Published in final edited form as:

J Cardiovasc Nurs. 2006 ; 21(5): 367–378.

Racial Disparities in Outcomes Following Coronary Artery Bypass Grafting

Marilyn Hravnak, PhD, RN, ACNP-BC, FCCM [Associate Professor],
School of Nursing, University of Pittsburgh, Pittsburgh, Pa

Said Ibrahim, MD, MPH [Associate Professor],
School of Medicine, University of Pittsburgh, Pittsburgh, Pa

Abigail Kaufer, RN, SRNA [Student],
School of Nursing, University of Pittsburgh, Pittsburgh, Pa

Ali Sonel, MD, MPH [Assistant Professor], and
School of Medicine, University of Pittsburgh, Pittsburgh, Pa

Joseph Conigliaro, MD, MPH [Associate Chief Medical Officer]
Program for Quality, Safety and Patient Rights, University of Kentucky Medical Center, Lexington, Ky

Abstract

More than 12 million people in the United States have coronary heart disease, the second leading cause of hospitalization in the United States. It is known that persons within racial minorities, specifically African Americans, have a higher prevalence of coronary heart disease, yet are much less likely to undergo invasive cardiac treatment interventions. An invasive intervention commonly used to treat coronary heart disease is coronary artery bypass grafting, with over 140,000 operations performed annually in the United States. However, blacks are known to experience higher post-coronary artery bypass graft morbidity and mortality. The causes for racial disparities in post-coronary artery bypass graft outcomes are not well known but may include factors related to the individual, provider, system, and society/environment, either alone or in combination. The purpose of this article is to provide an overview of the literature regarding disparities in the health and healthcare of black patients with coronary heart disease with respect to CABG, and examine potential hypotheses for variant outcomes after surgery.

Keywords

coronary heart disease; coronary artery bypass; disparities; race; population groups; Black African-American

More than 12 million people in the United States have coronary heart disease (CHD), the second leading cause of hospitalization in the United States.¹ Persons within racial minorities, specifically those belonging to the black race, have a higher prevalence of CHD,^{2(pp12–16)} yet are much less likely to undergo invasive cardiac treatment interventions.^{3–5} An invasive intervention commonly used to treat CHD is coronary artery bypass grafting (CABG), with over 140,000 operations performed annually in the United

States.⁶ However, blacks are less likely to undergo CABG than other racial populations with equivalent severity of disease,⁷ and they experience higher postsurgical morbidity and mortality.⁸ Although these racial disparities in post-CABG outcomes are frequently documented, the reasons remain unknown,^{3,4,9,10} but may include individual, provider, system, and social/environmental factors, either alone or in combination.¹¹ The purpose of this article is to provide an overview of the literature regarding disparities in the health and healthcare of black patients with CHD with respect to CABG, and examine potential hypotheses for variant outcomes. An electronic search was conducted of all existing literature. Keywords used in the search included: coronary artery bypass, disparities, race, population groups, Black, and African American. Research studies that clearly identified a purpose, methodology, statistical analysis and relation, and discussion of results, and were pertinent to the categories described within the following model, were included for consideration of discussion in the manuscript.

Model for Evaluating Racial Disparities in Health and Healthcare

Health disparities have been documented for as long as public health data have been recorded, and although death rates for many diseases have declined, gaps between white individuals and racial minority groups have shown little change.¹² The National Center for Health Statistics defines a disparity as the quantity that separates a group from a specified reference point on a particular measure of health that is expressed in terms of a rate, percentage, mean, or some other quantitative measure.¹³ *Healthy People 2010* indicates that the health of individuals and communities is determined by an array of critical influences, such as individual biology and behavior, physical and social environments, policies and interventions, and access to quality healthcare, and that differences in these influences can create disparities. One example of a model to evaluate health and healthcare disparities is used by the Center for Health Equities Research and Promotion (CHERP), a Veterans Affairs HSR&D Center of Excellence.¹¹ According to the CHERP model (Figure 1), health and healthcare disparities result from many factors. Differences in health can be related to *individual patient level factors* that result from genetic, biologic, or clinical differences among ethnic groups or genders. Some individual factors can also be attributed to culture and its effect on individual behavior or decision making. *Social and environmental factors* can also influence health and healthcare due to where people live and their exposure to diseases or harmful substances. Social factors, which can lead to disparities, include the availability of healthcare, level of income, or amount of education. Healthcare *providers* themselves are a factor in creating disparities. And finally, factors related to *health systems and health policy* can also affect disparities. Factors at this level contribute to differences in the quality of care, such as lack of provisions to overcome language barriers, geographic unavailability of quality healthcare, and the disproportionate presence of racial and ethnic minorities in lower-end health plans.¹⁴(p11) Many of these factors incorporated within the CHERP model, to be discussed, play a role individually or in combination to impact the health of black individuals with CHD, and the healthcare interventions (including CABG) used to treat their disease.

Overview of Research on Post-CABG Mortality in Black Patients

A number of studies have been conducted examining the short-term and long-term postsurgical outcomes of black patients who undergo CABG. Rumsfeld et al¹⁵ reported upon the short-term outcomes of 29,333 white and 2,500 black patients who underwent isolated CABG in any of the 43 hospitals participating in the Veterans Health Administration Continuous Improvement in Cardiac Surgery Program database (data from 1995 to 2001). They noted that at baseline, black patients were more likely to have had a prior percutaneous coronary intervention, ST-segment depression on preoperative

electrocardiogram, elevated serum creatinine, peripheral vascular disease, be current smokers, and receive preoperative diuretics. Conversely, white patients were more likely to have had prior heart surgery, lung disease, and have needed urgent or emergent surgery. They found no difference in unadjusted mortality between black and white patients at 30 days (3.9% vs 3.6%, $P = .48$), or at 6 months (6.3% vs 5.8%, $P = .27$). However, they did determine that the black patients were more likely to experience the following acute postoperative complications:

- renal failure requiring hemodialysis (black 1.7% vs white 1.0%, $P < .01$)
- prolonged mechanical ventilation (black 8.4% vs white 6.7%, $P < .01$)
- reoperation for bleeding (black 3.5% vs white 2.6%, $P < .01$)

They determined that although the black patients were more likely to have complications within 30 days after operation (OR, 1.28; $P < .01$), there were no significant differences in overall risk-adjusted mortality at 30 days or 6 months ($P = .59$ and $.31$, respectively). However, when they divided the study population into risk-deciles based upon preoperative risk, they did find between-group differences in patients in the lower-risk deciles. Black low-risk patients had a higher mortality than white low-risk patients at both 30 days (OR, 1.52; $P = .01$) and 6 months (OR, 1.45; $P < .01$). Further, black patients in the low-risk group had significantly more complications than white patients (12.3% vs 9%, $P < .01$). They therefore suggest that the higher mortality noted in the black low-risk patients as compared with the white low-risk patients was due to increased complications in this subgroup, a finding corroborated by others.¹⁶ They also suggest that the higher mortality in the low-risk black patient group may be potentiated by their greater prevalence of baseline hypertension (HTN), in turn perhaps leading to more left ventricular hypertrophy in black patients, a condition that has been associated with poorer outcomes regardless of race in other clinical settings.¹⁷

