# Comparison of In-Hospital Mortality From Acute Myocardial Infarction in HIV Sero-Positive Versus Sero-Negative Individuals

Daniel Pearce, DO[a,*], Chizobam Ani, MD[a,b], Yaminah Espinosa-Silva, BS[c], Ryan Clark, BS[c], Khuteja Fatima, BS[d], Munira Rahman, BS[c], Erik Diebolt, DO[c], and Bruce Ovbiagele, MD[e]

**Few studies have explored hospitalization outcome differences between patients who are seropositive for human immunodeficiency virus (HIV) compared to HIV-seronegative patients with acute myocardial infarctions (AMIs). The aim of this study was to explore in-hospital AMI mortality risk in seropositive and seronegative patients. A secondary analysis of the Nationwide Inpatient Sample from 1997 to 2006 was conducted. This sample allows the approximation of all United States hospitalizations. All AMI encounters with and without co-occurring HIV were identified using appropriate International Classification of Diseases and procedure codes. Descriptive and Cox proportional-hazards analyses were then conducted to estimate mortality differences between seropositive and seronegative patients while adjusting for demographic, clinical, hospital, and care factors. The results demonstrated higher AMI hospitalization mortality hazard in seropositive compared to seronegative patients after adjustment for age, gender, ethnicity, medical co-morbidities, hospital type, and number of in-hospital procedures (HR 1.38, 95% confidence interval 1.01 to 1.87, p = 0.04). Stratified analysis demonstrated greater although not statistically significant mortality hazard for non–ST-segment elevation myocardial infarction and ST-segment elevation myocardial infarction in seropositive compared to seronegative patients. Typical AMI care procedures occurred at significantly lower rates in seropositive versus seronegative patients, including thrombolytic and anticoagulant agents (18% vs 22%), coronary arteriography (48% vs 63%), left cardiac catheterization (52% vs 66%), and coronary artery bypass graft (6% vs 14%). In conclusion, additional mortality burden and lower procedure rates occur for HIV-seropositive patients receiving AMI care. Health care providers should be alert to the increased mortality burden when treating seropositive patients with AMI.**  **(Am J Cardiol 2012;xx:xxx)**

Cardiovascular disease remains the leading cause of mortality in the United States despite advancements in medicine, and acute myocardial infarctions (AMIs) contribute significantly to overall cardiovascular disease mortality.[1,2] Human immunodeficiency virus (HIV)–associated AMI treatment outcomes are important to examine because of the increased risk for AMI in HIV-positive patients related to unique pathophysiologic associations and, paradoxically, greater life expectancy in HIV-positive patients.[3,4] Some of these pathophysiologic mechanisms include HIV viremia, associated with coronary vessel endothelial irritation, platelet dysfunction, activation of proinflammatory cytokines, and thrombosis from reduced coronary blood flow and ischemia.[5,6] No study has evaluated the additional burden associated with co-morbid HIV infection on AMI hospitalization outcomes. The objective of this study was to explore in-hospital AMI mortality risk in HIV-positive patients compared to HIV-negative patients.

## Methods

Data were obtained from the Nationwide Inpatient Sample (NIS), developed as part of the Healthcare Cost and Utilization Project, a federal-state-industry partnership sponsored by the Agency for Healthcare Research and Quality. The NIS is designed to approximate a stratified 20% sample of all nonfederal, short-term, general, and specialty hospitals serving adults in the United States. The sampling strategy selects hospitals nationwide from the state inpatient database according to defined strata on the basis of ownership, bed size, teaching status, urban or rural location, and region. All discharges from sampled hospitals for the calendar year are then selected for inclusion into the NIS. To allow extrapolation for national estimates, hospital and discharge weights are provided. Detailed information on the design of the NIS is available at *http://www.hcup-us.ahrq.gov*.[7] From 1997 to 2006, the NIS captured discharge-level information on primary and secondary diagnoses and procedures, discharge vital status, and demographics on discharges by year. Data elements that could directly or indirectly identify patients

[a]Department of Internal Medicine, Loma Linda University, Loma Linda, California; [b]Department of Family Medicine, Charles Drew University of Medicine and Science, Los Angeles, California; [c]College of Osteopathic Medicine of the Pacific and [d]College of Podiatric Medicine, Western University of Health Sciences, Pomona, California; and [e]Department of Neurology, University of California, San Diego, San Diego, California. Manuscript received January 30, 2012; revised manuscript received and accepted May 31, 2012.

