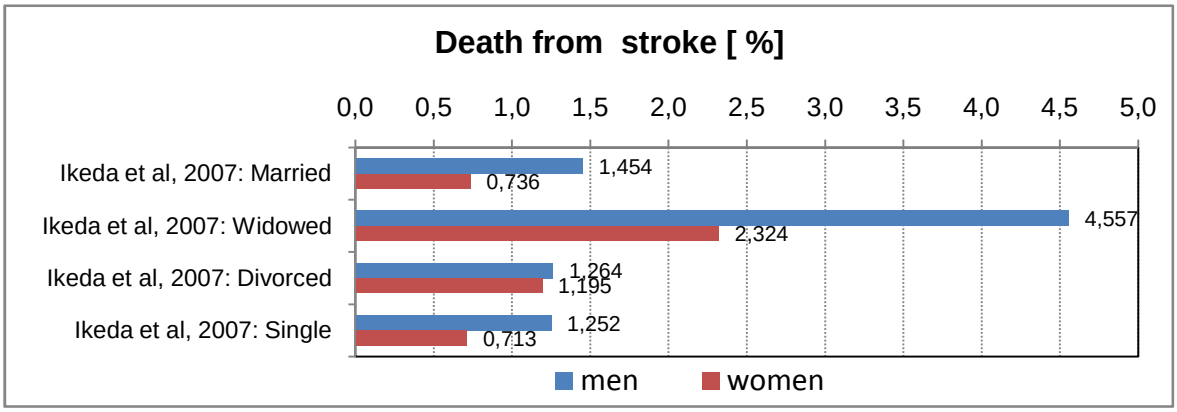

Figure 81: Mortality rate from stroke, depending on marital status

In the study of Ikeda et al (2007) mortality rate from CVD was highest among widowed men and women and lowest among married men (Figure 82). There was no significant difference between the divorced and single group among men whereas single women had a higher mortality rate from coronary heart disease than divorced women. Married women were affected by a slightly lower mortality rate than the single and divirced women. In all four groups men had a higher mortality rate than women.

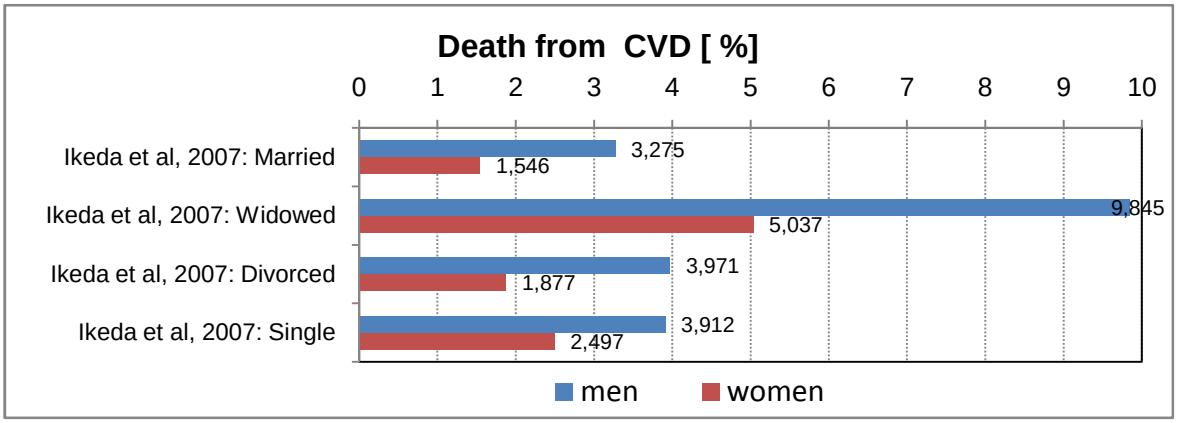

Figure 82: Mortality rate from cardiovascular diseases, depending on marital status

In the study of Ikeda et al (2007) widowed women had the highest mortality rate from coronary heart disease, whereas the mortality rate was similar among single and divorced women and lowest among married women (Figure 83). Interestingly, the mortality rate of men was highest among the single men followed by the married men and lowest among the widowed men. In the group of the married, divorced and single people, women were affected by a higher mortality rate than men, whereas widowedness caused the highest mortality rate in women which exceeded even the rate of single men.

