Coronary artery bypass graft surgery: socioeconomic inequalities in access and in 30 day mortality. A population-based study in Rome, Italy

Carla Ancona, Nera Agabiti, Francesco Forastiere, Massimo Arcà, Danilo Fusco, Salvatore Ferro, Carlo A Perucci

Abstract

Objectives—To evaluate whether coronary artery bypass graft (CABG) surgery is equally provided among different socioeconomic status (SES) groups in accordance with need. To estimate the association between SES and mortality occurring 30 days after CABG surgery.

Design—Individual socioeconomic index assigned with respect to the characteristic of the census tract of residence (level I = highest SES; level IV = lowest SES). Comparison of age adjusted hospital admission rates of ischaemic heart disease (IHD) and CABG surgery among four SES groups. Retrospective cohort study of all patients who underwent CABG surgery during 1996–97.

Setting—Rome (2 685 890 inhabitants) and the seven cardiac surgery units in the city.

Participants—All residents in Rome aged 35 years or more. A cohort of 1875 CABG patients aged 35 years or more.

Main outcome measures—Age adjusted hospitalisation rates for CABG and IHD and rate of CABG per 100 IHD hospitalisations by SES group, taking level I as the reference group. Odds ratios of 30 day mortality after CABG surgery, adjusted for age, gender, illness severity at admission, and type of hospital where CABG was performed.

Results—People in the lowest SES level experienced an excess in the age adjusted IHD hospitalisation rates compared with the highest SES level (an excess of 57% among men, and of 94% among women), but the rate of CABG per 100 IHD hospitalisations was lower, among men, in the most socially disadvantaged level (8.9 CABG procedures per 100 IHD hospital admissions in level IV versus 14.1 in level I) rate ratio= 0.63; 95% CI 0.44, 0.89). The most socially disadvantaged SES group experienced a higher risk of 30 day mortality after CABG surgery (8.1%) than those in the highest SES group (4.8%); this excess in mortality was confirmed even when initial illness severity was taken into account (odds ratio= 2.89; 95% CI 1.44, 5.80).

Conclusions—The universal coverage of the National Health Service in Italy does not guarantee equitable access to CABG surgery for IHD2 patients. Factors related to SES are likely to influence poor prognosis after CABG surgery.

Although many studies have demonstrated that morbidity and mortality for various conditions are associated with socioeconomic status (SES), researchers have only recently begun to focus on two independent dimensions of equity: SES differences in access to treatment and SES differences in the outcome of medical interventions and surgical procedures. For various diseases, both people with low SES and ethnic minorities have been shown to have less equitable rates in the provision of health care than other sectors of the population. At the same time, survival after myocardial infarction or cancer has been found to be related to SES.

Several studies have shown a higher occurrence of ischaemic heart disease (IHD) among people with lower SES, even after controlling for cardiovascular risk factors. Coronary artery bypass graft (CABG) surgery is an effective treatment of IHD, and the provision of cardiac surgery can be used to test whether health care services are offered in an equitable fashion among patients who suffer by SES. A recent study has suggested a strong effect of SES on access to specialised cardiac services in Canada, a country with an universal health care system. Moreover, access to CABG surgery has been found to be associated with SES and racial/ethnic groups in the UK and in USA. At the same time, CABG surgery can be used to determine whether differences by SES exist in the effectiveness of treatment. Living in a poor community has been described as a significant and independent risk factor for mortality 36 months after CABG surgery. However, to the best of our knowledge, no studies have investigated the association between 30 day mortality after CABG surgery and SES.

To evaluate whether cardiovascular health care resources are equally provided among various SES groups in accordance with need, we investigated socioeconomic differences in the provision of CABG surgery in Rome (Italy). Moreover, we studied the association between SES and mortality occurring 30 days after CABG surgery.