*Corresponding author: Tel: 909-993-3290; fax: 206-339-9250.

*E-mail address:* dpearce@llu.edu (D. Pearce).

0002-9149/12/$ – see front matter 
http://dx.doi.org/10.1016/j.amjcard.2012.05.045

Table 1
Frequency and distribution of all study variables (n = 1,428,146*)

| Variable | Value |
|---|---|
| Age (years)* | |
| 18–34 | 2% |
| 35–44 | 12% |
| 45–54 | 34% |
| 55–65 | 53% |
| Mean ± SE | 53.94 ± 0.02 |
| Race/ethnicity | |
| White | 77% |
| African American | 11% |
| Hispanic | 7% |
| Other† | 5% |
| Gender | |
| Male | 72% |
| Female | 28% |
| Primary payer | |
| Medicare | 15% |
| Medicaid | 10% |
| Private (including health maintenance organizations) | 61% |
| Other‡ | 14% |
| Total in-hospital charge | |
| <$10,000 | 11% |
| $10,000–$49,999 | 65% |
| ≥$50,000 | 24% |
| Length of hospital stay (days), mean ± SE | 5 ± 0.03 |
| CCI score | |
| <1 | 49% |
| 1 | 28% |
| 2 | 13% |
| ≥3 | 10% |
| Mean ± SE | 0.95 ± 0.01 |
| Co-morbid medical conditions | |
| Cancer | 1% |
| Cerebrovascular disease | 3% |
| Chronic pulmonary disease | 16% |
| Congestive heart failure | 20% |
| Connective tissue disease | 1% |
| Dementia | 0.1% |
| Diabetes with complications | 4% |
| Diabetes without complications | 24% |
| Hypertension | 51% |
| Metastatic carcinoma | 0.4% |
| Mild liver disease | 1% |
| Atrial fibrillation or flutter | 7% |
| Moderate to severe liver disease | 0.1% |
| Paraplegia/hemiplegia | 0.4% |
| Peptic ulcer disease | 1% |
| Peripheral vascular disease | 5% |
| Renal disease | 5% |
| Valvular heart disease | 7% |
| Other cardiovascular disease risk factors | |
| Dyslipidemia (International Classification of Diseases, Ninth Revision) | 42% |
| Smoker | 30% |
| Primary in-hospital procedures | |
| Left-sided cardiac catheterization | 66% |
| Coronary arteriography | 63% |
| Angiocardiography of left-sided cardiac structures | 56% |
| Single-vessel percutaneous transluminal coronary angioplasty or coronary atherectomy with or without mention of thrombolytic agent | 35% |
| Insertion of non-drug-eluting coronary artery stent(s) | 28% |
| Injection or infusion of platelet inhibitor | 18% |
| Insertion of drug-eluting coronary artery stent(s) | 14% |
| Extracorporeal circulation auxiliary to open-heart surgery | 11% |
| Single internal mammary coronary artery bypass | 11% |
| Diagnostic ultrasound of heart (echocardiography, transesophageal echocardiography) | 6% |
| Coronary artery bypass grafting | 14% |
| Number of procedures | |
| 0 or 1 | 17% |
| 2 or 3 | 20% |
| 4 or 5 | 26% |
| ≥6 | 38% |
| Mean ± SE | 4.36 ± 0.04 |
| Thrombolytic, antiplatelet, and anticoagulant agents§ | 22% |
| Mortality status | |
| Died in-hospital | 2% |
| HIV status | |
| HIV seropositive | 0.2% |

* Sample includes participants in the NIS data set with AMI encounters from 1997 to 2006, aged 18 to 65 years, with >1-day hospital stays recorded for the encounters.
† Asian/Pacific Islander, Native American, and unspecified.
‡ No pay, self-pay, and unspecified.
§ Does not include aspirin.

were excluded; we thus considered all discharge encounters to be independent. The unit of analysis was the discharge or encounter rather than the patient. A unique hospital identifier allows linkage of discharge data to an NIS data set with hospital characteristics.

