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Differences in Treatment Patterns and Outcomes of Acute Myocardial Infarction for Low- and High-Income Patients in 6 Countries

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IMPORTANCE Differences in the organization and financing of health systems may produce more or less equitable outcomes for advantaged vs disadvantaged populations. We compared treatments and outcomes of older high- and low-income patients across 6 countries.

OBJECTIVE To determine whether treatment patterns and outcomes for patients presenting with acute myocardial infarction differ for low- vs high-income individuals across 6 countries.

DESIGN, SETTING, AND PARTICIPANTS Serial cross-sectional cohort study of all adults aged 66 years or older hospitalized with acute myocardial infarction from 2013 through 2018 in the US, Canada, England, the Netherlands, Taiwan, and Israel using population-representative administrative data.

EXPOSURES Being in the top and bottom quintile of income within and across countries.

MAIN OUTCOMES AND MEASURES Thirty-day and 1-year mortality; secondary outcomes included rates of cardiac catheterization and revascularization, length of stay, and readmission rates.

RESULTS We studied 289 376 patients hospitalized with ST-segment elevation myocardial infarction (STEMI) and 843 046 hospitalized with non-STEMI (NSTEMI). Adjusted 30-day mortality generally was 1 to 3 percentage points lower for high-income patients. For instance, 30-day mortality among patients admitted with STEMI in the Netherlands was 10.2% for those with high income vs 13.1% for those with low income (difference, −2.8 percentage points [95% CI, −4.1 to −1.5]). One-year mortality differences for STEMI were even larger than 30-day mortality, with the highest difference in Israel (16.2% vs 25.3%; difference, −9.1 percentage points [95% CI, −16.7 to −1.6]). In all countries, rates of cardiac catheterization and percutaneous coronary intervention were higher among high- vs low-income populations, with absolute differences ranging from 1 to 6 percentage points (eg, 73.6% vs 67.4%; difference, 6.1 percentage points [95% CI, 1.2 to 11.0] for percutaneous intervention in England for STEMI). Rates of coronary artery bypass graft surgery for patients with STEMI in low- vs high-income strata were similar but for NSTEMI were generally 1 to 2 percentage points higher among high-income patients (eg, 12.5% vs 11.0% in the US; difference, 1.5 percentage points [95% CI, 1.3 to 1.8]). Thirty-day readmission rates generally also were 1 to 3 percentage points lower and hospital length of stay generally was 0.2 to 0.5 days shorter for high-income patients.

CONCLUSIONS AND RELEVANCE High-income individuals had substantially better survival and were more likely to receive lifesaving revascularization and had shorter hospital lengths of stay and fewer readmissions across almost all countries. Our results suggest that income-based disparities were present even in countries with universal health insurance and robust social safety net systems.

Multimedia

Supplemental content

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Research comparing treatment approaches and outcomes across countries can illuminate policy efforts to optimize population health.[1-5] Many international comparisons, reliant on aggregated country-level data, have reported that the US spends more but has poorer health as measured by life expectancy and childbirth outcomes.[2,6] A small number of these comparisons have evaluated between-country differences for racial minorities or lower-income individuals, reporting substantial disparities in care, which manifests as shorter lifespans for these populations in the US.[7,8]

These high-level analyses lack detailed information on how disease-specific processes of care and outcomes differ for patients presenting with a single illness or condition across different countries.[9] Such disease-specific studies could provide insights into the potential impact of health system factors on treatment and outcomes for specific conditions as distinct from other social factors, which consistently have been shown to be major factors influencing health.[8,10,11] There are reasons to believe that income-based disparities may be larger in the US than in other countries, even though for almost all older patients who are insured by Medicare, due to wealthier patients having the ability to seek care from higher-quality physicians and hospitals.[8] Alternatively, income-based disparities could be smaller for older patients in the US than for those in other countries because of Medicare's generous coverage of advanced therapies and wide availability of these services. Moreover, like health systems in other countries, the US Medicare program provides nearly universal insurance for people aged 65 or older, and those with low incomes and disabilities also qualify for Medicaid, which eliminates most Medicare cost-sharing.

We developed the International Health System Research Collaborative (IHSRC) to facilitate population-level comparisons of treatment patterns and outcomes in the US, Canada, England, the Netherlands, Israel, and Taiwan; countries with highly developed health care systems and accessible administrative data but that have significant differences in financing, organization, and performance in international rankings.[12-16] In this study, we compare differences in acute myocardial infarction (MI) treatment (eg, cardiac catheterization, revascularization) and outcomes (mortality, readmissions) for high- and low-income patients across 6 countries. Acute MI is an exemplar condition for cross-country comparison because it is common, has internationally agreed upon diagnostic criteria, and has validated coding schemes in administrative data.[17-21] Moreover, patients with acute MI are consistently hospitalized in high-income countries, so hospital data generally capture all cases. Thus, these data are ideal for comparing the differences in treatment processes and outcomes of high- vs low-income patients across countries. We hypothesized that despite each country offering universal insurance for older adults, there would be larger income-based disparities in treatment and outcomes in the US than in other countries, notwithstanding the fact that low-income older adults would do worse in all countries.