Differences in presentation and poorer post-CABG outcomes for black patients in the long-term have also been identified. Maynard and Ritchie¹⁸ also studied veterans (29,918 subjects, 8% black). They determined that black patients undergoing CABG were younger, less often married, and less likely to receive internal mammary artery (IMA) grafts, and that black patients had more HTN (84% vs 54%), diabetes (36% vs 23%), and more active smoking (21% vs 14%, all $P < .05$). At 2 years post-CABG, black patients had a 9% higher risk of death (OR, 1.09; CI, 1.03–1.14; $P = .01$), and also had a 3% higher risk for rehospitalization (OR, 1.03; CI, 1.00–1.05; $P = .02$). Gray et al¹⁹ also examined long-term outcomes post-CABG in a sample of 3,728 isolated CABG patients in a single institution. They determined that the survival probability was worse for black than white patients at 1 year after surgery (84% vs 92%, respectively), and that this survival disparity widened at 5 years (only 64% vs 82%, $P = .001$). In addition to increased mortality, racial disparities have been noted in the need for higher readmission post-CABG. Hannan et al²⁰ examined the New York State data-base for risk factors for early re-admission post-CABG surgery. Of 16,325 eligible patients, 12.9% were readmitted within 30 days for CABG-related reasons. The most common causes for readmission were infection (28%) and heart failure (16%). Black race was a significant predictor for readmission, as was older age, female gender, increased body surface area, and comorbidities. Some of the limitations of the above named studies include the focus upon primarily male veterans, which limits generalizability and retrospective review of administrative databases.

The causes for these documented higher complications, mortality, and readmission rates for black patients after CABG are not well known, but a variety of factors discussed below, either singly or in combination, may be implicated.

Individual Patient Level Factors

Modifiable and Nonmodifiable Risk Factors

Major CHD risk factors, described by the American Heart Association and the American College of Cardiology, are HTN, elevated levels of serum total cholesterol and low-density lipoprotein cholesterol, low high-density lipoprotein cholesterol, diabetes mellitus (DM), and advancing age.²¹ These major risk factors are independently predictive, as well as additive, in their predictive power. Predisposing risk factors have also been identified (obesity, abdominal obesity, physical inactivity, familial history of CHD, minority race/ethnicity, and psychosocial factors), and although each may be independently predictive of CHD risk, their causative relationship is not as well defined.^{21,22} Although some of the risk factors cannot be changed, modifiable risk factors (MRFs), such as HTN, hypercholesterolemia, DM, obesity, and physical inactivity, can potentially be acted upon to diminish risk.

The First National Health and Nutrition Examination Survey (NHANES 1) from 1971 to 1975 established that black individuals with CHD had an increased prevalence of HTN and smoking, and were more likely to be female, but had lower mean serum cholesterol levels²³ and higher high-density lipoprotein cholesterol²⁴ than white individuals with CHD. These findings continue to be corroborated by *Healthy People 2010*^(pp12–27) and others.^{25,26} Diabetes mellitus, obesity, and physical inactivity have also been shown to be more prevalent in blacks with CHD.^{27,28} The Meharry Cohort Study followed black medical students from Meharry Medical College (classes 1957–1964, $n = 435$) and white medical students from Johns Hopkins University (classes 1957–1964, $n = 580$).²⁹ At baseline, black medical students had a higher systolic blood pressure (120 vs 116 mm Hg). At follow-up (25–35 years later), black physicians had a higher (1.4 times) incidence of CHD and much higher case fatality (51.5% vs 9.4%). Predictors of cardiovascular disease in the white physicians were smoking, cholesterol, and paternal history, whereas HTN was the best predictor in the black physicians.³⁰ It is possible that this predisposition of blacks to HTN at an early age sets the stage for later coronary disease with a more lethal impact.

One of the earliest evaluations of survival of black patients after CABG used data from the Coronary Artery Surgery Study (CASS),³¹ wherein subjects were randomized to CABG or medical management. In a post hoc analysis, age and sex-adjusted survival at 5 years was higher for white than black patients ($P < .0001$). Of note, black patients were more likely to have normal coronary arteries despite the presence of chest pain. Modifiable risk factors impacted survival. If both smoking and HTN were present, 5-year survival was 83% for white and 79% for black patients (P value not reported). This study provided the first evidence that MRFs had a more negative impact upon post-CABG survival for black patients despite less angiographic evidence of epicardial disease.

Contemporarily, Hartz et al¹⁶ examined 30-day operative mortality after isolated CABG using the Society of Thoracic Surgeons national database records of 441,452 patients (nonwhites 11.9%). Nonwhite patients were younger and had a higher incidence of renal failure and DM ($P < .001$). Of concern, nonwhite patients had a higher operative mortality among the low-risk subgroups (up to 10% of predicted operative mortality, $P < .05$), but there were no differences for higher risk subgroups. Bridges et al³² conducted a retrospective study using the same database to examine the operative (30-day) mortality of 581,789 patients (black patients 4.4%) undergoing isolated CABG. Black patients were more likely to be younger, female, and have HTN, DM, and heart failure. Using stepwise logistic regression, 27 preoperative characteristics were identified as significant predictors for operative mortality. After controlling for these risk factors, black patients still had a 29% higher operative mortality risk as compared with white patients (OR, 1.29; CI, 1.21–1.38),

indicating that race was an independent risk factor of mortality. Once again, racial differences in mortality were greatest among those at lowest predicted operative risk (OR, 1.83) compared with highest risk subjects (OR, 1.03). Additionally, the hypertensive black patients had a higher mortality rate (4.12%) as compared with hypertensive white patients (3.46%). Because black patients were generally younger and slightly sicker for their age, the authors hypothesized that race might be a marker for patients with a more destructive type of CHD and a more rapid rate of coronary disease progression specifically, and vascular disease in general. An alternative hypothesis may be that when black patients are relatively well and the treatment is less well defined, they get inferior care, but when they become sicker and the treatment and management is more obvious, the care becomes more equal.

In another study more specifically aimed at examining short-term post-CABG outcomes for patients with diabetes, Woods et al³³ examined 30-day mortality for 6,711 patients (2,178 patients with diabetes and 4,533 patients without diabetes). They found more black patients in the diabetic group (9.3%) than in the nondiabetic group (5.2%, $P < .001$). Diabetic patients experienced significantly more mortality than the patients without diabetes (RR, 1.67; CI, 1.20–2.3; $P < .004$). Additionally, the diabetic patients had more left ventricular hypertrophy and were more likely to have histories of cerebrovascular disease and HTN. Although data were not examined specifically with regard to race, the increased prevalence of diabetes and HTN in the black population may indicate that differences in DM prevalence might contribute to the variant short-term outcomes between racial groups.

Other research has examined the impact of race and MRFs upon long-term post-CABG mortality. Gray et al¹⁹ retrospectively examined race and 5-year CABG outcomes in 3,230 patients (black 3%). Black patients were more likely than white patients to have HTN (84% vs 54%), DM (36% vs 23%), and be currently smoking (21% vs 14%, all $P < .05$). Operative mortality was similar between groups (5.2% blacks vs 4.1% white, $P = .48$), but the late survival probability was significantly worse for black versus white patients at 1 year (84% vs 92%) and 5 years (64% vs 82%, $P = .001$). Medical insurance coverage was similar (Medicare 60% vs 57%, private 38% vs 42%, and Medi-Cal 2% vs 2%). Black patients had a 5-times higher risk for death at 5 years compared with whites, with some implication for the disparities in MRFs.