Our sample included hospitalization events for AMIs from 1997 to 2006 in patients aged 18 to 65 years with >1-day hospital stays recorded for the encounters. To analyze AMI hospitalizations, we identified all discharges for which an International Classification of Diseases, Ninth Revision, Clinical Modification code of 410.xx (AMI) was listed as the primary diagnosis. This approach has been used in other studies[8] and was taken to specifically focus on encounters that presented with acute myocardial ischemia and not those encounters with AMIs secondary to surgery, hypotension, or other events after admission. Total numbers of myocardial infarctions were obtained by summation across all 410.xx International Classification of Diseases, Ninth Revision, Clinical Modification, codes. For encounters with >1 reported code of 410.xx, only the first reported code was used. Similarly, procedure codes for the 10 most common procedures were also identified using the reported International Classification of Diseases, Ninth Revision, Clinical Modification, code. ST-segment elevation AMI (STEMI) and non–ST-segment elevation AMI (NSTEMI) were also identified and coded using appropriate International Classification of Diseases coding. We were careful to account for code changes that occurred in 2005 while extracting the data (single vessel percutaneous transluminal coronary angioplasty or coronary atherectomy with and without a thrombolytic agent; 36.01 and 36.02 were newly added procedures at that time). HIV co-morbidity was identified using the NIS clinical classification software. In-hos-

Table 2
Bivariate analysis and distribution of study variables by human immunodeficiency virus serostatus

| Variable | HIV Seronegative (n = 2,501,904) | HIV Seropositive (n = 5,984) | p Value[§] |
|---|---|---|---|
| Age (years)* | | | <0.001 |
| 18–34 | 2% | 6% | |
| 35–44 | 12% | 28% | |
| 45–54 | 34% | 44% | |
| 55–65 | 53% | 22% | |
| Mean ± SE | 54 ± 0.02 | 48 ± 0.27 | |
| Race/ethnicity | | | <0.001 |
| White | 77% | 50% | |
| African American | 11% | 35% | |
| Hispanic | 7% | 10% | |
| Other[†] | 5% | 5% | |
| Gender | | | <0.001 |
| Male | 72% | 85% | |
| Female | 28% | 15% | |
| Primary payer | | | <0.001 |
| Medicare | 15% | 39% | |
| Medicaid | 10% | 23% | |
| Private (including health maintenance organizations) | 61% | 28% | |
| Other[‡] | 14% | 10% | |
| Total in-hospital charge | | | 0.03 |
| <$10,000 | 11% | 11% | |
| $10,000–$49,999 | 65% | 60% | |
| ≥$50,000 | 24% | 29% | |
| Length of hospital stay (days), mean ± SE | 5 ± 0.03 | 6 ± 0.02 | 0.005 |
| CCI score | | | <0.001 |
| <1 | 49% | 43% | |
| 1 | 28% | 26% | |
| 2 | 13% | 16% | |
| ≥3 | 10% | 15% | |
| Mean ± SE | 0.94 ± 0.01 | 1.14 ± 0.05 | 0.007 |
| Co-morbid medical conditions | | | |
| Cancer | 1% | 3% | <0.001 |
| Cerebrovascular disease | 3% | 3% | NS |
| Chronic pulmonary disease | 16% | 14% | NS |
| Congestive heart failure | 20% | 26% | <0.001 |
| Connective tissue disease | 1% | 0.5% | 0.02 |
| Dementia | 0.1% | 1% | <0.001 |
| Diabetes with complications | 4% | 3% | 0.01 |
| Diabetes without complications | 24% | 17% | <0.001 |
| Hypertension | 51% | 46% | <0.001 |
| Metastatic carcinoma | 7% | 3% | <0.001 |
| Mild liver disease | 0.4% | 0.2% | NS |
| Atrial fibrillation or flutter | 1% | 8% | <0.001 |
| Moderate to severe liver disease | 0.1% | 0.3% | 0.05 |
| Paraplegia/hemiplegia | 0.4% | 0.6% | NS |
| Peptic ulcer disease | 1% | 0.6% | NS |
| Peripheral vascular disease | 5% | 3% | 0.01 |
| Renal disease | 5% | 13% | <0.001 |
| Valvular heart disease | 7% | 7% | NS |
| Other cardiovascular disease risk factors | | | <0.0001 |
| Dyslipidemia (International Classification of Diseases, Ninth Revision) | 42% | 25% | |
| Smoker | 30% | 25% | |
| Primary in-hospital procedures | | | 0.001 |
| Left-sided cardiac catheterization | 66% | 52% | <0.001 |
| Coronary arteriography | 63% | 48% | <0.001 |
| Angiocardiography of left-sided cardiac structures | 56% | 44% | <0.001 |
| Single-vessel percutaneous transluminal coronary angioplasty or coronary atherectomy with or without mention of thrombolytic agent | 35% | 24% | <0.001 |
| Insertion of non-drug-eluting coronary artery stent(s) | 28% | 20% | <0.001 |
| Injection or infusion of platelet inhibitor | 18% | 14% | 0.003 |
| Insertion of drug-eluting coronary artery stent(s) | 14% | 13% | NS |
| Extracorporeal circulation auxiliary to open-heart surgery | 11% | 4% | <0.001 |