Key Points

Question How do treatment patterns and outcomes for older patients presenting with acute myocardial infarction differ for low- vs high-income individuals across 6 countries.

Findings In this study of 289 376 patients aged 66 years or older hospitalized with ST-segment elevation myocardial infarction (STEMI) and 843 046 hospitalized with non-STEMI across 6 health systems, adjusted 30-day and 1-year mortality rates were higher for low-income patients, whereas rates of cardiac catheterization and percutaneous coronary interventions were lower. High-income patients also had shorter length of stay and lower rates of readmissions.

Meaning These results suggest that income-based disparities were present even in countries with universal health insurance and robust social safety net systems.

Methods

Data and Patients

Following prior work, we used population-representative administrative claims to identify all adults aged 66 years or older hospitalized for at least 1 day (or who died on the day of admission) with a primary diagnosis of ST-elevation MI (STEMI) or non-STEMI (NSTEMI) between January 1, 2013, and December 31, 2018, in any of the 6 IHSRC countries (Canada was represented by data from the provinces of Ontario and Manitoba) using relevant *International Classification of Diseases, Ninth Revision (ICD-9)* and *ICD-10* codes (see eTable 1 in Supplement 1 for coding). We applied the same inclusion and exclusion criteria in the same order in each country, although some variations to reflect local differences in data architecture were allowed. More detail is available elsewhere on the data sources used for each country.[22]

Patients with an acute MI admission during the year prior were excluded to avoid counting readmissions as new admissions. We also excluded patients with less than a year of preadmission or postadmission follow-up data except in the case of death. The complete episode of care for patients who were transferred between hospitals as part of their admission was evaluated. We used data from 2012 for a 1-year lookback and data from 2019 for 1-year follow-up.

We recorded demographic information (age, sex) and comorbidities. Comorbid conditions present on the index admission and previous admissions during the 1-year lookback were captured using a Manitoba adaptation of the Elixhauser comorbidity index.[23,24] Following Agency for Healthcare Research and Quality convention, we excluded cardiovascular conditions identified in the index admission that could plausibly have arisen due to the acute MI, but included other noncardiovascular conditions from that admission.[25] In the Netherlands, where comorbidities from hospital data were unavailable, we used medications related to chronic conditions to identify comorbidities (see eTable 2 in Supplement 1 for each country's approach to identifying comorbidities).[26-28]

Ascertaining Income Status

Income was used as a proxy measure of socioeconomic status. In most countries, we defined high-income patients as those living in an area (eg, postal code) in the top 20% of the income distribution and low-income as those living in areas in the bottom 20% of the distribution such that we used a similar definition for each country that defined high- and low-income relative to the incomes in that particular country. The income distributions used to define high and low were based on regions within countries, except in Israel and England, where they were national. (Sensitivity analyses by region in Israel showed similar results.) Thus, these methods are subject to misclassification at the individual level and vary across countries based on the level of income mixing within the regions. In the Netherlands, household income was observed for individuals, rather than areas. More details on the country-specific approaches are available in eTable 3 in Supplement 1.

Outcomes

The primary outcomes were age-, sex-, and comorbidity-adjusted 30-day and 1-year mortality, which were available in the administrative data from each country. Secondary outcomes included use of cardiac catheterization, percutaneous coronary intervention (PCI), and coronary artery bypass graft (CABG) surgery during the index hospitalization and within 90 days of admission. These outcomes were selected because there is a strong body of evidence for the benefits of early PCI in patients with STEMI, but there is also concern about potential overuse of PCI in the NSTEMI population.[29-31] We also examined hospital length of stay (LOS) and readmission within 30 days of discharge.

Statistical Analyses

Our analyses were focused on comparison of low- vs high-income patients within each country and stratified by STEMI vs NSTEMI. We compared age, sex, and comorbidities of low- and high-income patients hospitalized with acute MI in each year and country. We calculated population-level acute MI rates (hospitalizations per 1000 population aged ≥66 years per year) for each country and year and adjusted (via direct standardization) the results for the high-income patients to the age and sex distribution of the low-income patient in that country. We were not able to calculate adjusted acute MI rates for England because we lacked denominator populations by income.

From prior work, recording of comorbidities differs markedly across countries due to different incentives for coding.[22] As a result, adjusting for recorded comorbidities in between-country comparisons is likely biased. However, coding for comorbidities for within-country comparisons should be congruent; therefore, within each country, we compared outcomes for high- and low-income patients by estimating 30-day mortality and readmissions after adjusting for age, sex, and comorbidities. In each country and for each outcome, we fit logistic regression models with indicators for age (in 5-year ranges), sex, and comorbidities. We interpreted the regression coefficient on the highest income quintile vs the lowest income quintile.