Brooks et al⁸ examined 3,839 patients revascularized by either percutaneous transluminal coronary angioplasty or CABG in the Bypass Angioplasty Revascularization Investigation (BARI) project to determine predictors of cardiac and noncardiac mortality at 5 years. Black race was an independent predictor of cardiac mortality at 5 years (adjusted RR = 1.49, $P = .019$), along with DM treated with insulin (RR = 2.08) or oral agents (RR = 1.68), age per decade (RR = 1.54), current smoker (RR = 1.72), former smoker (RR = 1.50), peripheral vascular disease (RR = 1.50), and HTN (RR = 1.40) (all $P < .001$).

In summary, black patients who undergo CABG are more likely to have more postsurgical complications, and increased mortality among lower surgical risk patients, as well as increased mortality overall in the long-term. Possibly, some of these differences may be related to the corresponding differences in MRF profiles, in particular, the pattern of more HTN, smoking, and diabetes. However, the manner in which these MRF profile manifests in differences in disease expression, either pathophysiologically or histologically, is still not explained.

Physiologic Factors and Responses

Although, as described above, documented differences in MRFs may contribute to some of the differences seen in post-CABG outcomes for black and white patients, why these differences in risk factor profiles exist at all, and how they contribute to outcomes, are still

not well explained. Some theorize that CHD in black patients is more likely to cause small-vessel disease that is less amenable to epicardial revascularization,³² a theory supported by their more limited epicardial arterial stenosis^{5,34} and calcification.^{35,36} It is possible that the preponderance of HTN in the black population fosters the development of small (distal) coronary vessel disease, whereas the preponderance of hypercholesterolemia in the white population fosters the development of disease in larger (proximal) vessels.

Differences in Vasoreactivity—Why HTN is more prevalent and consequential in black patients is not well explained. There is some evidence that white and black individuals demonstrate differences in vasoreactivity. Ergul et al³⁷ demonstrated that plasma levels of endothelin-1 (ET-1), a powerful vasoconstrictor, were 4-fold to 8-fold higher in black individuals diagnosed with HTN than in whites diagnosed with HTN and white normotensive controls, respectively. A later study by Ergul et al³⁸ examined endothelin receptors, as the density of endothelin-receptor subtypes (endothelin A [ETa] on endothelial cells and endothelin B [ETb] on smooth muscle cells) is the major determinant of the contractile response to ET-1. They examined samples of saphenous veins obtained from black and white patients undergoing CABG, and determined that whereas only ETa receptors were present in the saphenous veins of white patients, the veins of Black patients contained both ETa and ETb receptors, thereby denoting a higher propensity for vasoconstriction. In a study by Grubbs et al,³⁹ also utilizing saphenous vein samples, the effects of race upon vascular mRNA and protein levels of ET-converting enzyme (ECE)-1 subisoforms, ET-1, and ET receptor profiles in HTN were examined. The ETb mRNA was 3-fold higher in blacks, who also demonstrated higher vascular ET-1 levels and ECE-1 activity, suggesting that the biosynthetic activity of ET-1 is activated to a higher degree. Therefore, these studies imply that augmented synthesis and reception to endothelin leads to black patients having more reactive vessels, which may in turn play a role in the increased prevalence and consequence of HTN in black individuals. Theoretically, these variations may be further implicated in the noted differences in post-CABG outcomes for black patients. However, this chain of hypotheses has never been tested or demonstrated.

Differences in Hyperlipidemia and Manifestations—Strong and McGill⁴⁰ reported that black patients demonstrated a greater prevalence of arterial fatty streaks than white patients, whereas white patients had a greater prevalence of arterial fibrous plaques. Lee et al⁴¹ reported that atherosclerotic calcification, identified by computed tomography, is less prevalent and severe in black patients. Doherty et al⁴² also noted less coronary calcium mass in black patients by electron-beam computed tomography that could not be explained by differences in calcium metabolism. Newman et al³⁵ also found lower coronary artery calcification scores as calculated from electronbeam computed tomography for black patients compared with white patients, even among a subset of those who had had a prior myocardial infarction. However, black patients have been shown to demonstrate more pronounced arterial intimal thickness than white patients.⁴³

These findings may imply a hypothesis that CHD in blacks is more likely related to small-vessel disease resulting in cardiomyopathy manifested by chronically increased oxygen demand, whereas CHD in whites is related to more prominent atherosclerosis in epicardial vessels and acutely decreased oxygen supply. Whether these differences are genetically based, linked to ethnic variation in risk factors, mediated by socioeconomic and environmental conditions, or by interactions between these variables still remains unknown. Others suggest that there may be slight genetic variations between races that influence CHD development, thereby altering disease susceptibility and response to drug therapy⁴⁴ and resulting in more significant physiologic consequence.

Patient Preferences—How patient preferences affect the outcomes of black patients undergoing CABG also remains underexplored. It is known that black patients are more likely to refuse recommendations for CABG surgery than white patients. Kelly et al⁴⁵ gathered clinical and diagnostic cardiac catheterization data for 1,961 black and white patients at an inner-city hospital. They did not demonstrate any significant differences with regard to recommendations for revascularization for black and white patients with 3-vessel or left main coronary artery disease (87% vs 92%, respectively, $P = .39$). Although there was no difference between black and white patients regarding performance of recommended angioplasty (80% vs 85%, $P = .39$), black patients were significantly less likely to undergo recommended CABG than white patients (52% vs 72%, $P = .002$), and these differences become greater as the extent of coronary artery disease increased. After adjustment for clinical characteristics, black race was a significantly negative predictor for patients receiving a recommended CABG (OR, 0.43; CI, 0.27–0.70; $P = .004$), but not angioplasty (OR, 0.84; CI, 0.43–1.66; $P = .68$). In another study, Hannan et al⁴⁶ examined 1,261 patients in New York state postangiography for whom CABG surgery was designated as appropriate and necessary by RAND methodology, and tracked their outcomes for 3 months. They found that after controlling for age, payer, number of vessels diseased, and left-main disease, black patients were significantly less likely to undergo CABG surgery than white patients (OR, 0.64; $P = .004$). Similar results were found by Kelly et al.⁴⁷ They analyzed treatment recommendations made following cardiac catheterization for 1,961 patients (83% black and 17% white). The treatment recommendations made for patients with significant coronary disease were not different ($P = .82$) between black and white patients for medical therapy (33% vs 30%), angioplasty (33% vs 31%), or CABG (33% vs 40%). Although there was no significant difference between groups in the patients who underwent recommended angioplasty (black 80% vs white 85%, $P = .39$), black patients were significantly less likely to undergo recommended CABG than white patients (52% vs 72%, respectively, $P = .002$).

