Special Article

EFFECTS OF SOCIOECONOMIC STATUS ON ACCESS TO INVASIVE CARDIAC PROCEDURES AND ON MORTALITY AFTER ACUTE MYOCARDIAL INFARCTION

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ABSTRACT

Background Universal health care systems seek to ensure access to care on the basis of need rather than income and to improve the health status of all citizens. We examined the performance of the Canadian health system with respect to these goals in the province of Ontario by assessing the effects of neighborhood income on access to invasive cardiac procedures and on mortality one year after acute myocardial infarction.

Methods We linked claims for payment for physicians' services, hospital-discharge abstracts, and vital-status data for all patients with acute myocardial infarction who were admitted to hospitals in Ontario between April 1994 and March 1997. Patients' income levels were imputed from the median incomes of their residential neighborhoods as determined in Canada's 1996 census. We determined rates of use and waiting times for coronary angiography and revascularization procedures after the index admission for acute myocardial infarction and determined death rates at one year. In multivariate analyses, we controlled for the patient's age, sex, and severity of disease; the specialty of the attending physician; the volume of cases, teaching status, and on-site facilities for cardiac procedures at the admitting hospital; and the geographic proximity of the admitting hospital to tertiary care centers.

Results The study cohort consisted of 51,591 patients. With respect to coronary angiography, increases in neighborhood income from the lowest to the highest quintile were associated with a 23 percent increase in rates of use and a 45 percent decrease in waiting times. There was a strong inverse relation between income and mortality at one year ($P<0.001$). Each $10,000 increase in the neighborhood median income was associated with a 10 percent reduction in the risk of death within one year (adjusted hazard ratio, 0.90; 95 percent confidence interval, 0.86 to 0.94).

Conclusions In the province of Ontario, despite Canada's universal health care system, socioeconomic status had pronounced effects on access to specialized cardiac services as well as on mortality one year after acute myocardial infarction. (N Engl J Med 1999;341:1359-67.)

UNIVERSAL health care systems have been organized in most industrialized nations with a view to ensuring equitable access to medical services and improving health status for all citizens. Canada's federal–provincial Medicare plan covers all medically necessary services provided by hospitals and physicians without any user fees and is based on the principle of access according to need rather than income.[1,2] Considerable evidence suggests that Medicare has improved access to health services for poorer Canadians,[3,4] but some studies have found that those of low socioeconomic status remain less likely to receive specific services than wealthier patients.[3,5-7] Several Canadian studies have also demonstrated a persistent relation between socioeconomic class and health status.[8-10] For example, a recent population-based study conducted in Winnipeg, Manitoba, demonstrated a 43 percent relative increase in standardized mortality from ischemic heart disease among the lowest income quintile as compared with the highest.[8]

The available data on access to health care according to income in Canada can be challenged on the grounds that the study designs did not control adequately for potential differences in the severity of illness or health status among socioeconomic subgroups. Similarly, Canadian studies addressing differences in health status among socioeconomic groups have generally examined overall populations rather than groups of patients with specific major health problems.

We accordingly devised a two-pronged test of the degree to which the Canadian health system has achieved equity in access to care and outcomes. We examined data on patients who were hospitalized with acute myocardial infarction in the province of Ontario — first, to determine whether socioeconomic status (as indicated by neighborhood income levels)

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affected access to major coronary procedures and, second, to examine the associations between socioeconomic status and mortality one year after acute myocardial infarction. Because there is evidence that more aggressive use of revascularization does not lead to any immediate gains in life expectancy after myocardial infarction,[11-15] we did not expect that differences in the rates of use of procedures would affect medium-term survival. The two aspects of equity on which we wished to focus could therefore be analyzed independently.

METHODS

Sources of Data

We obtained information from the Ontario Myocardial Infarction Database (OMID),[16] which draws together data from a variety of administrative sources. Hospital-discharge abstracts compiled by the Canadian Institute for Health Information (CIHI) yielded information pertaining to the index admission, demographic characteristics of patients, coexisting illnesses, use of in-hospital procedures, and mortality. Data on claims for payment for physicians' services from the Ontario Health Insurance Plan and CIHI hospital-discharge data were used to determine rates of use of cardiac procedures. The Ontario Registered Persons Database provided us with data on mortality over time, regardless of where death occurred.