Table 2
(continued)

| Variable | HIV Seronegative (n = 2,501,904) | HIV Seropositive (n = 5,984) | p Value[§] |
|---|---|---|---|
| Single internal mammary coronary artery bypass | 11% | 5% | <0.001 |
| Diagnostic ultrasound of heart (echocardiography, transesophageal echocardiography) | 6% | 7% | NS |
| Coronary artery bypass grafting (includes 36.10–36.19) | 14% | 6% | <0.001 |
| Number of procedures | | | 0.009 |
| 0 or 1 | 17% | 29% | |
| 2 or 3 | 20% | 19% | |
| 4 or 5 | 26% | 23% | |
| ≥6 | 38% | 29% | |
| Mean ± SE | 4.36 ± 0.04 | 3.71 ± 0.11 | |
| Thrombolytic, antiplatelet, and anticoagulant agents[‖] | 22% | 18% | 0.001 |
| Hospital type | | | <0.001 |
| Rural | 9% | 4% | |
| Urban nonteaching | 41% | 34% | |
| Urban teaching | 50% | 62% | |
| Mortality status | | | |
| Died in-hospital | 2% | 4% | <0.001 |
| AMI type | | | <0.001 |
| STEMI | 56% | 50% | |
| NSTEMI | 44% | 50% | |

* Sample includes participants in the NIS data set with AMI encounters from 1997 to 2006, aged 18 to 65 years, with >1-day hospital stays recorded for the encounters.

[†] Asian/Pacific Islander, Native American, and unspecified.

[‡] No pay, self-pay, and unspecified.

[§] Significance based on chi-square, Fisher's exact, or analysis-of-variance test.

[‖] Does not include aspirin.

pital mortality was defined as "died" during the hospitalization encounter in the NIS data set.

We examined the association between in-hospital AMI mortality in HIV-seropositive versus HIV-seronegative AMI encounters. First, the distribution of all study variables was examined for normality. These variables included the primary outcome (AMI mortality) and the primary predictor (HIV serostatus).

Other independent predictors and covariates used for the analysis included (1) sociodemographic characteristics (age, race [white, black, Hispanic, other], primary payer [Medicare, Medicaid, private, other]), (2) dyslipidemia, (3) hospital type, and (4) clinical factors, including medical co-morbidities and procedures performed. Co-morbid medical conditions are defined by the NIS protocol as documented International Classification of Diseases, Ninth Revision, diagnoses and documentation of such conditions.

The number and severity of co-morbid conditions were assessed using Charlson's co-morbidity index (CCI).[9] We used the modified version of the CCI on the basis of recent work by Quan et al.[10] The CCI is a numerically weighted score composed of 17 co-morbid conditions: congestive heart failure, chronic pulmonary disease, cerebrovascular disease, dementia, diabetes without complications, liver disease, peptic ulcer disease, peripheral vascular disease, rheumatologic disease, hemiplegia or paraplegia, diabetes with complication, malignancy, renal disease, metastatic solid tumor, and HIV/acquired immune deficiency syndrome (excluded here and used as an independent predictor). For the purpose of the multivariate Cox regression analysis, the CCI score was used as a numerical categorical variable. The CCI has been used in HIV and cardiovascular studies as a validated index for acute care outcomes.[7,8]

We initially conducted tests to rule out collinearity among the predictors and covariates and the final mortality comparison was adjusted for demographic factors, medical co-morbidities, dyslipidemia, hospital type, and in-hospital procedures. Appropriate NIS sampling and design parameters were used during this analysis. All data analyses were conducted using PASW version 18.0 (with the complex samples module; SAS Institute Inc., Cary, North Carolina). Statistical hypotheses were tested using $p < 0.05$ as the level of statistical significance. This study was approved by the Arrowhead Regional Medical Center's institutional review board.