The reasons for black patients not undergoing a recommended CABG procedure are not clear but can potentially be due to lack of understanding, differences in health beliefs, or even patient refusals. A higher refusal rate for CABG by black patients is documented in several studies,^{5,48,49} but the reasons for refusal are not well described. One reason could be a lack of familiarity with a procedure. Whittle et al⁵⁰ demonstrated that black patients were more likely to misunderstand the risks and benefits of revascularization procedures and were less likely to have a friend or close relative who had undergone CABG to serve as an information source. Gordon et al⁵¹ indicated that a patient's willingness to accept a revascularization procedure may be influenced by the effectiveness of the doctor-patient communication. However, how these differences in patients' preferences for not undergoing, or perhaps delaying, the CABG procedure upon both the short-term and long-term postprocedure outcomes of black patients is not known.

Provider Factors

It is possible that treatment decisions by providers may also play a role in racial disparities in post-CABG outcomes. Surgeons determine the type of conduit used—free or pedicled arterial grafts versus free saphenous vein grafts. Arterial conduits, in particular, IMA grafts, are shown to have superior late patency compared with saphenous vein grafts, and are associated with improved later survival times in patients with left anterior descending disease.⁵² However, a number of studies demonstrate lower utilization of IMA grafts for black patients.

Analyses of the BARI (previously described) data demonstrated that IMA conduits were used less frequently in elderly, female, and black patients (83% white vs 65% black, $P < .05$).⁵³ This same finding of less IMA grafting has also been reported more contemporarily

by Groeneveld et al.⁵⁴ Using a 12-year (1989–2000) sample of Medicare Provider Analysis and Review record data for over 2 million patients, they also found that black patients were less likely to receive an IMA graft (OR, 0.43; CI, 0.40–0.46; $P < .01$). Although conduit selection occurs at the preference of the surgeon, this study also noted that technology utilization per hospital site is also implicated, and that IMA graft utilization was lower for black patients treated in hospitals with larger black populations. They noted that, compared with black patients admitted to hospitals with <9% black patients, black patients admitted to hospitals with >20% blacks had significantly lower rates of IMA CABG (OR, 0.78; CI, 0.69–0.87). They suggest that technology adoption and utilization is lower in hospitals with higher proportions of black patients and may be a factor in the racial disparities seen in IMA graft selection as well. However, the reasons for lower arterial conduit selection, such as variant surgical suitability, provider bias, and black patients predominantly treated in hospitals with lower technology utilization, can be hypothesized but are not demonstrated.

Although it has not been studied specifically related to CABG, race has been demonstrated to independently predict provider's decisions. Schulman et al⁵⁵ studied the effect of race on primary care provider's decisions to refer patients for cardiac catheterization. They asked physicians in full-time clinical practice and who attended the 1997 meeting of the American College of Physicians or the 1996 annual meeting of the American Academy of Family Practice to view recorded interviews and evaluate other data for hypothetical patients (actors) in 8 clinical scenarios for CHD. The physicians were told they were participating in a study of clinical decision making, but they were not informed that the primary purpose of the study was to assess the effects of a patient's race and gender on decision making. The physicians were asked to categorize the patients according to their probability of clinically significant coronary disease, and whether they wished to refer the patient for cardiac catheterization in 1 of 8 clinical scenarios. The scenarios differed by age, race, and gender and included data on blood pressure, cholesterol, smoking history, diabetes, family history, and thallium stress tests. Logistic regression analysis indicated that black patients (OR, 0.60; $P = .02$) and women (OR, 0.60; $P = .02$) were less likely to be referred for cardiac catheterization than men and white patients, respectively, regardless of risk category, and that black women were the least likely to be referred. Thus, providers' decisions may be biased for reasons not explained by clinical criteria alone.

System and Social Factors

Healthcare Access

Research has shown that variables related to healthcare access and utilization must be taken into account when assessing minority health outcomes.^{56,57} The Institute of Medicine recently reported that a substantial number of studies have documented the existence of health disparities between races in the United States, but little has been done to elucidate their causes. The Institute of Medicine report suggests that decreased minority access to care is likely a significant contributor to disparities, and requires further study.¹⁴(p190) Some factors known to influence access and utilization besides race⁵⁸ include income,^{14,56} education,⁵⁹ insurance,⁶⁰ and having a usual care provider.^{61,62} Low-income families are twice as likely to recount decreased access to healthcare. More than twice as many uninsured persons complain of reduced care access compared with persons holding private insurance. Medicare-eligible persons are least likely to report this problem.⁶³ Although Medicaid may improve access for the uninsured,⁶⁰ recipients report less ease of access. Lack of a usual provider is another important influence. Lack of a primary care provider was predictive of uncontrolled HTN among black and Hispanic patients (OR, 3.5; CI, 1.6–7.7), whereas lack of health insurance was only marginally predictive when adjusted for lack of primary care provider,⁶¹ a finding corroborated by others.⁶⁴ However, there is conflict regarding the impact of insurance and accessibility upon outcomes, as some studies indicate

that racial disparities exist even in systems where there are no financial barriers to access, such as the Veterans Administration Healthcare System.^{7,65}

How access to (and utilization of) healthcare impacts post-CABG outcomes has been examined to only a small degree. There is recent evidence that even when patients receive CABG surgery, racial minorities are more likely to be treated by lower quality providers. Rothenberg et al⁶⁶ examined the New York State hospital discharge data for 1996 to 1997 for all patients undergoing CABG as well as the risk-adjusted mortality rates for cardiac surgeons as calculated by the New York State Department of Health. They found that black patients were treated by surgeons with higher risk-adjusted mortality rates as compared with white patients. Even after adjusting for the hospital to which the patients were admitted, and the education and income of the patient, race continued to be associated with treatment by a surgeon with a higher risk-adjusted mortality. Although not specifically examined, they hypothesize that patients treated by surgeons with higher risk-adjusted mortality could experience not only higher mortality but also higher rates of complications and poorer outcomes. They concluded that improving not only access to care but the quality of care to which patients have access must be achieved to eliminate racial disparities in post-CABG outcomes. A similar finding of nonwhites being significantly more likely to have their CABG performed by surgeons with higher risk-adjusted operative mortality was also reported by Mukamel et al.⁶⁷

Fiscella et al⁶⁸ noted that hospital characteristics may be implicated in racial disparities in overall surgical outcomes. They examined New York State hospital discharge data from 1998 to 2000 ($n = 145,833$ black and $865,293$ white patients). The black patients were more likely to be admitted to hospitals located in zip codes with lower median income, or that served more patients who were black or had Medicaid. Following adjustment for patient age and gender, the black patients had higher adjusted odds for developing a complication following any surgical procedure including CABG (OR, 1.65; CI, 1.51–1.81). When further adjusted for comorbid conditions and length of stay (LOS), the odds for black patients developing a complication decreased to 1.19 (CI, 1.09–1.31), and when adjusted for hospital characteristics, the odds for complication development dropped to only 1.06 (CI, 0.96–1.17). They concluded that both comorbidities and hospital characteristics explained the higher rates of surgical complications for black patients.

Konety et al⁶⁹ corroborated that hospital characteristics were also different for black and white patients undergoing CABG, and that black patients were more likely to undergo CABG at hospitals with the highest mortality and the lowest procedural volume.

Socioeconomic Status

Race and socioeconomic status (SES) are closely entwined in the United States, and separating health outcomes related to race from health outcomes related to socioeconomic deprivation is difficult.⁷⁰ Nevertheless, several studies have been conducted examining the impact of SES upon post-CABG outcomes.