Age- and sex-standardized rates of in-hospital and 90-day cardiac interventions were calculated (cardiac catheterization [with or without PCI], PCI, and CABG surgery) within each country for those in the top- and bottom-income quintiles. We did not adjust these comparisons for comorbid conditions because treatment approaches for acute MI generally are dictated by the type of acute MI rather than by the presence or absence of comorbid conditions. We analyzed readmissions and LOS in a similar manner.

Analyses were conducted for all the years pooled. Our analyses were conducted locally by investigative teams from each of the 6 IHSRC countries and approved by the appropriate ethics oversight boards in each country. This project was approved by the Centers for Medicare & Medicaid Services privacy board and the Harvard Medical School institutional review committee, which also waived the requirement for obtaining informed consent because the claims data were deidentified and not collected for this study.

Analyses were conducted using SAS Institute Inc (US, Ontario, Manitoba, Taiwan), and R (Israel, England, the Netherlands).

Results

The study population consisted of 289 376 hospitalizations for STEMI and 843 046 for NSTEMI from 2013 through 2018 in the US, Canada (Ontario and Manitoba), England, the Netherlands, Israel, and Taiwan. The average income in the lowest- and highest-income quintiles are presented in the **Table** in each country's native currency. Across the countries, the ratio of income (mean income for highest quintile compared with the lowest quintile) ranged from 1.35 for Taiwan to 4.36 for Israel (US 2.14). STEMI and NSTEMI incidence rates were higher for low-income than for high-income populations in all countries. For instance, annual STEMI incidence in Canada was 1.55 per 1000 among the low-income population vs 1.32 among the high-income population.

Average age was generally similar within countries for high- and low-income and across countries (Table). Similar data broken out by STEMI and NSTEMI are in eTable 4 in Supplement 1. There were large differences among countries in rates of comorbid illness, which reflect known country-specific coding patterns. For example, rates of hypertension among patients in the lowest-income quintile were 87% in the US compared with 67% in England and 10% in the Netherlands. Looking across income quintiles within a given country, rates of comorbid conditions were much more similar though conditions such as diabetes and congestive heart failure were generally more common in the lowest- vs the highest-income quintile (eg, diabetes in Israel was 71% vs 40%; congestive heart failure in England was 8.6% vs 5.7%). A full listing of comorbidities is available in eTables 5 and 6 in Supplement 1.

Mortality

Adjusted 30-day and 1-year mortality for both STEMI and NSTEMI were lower for the high-income patients in all countries except Taiwan (**Figure 1**). The largest differences in 30-day

Table. Study Population by Jurisdiction for Socioeconomic Status Quintiles Across All Study Years, 2013 Through 2018

	Quintile											
	Canada		England		Israel		The Netherlands		Taiwan		US	
	Poorest	Wealthiest	Poorest	Wealthiest	Poorest	Wealthiest	Poorest	Wealthiest	Poorest	Wealthiest	Poorest	Wealthiest
Sample size												
Overall No. of admissions	17 367	12 412	6829	10 056	715[a]	1833[a]	17 483	13 216	11 507	10 242	194 462	142 104
STEMI												
No. of admissions	4398	3586	1803	3044	217	554	5603	5072	4444	3888	42 585	35 956
Incidence per 1000[b]	1.55	1.32	NA	NA	2.11	1.08	1.64	1.54	1.65	1.46	1.24	1.08
NSTEMI												
No. of admissions	12 969	8826	5026	7012	498	1279	11 880	8144	7063	6354	151 877	106 148
Incidence per 1000[b]	4.57	3.41	NA	NA	4.83	2.26	3.48	2.64	2.58	2.38	4.36	3.25
Income metrics												
Average income, local currency	44 160[c]	113 920[c]	27 913[d]	51 116[d]	102 360[e]	446 076[e]	17 149[f]	50 783[f]	549 600[g]	676 800[g]	35 525[h]	75 989[h]
Ratio of average incomes[i]	1.00	2.58	1.00	1.83	1.00	4.36	1.00	2.96	1.00	1.23	1.00	2.14
Gini index of income inequality		33.3[j]		35.1[k]		38.6[l]		29.2[m]		NA		41.1[m]
Demographics												
Age, y	78.7	78.0	78.6	79.9	76.3	80.5	79.1	75.2	78.1	77.7	79.1	79.8
Female, %	47.4	38.2	44.1	40.9	42.0	39.0	50.5	29.6	40.8	36.8	49.3	45.1
Male, %	52.6	61.8	55.9	59.1	58.0	61.0	49.5	70.4	59.2	63.2	50.7	54.9
Comorbidities, %[n]												
Hypertension	53.1	50.7	66.7	62.8	73.0	66.3	10.3	7.3	63.0	64.5	87.3	85.0
Diabetes	37.0	29.6	36.3	25.4	70.9	40.4	10.7	4.9	39.3	40.4	43.7	35.8
Congestive heart failure	6.3	4.8	8.6	5.7	14.8	12.7	0.2	0.1	13.1	11.7	15.5	12.4
Hypothyroidism	2.1	1.9	9.3	8.6	6.4	13.2	0.3	0.1	0.6	0.5	18.7	20.4

Abbreviations: NA, not available; SES socioeconomic status.