## Results

The frequency and distribution of all study variables are listed in Table 1. The results demonstrate that most in-hospital encounters for AMI were in patients aged ≥55 years who were white, male, and privately insured. Most AMI encounters occurred in patients with CCI scores ≤2, and the mean length of hospital stay was 5.29 days (SE 0.03). The most common medical co-morbidities for patients with AMI were hypertension (51.0%), diabetes without complications (23.6%), congestive heart failure (19.7%), and chronic pulmonary disease (15.7%). The most common in-hospital AMI-associated procedures reported were left-sided cardiac catheterization (66.0%), coronary arteriography (62.5%), and angiography of left-sided cardiac structures (56.2%). A total of 13.8% had coronary artery bypass grafts,

Table 3
Multivariate Cox proportional-hazards models: acute myocardial infarction mortality versus human immunodeficiency virus serostatus (adjusted for age, race, gender, medical co-morbidities, hospital type, dyslipidemia, and number of procedures) (n = 1,829,786*)

| Variable | Hazard Ratio | 95% Confidence Interval | p Value |
|---|---|---|---|
| Age (years) | | | |
| 18–34 | 0.68 | 0.55–0.85 | <0.001 |
| 35–44 | 0.66 | 0.60–0.73 | <0.001 |
| 45–54 | 0.79 | 0.75–0.83 | <0.001 |
| 55–65† | 1.00 | NA | |
| Race/ethnicity | | | |
| White† | 1.00 | NA | |
| African American | 0.96 | 0.87–1.05 | 0.50 |
| Hispanic | 0.92 | 0.85–1.00 | 0.06 |
| Other | 0.98 | 0.91–1.05 | 0.37 |
| Gender | | | |
| Female† | 1.00 | NA | |
| Male | 0.93 | 0.89–0.97 | 0.001 |
| CCI score | | | |
| <1 | 0.40 | 0.37–0.44 | <0.001 |
| 1 | 0.69 | 0.65–0.73 | <0.001 |
| 2 | 0.87 | 0.82–0.92 | <0.001 |
| ≥3† | 1.00 | NA | |
| Dyslipidemia (International Classification of Diseases, Ninth Revision) | | | |
| No | 0.35 | 0.33–0.37 | <0.001 |
| Yes† | 1.00 | NA | |
| Hospital type | | | |
| Rural | 1.21 | 1.10–1.33 | <0.001 |
| Urban nonteaching | 1.14 | 1.08–1.22 | <0.001 |
| Urban teaching† | 1.00 | NA | |
| Number of procedures | | | |
| 0 or 1 | 1.20 | 1.10–1.31 | <0.001 |
| 2 or 3 | 1.71 | 1.60–1.84 | <0.001 |
| 4 or 5 | 1.05 | 0.98–1.13 | NS |
| ≥6† | 1.00 | NA | |
| HIV status | | | |
| HIV seronegative† | 1.00 | NA | |
| HIV seropositive | 1.38 | 1.01–1.87 | 0.04 |

* Excludes missing cases for variables specified in regression model.
† Reference category in multivariate model.

and 22.2% received thrombolytic agents, antiplatelet agents, or anticoagulant agents during the hospitalization event. Dyslipidemia and tobacco use occurred in 41.6% and 29.6% of the sample, respectively. Most AMIs were treated in urban teaching hospital settings (50.2%). There were 5,984 AMI encounters (population adjusted) in patients with co-occurring HIV. Overall AMI encounter mortality was 2.4% in the sample. Finally, STEMI was more common in the sample than NSTEMI (56.2% vs 43.8%).

The associations between study variables and HIV serostatus are listed in Table 2. The results demonstrate that compared with the seronegative patients, most of the seropositive patients were younger (age <54 years), male (85%), and insured primarily by Medicare and Medicaid (63%). Total costs were slightly higher in the seropositive sample. The mean length of hospital stay was higher in HIV-positive encounters (6 vs 5 days). The co-morbidity burden was also higher in HIV-positive encounters (CCI score 1.14 vs 0.94). The prevalence of the following co-morbidities was higher in seropositive encounters: renal disease (13% vs 5%), mild liver disease, (8% vs 1%), and congestive heart failure (26% vs 19%). Dyslipidemia and tobacco use were significantly lower in seropositive patients. Among seropositive encounters, statistically significant lower procedure rates were also recorded for the most common in-hospital AMI procedures: left-sided cardiac catheterization (52% vs 66%), coronary arteriography (48% vs 63%), and angiography of left-sided cardiac structures (44% vs 56%). Coronary artery bypass grafting was performed at significantly lower rates in seropositive patients (6% vs 14%). Thrombolytic, antiplatelet, and anticoagulant use was also significantly lower in seropositive patients (18% vs 22%). STEMI was more common than NSTEMI in seropositive and seronegative individuals. Overall, in-hospital AMI encounter mortality was higher among seropositive compared to seronegative encounters (4% vs 2%).