Johnston et al⁷¹ explored the potential link between SES and social situation on post-CABG prolonged LOS defined as more than 7 days. They examined 1,073 subjects undergoing isolated CABG and determined that self-reported variables that were significantly associated with extended LOS were: not being married (OR, 12.3; $P < .001$), unemployment (OR, 18.0; $P < .001$) and 1 or more social risk factors such as loneliness, not having someone to trust, and living alone or not enough social contact (OR, 19.3; $P < .001$). They also applied the Medical Outcomes Short Form 36 (MOS-SF 36), a 36-item survey which assesses how patients perceive that their physical and emotional health impacts their quality of life.⁷² In multivariate analysis, they found that the social risk variables noted previously and the

MOS-SF 36 physical health perception item were independently predictive of extended LOS (along with the clinical site and clinical factors of age, gender, comorbidity score, prior CABG, chronic heart failure, and preoperative stay >2 days). In their final prediction model, only clinical site was more highly predictive of extended LOS than the patients' social risk scales and their own perception of physical health. Thus, the facility where patients are able to receive care, their social situation, and their own perception of physical health all have an important impact upon outcomes that may exceed other clinical factors.

Boscarino and Chang⁷³ also found that lower SES was a predictor for adverse post-CABG outcomes. In a study of over 771 post-CABG patients over 36 postsurgical months, patients from counties with lower housing values had a significantly increased risk of death (HR, 2.46; CI, 1.26–4.78; $P = .008$), as did belonging to the black race (HR, 4.55; CI, 1.37–15.11; $P = .013$), suggesting that residence in a poor community and perhaps belonging to the black race are significant and independent risk factors for mortality 3 years after surgery.

Socioeconomic deprivation is a predictor of poor outcomes post-CABG outside the United States as well. Taylor et al⁷⁴ observed 3,578 isolated CABG patients in the United Kingdom divided into 5 quintiles of economic deprivation. A European System for Cardiac Operative Risk Evaluation (Euro-SCORE) value, which predicts the likelihood of cardiac surgical mortality based upon preoperative clinical factors and operative conditions,⁷⁵ was calculated for all patients. Higher socioeconomic deprivation scores were associated with younger age ($P < .004$), greater body mass index, diabetes, active smoking, and higher EuroSCOREs (all $P < .001$). After adjustment for EuroSCORE, socioeconomic deprivation was independently associated with combined postoperative myocardial infarction, stroke, and death ($P = .016$). Hospital LOS was also significantly higher for those in the lower income quintiles ($P = .03$). They suggest that lesser economic advantage is associated with a higher prevalence of MRF for CHD, and perhaps higher stress or different medical management. They indicate that these effects may be independent of race, as patients of minority races comprised only 1% of their population.

Payer Status

Several studies examined the relationship between payer status and post-CABG outcomes with attention to race. Higgins et al⁷⁶ retrospectively studied 2,776 subjects undergoing isolated CABG (18% black). Insurance status was comparable between black and white patients in the fee-for-service, managed care, and Medicare categories, but more black patients held Medicaid insurance than white patients (7.5% vs 1.4%, respectively). Black patients had a higher incidence of HTN, DM, and renal disease than white patients ($P < .001$). Thirty-day operative mortality was higher for black versus white patients (5.5% vs 2.5%; $P < .003$). Multivariate analysis found an association between mortality and procedure urgency, redo CABG, HTN, heart failure, age, and left ventricular ejection fraction, but payer status was not predictive.

In another study, Mancini et al⁷⁷ retrospectively reviewed 1,556 patients who underwent CABG in a public hospital to examine the impact of insurance status (insured vs uninsured) on 10-year survival. The uninsured cohort (66% of the total sample) was 72% white and 28% black. Mean age of the uninsured (55 years) was lower than that of insured patients (65 years, $P < .001$), with comparable left ventricular ejection fraction (63% vs 57%, respectively). There was no between-group difference in DM, HTN, hypercholesterolemia, or smoking. By Kaplan-Meier analysis, the uninsured had a significantly better 10-year survival (87%) than the insured (76%, $P < .05$). Although these findings suggest that insurance status does not determine survival, the disproportionately large number of white uninsured subjects, and lack of data regarding baseline health status, presence of MRFs, or income data, make interpretation of the findings difficult.

However, a study by Zacharias et al⁷⁸ did find payer status to be predictive of outcomes. They studied a sample of 6,377 patients (4.6% black, 92.4% white), and developed propensity scores based upon 37 variables accounting for demographic, comorbidity, functional status, and operative characteristics. They found that the unadjusted Kaplan-Meier 0–12 year survival was significantly worse for black patients (HR, 1.38; $P = .004$). However, in a regression analysis, only propensity score was a significant predictor for 0–12 year mortality ($P < .0001$), whereas race was not (HR, 1.15; $P = .28$), suggesting that demographic and clinical variables are responsible for the higher mortality for blacks rather than race per se. However, they did find that Medicaid status, which was 4-fold more frequent among black patients, was associated with a 61% greater 12-year mortality (HR, 1.61; $P < .0001$), despite those patients being an average of 5 years younger. They hypothesize that the differences in long-term outcomes may be due to less physician follow-up and risk factor modification programs in the Medicaid system but they also acknowledge that Medicaid is also a marker for lower SES, which can impact long-term post-CABG outcomes in ways that are independent of the Medicaid system. The reasons why insurance status was associated with poorer outcomes in this study and not detected by the 2 studies previously described may be due to its larger sample size.

CONCLUSIONS

Black patients undergoing CABG experience higher 30-day readmission rates, more complications, and higher mortality among low-risk groups in the short-term, as well as higher long-term mortality. Unfortunately, we still do not fully understand the causes of these racial disparities in post-CABG morbidity and mortality. We do know that differences in preoperative MRF profiles exist. Black patients exhibit more HTN and DM, and the causes remain unknown,⁷⁹ although differences in vascular reactivity and how hyperlipidemia is physiologically manifested may be implicated. Increased prevalence of smoking and physical inactivity among black patients has also been noted, although interaction of these learned risk-factor behaviors and socioeconomic and educational inequality may be possible. More research explicating why and how HTN, DM, and smoking set the stage for poorer postsurgical outcomes is needed. Possibly these particular risk factors result in more small-vessel disease and ventricular hypertrophy, leading to chronically increased oxygen demand. If such a situation coexists with and underlies the condition of large epicardial stenosis requiring revascularization, patients with these particular MRFs may be less well able to tolerate the myocardial stress of surgery. Racial and culturally specific risk factor modification in both the pre and post revascularization period may be needed.

The role of patient preferences is also poorly understood. It is known that black patients have a higher refusal rate for CABG than white patients, but whether this results in delay in undergoing CABG, which in turn results in more advanced myocardial disease at the time of surgery, still must be explored. Provider treatment selections may also be implicated, and the rationale for the lower use of arterial conduit grafts needs to be further explored, explained, and revised so that optimum long-term graft patency can be achieved.