[a] Israel reflects cases from 2011 through 2018 to accrue additional sample.

[b] Age- and sex-standardized number of admissions per year during the study period.

[c] Median neighborhood income of ST-elevation myocardial infarction (STEMI) sample, Canadian dollars.

[d] Mean net income by SES quintile, not based on the study sample, British pounds. Data from English Indexes of Deprivation 2019 and the UK Office of National Statistics.

[e] Mean net household income by SES quintile for 2018 only, not based on study sample, Shekels.

[f] Median household income of STEMI sample, Euros.

[g] Median household income of STEMI sample, New Taiwan Dollars.

[h] Median neighborhood income of STEMI sample, US dollars. Data from US Census.

[i] The income quintiles empirically defined differ from other available reports of income disparities for at least 2 different reasons. First, use of area levels measures serves to dampen the disparity between the highest and lowest quintile. Second, this study focuses on the an older population and for those at the high end of the income spectrum, the use of income may underestimate differences in underlying wealth.

[j] As of 2017, World Bank. Higher scores indicate greater inequality.

[l] As of 2018, World Bank. Higher scores indicate greater inequality.

[m] As of 2019, World Bank. Higher scores indicate greater inequality.

[n] Listed comorbidities were selected for parsimony and relevance to acute MI. Additional details are in eTables 4 and 5 in Supplement 1.

mortality were seen in Canada for STEMI (14.9% vs 17.8% for high vs low socioeconomic status [SES]-quintile; difference, -2.9 percentage points [95% CI, −4.7 to −1.2]) and Israel for NSTEMI (8.8% vs 11.5%; difference, −2.8 percentage points [95% CI, −6.4 to 0.9]). One-year mortality differences were even larger, with the highest difference being in Israel (16.2% vs 25.3%; difference, −9.1 percentage points [95% CI, −16.7 to -1.6] for STEMI and 22.2% vs 28.9%; difference, −6.7 percentage points [95% CI, −12.4 to -0.9] for NSTEMI). Age- and sex-standardized results are shown in eFigure 1 in Supplement 1.

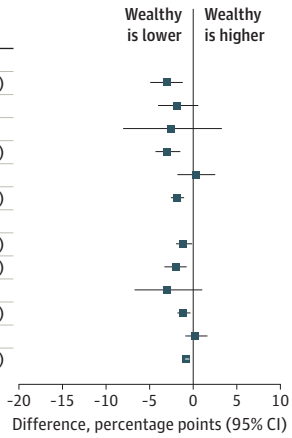
Treatment Patterns

Rates of cardiac catheterization and PCI within 90 days of admission for STEMI were higher for high-income patients than for low-income patients in all countries (**Figure 2**). For instance, rates of catheterization among high- vs low-income patients with STEMI in England were 85.3% vs 79.4% (difference, 5.9 percentage points [95% CI, 0.6 to 11.2]). Rates of catheterization for NSTEMI also were higher among high-income patients in all 6 countries (eg, 50.7% vs 45.1%; difference, 5.7 percentage points [95% CI, 3.5 to 7.8] for the Netherlands). Rates of PCI showed similar patterns (higher rates of PCI for those in the highest-income quintile). Rates of CABG surgery within 90 days of STEMI were not uniformly higher or lower in the highest income quintile (Figure 2). Among patients with NSTEMI, however, high-income patients had higher CABG surgery rates in all countries except Israel and Taiwan. Taken together, rates of revascularization were substantially higher for high-income patients in all countries for STEMI and NSTEMI.

Figure 1. Adjusted 30-Day and 1-Year Mortality[a]