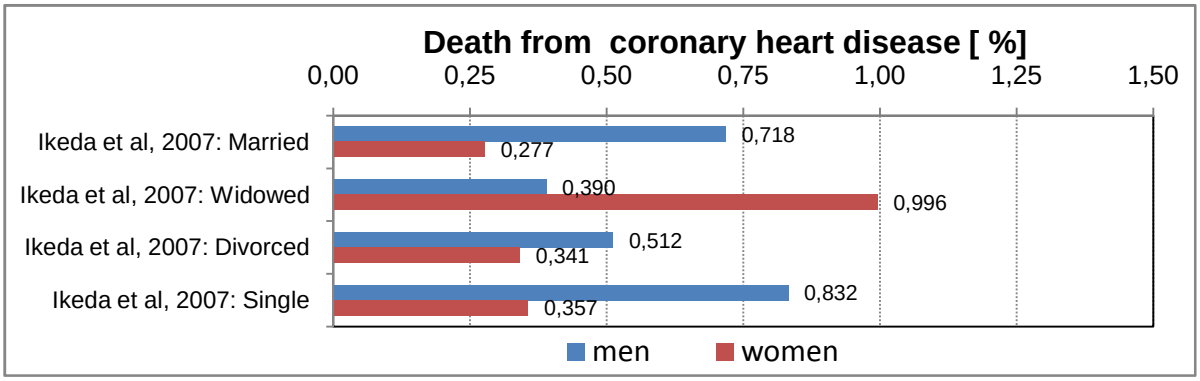

Figure 83: Mortality rate from coronary heart diseases, depending on marital status

5. Discussion

Cardiovascular diseases are the number one cause of death worldwide. The prevalence of several risk factors like abdominal obesity, hypertension, hyper- and dyslipidemia and diabetes summarised as metabolic syndrome correlates with the incidence of cardiovascular morbidity and mortality. Several lifestyle factors like smoking, physical activity and alcohol intake influence the developing of cardiovascular risk factors and so the progression of cardiovascular diseases.

In this meta-analysis including 78 studies an association of gender, ethnicity and socioeconomic status on the occurrence, outcome, and mortality rate from cardiovascular diseases was found. Furthermore cardiovascular risk factors and lifestyle risk factors varied with gender, ethnicity and SES.

In this study various data on the prevalence of the defined outcome variables were compared. The absolute values of the prevalence of the different variables like cardiovascular risk factors varied due to different definitions of the components of metabolic syndrome. Several studies used criteria from ATPIII (NCEP, 2002) and other studies used criteria of WHO (Khatib, 2006), but the comparison of the values within one study like between two different subject groups was possible which was the goal of the study. Furthermore values also differed because of the different age groups which were evaluated in different studies.

In nearly all studies the number of male CVD patients significantly exceeded the number of female patients indicating that more men were affected by a CVD than women. Women were significantly older at the first incidence of a CVD. On average women were 5.7 years older than men and the age difference ranged from one to nine years. Female patients with CVD had a higher prevalence of cardiovascular risk factors. The mean prevalence of hypertension and diabetes among CVD patients was significantly higher in women and the mean prevalence of dyslipidemia was slightly higher in women. Similar proportions of male and female CVD patients were overweight or obese. It has to be considered that female patients were significantly older than male patients and as the prevalence of cardiovascular risk factors increase with age (EGIR et al, 2002) an age-adjustment would reduce gender difference in risk factor prevalence. More men were current or former smokers. Especially in Asiatic countries the gender difference in smoking rate was very high. The prevalence of recurrent

cardiovascular events within 28 days was higher in men whereas the prevalence within one year was higher in women. The mortality rate in hospital or within 28 days was significantly higher among women whereas the 1 year – mortality rate was only slightly higher in women. One has to consider that female CVD patients were significantly older than men. Furthermore treatment containing medical treatment like thrombolytic therapy or invasive procedures like revascularization, cardiac catherisation or percutaneous coronary interventions differed between genders with a lower probability for women to get these treatments (Alfredsson et al, 2007; Radovanovic et al, 2007; Matsui et al, 2002). After adjustment for age, for comorbidities, for social deprivation or for interventions the gender difference in in-hospital or 28/30-days mortality rate decreased or disappeared. Long-term mortality rates (after one year or 2-7 years) were higher in women in all analysed studies, whereas after adjustment to age or comorbidites rates were similar or even higher in men.