The cohort consisted of all patients admitted to a hospital with a "most responsible" diagnosis of acute myocardial infarction (code 410 of the *International Classification of Diseases, 9th Revision, Clinical Modification* [ICD-9-CM][17]) between April 1, 1994, and March 31, 1997, inclusive. The accuracy of the coding of acute myocardial infarction in the OMID data base has been validated previously through multicenter chart audits.[16] To reduce the chances that subgroups within the cohort varied in terms of the severity of cardiovascular disease, we excluded any patient who had been hospitalized with an acute myocardial infarction in the year before the index admission. We also excluded patients who were not residents of Ontario, patients with invalid Ontario health card numbers, patients who were younger than 20 or more than 105 years of age, those discharged alive for whom the total length of the hospital stay was less than four days, those for whom acute myocardial infarction was coded as an in-hospital complication, and those who had been transferred from another acute care facility. Complete details of and the rationale for the inclusion and exclusion criteria have been reported previously.[16]

In Ontario, administrative data do not include personal income. Hence, we used 1996 official Canadian census data to calculate the median income for each neighborhood area corresponding to the first three digits of the postal code (Forward Sortation Area), and imputed patients' incomes on the basis of their principal residence. Statistics Canada suppressed income data for 11 of the 504 Forward Sortation Areas in Ontario because of small samples. Accordingly, our cohort of patients with acute myocardial infarction was linked to income data for a total of 493 Forward Sortation Areas. Area-level data have been widely used to impute individual socioeconomic status, and inferences based on this method appear to be valid.[8,18-20]

Characteristics of the Hospitals

According to previous work by our group and others,[21-23] the likelihood of undergoing a major coronary procedure during the 6 to 12 months after acute myocardial infarction is most strongly influenced by whether the patient was admitted to a hospital with the on-site capacity to perform such procedures (e.g., a catheterization laboratory, with or without revascularization facilities). Patients were categorized according to the type of facilities available at the admitting institution (no on-site facilities, on-site facilities for angiography only, or on-site facilities for angiography and revascularization), regardless of whether they were subsequently transferred to another hospital. Since the rates of use of procedures and outcomes after myocardial infarction are also influenced by other characteristics of the hospitals,[24] we adjusted for a number of additional factors, including the hospital volume, the distance from hospitals without on-site facilities to the nearest tertiary care hospital with on-site facilities for cardiac procedures, teaching or nonteaching status, urban or rural location, and the specialty of the attending physician. The hospital volume was defined as the annual number of patients with myocardial infarction admitted to the facility,[16] and distance to the nearest hospital with on-site facilities for cardiac procedures was measured directly from latitude and longitude ("as the crow flies").

Severity of Illness

To control for variations in the severity of illness on admission, we used the Ontario acute myocardial infarction mortality prediction rule for 30-day and 1-year mortality.[16] ICD-9-CM codes were used to identify various clinical and demographic variables from the 15 secondary diagnostic fields in the data base for the index admission only. These variables included age, sex, the severity of cardiac disease (e.g., congestive heart failure, cardiogenic shock, and arrhythmia), and the presence or absence of coexisting illnesses (e.g., diabetes mellitus, stroke, cancer, and acute or chronic renal disease). The models showed excellent discrimination (i.e., areas under the receiver operating curve of 0.775 for 30-day mortality and 0.793 for 1-year mortality). The development of these models is described in more detail elsewhere.[16]

Use of Procedures

Coronary angiography and revascularization procedures (coronary-artery bypass surgery or percutaneous transluminal coronary angioplasty) were identified with use of both data on claims for physicians' services and procedure codes in the hospital-discharge data base. Rates of coronary angiography were examined for up to six months after myocardial infarction and rates of revascularization for one year, in order to allow for appropriate stratification of risk after the myocardial infarction and for waiting times. All patients who underwent revascularization procedures were required to have undergone previously documented coronary angiography in order for revascularization to be included in our analyses.

The exact dates of referrals for procedures could not be determined from the available administrative data. However, as reasonable surrogates for waiting times, we tallied the numbers of days from the index admission to the date of angiography and from angiography to revascularization. Generally, these surrogate measures slightly overestimate true waiting times for procedures.

Statistical Analysis

Neighborhoods were divided into five categories according to median personal income; each category contained a roughly equal proportion of the Ontario population. The lowest quintile corresponded to a median personal income ranging from $12,508 to $17,930, whereas the highest quintile corresponded to a range of $26,300 to $44,409 (all income values are given in Canadian dollars [1 Canadian dollar is equivalent to 68 U.S. cents]). Procedure rates, waiting times, and one-year mortality were adjusted for age, sex, and types of facilities on site at the hospital (i.e., no on-site facilities for invasive procedures, on-site facilities for angiography only, or on-site facilities for angiography and revascularization) within each income quintile by means of direct standardization. The 95 percent confidence intervals for the standardized median time to an event were calculated with use of bootstrap methods.[25] To assess whether there was a gradient in standardized rates of use of procedures and mortality rates across income quintiles, we used a Mantel–Haenszel chi-square test for trend. Similarly, to examine the possibility of a gradient in standardized waiting times for procedures across income quintiles, a weighted linear regression analysis, with one degree of freedom, for income quintiles was used as a test for trend. One-year mortality across income