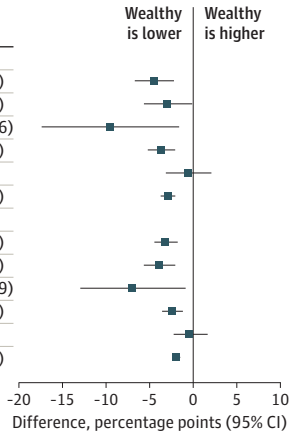
A 30-d Mortality

Source	Wealthiest quintile Patients, %	Wealthiest quintile Total No. of patients	Poorest quintile Patients, %	Poorest quintile Total No. of patients	Difference, percentage points (95% CI)
STEMI[b]					
Canada	14.9	3586	17.8	4398	-2.9 (-4.7 to -1.2)
England	11.9	3044	13.6	1803	-1.7 (-3.9 to 0.5)
Israel	9.8	554	12.2	217	-2.4 (-7.8 to 3.1)
The Netherlands	10.2	5072	13.1	5603	-2.8 (-4.1 to -1.5)
Taiwan	22.1	3888	21.8	4444	0.3 (-1.7 to 2.4)
US	18.4	35956	20.2	42585	-1.8 (-2.4 to -1.1)
NSTEMI[b]					
Canada	9.7	8826	10.7	12969	-1.1 (-1.9 to -0.2)
England	9.2	7012	11.1	5026	-1.9 (-3.1 to -0.7)
Israel	8.8	1279	11.5	498	-2.8 (-6.4 to 0.9)
The Netherlands	6.4	8144	7.4	11880	-1.0 (-1.8 to -0.3)
Taiwan	12.7	6354	12.4	7063	0.3 (-0.9 to 1.5)
US	11.6	106148	12.3	151877	-0.7 (-0.9 to -0.4)



B 1-y Mortality

Source	Wealthiest quintile Patients, %	Wealthiest quintile Total No. of patients	Poorest quintile Patients, %	Poorest quintile Total No. of patients	Difference, percentage points (95% CI)
STEMI[b]					
Canada	21.2	3586	25.5	4398	-4.3 (-6.5 to -2.2)
England	17.7	3044	20.5	1803	-2.8 (-5.4 to -0.2)
Israel	16.2	554	25.3	217	-9.1 (-16.7 to -1.6)
The Netherlands	14.3	5072	17.8	5603	-3.5 (-5.0 to -2.0)
Taiwan	33.3	3888	33.8	4444	-0.5 (-3.0 to 2.0)
US	27.0	35956	29.8	42585	-2.8 (-3.6 to -2.1)
NSTEMI[b]					
Canada	22.2	8826	25.2	12969	-3.0 (-4.3 to -1.7)
England	19.8	7012	23.4	5026	-3.7 (-5.4 to -2.0)
Israel	22.2	1279	28.9	498	-6.7 (-12.4 to -0.9)
The Netherlands	13.6	8144	15.9	11880	-2.3 (-3.4 to -1.2)
Taiwan	30.6	6354	30.9	7063	-0.4 (-2.2 to 1.5)
US	28.3	106148	30.2	151877	-1.9 (-2.3 to -1.5)



[a] Adjusted for age, sex, and comorbidity.

[b] See eTable 1 in Supplement 1 for definitions.

STEMI indicates ST-elevation myocardial infarction; NSTEMI, non-STEMI.

LOS and Readmissions

LOS was generally shorter for high- vs low-income patients for both STEMI and NSTEMI except for Israel and Taiwan (**Figure 3**). Thirty-day readmission rates were consistently lower for higher-income patients for both STEMI and NSTEMI. The difference among NSTEMI patients ranged from −0.7 percentage points in the US (15.7% vs 16.4%; [95% CI, −1.0 to −0.4] to −2.4 percentage points in Canada (13.8% vs 16.2%; [95% CI, −3.5 to −1.3]). Age- and sex-standardized readmission rates are shown in eFigure 2 in Supplement 1.

Discussion

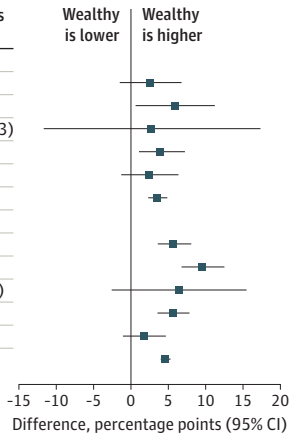
This analysis of population-representative, patient-level, administrative data from 6 high-income countries has several notable findings. First, despite vastly different health care systems, acute MI mortality rates were generally higher for low-income patients, although this was not the case in Taiwan, which also had the smallest relative difference between the highest and lowest income quintiles. Second, low-income patients in all countries were less likely to receive cardiac catheterization and PCI than were high income patients. Third, both per-capita acute MI rates and 30-day hospital readmission rates were consistently higher for low-income patients. Taken together, these results suggest that for acute MI, patients from low-income groups are subject to disparities in care processes and outcomes across all 6 countries despite vastly different health care and social safety net systems.