In one study not only a subject group with patients admitted to hospital with CVD were analysed, but also the mortality rate before hospitalization was recorded. The probability to survive to reach the hospital was higher in women. So the 30-days mortality was significantly higher in women among the admitted patients and only slightly higher in women in the patient group including also the patients who did not reach hospital alive. It has to be considered that the values of several other studies could also change when considering death rates before hospital admission. The mean age of patients who did not survive to reach a hospital was about 6 to 7 years higher than in the subject group that was admitted to hospital in both sexes. The gender difference of age in both groups was 6 years (MacIntyre et al, 2002).

In cross sectional analysis with a healthy or diabetic population men had a higher incidence and prevalence of stroke and myocardial infarct and also a higher cardiovascular mortality over a defined follow-up period, a finding which was consistent to previous literature reports (Roeters van Lennep et al, 2002).

Because of the necessity of the interaction of more risk factors in women than in men to cause a cardiovascular event it was assumed that there are protective mechanisms among the female population especially prior to menopause. This effect could be explained by female hormones such as estrogen which protects women from cardiovascular disease. Several studies have tried to find an

explanation on the protective effect of the female sexual hormones. Estrogen improves cardiovascular risk factors like lipid profile by increasing the HDL-level and decreasing the LDL-level. Furthermore estrogen directly improves vascular function by increasing nitric oxide synthase activity and so NO production which has beneficial effects on endothelial dysfunction. It was also shown that estrogen decreases LDL oxidation and so contributes to the prevention of foam cell formation and lesion progression (Medina et al, 2003; Roeters van Lennep et al, 2002) and improves heart function and health. 17ß-estradiol was demonstrated to inhibit cardiomyocyte apoptosis in vitro and in vivo in mice (Patten et al, 2004). This fact could explain that in men's hearts myocyte cells are lost during aging, an observation which is not made in women's heart (Olivetti et al, 1995). In studies with mice it was shown that estrogen and testosterone had opposing effects on chronic cardiac remodeling and function after MI. Estrogen seems to prevent destroying of cardiac function, but testosterone seems to increase cardiac dysfunction (Cavasin et al, 2003). In cell culture experimental stroke caused less injury in female than male culture, an effect maybe attributable to female sex hormones (Li et al, 2005).

After menopause women are more often affected by cardiovascular events due to hormonal changes like a decline of protecting estrogens in blood. There are converse opinions on influence of exogenous hormonal treatment such as hormone replacement therapy. Collins et al (2002) could not find a benefit of hormone replacement therapies. Kuh et al (2005) showed that postmenopausal women had higher levels of metabolic risk factors compared with premenopausal or perimenopausal women of the same age. During hormone replacement therapy levels of metabolic risk factors decreased and might protect against cardiovascular disease. Additionally the typical male pattern of fat distribution which means increased visceral adiposity correlated with a greater risk of myocardial infarct (Yusuf et al, 2005).

Besides these biological factors, psychosocial factors seem to influence gender difference in CVD morbidity and mortality. In a recent study a higher "femininity" scores in men and so a lower stereotypically masculine self-image was associated with a lower risk of cardiovascular mortality. It is suggested that social constructs are important for health and may explain gender difference in longevity due to the substantial contribution of CHD to premature mortality (Hunt et al, 2007).

Furthermore the prevalence of cardiovascular risk factors in studies with a healthy population was higher in men in most European or North American studies but not in second world or developing countries like West-Bank, Benin, Taiwan. The prevalence of obesity was higher in men in most European studies whereas the prevalence was higher in women in studies performed in Benin, Europe, USA, Singapore, Cuba, Tunisia and West-Bank.
The higher occurrence of risk factors of women in developing countries and in emerging markets could be explained by the higher susceptibility of women for rapid transition from undernutrition to overnutrition (Delisle et al, 2008).
In nearly all countries men more often were smokers than women. The higher prevalence of risk factors in men in several European or North American studies could be caused by a more adverse lifestyle factor profile like the higher smoking rate and an unhealthier diet (Petersen et al, 2005).