TABLE 1. BASE-LINE CHARACTERISTICS OF PATIENTS, ACCORDING TO QUINTILE OF NEIGHBORHOOD MEDIAN INCOME.*

CHARACTERISTIC	INCOME QUINTILE					P VALUE†
	1 (N=13,115)	2 (N=13,935)	3 (N=11,837)	4 (N=8,090)	5 (N=4,614)	
Neighborhood income (dollars)						
Median	16,621	19,136	21,255	24,628	28,988	<0.001
Interquartile range	15,652–17,302	18,434–19,683	20,376–21,765	23,946–25,301	26,916–30,469	
Age (yr)	67.8±0.1	67.9±0.1	67.5±0.1	66.8±0.2	66.0±0.2	<0.001
Male sex (%)	61.0	62.7	63.1	65.6	66.2	<0.001
Clinical status at admission (%)						
Cardiogenic shock	2.1	2.5	2.8	2.3	2.3	0.30
Congestive heart failure	21.7	20.6	21.4	19.2	18.5	<0.001
Pulmonary edema	1.5	1.2	1.2	1.6	1.0	0.30
Cardiac dysrhythmia	14.3	13.7	16.1	14.9	13.9	0.09
Cancer	1.8	2.0	1.8	1.9	1.6	0.70
Diabetes with complications	2.2	2.1	2.1	1.7	1.9	0.03
Stroke	4.4	4.0	4.3	3.8	3.4	0.01
Acute renal insufficiency	1.6	1.5	1.8	1.4	1.2	0.30
Chronic renal insufficiency	2.4	2.2	2.5	2.2	2.5	0.70
Predicted 30-day mortality	14.7	14.8	15.2	14.2	13.9	0.39
Specialty of attending physician (%)						<0.001
General practice	29.7	27.6	19.5	14.9	11.6	
Internal medicine	46.3	49.2	49.4	48.6	46.8	
Cardiology	23.9	23.2	31.1	36.6	41.6	
Hospital volume (%)‡						<0.001
Low (≤33/yr)	13.8	6.1	6.3	2.6	1.1	
Medium (34–99/yr)	19.5	26.6	19.1	15.8	9.6	
High (≥100/yr)	66.7	67.3	74.6	81.5	89.3	
Teaching hospital (%)						<0.001
No	84.6	85.7	79.1	81.7	75.0	
Yes	15.4	14.3	20.9	18.3	25.0	
On-site facilities (%)						<0.001
None	87.6	87.5	83.0	87.6	77.9	
Angiography only	2.4	3.8	5.5	1.9	4.8	
Angiography and revascularization	10.0	8.7	11.5	10.5	17.4	
Distance to nearest tertiary facility (%)§						<0.001
>50 km	52.6	50.5	30.7	16.8	10.2	
10–50 km	16.4	24.0	31.8	45.6	43.5	
<10 km	31.1	25.6	37.5	37.5	46.3	

*Median income (in Canadian dollars) was obtained from 1996 Canadian census data and corresponds to the median personal income of residents in each of 493 Forward Sortation Areas (neighborhoods defined by the first three digits of the postal code) in Ontario. Plus–minus values are means ±SE. Because of rounding, not all percentages sum to 100.

†P values reflect the results of the test for linear trend across income quintiles.

‡Hospital volume was defined as the number of patients admitted with acute myocardial infarction per year.

§The distance shown is the distance from the admitting hospital to the nearest institution with on-site facilities for angiography and revascularization.

quintiles was also assessed with use of Kaplan–Meier plots and the log-rank test.

We developed a Cox proportional-hazards model to determine the relations of neighborhood median income to 1-year mortality and to the likelihood of undergoing coronary angiography, after adjustment for age, sex, severity of illness (i.e., the predicted probability of death at 30 days after acute myocardial infarction), and characteristics of the hospitals and physicians. Similarly, we used multiple linear regression techniques with the least-squares method to determine whether neighborhood median income predicted waiting times for angiography in a manner that was independent of all other base-line characteristics. All multivariate analyses were constructed in a similar fashion by forcing both patients' characteristics and income into the model. Hospital-related and physician-related factors were first examined by univariate analysis. Variables that were significant at a P value of 0.20 or less were included in multivariate analyses. Variables were selected by means of backward stepwise regression and by comparison of the −2 log likelihoods and regression sum of the squares of the Cox proportional-hazards and ordinary least-squares regression models, respectively. In survival models that examined rates of use of procedures, death was the main reason for censoring data. To ensure consistency, multiple logistic regression was also used to examine the effects of neighborhood income on rates of angiography and mortality. However, these results are reported only if they differed significantly from those of the proportional-hazards model. Statistical significance was considered to be indicated by a P value of less than 0.05 in all analyses. SAS (version 6.12) and S-Plus statistical software packages were used.