After adjustments were made for age, race, gender, medical co-morbidities, dyslipidemia, hospital type, and number of in-hospital procedures, the results demonstrated a higher mortality hazard for AMI for seropositive compared to seronegative patients (hazard ratio 1.38, 95% confidence interval 1.01 to 1.87, p = 0.04; Table 3).

Mortality was less in younger age groups, patients without dyslipidemia, and men, whereas mortality was higher in rural and urban nonteaching hospitals and patients with greater medical co-morbidity burden and higher in patients with ≤3 procedures recorded during the hospitalization event. Stratified analysis to explore mortality differences for STEMI and NSTEMI AMI subtypes demonstrated higher but not statistically significant greater mortality in seropositive patients compared to seronegative patients.

## Discussion

Our study demonstrates that the relative in-hospital mortality risk from an AMI event was significantly higher for seropositive compared to seronegative patients. This risk remained significantly higher even after accounting for the influence of demographics, medical co-morbidities, hospital type, dyslipidemia, and number of in-hospital procedures. Although it is difficult to determine the causes for the observed disproportionate mortality outcome, an underlying increased co-morbidity burden, measured using the CCI,[9,10] higher in seropositive compared to seronegative patients, may explain some of the differences. Interestingly, with the exception of congestive heart failure and renal disease, which were significantly higher in seropositive patients, most of the common cardiometabolic risk factors were lower in seropositive patients.

Although the incidence of cardiometabolic risk and diseases has increased in seropositive patients, because of increasing life expectancy,[11] some evidence suggests that variant and earlier occurring cardiovascular diseases may occur.[12–14] This may in part be attributable to antiretroviral agents[15–17] or unique, direct pathologic effects of HIV viremia on cardiac vasculature, including arterial endothelial inflammation, intimal fibrosis with luminal narrowing of coronary vessels, endothelial irritation, platelet dysfunction,

activation of proinflammatory cytokines, thrombosis from reduced coronary blood flow, and ischemia.[5,6,18] Although an increased risk for small-vessel vasculitis in HIV-infected patients has not been empirically established,[19] coronary vessel disease may occur commonly in HIV-seropositive patients and increase the risk for AMI when other traditional risk factors are accounted for. Several mechanisms for coronary atherosclerosis have been implicated, including abnormalities in lipid-related processes[20] and the suggestion that chronic inflammation contributes significantly through the effect of increased proinflammatory macrophages on noncalcified coronary plaque.[21]

In our sample, however, dyslipidemia occurred with less frequency in seropositive patients but was associated with increased overall mortality risk. The lower occurrence of dyslipidemia and smoking in our results may be explained by the limitation associated with the possible underrecording in seropositive patients in the NIS database, especially because studies report that in seropositive patients, smoking is more frequent,[22] and those treated with antiretroviral agents have an increased risk for dyslipidemia.[23] Likewise, the role of lifestyle risk factors such as co-occurring substance use, including alcohol, was not incorporated into our analysis and may also explain some of the observed variation in mortality outcomes. Several studies have demonstrated a higher prevalence of substance use in seropositive compared to seronegative patients.[24]

The study results document lower post-AMI procedure rates for seropositive patients. In our study model that accounted for the number of hospitalization associated procedures, AMI mortality disparities in seropositive patients decreased slightly but persisted, suggesting that although procedure rates may be an important contributor, they do not completely explain the mortality differential observed. In fact, most of the common AMI in-hospital procedures occurred with significantly lower frequency in seropositive AMI hospitalizations. Additionally, thrombolytic agents, antiplatelet agents, and anticoagulant agents were used much less frequently in seropositive patients. Similar disparities in care procedures have been associated with poorer AMI outcomes in women, reported to receive less aggressive therapy, including percutaneous coronary intervention, compared to men.[25] This is the first study we know of to document disparities in treatment processes for AMI in seropositive patients, and although we cannot explicitly ascribe our observations to discrimination in the process of care, further studies may be required to explore the underlying explanatory factors associated with this observation. It is important to note that the use of aspirin was not considered in this analysis, because the reliability of its recording may be subject to significant limitations despite aspirin's known impact on absolute mortality risk reduction for AMI.