Methods

DATA SOURCES AND SES

In Lazio, the region where Rome is located, hospital care (acute hospitalisation rate about 200 per 1000 inhabitants) is mostly covered by the National Health Service (NHS) through teaching and non-teaching hospitals. In Rome (2 685 890 inhabitants) there are seven specialised hospitals with CABG units (three teaching hospitals, two non-teaching public hospitals, and two private—non-NHS—hospitals).
Coronary artery bypass graft surgery

Discharge data on all IHD and CABG patients, aged 35 years or more, residing in Rome and hospitalised in 1996–97, were obtained from the Lazio Region Hospital Information System (HIS).

Individual socioeconomic data on hospitalised people are not available. However, a method to assign a SES to each citizen in Rome has been developed based on information collected at the level of census tract of residence, the smallest territorial unit for which population data are available (average of 480 inhabitants in each census tract). In brief, this method included the development of a small area socioeconomic index for the inhabitants of each census tract, according to selected census variables, including level of education, occupation, dwelling ownership, family size, and people/room density. Four levels of SES were defined (that is, SES levels I, II, III, and IV); SES level I refers to the population with the highest SES. According to Municipal Registry data, in 1996 residents in the four categories were as follows: level I = 302,771; level II = 514,731; level III = 459,198; level IV = 279,059. Based on the home address, a SES level was assigned to each IHD and CABG patient.

PATIENTS
To study early mortality after CABG surgery, on the basis of data from the HIS, we identified a cohort of 1875 patients (aged 35 years or more) residing in Rome who underwent CABG surgery in any of the city’s specialised hospitals with CABG units in the period 1996–97. Three people were excluded because information on the census tract of residence was missing; thus, 1872 patients were included in the analysis. The following individual information on patients was taken from the HIS database: gender, age, up to four diagnoses (ICD-9 codes) and up to four surgical procedures (ICD-9-CM codes) during the hospital stay, dates of hospital admission and discharge. Vital status (dead or alive) 30 days after hospital discharge was obtained for each patient from the Municipal Registry of Rome, which collects demographic information on all the residents in the city. Death attributable to any cause was considered the study end point.

SEVERITY OF ILLNESS
To adjust mortality rates with respect to the severity of illness on admission, we identified variables known to be associated with 30 day mortality after CABG surgery:

1. type of IHD (none, acute/subacute forms, angina pectoris, chronic forms, old myocardial infarction, acute myocardial infarction, mixed forms, defined when more than one type was reported);
2. comorbidities, defined as chronic conditions apart from IHD that existed before hospital admission (other heart disease, diabetes, hypertension, chronic obstructive pulmonary disease (COPD), chronic renal disease, malignant neoplasm, peripheral arterial disease including cerebrovascular disease);
3. heart surgery other than CABG and operations on arteries during the episode of care.

Comorbidities were defined according to the ICD-9 codes assigned by Deyo to the Charlson comorbidity index. Severity of illness did not include surgery related complications or death related conditions (for example, cardiac arrest).

ANALYSIS
We computed age standardised rates of hospitalisation for IHD (ICD-9 diagnosis codes 410–414) and CABG surgery (ICD-9-CM procedures code 36.1) by gender and SES level. We used all persons aged 35 years or more residing in Rome (1996) as the denominator population. All rates were directly standardised for age to the European standard population and expressed as the number of IHD hospital admissions and CABG procedures per 10 000 inhabitants. Given the severity of IHD, hospital discharge data can provide a fair approximation of the occurrence within the population and may be considered as a proxy of the population’s needs in terms of health care. We then analysed the age standardised ratio between the number of CABG operations and the number of IHD hospital admissions (CABG per 100 IHD) by SES level, separately for men and women.

We used rate ratios (RRs) to compare IHD hospital admission rates, CABG surgery rates, and CABG per 100 IHD among SES levels, using level I (highest SES) as the reference group. Confidence intervals (CI) were calculated at the 95% level of significance.