RESULTS

Base-Line Data

The study cohort consisted of 51,591 patients. The median age was 69 years (interquartile range, 58 to 77); 48.5 percent of the patients were 70 years old or older (referred to as elderly patients), and 63.1 percent were male. There were small but significant differences with respect to age and sex among income quintiles (Table 1). Although some clinical characteristics varied among income quintiles, no significant differences in overall predicted 30-day mortality

were observed. A disproportionate number of patients with acute myocardial infarction were in the lower income quintiles, illustrating the greater burden of illness among those with lower socioeconomic status.

Hospital-related characteristics are summarized for patients in Table 1 and for hospitals in Table 2, according to neighborhood median income. There were significant positive relations between the availability of specialized hospital services and socioeconomic status. The degree of mismatching between the income quintile of the patient and that of the hospital was limited, since most patients were admitted to local hospitals in neighborhoods that were similar in socioeconomic status to those where they lived.

Rates of Use of Procedures and Waiting Times

We examined the use of angiography according to the availability of on-site facilities. As shown in Table 3, there were significant positive relations between income and the rate of use of angiography and revascularization, both at hospitals with on-site facilities for angiography and revascularization and at hospitals without such facilities. Waiting times for coronary angiography were inversely correlated with neighborhood income quintiles. Median waiting times, adjusted for age and sex, varied from 34.5 days to 23.3 days (P for trend=0.02) for hospitals without on-site revascularization facilities and from 6.9 days to 4.6 days (P for trend=0.04) for hospitals with on-site facilities.

Figure 1 illustrates the differences in standardized

TABLE 2. CHARACTERISTICS OF THE ADMITTING HOSPITALS ACCORDING TO QUINTILE OF NEIGHBORHOOD MEDIAN INCOME.*

CHARACTERISTIC	INCOME QUINTILE					TOTAL	P VALUE†
	1	2	3	4	5		
No. of hospitals	78	50	42	22	9	201	
Discordance between hospital and patient — %‡							<0.001
None or small	77.4	90.4	83.1	83.6	64.6	81.9	
Significant	22.6	9.6	16.9	16.5	35.4	18.2	
Location — no. (%)							0.38
Rural	10 (12.8)	3 (6.0)	3 (7.1)	3 (13.6)	0	19 (9.5)	
Urban	68 (87.2)	47 (94.0)	39 (92.9)	19 (86.4)	9 (100.0)	182 (90.5)	
Volume — no. (%)§							<0.001
Low (≤33/yr)	41 (52.6)	18 (36.0)	17 (40.5)	4 (18.2)	1 (11.1)	81 (40.3)	
Medium (34–99/yr)	18 (23.1)	18 (36.0)	12 (28.6)	6 (27.3)	1 (11.1)	55 (27.4)	
High (≥100/yr)	19 (24.4)	14 (28.0)	13 (31.0)	12 (54.5)	7 (77.8)	65 (32.3)	
Teaching hospital — no. (%)							0.03
No	73 (93.6)	47 (94.0)	39 (92.9)	19 (86.4)	6 (66.7)	184 (91.5)	
Yes	5 (6.4)	3 (6.0)	3 (7.1)	3 (13.6)	3 (33.3)	17 (8.5)	
On-site facilities — no. (%)							0.02
None	76 (97.4)	47 (94.0)	35 (83.3)	21 (95.5)	7 (77.8)	186 (92.5)	
Angiography only	0	2 (4.0)	4 (9.5)	0	0	6 (3.0)	
Angiography and revascularization	2 (2.6)	1 (2.0)	3 (7.1)	1 (4.5)	2 (22.2)	9 (4.5)	
Distance to nearest tertiary care facility — no. (%)¶							<0.001
>50 km	63 (80.8)	35 (70.0)	24 (57.1)	4 (18.2)	1 (11.1)	127 (63.2)	
10–50 km	7 (9.0)	10 (20.0)	10 (23.8)	11 (50.0)	4 (44.4)	42 (20.9)	
<10 km	8 (10.3)	5 (10.0)	8 (19.0)	7 (31.8)	4 (44.4)	32 (15.9)	
Degree of medical specialization — no. (%)‖							0.02
Low	47 (60.3)	29 (58.0)	24 (57.1)	10 (45.5)	2 (22.2)	112 (55.7)	
Intermediate	23 (29.5)	14 (28.0)	13 (31.0)	7 (31.8)	4 (44.4)	61 (30.3)	
High	8 (10.3)	7 (14.0)	5 (11.9)	5 (22.7)	3 (33.3)	28 (13.9)	

*Median income (in Canadian dollars) was obtained from 1996 Canadian census data and corresponds to the median personal income of the residents of each of 493 Forward Sortation Areas (neighborhoods defined by the first three digits of the postal code) in Ontario. Because of rounding, not all percentages sum to 100.