Unequal access by black patients to healthcare or to inferior healthcare, which may result when patients lack a usual provider or are operated upon by surgeons with higher risk-adjusted mortality rates, has also been shown to be a factor in poorer post-CABG outcomes. The type and quality of care which patients can access is, however, linked to payer status, which is in turn associated with SES. Efforts to reduce these disparities in healthcare will not be achieved solely through health policy changes but will require changes in social and economic policy as well. It is unlikely that health disparities can be decreased unless healthcare disparities can be reduced or eliminated.⁸⁰

Therefore, how variances in individual, provider, system, and social factors contribute to these post-CABG outcome disparities, singly or in combination, must be better explored. Limitations in prior research include a focus upon retrospective review of administrative databases, which are not necessarily structured to answer clinical questions, and a dearth of prospective research outside the veteran's population, which limits generalizability. Concerted efforts by funding agencies to support prospective disparities research in the federal (National Institutes of Health, National Center on Minority Health and Health Disparities, Agency for Healthcare Research and Quality, Center for Disease Control) and private (Robert Wood Johnson Foundation, Hartford Foundation, Commonwealth Fund) sectors are ongoing. We have provided some direction for areas in which such research is needed. Nevertheless, awaiting this research should not delay the consistent application of established guidelines for cardiac care without regard for race or ethnicity, nor delay simultaneous efforts to eliminate known barriers to healthcare access.⁸¹

Healthy People 2010 calls for total elimination of racial disparities in health by 2010.²(p11) The number of racial minority citizens is expected to grow significantly, and although currently only 1 out of 5 US citizens is a person of color, this will increase to 1 out of 4 by the year 2050, and almost 1 out of 3 by 2100.⁸² Therefore, as the number of black individuals with CHD in the United States increases, we might anticipate that the trend toward higher mortality for black patients undergoing CABG will affect more individuals. It is important that we identify strategies to eliminate racial disparities in health and healthcare. Some action steps suggested by Lillie-Blanton et al⁸¹ include the following:

- Engage professional colleagues and patients in discussions on disparities in healthcare in general.
- Disseminate evidence on disparities in cardiac care in an effort to inform healthcare providers, patients and their families, and the general public.
- Participate in research efforts to identify the key determinants of the disparities in cardiac care and the best strategies for their elimination.
- Support community demonstration projects that target identification of best practices for eliminating psychosocial and environmental determinants of health disparities.
- Assure a culturally competent and diverse healthcare workforce.
- Make all efforts to provide language translation services available to patients who are not fluent in English.
- Form strategic partnerships with federal, state, and local health agencies and private foundations dedicated to the elimination of disparities in care.
- Recognize and address, whenever possible, discrimination of all forms when present in the healthcare setting.
- When necessary, refer patients to resources that address the effects of poverty and social exclusion.
- Support the *Health People 2010* partnerships and the overarching goal of eliminating health disparities.

Acknowledgments

Funding: 1 KO1 NR008560 National Institute of Nursing Research, HFP 01-063 Center for Health Equities Research and Promotion, VAHS R&D.

References

1. Elixhauser, A.; Yu, K.; Steiner, C.; Bierman, AL. Agency for Healthcare Research and Quality. AHRQ Publication No 00-0031. Rockville, Md: 2000. Hospitalization in the United States, 1997, HCUP Fact Book No. 1.
2. U.S. Department of Health and Human Services. Healthy People 2010. McLean, Va: International Medical Publishing; 2000.
3. Kressin NR, Petersen LA. Racial differences in the use of invasive cardiovascular procedures: review of the literature and prescription for future research. *Ann Intern Med.* 2001; 135:352–366. [PubMed: 11529699]
4. Petersen LA, Wright SM, Peterson ED, Daley J. Impact of race on cardiac care and outcomes in veterans with acute myocardial infarction. *Med Care.* 2002; 40(1 suppl):I86–I96. [PubMed: 11789635]
5. Conigliaro J, Whittle J, Good CB, et al. Understanding racial variation in the use of coronary revascularization procedures: the role of clinical factors. *Arch Intern Med.* 2000; 160:1329–1335. [PubMed: 10809037]
6. Society of Thoracic Surgeons National Database. [Accessed October 30, 2005] Executive summary —STS Spring 2005 report. Available at: <http://www.sts.org.documents.pdf/spring2005STSExecutiveSummary.pdf>
7. Conigliaro J, Whittle J, Good CB, Skanderson M, Kelley M, Goldberg K. Delay in presentation for cardiac care by race, age, and site of care. *Med Care.* 2002; 40(1 suppl):I97–I105. [PubMed: 11789636]
8. Brooks MM, Jones RH, Bach RG, Chaitman BR, Kern MJ, Orszulak TA. Predictors of mortality and mortality from cardiac causes in the bypass angioplasty revascularization investigation (BARI) randomized trial and registry. *Circulation.* 2000; 101:2682–2689. [PubMed: 10851204]
9. Mayberry RM, Mili F, Ofioi E. Racial and ethnic differences in access to medical care. *Med Care Res Rev.* 2000; 57:108–145. [PubMed: 11092160]
10. Sheifer SE, Rathore SS, Gersh BJ, et al. Time to presentation with acute myocardial infarction in the elderly: associations with race, sex and socioeconomic characteristics. *Circulation.* 2000; 102:1651–1656. [PubMed: 11015343]
11. Center for Health Equities Research and Promotion. [Accessed October 30, 2005] Available at: <http://www.cherp.research/med/va/gov/primer3.php>
12. Keppel KG, Percy JN, Wagener DK. Trends in racial and ethnic-specific rates for the health status indicators: United States, 1990–98. *Healthy People 2000 Stat Notes.* 2002; 23:1–16. [PubMed: 11808619]
13. Keppel K, Pamuk E, Lynch J, et al. Methodological issues in measuring health disparities. *National Center for Health Statistics. Vital Health Stat 2.* 2005; 141:1–16. [PubMed: 16032956]
14. Institute of Medicine. *Unequal Treatment: Confronting Racial and Ethnic Disparities in Health Care.* Washington, DC: National Academy Press; 2002.
15. Rumsfeld JS, Plomondon ME, Peterson ED, et al. The impact of ethnicity on outcomes following coronary artery bypass graft surgery in the Veterans Health Administration. *J Am Coll Cardiol.* 2002; 40:1786–1793. [PubMed: 12446062]
16. Hartz RS, Rao AV, Plomondon ME, Grover FL, Shroyer LW. Effects of race, with or without gender, on operative mortality after coronary artery bypass grafting: a study using the society of thoracic surgeons' national database. *Ann Thorac Surg.* 2001; 71:512–520. [PubMed: 11235699]
17. Benjamin EJ, Levy D. Why is left ventricular hypertrophy so predictive of morbidity and mortality? *Am J Med Sci.* 1999; 317:168–175. [PubMed: 10100690]
18. Maynard C, Ritchie JL. Racial differences in outcomes of veterans undergoing coronary artery bypass grafting. *Am J Cardiol.* 2001; 88:893–895. [PubMed: 11676956]
19. Gray RJ, Nessim S, Khan SS, Denton T, Matloff JM. Adverse 5-year outcome after coronary artery bypass surgery in blacks. *Arch Intern Med.* 1996; 156:769–773. [PubMed: 8615710]
20. Hannan E, Racz MJ, Walford G, et al. Predictors of readmission for complications of coronary artery bypass graft surgery. *JAMA.* 2003; 290:773–780. [PubMed: 12915430]