We evaluated the association between 30 day mortality and the four SES levels using logistic regression analysis (odds ratios (OR), and 95% CI). We adjusted for the following variables: age, gender, type of IHD, comorbidities, and other surgical procedures during the same admission (model 1: area under the receiver operating characteristic (ROC) curve = 0.789). In addition, we evaluated a model including the type of hospital (teaching, non-teaching, and private) as a potential confounder (model 2: ROC = 0.799). All analyses were conducted using the statistical program STATA 5.0.

Results
ACCESS TO CABG SURGERY AND SES
Table 1 shows the hospital admission rates (per 10 000) for IHD and CABG surgery by gender and SES level (level I = highest SES; level IV = lowest SES). In both genders, hospitalisation for IHD increased steadily with decreased SES. CABG hospitalisation rates among men were relatively constant among SES levels (RR 1.07, 95% CI 0.84, 1.35 when comparing level IV to level I). For women with the lowest SES (level IV), an increase in the CABG hospitalisation rate was observed (RR 2.05, 95% CI 1.22, 3.45 with respect to SES level I). However, the overall hospitalisation rate was lower among women than among men.

The rate of PCA per 100 IHD hospitalisations was lower among men with the lowest SES (RR 0.63, 95% CI 0.44, 0.89 when comparing level IV to level I). Among women, no
The document discusses the statistical significance of differences in patient characteristics and mortality within 30 days after a coronary artery bypass graft (CABG) surgery. Patients with the lowest socioeconomic status (SES) level showed a higher severity of illness compared to patients with the highest SES level. The percentage of patients treated in private hospitals was highest in level I (9.4% compared with 0.6% for level IV). Patients with the lowest SES showed a higher severity of illness upon hospital admission compared with patients with the highest SES (44.7% versus 37.9%). Overall, hypertension and diabetes were the most frequently reported comorbidities (18.3% and 13.5%, respectively); diabetes was more common in SES level IV compared with level I (16.3% versus 9.7%).
The overall crude mortality within 30 days after CABG surgery was 6.1%, with excess among patients in SES level IV (8.1%) compared with those in level I (4.8%). After adjusting for gender, age, type of IHD, comorbidities, and other surgical procedures during the same admission, we found a statistically significant association between SES and 30 day mortality (OR= 2.89; 95% CI 1.44, 5.80 when comparing level IV with level I) (table 4).

Variability in mortality was observed across hospitals: 5.0% for teaching hospitals, 9.5% for non-teaching hospitals, 2.3% for private hospitals; taking teaching hospitals as reference, and considering all the potential confounders included in model 1, non-teaching hospitals showed an excess in mortality risk (OR= 2.10, 95% CI 1.32, 3.34). The association between SES level and mortality was confirmed, though slightly reduced (OR= 2.45; 95% CI 1.21, 4.96), when we included in the model, as potential confounder, the type of hospital, a variable possibly related to the quality of care, thus representing an intermediate factor in the association under study (model 2 in table 4).

The possible effect modification of gender, age, and type of hospital on the relation between SES and 30 day mortality was tested by forcing interaction terms in the logistic model. However, no significant contribution was observed.

### Discussion

In Italy, as in the United Kingdom, the NHS theoretically provides universal coverage to any citizen in any part of the country without economic barriers to medical care. We found that, even though people with the lowest SES showed an excess in the age adjusted IHD hospitalisation rates compared with those with the highest SES (an excess of 57% among men and of 94% among women), the rate of CABG procedures per 100 IHD hospitalisations among men was lower in the most socially disadvantaged group. These data suggest that this sector of the population was receiving fewer operations than needed. Moreover, in our study, the most socially disadvantaged socioeconomic group experienced a higher risk of 30 day mortality after CABG surgery, even after taking into account differences in the initial severity of illness.