†P values reflect the results of the test for linear trend across income quintiles.

‡Discordance indicates a difference between the income quintile of the neighborhood where the hospital was located and that of the neighborhood where the patient lived. None or small denotes an absolute difference of 0 or 1 quintile between the patient and the hospital. Significant denotes an absolute quintile difference of 2 or more between the patient and the hospital.

§Hospital volume was defined as the number of patients admitted with acute myocardial infarction per year.

¶The distance shown is the distance from the admitting hospital to the nearest institution with on-site facilities for angiography and revascularization.

‖Low denotes that less than 50 percent of patients admitted with acute myocardial infarction were under the care of an attending cardiologist or internist; intermediate that less than 50 percent of the patients admitted were under the care of a cardiologist but 50 percent or more were under the care of an attending internist; and high that 50 percent or more of the patients admitted were under the care of an attending cardiologist.

TABLE 3. ADJUSTED RATES OF CARDIAC PROCEDURES AND ONE-YEAR MORTALITY ACCORDING TO THE AVAILABILITY OF ON-SITE FACILITIES AND ACCORDING TO QUINTILE OF NEIGHBORHOOD MEDIAN INCOME.*

ON-SITE FACILITIES AND OUTCOME	INCOME QUINTILE					P VALUE†
	1	2	3	4	5	
None						
No. of patients	11,493	12,195	9829	7088	3593	
Angiography rate (%)	23.9	23.5	25.7	27.5	30.6	<0.001
Revascularization rate (%)	15.0	14.5	16.3	17.0	19.6	<0.001
One-year mortality (%)	23.6	23.4	23.0	21.7	20.8	<0.001
Angiography only						
No. of patients	316	525	653	154	219	
Angiography rate (%)	31.8	32.6	29.4	29.9	35.9	0.71
Revascularization rate (%)	20.8	18.7	16.0	13.7	18.1	0.13
One-year mortality (%)	26.0	23.6	23.9	28.8	21.6	0.60
Angiography and revascularization						
No. of patients	1306	1215	1355	848	802	
Angiography rate (%)	33.9	35.1	39.8	42.9	47.4	<0.001
Revascularization rate (%)	19.4	22.4	24.6	27.1	27.8	<0.001
One-year mortality (%)	25.9	24.7	23.5	22.0	20.9	0.003

*Median income (in Canadian dollars) was obtained from 1996 Canadian census data and corresponds to the median personal income of residents in each of 493 Forward Sortation Areas (neighborhoods defined by the first three digits of the postal code) in Ontario. All rates have been adjusted for age and sex.

†P values reflect the results of the test for linear trend across income quintiles.

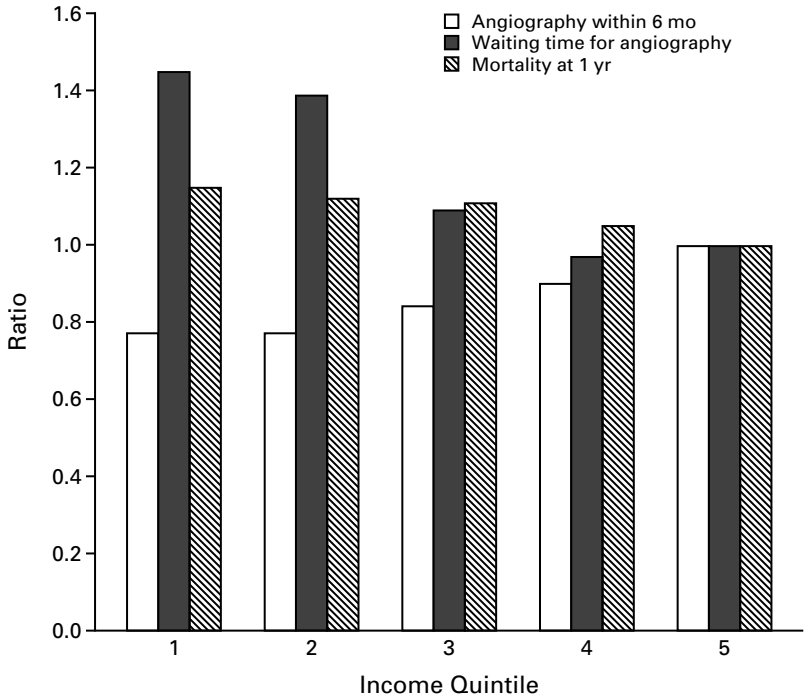

Figure 1. Adjusted Relative Rates of Angiography within Six Months after Acute Myocardial Infarction, Waiting Times for Angiography, and One-Year Mortality According to Income Quintile.