Our study challenges an important and deeply held belief that income-based disparities in health and health care are larger in the US than other high-income countries, although with the caveat that an older population that is eligible for Medicare coverage was examined, which may be more similar to available coverage in other countries. There are very few studies that have directly addressed this issue using patient-level data for circumscribed diseases or conditions. Recent studies from the International Collaborative on Costs, Outcomes, and Needs in Care (ICCONIC) group[3,32] found that persistently costly Medicare patients were more

Figure 2. Age- and Sex-Standardized Rates of Cardiac Catheterization, Percutaneous Coronary Intervention, and Coronary Artery Bypass Graft Surgery Within 90 Days of Admission

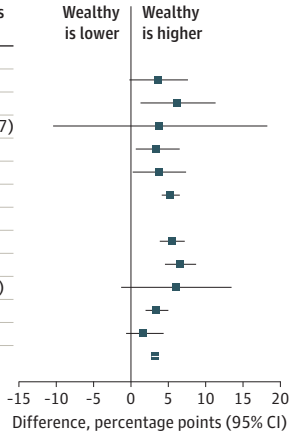
A Cardiac catheterization

Source	Wealthiest quintile Patients, %	Wealthiest quintile Total No. of patients	Poorest quintile Patients, %	Poorest quintile Total No. of patients	Difference, percentage points (95% CI)
STEMI[a]					
Canada	86.7	3586	84.1	4398	2.6 (-1.5 to 6.7)
England	85.3	3044	79.4	1803	5.9 (0.6 to 11.2)
Israel	83.8	554	81.1	217	2.7 (-11.9 to 17.3)
The Netherlands	57.7	5072	53.7	5603	4.0 (1.0 to 7.1)
Taiwan	78.2	3888	75.8	4444	2.4 (-1.4 to 6.2)
US	86.9	35956	83.3	42585	3.6 (2.3 to 4.9)
NSTEMI[a]					
Canada	66.9	8826	61.2	12969	5.7 (3.5 to 7.9)
England	64.7	7012	55.1	5026	9.6 (6.7 to 12.4)
Israel	66.2	1279	59.8	498	6.4 (-2.7 to 15.5)
The Netherlands	50.7	8144	45.1	11880	5.7 (3.5 to 7.8)
Taiwan	71.4	6354	69.7	7063	1.7 (-1.2 to 4.6)
US	66.0	106148	61.4	151877	4.5 (3.9 to 5.2)



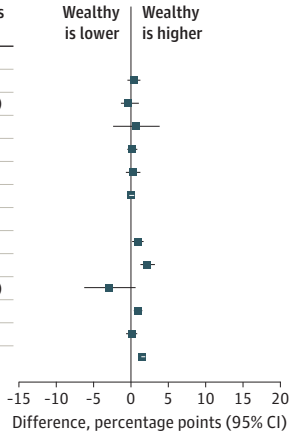
B Percutaneous coronary intervention

Source	Wealthiest quintile Patients, %	Wealthiest quintile Total No. of patients	Poorest quintile Patients, %	Poorest quintile Total No. of patients	Difference, percentage points (95% CI)
STEMI[a]					
Canada	77.9	3586	74.4	4398	3.5 (-0.4 to 7.3)
England	73.6	3044	67.4	1803	6.1 (1.2 to 11.0)
Israel	78.3	554	74.7	217	3.7 (-10.4 to 17.7)
The Netherlands	48.7	5072	45.4	5603	3.3 (0.5 to 6.2)
Taiwan	68.6	3888	64.9	4444	3.7 (0.2 to 7.2)
US	74.4	35956	69.3	42585	5.1 (3.9 to 6.3)
NSTEMI[a]					
Canada	39.6	8826	34.2	12969	5.4 (3.7 to 7.0)
England	34.6	7012	28.1	5026	6.5 (4.4 to 8.5)
Israel	44.0	1279	38.2	498	5.9 (-1.4 to 13.2)
The Netherlands	25.9	8144	22.6	11880	3.3 (1.8 to 4.9)
Taiwan	51.4	6354	49.7	7063	1.6 (-0.8 to 4.1)
US	34.8	106148	31.7	151877	3.2 (2.7 to 3.6)



C Coronary artery bypass graft surgery

Source	Wealthiest quintile Patients, %	Wealthiest quintile Total No. of patients	Poorest quintile Patients, %	Poorest quintile Total No. of patients	Difference, percentage points (95% CI)
STEMI[a]					
Canada	4.0	3586	3.6	4398	0.4 (-0.5 to 1.2)
England	3.4	3044	3.7	1803	-0.3 (-1.4 to 0.9)
Israel	4.4	554	3.7	217	0.7 (-2.5 to 3.8)
The Netherlands	2.7	5072	2.6	5603	0.1 (-0.5 to 0.7)
Taiwan	4.6	3888	4.5	4444	0.2 (-0.8 to 1.1)
US	7.7	35956	7.6	42585	0.0 (-0.3 to 0.4)
NSTEMI[a]					
Canada	9.2	8826	8.3	12969	0.9 (0.1 to 1.7)
England	7.9	7012	5.9	5026	2.0 (1.1 to 3.0)
Israel	7.2	1279	10.0	498	-2.9 (-6.3 to 0.6)
The Netherlands	3.2	8144	2.4	11880	0.8 (0.3 to 1.3)
Taiwan	4.9	6354	4.9	7063	0.1 (-0.7 to 0.8)
US	12.5	106148	11.0	151877	1.5 (1.3 to 1.8)



[a] See eTable 1 in Supplement 1 for definitions.