It is not surprising that the length of stay was significantly higher in HIV-seropositive patients, as seen in other studies, possibly because of co-morbidities and nosocomial complications.[26,27]

Low socioeconomic status has been reported to reduce relative AMI survival in the general population,[28] and more of the seropositive patients in our sample were on public insurance payer systems. Observations about mortality disparities associated with age are consistent with previous evidence. Finally, although differential AMI mortality occurred by hospital type, with rural and nonteaching settings having higher mortality compared to urban teaching settings, hospital type had little impact on overall AMI mortality disparity.

This study was subject to important limitations, including the use of administrative data that extrapolate AMI occurrence by using International Classification of Diseases, Ninth Revision, coding for incident disease encounters. Coding errors may overreport or underreport AMI incidence. Observations of AMI incidence without documented procedures recorded may indicate false AMI diagnoses in the sample, because it is rare that AMI encounters will exclude diagnostic or therapeutic risk assessment. This observed phenomenon may also indicate secondary referral of patients to centers with more appropriate risk exploration and stratification capacity. It is also important to note that HIV severity could not be appropriately estimated, because many of the conditions that define acquired immune deficiency syndrome and degree of HIV control could not be appropriately identified and classified.

1. Greenlund KJ, Giles WH, Keenan NL, Malarcher AM, Zheng ZJ, Casper ML, Heath GW, Croft JB. Heart Disease and Stroke Mortality in the 20th Century. Oxford, United Kingdom: Oxford University Press, 2006.
2. Minino AM, Anderson RN, Fingerhut LA, Boudreault MA, Warner M. Deaths: injuries 2002. *Natl Vital Stat Rep* 2006;54:1–124.
3. May MT, Sterne JA, Costagliola D, Sabin CA, Phillips AN, Justice AC, Dabis F, Gill J, Lundgren J, Hogg RS, de Wolf F, Fatkenheuer G, Staszewski S, d'Arminio Monforte A, Egger M. HIV treatment response and prognosis in Europe and North America in the first decade of highly active antiretroviral therapy: a collaborative analysis. *Lancet* 2006;368:451–458.
4. Smith C. Factors associated with specific causes of death amongst HIV-positive individuals in the D:A:D study. *AIDS* 2010;24:1537–1548.
5. Joshi VV, Pawel B, Conner E, Sharer L, Oleske JM, Morrison S, Marin-Garcia J. Arteriopathy in children with acquired immune deficiency syndrome. *Pediatr Pathol* 1987;7:261–275.
6. Torre D, Pugliese A. Interleukin-18: a proinflammatory cytokine in HIV-1 infection. *Curr HIV Res* 2006;4:423.
7. Agency for Healthcare Research and Quality. Nationwide Inpatient Sample (NIS), Healthcare Cost and Utilization Project (HCUP). Bethesda, Maryland: Agency for Healthcare Research and Quality, 1997–2006.
8. Ani C, Pan D, Martins D, Ovbiagele B. Age- and sex-specific in-hospital mortality after myocardial infarction in routine clinical practice. *Cardiol Res Pract* 2010;2010:752–765.
9. Charlson M, Szatrowski TP, Peterson J, Gold J. Validation of a combined comorbidity index. *J Clin Epidemiol* 1994;47:1245–1251.
10. Quan H, Sundararajan V, Halfon P, Fong A, Burnand B, Luthi JC, Saunders LD, Beck CA, Feasby TE, Ghali WA. Coding algorithms for defining comorbidities in ICD-9-CM and ICD-10 administrative data. *Med Care* 2005;43:1130–1139.
11. Battegay M, Elzi L. Morbidity and mortality in HIV-infected individuals—a shift towards comorbidities. *Swiss Med Wkly* 2009;139:564–570.
12. Matetzky S, Domingo M, Kar S, Noc M, Shah PK, Kaul S, Daar E, Cercek B. Acute myocardial infarction in human immunodeficiency virus-infected patients. *Arch Intern Med* 2003;163:457–460.
13. Sharma TS, Messiah S, Fisher S, Miller TL, Lipshultz SE. Accelerated cardiovascular disease and myocardial infarction risk in patients with the human immunodeficiency virus. *J Cardiometab Syndr* 2008;3:93–97.
14. Triant VA, Lee H, Hadigan C, Grinspoon SK. Increased acute myocardial infarction rates and cardiovascular risk factors among patients with human immunodeficiency virus disease. *J Clin Endocrinol Metab* 2007;92:2506–2512.