Results have been standardized for age, sex, and type of on-site facilities for cardiac procedures. Quintiles for neighborhood median income were derived from 1996 Canadian census data for 493 Forward Sortation Areas (neighborhoods defined by the first three digits of the postal code); the patients in the highest quintile served as the reference group. The bars show the relative differences in adjusted rates and waiting times. The absolute differences between the lowest and the highest income quintile were 7.4 percent for adjusted rates of angiography, 9.2 days for adjusted waiting times for angiography, and 3.1 percent for adjusted mortality rates. P for trend <0.001 for each of the three outcome variables.

rates of angiography and waiting times among income quintiles. Patients with myocardial infarction who lived in higher-income neighborhoods were significantly more likely to undergo catheterization and had shorter waiting times for angiography than patients in lower-income neighborhoods.

In total, 15.7 percent of patients in the lowest income quintile and 20.3 percent of those in the highest income quintile underwent revascularization procedures. However, among patients who had undergone angiography, we found no significant increase in the likelihood of revascularization in increasing income quintiles (range, 56.3 percent in the lowest quintile to 58.2 percent in the highest; P for trend=0.31) and no significant difference in waiting times (range, 16 days in the lowest quintile to 14 days in the highest; P for trend=0.10). Access to angiography was thus the rate-limiting step in access to revascularization.

The adjusted hazard ratios from the statistical models examining predictors of the rate of use of angiography are summarized in Table 4. Higher neighborhood median income consistently predicted greater use of angiography, independently of age, sex, the severity of clinical illness, the specialty of the attending physician, and characteristics of the hospital. Moreover, the effect of income on the rate of angiography was as pronounced for elderly patients (adjusted hazard ratio for each additional $10,000 of median income among patients 70 years of age and older, 1.27; 95 percent confidence interval, 1.17 to 1.38) as it was for younger patients (adjusted hazard ratio, 1.18; 95 percent confidence interval, 1.13 to 1.24). Similarly, higher neighborhood median income predicted shorter waiting times for angiography after control for all of the factors mentioned above (P<0.001).

Mortality

The overall crude 30-day and 1-year mortality rates were 14.7 percent and 23.1 percent, respectively. As Table 3 shows, mortality also varied according to income quintile within groups of hospitals with different types of on-site facilities. Figure 1 demonstrates a significant gradient in overall standardized mortality rates across income quintiles. The absolute difference in standardized mortality between the lowest and the highest income quintile was 3.1 percent (P<0.001). As Figure 2 illustrates, although most deaths occurred within the first 30 days after the acute myocardial infarction, the effects of income on survival persisted at 1 year (χ^2=61.54 by the log-rank test, P<0.001).

Income was a consistent independent predictor of mortality (Table 4). The effect of median income on adjusted mortality was large. Specifically, a $10,000 increase in neighborhood median income was associated with a 10 percent reduction in the risk of death at one year (adjusted hazard ratio, 0.90; 95 percent confidence interval, 0.86 to 0.94). Moreover, the effect of neighborhood income on adjusted mortality was consistent among age groups (adjusted hazard ratio for patients 70 years of age and older, 0.92; 95 percent confidence interval, 0.88 to 0.98; for patients under 70 years of age, 0.85; 95 percent confidence interval, 0.77 to 0.94).

TABLE 4. ADJUSTED HAZARD RATIOS FOR UNDERGOING CORONARY ANGIOGRAPHY WITHIN SIX MONTHS AND FOR DEATH AT ONE YEAR ACCORDING TO NEIGHBORHOOD INCOME AND CHARACTERISTICS OF THE PATIENT, PHYSICIAN, AND HOSPITAL.*