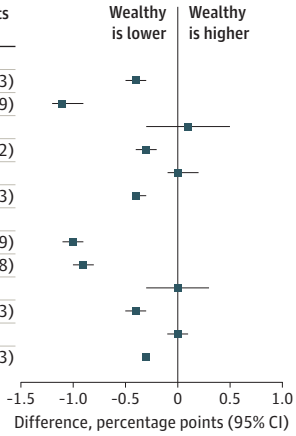
STEMI indicates ST-elevation myocardial infarction; NSTEMI, non-STEMI.

likely to be Medicaid eligible and to be members of racial and ethnic minority groups. Reports from the Organisation for Economic Co-operation and Development (OECD) have documented similar findings.[33] A recent cohort study using

Figure 3. Age- and Sex-Standardized Rates of Length of Stay and 30-Day Readmission[a,b]

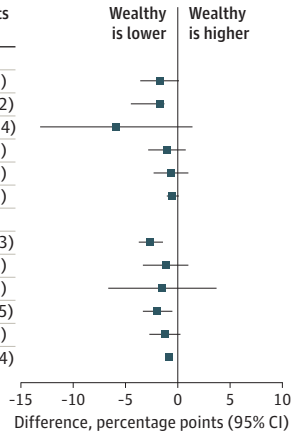
A Age- and sex-standardized length of stay, d

Source	Wealthiest quintile: Patients, %	Wealthiest quintile: Total No. of patients	Poorest quintile: Patients, %	Poorest quintile: Total No. of patients	Difference, percentage points (95% CI)
STEMI[c]					
Canada	6.3	3586	6.7	4398	-0.4 (-0.5 to -0.3)
England	6.0	3044	7.1	1803	-1.1 (-1.2 to -0.9)
Israel	5.2	554	5.2	217	0.1 (-0.3 to 0.5)
The Netherlands	5.3	5072	5.6	5603	-0.3 (-0.4 to -0.2)
Taiwan	9.0	3888	9.0	4444	0.0 (-0.1 to 0.2)
US	5.0	35956	5.4	42585	-0.4 (-0.4 to -0.3)
NSTEMI[c]					
Canada	7.4	8826	8.4	12969	-1.0 (-1.1 to -0.9)
England	8.5	7012	9.4	5026	-0.9 (-1.0 to -0.8)
Israel	6.5	1279	6.5	498	0.0 (-0.3 to 0.3)
The Netherlands	5.7	8144	6.2	11880	-0.4 (-0.5 to -0.3)
Taiwan	9.9	6354	9.9	7063	0.0 (-0.1 to 0.1)
US	6.0	106148	6.3	151877	-0.3 (-0.3 to -0.3)



B Adjusted 30-d readmission rate

Source	Wealthiest quintile: Patients, %	Wealthiest quintile: Total No. of patients	Poorest quintile: Patients, %	Poorest quintile: Total No. of patients	Difference, percentage points (95% CI)
STEMI[c]					
Canada	13.0	3586	14.5	4398	-1.5 (-3.3 to 0.2)
England	20.9	3044	22.4	1803	-1.5 (-4.2 to -1.2)
Israel	14.3	554	19.8	217	-5.5 (-12.4 to 1.4)
The Netherlands	16.8	5072	17.7	5603	-0.9 (-2.6 to 0.7)
Taiwan	12.5	3888	13.0	4444	-0.5 (-2.1 to 1.0)
US	12.0	35956	12.5	42585	-0.4 (-0.9 to 0.1)
NSTEMI[c]					
Canada	13.8	8826	16.2	12969	-2.4 (-3.5 to -1.3)
England	32.2	7012	33.2	5026	-1.0 (-3.1 to 1.1)
Israel	19.7	1279	21.0	498	-1.3 (-6.2 to 3.5)
The Netherlands	19.9	8144	21.7	11880	-1.8 (-3.1 to -0.5)
Taiwan	16.4	6354	17.5	7063	-1.1 (-2.5 to 0.3)
US	15.7	106148	16.4	151877	-0.7 (-1.0 to -0.4)



[a] See eTable 1 in Supplement 1 for definitions.

[b] Length of stay was adjusted for age and sex; readmission rates were adjusted for age, sex, and comorbidity

[c] See eTable 1 in the Supplement 1 for definitions.