Furthermore in this analysis ethnicity had a significant influence on CVD risk factors and CVD prevalence. Native Americans and blacks were affected by a cardiovascular event at the youngest age, followed by Hispanics. Asians and whites were significantly older than blacks and Hispanics. Hispanic CVD patients more likely had diabetes and hypertension than blacks, whites or Asians. Blacks more likely had diabetes and hypertension than Asians and whites and Asians had the lowest BMI. The prevalence of hyper- or dyslipidemia was higher in whites than in blacks and higher in blacks than in Asians. The cardiovascular risk factor profile was worse among Native Americans. In-hospital mortality rate and one-year mortality was slightly higher in Asians than in whites and not significantly different between Hispanics and non-Hispanic whites. Blacks had the lowest in-hospital mortality rate and a slightly lower one-year mortality rate than whites. It has to be considered that blacks are significantly younger than whites and Asians, so that an age-adjustment of in-hospital and one-year mortality could reduce or invert this lower rate of blacks. In one study black women had the highest mortality rate. It was suggested that the high prevalence of diabetes caused this low survival rate after one year (Quresi et al, 2006). The two-year mortality rate was lowest in Asians and highest in blacks. The significantly higher long-term mortality rate of blacks might be caused by ethnic difference in the pathophysiology of

cardiovascular diseases like the higher calcification of plaques during atherosclerosis (Detrano et al, 2003).

In cross sectional analysis of a healthy population the prevalence of cardiovascular risk factors was higher in Hispanics than whites and highest among black women. The prevalence of myocardial infarct and stroke and the mortality rate from myocardial infarct was slightly higher in white men than in women and in people from other ethnicity.

Literature reports showed significantly increased cardiovascular risks for blacks and slightly increased risks for Hispanics compared to whites which was independent of education and income (Seeman et al, 2008). Another study showed that an elevated risk for diabetes at same BMI for blacks, Asians and Hispanics compared to whites was found. This association of increasing BMI and greater weight gain and risk of diabetes was most pronounced among Asians (Shai et al, 2006).

The ethnic differences are partly related to socioeconomic differences because of the lower socioeconomic status or education of certain ethnic groups like blacks (Seeman et al, 2008).

One has to consider that in this analysis mostly the CVD prevalence of people with non-white ethnicity in countries with a white majority was compared. The prevalence of cardiovascular events or the occurrence of risk factor can differ significantly in their or their ancestor's original countries. Immigration was positively associated with increased burden of cardiovascular risk profile and sub-clinical atherosclerosis and increased over time as shown among Africans and Asians (Lear et al, 2009; Dominguez et al, 2008; Woo et al, 1999). Brondolo et al (2008) reported that perceived racism of blacks and Latinos was positively associated with nocturnal ambulatory blood pressure and so with an increased CVD risk even after adjusting to SES.

In a multic-ethnic study in Singapore Malay had the highest prevalence of obesity and hypertension whereas Indian people had the highest rate of dyslipidemia and diabetes. Interestingly, in another study included in this meta-analysis Chinese had a slightly higher stroke risk than Malay and Indians. The distribution of cardiovascular risk factors between the three ethnic groups was similar in another study performed in Singapore. In this study the highest prevalence of hypertension was found in Malay and the adverse lipid profile and the highest diabetes rate was

found in Indians. More Indians were overweight than Chinese or Malay and only slightly more Malay were obese than Indians (Ma et al, 2003). In addition to a higher prevalence of diabetes, Malays with diabetes had mortality rates which were nearly twice of those of Chinese and the rate of Indians with diabetes was more than threefold compared to a Chinese with diabetes (Ma et al, 2003). Another study showed that ethnicity was a significant predictor of cardiovascular disease even after adjustment for cardiovascular risk factors with the highest CVD risk for Indians (Lee et al, 2001). The multi-ethnic state Singapore has undergone rapid economic development over the past 30 years and urbanization which affected all three ethnic groups simultaneously. Distribution of socioeconomic class was relatively homogenous between people with different ethnicity. However, the three ethnic groups have not been equally affected by these changes when regarding cardiovascular risk factor prevalence, morbidity and mortality (Ma et al, 2003).