CHARACTERISTIC	ADJUSTED HAZARD RATIO (95% CI)	P VALUE
Angiography within 6 months		
Neighborhood median income (for each $10,000 increase)	1.17 (1.12–1.22)	<0.001
Characteristics of the patient		
Age (for each additional year)	0.97 (0.97–0.98)	<0.001
Female sex	0.94 (0.91–0.98)	0.004
Predicted 30-day mortality†	0.97 (0.97–0.97)	<0.001
Specialty of attending physician		
General practice	0.61 (0.57–0.65)	<0.001
Internal medicine	0.71 (0.69–0.74)	<0.001
Cardiology‡	1.00	
Characteristics of hospital		
Volume		
Low	1.05 (0.96–1.15)	0.28
Medium	1.15 (1.09–1.21)	<0.001
High‡	1.00	
Distance to nearest tertiary care hospital§		
>50 km	0.77 (0.73–0.82)	<0.001
10–50 km	0.86 (0.81–0.91)	<0.001
<10 km‡	1.00	
On-site facilities		
None	0.62 (0.58–0.66)	<0.001
Angiography only	0.84 (0.75–0.94)	0.002
Angiography and revascularization‡	1.00	
Teaching hospital (vs. nonteaching hospital)	0.91 (0.85–0.97)	0.006
Death within 1 year		
Neighborhood median income (for each $10,000 increase)	0.90 (0.86–0.94)	<0.001
Characteristics of the patient		
Age (for each additional year)	1.05 (1.04–1.05)	<0.001
Female sex	0.98 (0.94–1.01)	0.22
Predicted 30-day mortality†	1.03 (1.03–1.03)	<0.001
Specialty of attending physician		
General practice	1.41 (1.33–1.49)	<0.001
Internal medicine	1.36 (1.30–1.43)	<0.001
Cardiology‡	1.00	
Teaching hospital (vs. nonteaching hospital)	1.12 (1.07–1.18)	0.002

*The variables with the best predictive power in the Cox proportional-hazards models are shown. Patient factors and median income were forced into the models. Hospital and physician factors were determined with use of stepwise regression for selection of variables. CI denotes confidence interval.

†Each change of 1 unit represents an increase of 1 percent in the probability of death within 30 days.

‡Patients with this factor served as the reference group.

§The distance shown is the distance from the admitting hospital to the nearest institution with on-site facilities for angiography and revascularization.

DISCUSSION

In this population-based cohort study, we found pronounced effects of socioeconomic status on ac-

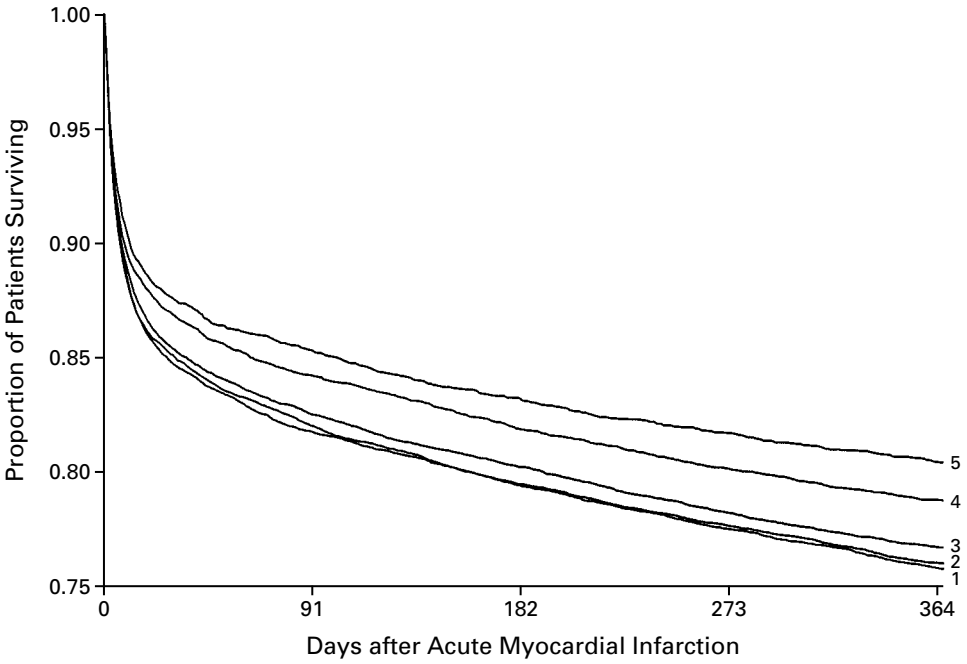

Figure 2. Kaplan–Meier Survival Curves According to Quintile of Neighborhood Median Income.

Quintiles for neighborhood median income were derived from 1996 Canadian census data on 493 Forward Sortation Areas (neighborhoods defined by the first three digits of the postal code). The difference in survival among income quintiles was significant (χ^2=61.54 by the log-rank test, P<0.001).

cess to specialized cardiac services in Ontario's universal health care system, as well as on mortality one year after acute myocardial infarction. Progressive increases in neighborhood median income levels predicted greater rates of use of coronary angiography, shorter waiting times for catheterization, and lower mortality one year after acute myocardial infarction, after adjustment for age, sex, the severity of clinical disease, the specialty of the attending physician, and characteristics of the hospital.