21. Pearson TA, Blair SN, Daniels SR, et al. AHA guidelines for primary prevention of cardiovascular disease and stroke: 2002 update: consensus panel guide to comprehensive risk reduction for adult patients without coronary or other atherosclerotic vascular diseases. *Circulation*. 2002; 106:388–391. [PubMed: 12119259]
22. Grundy SM, Pasternak R, Greenland P, Smith S, Fuster V. Assessment of cardiovascular risk by use of multiple-risk-factor assessment equations. *J Am Coll Cardiol*. 1999; 34:1348–1359. [PubMed: 10520820]
23. Gillum RF, Mussolino ME, Madans JH. Coronary heart disease incidence and survival in African-American women and men: the NHANES I epidemiologic followup study. *Ann Intern Med*. 1997; 127:111–118. [PubMed: 9229999]
24. Harris-Hooker S, Sanford GL. Lipids, lipoproteins and coronary heart disease in minority populations. *Atherosclerosis*. 1994; 108(suppl):S83–S104. [PubMed: 7802731]
25. Zoratti R, Godsland IF, Chaturvedi N, Crook D, Crook D, Stevenson JC. Relation of plasma lipids to insulin resistance, nonesterified fatty acid levels, and body fat in men from three ethnic groups: relevance to variation in risk of diabetes and coronary disease. *Metabolism*. 2000; 49:245–252. [PubMed: 10690953]
26. Zoratti R. A review on ethnic differences in plasma triglycerides and high-density-lipoprotein cholesterol: is the lipid pattern the key factor for the low coronary heart disease rate in people of Africa origin? *Eur J Epidemiol*. 1998; 14:9–21. [PubMed: 9517868]
27. Gillum RF, Mussolino ME, Madans JH. Diabetes mellitus, coronary heart disease incidence, and death from all causes in African American and European American women. The NHANES I epidemiologic follow-up study. *J Clin Epidemiol*. 2000; 53:511–518. [PubMed: 10812324]
28. Potts JL, Thomas J. Traditional coronary risk factors in African Americans. *Am J Med Sci*. 1999; 317:189–192. [PubMed: 10100693]
29. Thomas J, Semanya K, Thomas CB, et al. Precursors of hypertension in black compared to white medical students. *J Chronic Dis*. 1987; 40:721–727. [PubMed: 3597674]
30. Thomas J, Thomas DJ, Pearson T, Klag M, Mead L. Cardiovascular disease in African American and white physicians: the Meharry Cohort and Meharry-Hopkins Cohort Studies. *J Health Care Poor Underserved*. 1997; 8:270–283. [PubMed: 9253218]
31. Maynard C, Fisher LD, Passamani ER. Survival of black persons compared with white persons in the coronary artery surgery study (CASS). *Am J Cardiol*. 1987; 60:513–518. [PubMed: 3498357]
32. Bridges CR, Edwards FH, Peterson ED, Coombs LP. The effect of race on coronary bypass operative mortality. *J Am Coll Cardiol*. 2000; 36:1870–1876. [PubMed: 11092658]
33. Woods SE, Smith JM, Sohail S, Sarah A, Engle A. The influence of type 2 diabetes mellitus in patients undergoing coronary artery bypass graft surgery. *Chest*. 2004; 126:1789–1795. [PubMed: 15596675]
34. Ibrahim SA, Whittle J, Bean-Mayberry B, Kelley ME, Good C, Conigliaro J. Racial/ethnic variations in physician recommendations in cardiac revascularization. *Am J Public Health*. 2003; 93:1689–1693. [PubMed: 14534223]
35. Newman AB, Naydeck BL, Whittle J, Sutton-Tyrell K, Edmunowicz D, Kuller LH. Racial differences in coronary artery calcification in older adults. *Arterioscler Thromb Vasc Biol*. 2002; 22:424–430. [PubMed: 11884285]
36. Whittle J, Conigliaro J, Good B, Hanusa BH, Macpherson DS. African-American–Caucasian differences in severity of coronary artery disease among individuals with acute coronary syndromes. *J Gen Intern Med*. 2002; 17:876–882.
37. Ergul S, Parish CD, Puett D, Ergul A. Racial differences in plasma endothelin-1 concentrations in individuals with essential hypertension. *Hypertension*. 1996; 28:652–655. [PubMed: 8843893]
38. Ergul A, Tackett R, Puett D. Distribution of endothelin receptors in saphenous veins of African-Americans: implications of racial differences. *J Cardiovasc Pharm*. 1999; 34:327–332.
39. Grubbs AL, Anstadt MP, Ergul A. Saphenous vein endothelin system expression and activity in African-American patients. *Arterioscler Thromb Vasc Biol*. 2002; 22:1122–1127. [PubMed: 12117726]
40. Strong JP, McGill HC. The natural history of aortic atherosclerosis: relationship to race, sex and coronary lesions in New Orleans. *Exp Mol Pathol*. 1963; (suppl 1):15–27. [PubMed: 14079281]

41. Lee TC, O'Malley PG, Feuerstein I, Taylor AJ. The prevalence and severity of coronary artery calcification on coronary artery computed tomography in African-American and Caucasian patients. *J Am Coll Cardiol.* 2003; 41:39–44. [PubMed: 12570942]
42. Doherty TM, Tang W, Dasalos S, et al. Ethnic origin and serum levels of 1 alpha, 25-dihydroxyvitamin D3 are independent predictors of coronary calcium mass measured by electron-beam computed tomography. *Circulation.* 1997; 96:1477–1481. [PubMed: 9315534]
43. Manolio TA, Burke GL, Psaty BH, et al. African-American Caucasian differences in subclinical disease among older adults: the Cardiovascular Health Study (CHS) [abstract]. *Circulation.* 1993; 88:1913.
44. Wade, N. *The New York Times.* Jul 30. 2002 Race is seen as real guide to track roots of disease. Sect F: 1(col. 1)
45. Kelly RF, Hashim AS, Al-Sallow R. Recommendations and performance of coronary revascularization procedures in black and white patients. *Am J Cardiol.* 2005; 96:215–217. [PubMed: 16018845]
46. Hannan E, van Ryan M, Burke J, et al. Access to coronary artery bypass surgery by race/ethnicity and gender among patients who are appropriate for surgery. *Med Care.* 1999; 31:68–77. [PubMed: 10413394]
47. Kelly RF, Hashim AS, Al-Dallow R. Recommendations and performance of coronary revascularization procedures in black and white patients. *Am J Cardiol.* 2005; 96:215–217. [PubMed: 16018845]
48. Ferguson JA, Tierney WM, Westmoreland GR, et al. Examination of racial differences in management of cardiac disease. *J Am Coll Cardiol.* 1994; 24:1297–1304. [PubMed: 7930253]
49. Whittle J, Conigliaro J, Good CB, Lofgren RP. Racial differences in the use of invasive cardiovascular procedures in the department of the Veterans Affairs medical system. *N Engl J Med.* 1993; 329:621–627. [PubMed: 8341338]
50. Whittle J, Conigliaro J, Good CB, Joswiak M. Do patient preferences contribute to racial differences in cardiovascular procedure use? *J Gen Intern Med.* 1997; 12:267–273. [PubMed: 9159695]
51. Gordon HS, Paternitti DA, Wray NP. Race and patient refusal of invasive cardiac procedures. *J Gen Intern Med.* 2004; 19:962–966. [PubMed: 15333061]
52. Eagle KA, Guyton RA, Davidoff R, et al. ACC/AHA guidelines for coronary artery bypass graft surgery: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. *J Am Coll Cardiol.* 1999; 34:1262–1347. [PubMed: 10520819]
53. Schaff HV, Rosen AD, Shemin RJ, et al. Clinical and operative characteristics of patients randomized to coronary artery bypass surgery in the bypass angioplasty revascularization investigation (BARI). *Am J Cardiol.* 1995; 75:18C–26C. [PubMed: 7801857]
54. Groeneveld PW, Laufer SB, Garber AM. Technology diffusion, hospital variation, and racial disparities among elderly Medicare beneficiaries. *Med Care.* 2005; 43:320–329. [PubMed: 15778635]
55. Schulman KA, Berlin JA, Harless W, et al. The effect of race and sex on physicians' recommendations for cardiac catheterization. *N Engl J Med.* 1999; 340:618–626. [PubMed: 10029647]
56. Fiscella K. Is lower income associated with greater biopsychosocial morbidity? Implications for physicians working with underserved patients. *J Fam Pract.* 1999; 48:372–377. [PubMed: 10334614]
57. Brodish PH, Massing M, Tyroler HA. Income inequality and all-cause mortality in the 100 counties of North Carolina. *South Med J.* 2000; 93:386–391. [PubMed: 10798507]
58. Fiscella K, Franks P, Doescher MP, Saver BG. Disparities in healthcare by race, ethnicity, and language among the insured: Findings from a national sample. *Med Care.* 2002; 40:52–59. [PubMed: 11748426]
59. Sorlie PD, Backlund E, Keller JB. US mortality by economic, demographic, and social characteristics: the national longitudinal mortality study. *Am J Public Health.* 1995; 85:949–956. [PubMed: 7604919]