The medical decision to refer a patient for CABG surgery is complex. The physician’s choice of whether a patient should be managed conservatively or surgically mainly depends on the patient’s clinical characteristics (symptoms, exercise tolerance, angiographic evidence of coronary artery disease, and myocardial functional status). Medium and high risk patients with stable coronary artery disease are eligible for CABG surgery. A SES related difference in clinical indications for CABG surgery is an obvious explanation for the observed differences in rates of utilisation of CABG procedures in our study. We did not obtain information on all IHD hospitalised patients’ clinical characteristics to correctly estimate the need for surgery and the criteria used by clinicians. However, it is probable that IHD patients in the lower social class level had less favourable coronary profiles than people in the upper social class. In fact, disadvantaged patients tend to have more risk factors and more severe disease than those in the highest SES, and an association between SES and IHD mortality was observed in Rome. This could produce a possible underestimation of the association between access to CABG surgery and SES. Furthermore, IHD surgery is contraindicated for lower SES patients because of their more severe clinical conditions, this may imply a further discrimination, given that diagnostic and therapeutic measures for poor patients with IHD tend to be delayed compared with well off people.

Another possible explanation of our results is that patients with low SES could have received percutaneous transuminal coronary angioplasty (PTCA), an alternative revascularisation procedure for IHD patients. PTCA is generally used for treatment of proximal and single vessel disease lesions and only recently it has been proposed as an effective alternative to CABG surgery in selected populations of patients with multivessel coronary artery disease. Therefore, patients who are referred for PTCA have better medical baseline characteristics than those undergoing CABG. However, there is no evidence of the use of one revascularisation procedure for IHD patients compensating the lack of use of the other. Male age adjusted hospital admission rates for PTCA in Rome (1997; 580 hospitalisations) were not associated with SES level (level I 4.2 per 10 000; level IV 4.4 per 10 000).

We observed that women hospitalised for IHD undergo CABG surgery far less frequently than men. The association between access to CABG surgery and SES level (level I 4.2 per 10 000; level IV 4.4 per 10 000) was confirmed, even in countries with a NHS.

### Table 4 Socioeconomic status and 30 day mortality among patients with CABG surgery, Rome 1996–1997

<table>
<thead>
<tr>
<th>Patients</th>
<th>Mortality (%)</th>
<th>OR crude</th>
<th>OR1</th>
<th>95% CI</th>
<th>OR2</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>330</td>
<td>4.8</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>608</td>
<td>7.4</td>
<td>1.57</td>
<td>1.91</td>
<td>0.99, 3.67</td>
<td>1.89, 3.65</td>
</tr>
<tr>
<td>III</td>
<td>578</td>
<td>4.1</td>
<td>0.85</td>
<td>1.07</td>
<td>0.52, 2.19</td>
<td>0.93, 4.51</td>
</tr>
<tr>
<td>IV</td>
<td>356</td>
<td>8.1</td>
<td>1.74</td>
<td>2.89</td>
<td>1.44, 5.80</td>
<td>2.45, 1.21</td>
</tr>
</tbody>
</table>

OR1, odds ratios, adjusted for age, gender, type of IHD, comorbidities, other operations on heart apart from CABG, and operations on arteries. OR2, odds ratios, adjusted for age, gender, type of IHD, comorbidities, other operations on heart apart from CABG, operations on arteries, and type of hospital.

### Key Points
- Low social class people experience an excess in the age adjusted ischaemic heart disease (IHD) rates compared with people in the high social class level.
- Male patients in the low social class level receive coronary artery bypass graft (CABG) surgery less than those in the high social class level according to need.
- Socioeconomic status influence early mortality after CABG surgery, taking into account initial illness severity.
- Interventions to promote equal availability and effectiveness of CABG surgery for all citizens are recommended, even in countries with a NHS.
men. Such a sex bias in the delivery of CABG surgery has been previously reported, but the reasons for this evidence are still a matter of debate. Sex related differences in natural history of disease, behavioural and life style risk factors, and benefits from surgery have been advocated to explain this difference. We failed to show differences by SES among women. We cannot exclude that this is attributable to the limited sample size of our study among women (given \( \alpha=0.05 \), we had a power of 80% to detect \( RR \leq 0.59 \) or \( RR \geq 1.7 \), but we can also presume that gender differences were so strong that inequalities in provision of CABG surgery could not be detected.