STEMI indicates ST-elevation myocardial infarction; NSTEMI, non-STEMI.

survey and self-reported data from the US and England found larger income-based disparities in health outcomes in the US for adults aged 55 through 64 years.[7] That study relied on self-report of adults who were not yet eligible for Medicare, so some of those observed differences in health outcomes may have been driven by higher underinsurance or uninsurance rates in the US. This study also builds on a recent study that examined health outcomes of US residents from wealthier and poorer geographic regions compared with similar populations in other high-income countries, finding that outcomes for wealthy US residents were no better than average outcomes in other countries.[11] That study, however, used mostly aggregated data, which might obscure more substantial heterogeneity by income level within counties. Moreover, because health outcomes also are dependent on the availability of health system resources in an area, that study also might have been confounded by geographic differences in health care resources available in different areas of the country.[34]

The mortality differences identified in this study were substantial, including differences in 30-day mortality for STEMI in the almost all countries that were 2 to 3 percentage points higher (absolute difference) for low-income patients (a 10%-20% relative difference). For context, a 2% to 3% absolute difference in mortality is similar to or exceeds the mortality benefits afforded by treatment innovations such as primary PCI or thrombolytic therapy.[31,32] That low-income patients were treated less aggressively, with lower rates of both cardiac catheterization and revascularization, may be a potential explanation for worse outcomes. That lower-income patients received less aggressive treatment in all countries builds on prior studies suggesting that lower-income patients are less likely to receive many types of both evidence-based and nonevidence-based care.[35-37]

It also is possible that factors beyond revascularization may contribute to the higher mortality for lower-income patients. For instance, smoking rates are higher among low-income vs higher-income populations in most countries.[33,38] In addition, geography and differential access for lower-income patients to facilities with advanced cardiovascular services might explain lower rates of PCI and CABG surgery. Although measured comorbidities were controlled for in each country in the

mortality analyses for this study, there also may be higher rates of other unmeasured comorbidities among lower-income populations that might also influence short-term outcomes.[39] Irrespective of the cause, these finding of increased mortality of a similar magnitude for lower-income patients in all countries suggest that poverty and disadvantage are problems that afflicts all countries irrespective of history, culture, health care system, and social safety net.[8,40-42]

Readmission rates were universally higher among lower-income patients in all countries, although the magnitude of this difference varied. The largest difference was in Israel for STEMI, but differences across the countries were relatively similar. Readmission rates have been an area of intense scrutiny in the US since the publication of a landmark 2009 study that found readmission rates approaching 20% for Medicare patients.[43] The Hospital Readmission Reduction Program (HRRP) has been one of the signature value-based purchasing programs for hospital by the US Medicare program. The HRRP penalizes Medicare payments for hospitals with higher readmission rates and has been associated with reductions in readmissions over time.[44,45] Perhaps related to the HRRP, but also potentially due to other factors, readmission rates observed in the US were among the lowest of the 6 countries studied.[46-48] More recently, there also has been a widespread recognition in the US that readmissions are strongly related to social factors.[44,49-51] As a result, the HRRP has adopted a new method for determining penalties that compares hospitals to peer hospitals that care for similar proportions of disadvantaged populations.[52] The finding in this study of higher readmission rates for patients with low income in all countries provides important new information that the challenges of reducing hospital readmissions for disadvantaged populations are not easily rectified.

Limitations

This study has several limitations that warrant mention. First, this analysis relied on administrative claims data and lacked detailed clinical information about MI severity or treatments, so subgroups of patients could not be stratified (eg, by severity) beyond the STEMI-NSTEMI dichotomy, age, and sex. Information on potentially important confounders such as smoking rates was not available. Second, there is no universal method for identifying low- and high-income populations across countries and most existing methods may not account for assets or consumption.[53] Moreover, rates of misclassification might vary as a result of differential rates of income mixing within geographic regions in each country. Using area-level measures in this study also leads to misclassification, but this misclassification biases our results toward the null and would not explain the observed results. Third, race and ethnicity were not adjusted for because race and ethnicity data were not available for all countries and populations considered to be disadvantaged also differed across the countries. Fourth, this study was limited to adults aged 66 years or older who were hospitalized for acute MI and may not apply to younger patients or those with private insurance or enrolled in Medicare managed care in the US. Moreover, by focusing on US residents insured by Medicare, we were not able to evaluate whether income-based disparities in the US might be magnified relative to other countries in younger populations where US uninsurance rates approach 10% and underinsurance 20%. Fifth, some of these results might be explained by variation in the availability of hospitals that perform PCI and/or CABG surgery or the quality of hospitals within an area. Thus, further research is warranted to explore the contribution of supply side factors to the outcomes observed.

Conclusion

In this analysis of disparities in treatment and outcome for acute MI across 6 different countries, relatively consistent disparities in both treatment and outcomes by income existed. These results suggest that in contrast to findings from other studies, the US is not an outlier in terms of the care provided to and outcomes among patients with low vs high incomes for the population of older patients admitted with an acute MI.

ARTICLE INFORMATION

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Author Contributions: Dr Landon takes responsibility for the integrity of the data and the accuracy of the data analysis. Because the data analyses were conducted by country and later aggregated, no single author had access to all of the data.
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