Furthermore the socioeconomic status influenced the prevalence of cardiovascular risk factors and diseases. The definition of the socioeconomic factors was very heterogeneous and they were mainly divided into general socioeconomic status, occupational class, educational class, residency and marital status. The age of CVD patients was only influenced by educational status with the youngest age in the group with medium educational level. The prevalence of diabetes and obesity among CVD patients was higher in groups with low SES. The same correlation was found with hypertension which was positively associated with low SES with the exception of one study where the relation was reverse. The in-hospital and 28-days-mortality was higher in the lowest income group.

In cross-sectional analysis with healthy patients a higher prevalence of the cardiovascular risk factors diabetes, hypertension, hyper- or dyslipidemia, obesity and smoking and a higher mean BMI was associated with a low SES indicated by educational or occupational status. In two studies performed in Africa or the Middle East an adverse risk factor profile correlated with urban residency. Furthermore occurrence of cardiovascular events was significantly correlated with low SES with a higher occurrence among men in all socioeconomic groups. These results go conform to literature report which showed a significant education and income gradient in cardiovascular, metabolic and inflammatory risk. This socioeconomic

and educational gradient in cardiovascular morbidity and mortality was seen within various ethnic groups (Seeman et al, 2008). In the study of Kivimäki et al (2007) it was shown that behavioural related risk factors like smoking, heavy alcohol consumption and physical inactivity were associated with low SES. Nevertheless these risk factors did not fully explain the socioeconomic difference of CHD. Another study reported that emotional stress was significantly associated with coronary heart disease risk in a low socioeconomic community (Kim et al, 2008). In contrast to another study which could not explain the socioeconomic gradient in the prevalence of the metabolic syndrome with psychosocial risk factors like fatigue and depression, perceived stress, social network and cohabitation and behavioural risk factors like smoking, alcohol and physical activity and low SES (Prescott et al, 2007).

Furthermore marital status influenced the occurrence of cardiovascular risk factors and the mortality rate. An especially adverse risk factor profile and mortality rate was found in divorced men. Most data was obtained from only one Japanese study and could vary in other countries.

Conclusion

Women were older than men at the incidence of the first cardiovascular event and had more likely hypertension and diabetes, but not significantly more likely hyperlipidemia and obesity. Women with CVD had a higher mortality rate which was not the case for age-adjusted mortality rate. The prevalence and mortality rate of cardiovascular diseases was higher among people of low socioeconomic status. Blacks and Hispanics had a higher incidence of cardiovascular risk factors compared to whites and Asians especially black women. Indian ethnicity was associated with adverse cardiovascular risk compared to Chinese and Malay. The prevalence of cardiovascular risk factors in a cross sectional analysis was higher among men in studies in Europe or North America, whereas the prevalence was higher in women in second world or developing countries. For developing global strategies to reduce cardiovascular burden the gender, ethnic and socioeconomic influences on cardiovascular risk factors, morbidity and mortality should be considered.

6. Abstract

Cardiovascular diseases (CVDs) are the principal cause of death worldwide. The prevalence of several risk factors like abdominal obesity, hypertension, hyper- and dyslipidemia and diabetes and lifestyle factors like smoking, physical activity and alcohol intake correlates with the incidence of cardiovascular morbidity and mortality. In this study a systematic review and meta-analysis was performed to evaluate the influence of gender, ethnicity and socioeconomic status (SES) on the prevalence and outcome of cardiovascular diseases. Female gender was significantly correlated with a higher age at a cardiovascular event and with a higher prevalence of diabetes, hypertension and a higher mortality rate among CVD patients. In a healthy population the prevalence of cardiovascular risk factors was higher in men in most European or North American studies but not in second world or developing countries. In nearly all studies men more often were smokers than women. Furthermore ethnicity had a significant influence on CVD risk factors and CVD prevalence. Native Americans, blacks and Hispanics were affected by a cardiovascular event at a younger age than Asians and whites. Native American, Hispanic and black CVD patients more likely had diabetes and hypertension than whites or Asians. In-hospital mortality rate and one-year mortality was highest among Asians and lowest in blacks whereas two-years mortality rate was highest in blacks and lowest in Asians. In cross sectional analysis of a healthy population the prevalence of cardiovascular risk factors was higher in Hispanics than whites and highest among black women. The prevalence of myocardial infarct and stroke and the mortality rate from myocardial infarct was highest in white men. Indians had the adverse cardiovascular risk compared to Malay and Chinese. Low SES indicated by income, occupational class and educational class was associated with a higher prevalence of diabetes, hypertension and obesity among CVD patients and a higher mortality rate. Among a healthy population a higher prevalence of several cardiovascular risk factors correlated with a low SES, divorce or urban residency. The occurrence of cardiovascular events was significantly correlated with low SES with a higher occurrence among men in all socioeconomic groups.