60. Andrulis DP. Access to care is the centerpiece in the elimination of socioeconomic disparities in health. *Ann Intern Med.* 1998; 129:412–416. [PubMed: 9735070]
61. Shea S, Misra D, Ehrlich MH, Field L, Francis CK. Predisposing factors for severe, uncontrolled hypertension in an inner-city minority population. *N Engl J Med.* 1992; 327:776–781. [PubMed: 1501654]
62. Saver BG, Peterfreund N. Insurance, income, and access to ambulatory care in King County, Washington. *Am J Public Health.* 1993; 83:1583–1588. [PubMed: 8238683]
63. Lesser, CS.; Cunningham, PJ. Access to care: is it improving or declining?. Center for Studying Health System Change; Fall. 1997 data bulletin no. 1. Available at: <http://www.hschange.com> [Accessed December 5, 2005]
64. Sung JF, Harris-Hooker S, Alema-Mensah E, Mayberry R. Is there a difference in hypertensive claim rates among Medicaid recipients? *Ethn Dis.* 1997; 7:19–26. [PubMed: 9253552]
65. Sedlis SP, Fisher VJ, Tice D, et al. Racial differences in performance of invasive cardiac procedures in a department of Veterans Affairs Medical Center. *J Clin Epidemiol.* 1997; 50:899–901. [PubMed: 9291874]
66. Rothenberg BM, Pearson T, Zwanziger J, Mukamel D. Explaining disparities in access to high-quality cardiac surgeons. *Ann Thorac Surg.* 2004; 78:18–25. [PubMed: 15223394]
67. Mukamel DB, Murthy AS, Weimer DL. Racial differences in access to high-quality cardiac surgeons. *Am J Public Health.* 2000; 90:1774–1777. [PubMed: 11076249]
68. Fiscella K, Franks P, Meldrum MS, Barnett S. Racial disparity in surgical complications in New York state. *Ann Surg.* 2005; 242:151–155. [PubMed: 16041203]
69. Konety SH, Sarrazin MS, Rosenthal GE. Patient and hospital differences underlying racial variations in outcomes after coronary artery bypass surgery. *Circulation.* 2005; 111:1210–1216. [PubMed: 15769760]
70. Fiscella K, Franks P, Gold M, Clancy CM. Inequality in quality: addressing socioeconomic, racial, and ethnic disparities in healthcare. *JAMA.* 2000; 283:2579–2584. [PubMed: 10815125]
71. Johnston G, Goss R, Malmgren JA, Spertus JA. Health status and social risk correlates of extended length of stay following coronary artery bypass surgery. *Am Thorac Surg.* 2004; 77:557–562.
72. Ware JR, Sherbourne CD. The MOS 36-Item Short Form Health Survey (SF-36): I. Conceptual framework and item selection. *Med Care.* 1992; 30:473–483. [PubMed: 1593914]
73. Boscarino JA, Chang J. Survival after coronary artery bypass graft surgery and community socioeconomic status: clinical and research implications. *Med Care.* 1999; 37:210–216. [PubMed: 10024125]
74. Taylor FC, Ascione R, Rees K, Narayan P, Angelini GD. Socioeconomic deprivation is a predictor of poor post-operative cardiovascular outcomes in patients undergoing coronary artery bypass grafting. *Heart.* 2003; 89:1062–1066. [PubMed: 12923028]
75. European System for Cardiac Operative Risk Evaluation (EuroSCORE). [Accessed March 6, 2006] Available at: http://www.euroscore.org/euroscore_scoring.htm
76. Higgins RSD, Paone G, Borzak S, et al. Effect of payer status on outcomes of coronary artery bypass surgery in blacks. *Circulation.* 1998; (suppl 19):II46–II49. [PubMed: 9852879]
77. Mancini MC, Cush P, Sweatman K, Dansby J. Coronary artery bypass surgery: are outcomes influenced by demographics or ability to pay? *Ann Surg.* 2001; 233:617–622. [PubMed: 11323499]
78. Zacharias A, Schwann TA, Riordan CJ, Durham SJ, Shah A, Habib R. Operative and late coronary artery bypass grafting outcomes in matched African-American versus Caucasian patients. *J Am Coll Cardiol.* 2005; 46:1526–1535. [PubMed: 16226179]
79. Bridges CR. Cardiac surgery in African-Americans. *Ann Thorac Surg.* 2003; 76:S1356–S1362. [PubMed: 14530064]
80. Lillie-Blanton M, Maddox TM, Rushing O, Mensah GA. Disparities in cardiac care: rising to the challenge of health people 2010. *J Am Coll Cardiol.* 2004; 44:503–508. [PubMed: 15358011]
81. Lillie-Blanton, M.; Rushing, O.; Ruiz, A.; Mayberry, R.; Boone, L. Racial and ethnic differences in cardiac care: the weight of the evidence. The Henry J. Kaiser Family Foundation; 2002. Available at: <http://www.kff.org/minorityhealth/6040-index.cfm> [Accessed March 5, 2006]

82. U.S. Census Bureau. [Accessed December 5, 2005] National population projections: I. Summary files total population by race, Hispanic origin and nativity. (NP-T5) projections of the resident population by race, Hispanic origin and nativity: middle series: 1999–2100. [revised 2 Aug, 2002]. Available at: <http://www.census.gov/population/www/projections/natsumT5.html>

FIGURE 1.

Factors influencing health and healthcare disparities. Graphic provided by the Center for Health Equity Research and Promotion (CHERP), a VA HSR&D Center of Excellence.