Although Canada's universal health insurance programs have promoted greater equity in access to care,[3,4] several studies have shown continuing income-related differences in the rates of use of specific services.[3,5-7] Our findings offer a dramatic demonstration of these persisting inequities in access for a cohort of persons who were hospitalized with the same condition and who should, in theory, have been treated similarly. Although more affluent neighborhoods tended to have a greater concentration of specialized services, inequitable distribution of hospital resources did not account entirely for the effects of socioeconomic status on access to procedures and on outcome after acute myocardial infarction. Moreover, it is implausible that these differences are explained by the presence of less severe illness among patients in the lower socioeconomic groups. Not only did we adjust for age, sex, and various prognostic markers at the index admission, but in general, one would expect poorer patients who were hospitalized for acute myocardial infarction to have more severe coronary artery disease than those with higher incomes.

Although persons with lower incomes had both reduced access to invasive procedures and worse outcomes, it is unlikely that these two findings are causally related. Indeed, on the basis of the available evidence,[11-15,26,27] we interpreted our design as measuring two independent dimensions of equity. Within our study, access to coronary angiography was strongly influenced by whether or not the index admission took place in or near a hospital with on-site facilities for invasive procedures. However, income-related differences in mortality were found within groups of hospitals with different types of on-site facilities. Moreover, lower income was a significant and independent predictor of higher one-year mortality in all our multivariate analyses.

Even if reduced access to coronary revascularization does not account for income-related differences in one-year mortality, however, this does not justify the observed disparities in access. Other outcomes, such as the quality of life and functional status, are improved by higher rates of revascularization after acute myocardial infarction.[28,29] Moreover, a one-year follow-up period may be too short to demonstrate the full benefits of revascularization in terms of mortality.

Our study was not designed to address the myriad social and clinical determinants of adverse outcomes. However, poorer medium-term outcomes for patients in the lower-income groups are consistent with a large body of research showing that people with lower incomes live shorter, less healthy lives.[30] Indeed, our cohort of patients itself illustrates the consistent inverse relation between health status and socioeconomic status. Although each income quintile contained essentially the same proportion of Ontario's population, there were significantly more patients with acute myocardial infarction in the lower income quintiles. With respect to excess mortality from cardiovascular causes, in particular, lower socioeconomic status has been shown to be associated with a higher prevalence of cardiac risk factors such as hypertension, cigarette smoking, obesity, diabetes, and prothrombotic factors such as elevated fibrinogen levels.[31-34] Thus, patients of lower socioeconomic status may have more extensive coronary disease in the first instance, and they are certainly at greater risk for recurrent events.[35] Their higher levels of risk factors may be compounded by poorer compliance with medical therapy.[27,36] Although the exact mechanisms remain controversial, psychosocial factors are also likely to mediate adverse outcomes for poorer or less well educated persons with coronary artery disease. Occupational stress,[37,38] social isolation,[38] and depression[39] are all more prevalent among persons with lower socioeconomic status and may contribute to higher mortality.[31,40]

Several limitations of our study should be noted. The use of linked administrative data limited our ability to characterize the patients in our cohort, either with regard to their own base-line health status or with regard to the specific nature of the care they received during the index hospitalization and thereafter. Nonetheless, we did control for many important prognostic variables, such as age, sex, presence or absence of coexisting conditions, and presence or absence of complications, such as cardiogenic shock, at the time of the index admission. A further limitation resulted from the fact that we imputed socioeconomic status to patients on the basis of median incomes at the neighborhood level rather than on the basis of data on individual patients. However, there is good evidence to support this method of imputing incomes.[18,20] Indeed, any risk of inaccuracy due to the so-called ecologic fallacy (the misclassification of personal socioeconomic status on the basis of the socioeconomic characteristics of the neighborhood) may be offset by the avoidance of an "individualistic fallacy," whereby one wrongly assumes that individual patients are unaffected by the neighborhood in which they live. Finally, we assessed only one outcome — albeit a very important one — mortality.

In conclusion, despite universal health insurance coverage, Ontario residents living in lower-income areas have reduced access to invasive procedures, as compared with residents of wealthier neighborhoods, and have sharply higher mortality one year after hospitalization for acute myocardial infarction. The causes of these socioeconomic disparities in access and outcome remain obscure, but their persistence poses a clear challenge to the egalitarian principles of Canada's publicly funded health care system.

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