15. Boccara F. Cardiovascular complications and atherosclerotic manifestations in the HIV-infected population: type, incidence and associated risk factors. *AIDS* 2008;22(suppl):S19–S26.
16. Worm SW, Sabin C, Weber R, Reiss P, El-Sadr W, Dabis F, De Wit S, Law M, Monforte AD, Friis-Moller N, Kirk O, Fontas E, Weller I, Phillips A, Lundgren J. Risk of myocardial infarction in patients with HIV infection exposed to specific individual antiretroviral drugs from the 3 major drug classes: the Data Collection on Adverse Events of Anti-HIV Drugs (D:A:D) study. *J Infect Dis* 2010;201:318–330.
17. Zhou H, Pandak WM Jr, Lyall V, Natarajan R, Hylemon PB. HIV protease inhibitors activate the unfolded protein response in macrophages: implication for atherosclerosis and cardiovascular disease. *Mol Pharmacol* 2005;68:690–700.
18. Paton P, Tabib A, Loire R, Tete R. Coronary artery lesions and human immunodeficiency virus infection. *Res Virol* 1993;144:225–231.
19. Guillevin L. Vasculitides in the context of HIV infection. *AIDS* 2008; 22(suppl):S27–S33.
20. Shahmanesh M, Das S, Stolinski M, Shojaee-Moradie F, Jackson NC, Jefferson W, Cramb R, Nightingale P, Umpleby AM. Antiretroviral treatment reduces very-low-density lipoprotein and intermediate-density lipoprotein apolipoprotein B fractional catabolic rate in human immunodeficiency virus-infected patients with mild dyslipidemia. *J Clin Endocrinol Metab* 2005;90:755–760.
21. Burdo TH, Lo J, Abbara S, Wei J, DeLelys ME, Preffer F, Rosenberg ES, Williams KC, Grinspoon S. Soluble CD163, a novel marker of activated macrophages, is elevated and associated with noncalcified coronary plaque in HIV-infected patients. *J Infect Dis* 2011;204:1227–1236.
22. Burkhalter JE, Springer CM, Chhabra R, Ostroff JS, Rapkin BD. Tobacco use and readiness to quit smoking in low-income HIV-infected persons. *Nicotine Tob Res* 2005;7:511.
23. Carr A, Samaras K, Thorisdottir A, Kaufmann GR, Chisholm DJ, Cooper DA. Diagnosis, prediction, and natural course of HIV-1 protease-inhibitor-associated lipodystrophy, hyperlipidaemia, and diabetes mellitus: a cohort study. *Lancet* 1999;353:2093–2099.
24. Carey JW, Mejia R, Bingham T, Ciesielski C, Gelaude D, Herbst JH, Sinunu M, Sey E, Prachand N, Jenkins RA, Stall R. Drug use, high-risk sex behaviors, and increased risk for recent HIV infection among men who have sex with men in Chicago and Los Angeles. *AIDS Behav* 2009;13:1084–1096.
25. Lansky AJ, Hochman JS, Ward PA, Mintz GS, Fabunmi R, Berger PB, New G, Grines CL, Pietras CG, Kern MJ, Ferrell M, Leon MB, Mehran R, White C, Mieres JH, Moses JW, Stone GW, Jacobs AK. Percutaneous coronary intervention and adjunctive pharmacotherapy in women: a statement for healthcare professionals from the American Heart Association. *Circulation* 2005;111:940–953.
26. Masoomi H, Mills SD, Dolich MO, Dang P, Carmichael JC, Nguyen NT, Stamos MJ. Outcomes of laparoscopic and open appendectomy for acute appendicitis in patients with acquired immunodeficiency syndrome. *Am Surg* 2011;77:1372–1376.
27. Morrison CA, Wyatt MM, Carrick MM. Effects of human immunodeficiency virus status on trauma outcomes: a review of the national trauma database. *Surg Infect* 2010;11:41–47.
28. McDavid Harrison K, Ling Q, Song R, Hall HI. County-level socioeconomic status and survival after HIV diagnosis, United States. *Ann Epidemiol* 2008;18:919–927.