This analysis implicates that strategies for reducing cardiovascular burden should consider gender, ethnic and socioeconomic differences.

Zusammenfassung

Kardiovaskuläre Krankheiten stellen weltweit die häufigste Todesursache dar. Sämtliche Risikofaktoren wie abdominale Adipositas, Hypertonie, Hyperlipidämie, Diabetes und Lebensstilfaktoren wie Rauchen, Bewegung und Alkoholkonsum korrelieren mit dem Auftreten kardiovaskulärer Krankheiten. In dieser Meta-Analyse wurde der Einfluss von Geschlecht, Ethnizität und sozio-ökonomischem Status auf die Häufigkeit kardiovaskulärer Krankheiten getestet. Frauen waren signifikant älter beim Auftreten kardiovaskulärer Krankheiten und litten an einer höheren Diabetes-, Hypertonie- und Mortalitätsrate. In Querschnittstudien von einer gesunden Probandengruppe war die Häufigkeit kardiovaskulärer Risikofaktoren höher bei Männern in den meisten Europäischen und Nordamerikanischen Studien und höher bei Frauen in Schwellen- oder Entwicklungsländern. In fast allen Studien waren mehr Männer Raucher als Frauen. Außerdem beeinflusste die Ethnizität das Auftreten von kardiovaskulären Risikofaktoren und Krankheiten. Amerikanische Ureinwohner, Schwarze und Lateinamerikaner waren jünger beim ersten kardiovaskulären Ereignis und hatten häufiger Diabetes und Hypertonie als Asiaten und Weiße. Die Mortalitätsrate im Krankenhaus und nach einem Jahr war höher bei Asiaten und geringer bei Schwarzen während die Mortalitätsrate nach zwei Jahren bei Schwarzen am höchsten und bei Asiaten am niedrigsten war. In Querschnittstudien war die Häufigkeit von kardiovaskulären Risikofaktoren bei Lateinamerikanern höher als bei Weißen und am höchsten bei schwarzen Frauen. Weiße Männer waren am stärksten von Herzinfarkt und Schlaganfall betroffen. Inder hatten ein ungünstigeres kardiovaskuläres Risiko als Chinesen und Malayen. Niedriger sozialer Status gemessen an Ausbildung, Beruf und Einkommen waren mit einer höheren Diabetes, Hypertonie und Adipositasrate sowie einer höheren Mortalitätsrate assoziiert. In Querschnittstudien korrelierte ein erhöhtes Auftreten sämtlicher kardiovaskulärer Risikofaktoren mit niedrigem sozio-ökonomen Status, Scheidung und urbanem Wohnsitz. Die Häufigkeit kardiovaskulärer Ereignisse korrelierte signifikant mit niedrigem sozio-ökonomischem Status mit einem höheren Auftreten unter Männern in allen sozialen Gruppen.
Strategien zur Reduzierung der globalen kardiovaskulären Epidemie sollten Geschlechts-. Ethnizitäts- und soziale Unterschiede berücksichtigen.

7. Abbreviations

ABI Ankle-brachial blood pressure index
ACS acute coronary syndrome
ATP Adult Treatment Pannel
BMI body mass index
CHD coronary heart disease
CVD cardiovascular disease
CRP C-reactive protein
DBP diastolic blood pressure
ECG electrocardiogram
EGIR European group for the study of insulin resistance
HDL high density lipoprotein
IMT intima media thickness
LDL low density lipoprotein
NCEP National Cholesterol Education Program
PAD peripheral arterial disease
PCI percutaneous coronary intervention
SA stable angina
SBP systolic blood pressure
SES socioeconomic status
WHO World Health Organization

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