Sociodemographic factors may also interact with clinical characteristics to both directly and indirectly influence the physician’s choice in diagnostic and therapeutic procedures. Han nan et al recently found that African-American and Hispanic candidates were less likely to undergo CABG surgery than white patients despite the fact that CABG surgery was clinically judged to be appropriate and necessary. Moreover, given that those patients who smoke have poorer results after revascularisation procedures, many clinicians are reluctant to perform these procedures unless patients have stopped smoking. Finally, a strong inverse relation between income and rates of use and waiting times for invasive cardiac procedures has been recently found in a cohort of acute myocardial infarction patients in Canada, after controlling for patients’ clinical characteristics.

The decision of whether or not a procedure will be performed also depends on the patient’s preferences for care, yet the issue of patient’s preferences versus physician’s judgement has received attention only recently. In our study, no information was available to determine the importance of patient’s awareness of their health status in explaining the observed differences among SES levels. It should also be pointed out that in Italy many surgeons belonging to the NHS also have private outpatient practices, though strict regulations to this regard have been issued. Thus, a patient who privately approaches a cardiologist employed by the NHS has a greater probability of receiving CABG surgery.

Mortality after CABG surgery is a function of the rate of occurrence of complications, and both mortality and complications have been shown to be closely related to the preoperative risk as predicted by different illness severity scores. Differences in the level of preoperative risk, including clinical symptoms, anatomic compromising of coronary vessels, adequacy of previous treatment, severity of comorbidities, immunological status, stress, depression, and social isolation could explain the finding that mortality after CABG surgery was highest among the people with the lowest SES. In fact, although people with low SES were significantly younger in our study, they had a higher prevalence of mixed forms of IHD (a presumable index of more severe disease), more comorbidities (diabetes, COPD), and more postoperative complications (table 3).

Differential standards of medical care and management, measured as percentage of medical injuries attributable to negligence, have been observed in New York. Egbert and Rothman have shown that African-Americans undergoing surgery are more likely to receive care from a physician in training than from a senior staff surgeon. The possibility that people with the lowest SES level have the worst prognosis as a consequence of inadequate medical care during CABG hospitalisation is difficult to evaluate in our study. We lack detailed information on the process of care (that is, technical aspects of operations, preoperative and postoperative care programmes) and other possible factors influencing poor prognosis after CABG surgery such as the ability to adapt lifestyle (smoking, diet) and compliance to treatment.

The interpretation of our results is potentially limited by several factors. People were classified using a small area index: although this index strongly predicts socioeconomic inequalities in mortality in Rome, it is still an aggregate index and individual data on various components of SES are lacking. However, aggregate indices of SES have been widely proposed in the US and in the UK as a valid mean of overcoming lack of individual information. The definition of the severity of illness was derived from the ICD-9 diagnosis and procedure codes, as assigned in the HIS database. Administrative data have been widely used to assess the effectiveness and quality of care provided by various services, especially in cardiac surgery. Although clinical datasets seem to be more accurate in detecting clinical and functional myocardial impairment, code-based measures have been shown to have good statistical performance in predicting inhospital deaths from CABG surgery. Moreover, we empirically attempted to distinguish comorbidities from complications and death related conditions, as suggested by other investigators, to improve the clinical validity of our model. We have no reason to suspect that the accuracy of coding may be biased toward a specific SES level.

Other studies have reported that access to a resource consuming procedure such as CABG surgery may be affected by SES. Inequalities in provision have been observed not only in the USA, where no NHS programme exists and where the patient’s insurance status could thus influence access to care, but also in Canada and the UK, countries with universal health coverage. Our study suggests that interventions to promote equal availability and effectiveness of CABG procedures will be crucial to reduce inequalities among social groups, even in countries with a NHS.
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*J Epidemiol Community Health* 2000 54: 930-935
doi: 10.1136/jech.54.12.930

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