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Relationship between Patient Income Level and Mitral Valve Repair Utilization

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ABSTRACT

Background: The superiority of mitral valve (MV) repair is well established with respect to long-term survival, preservation of ventricular function, and valve-related complications. The relationship between patient income level and the selection of MV procedure (repair versus replacement) has not been studied.

Methods: The 2005 to 2007 Nationwide Inpatient Sample database was searched for patients ≥ 30 years old with MV repair or replacement; patients with ischemic and congenital MV disease were excluded. Patients were stratified into quartiles according to income level (quartile 1, lowest; quartile 4, highest). We used univariate and multivariate models to compare patients with respect to baseline characteristics, selection of MV procedure, and hospital mortality.

Results: The preoperative profiles of the income quartiles differed significantly, with more risk factors occurring in the lower income quartiles. Unadjusted hospital mortality decreased with increasing income quartile. The percentage of patients receiving MV repair increased with increasing income (35.6%, 39.6%, 48.2%, and 55.8% for quartiles 1, 2, 3, and 4, respectively; $P = .0001$). Following adjustment for age, race, sex, urban residency, admission status, primary payer, Charlson comorbidity index, and hospital location and teaching status, the income quartiles had similar hospital death rates, whereas the highly significant relationship between valve repair and income level persisted ($P = .0008$).

Conclusions: Significant disparity exists among patients in the different income quartiles with respect to the likelihood of receiving MV repair. MV repair is performed less frequently in patients with lower incomes, even after adjustment for differences in baseline characteristics. The higher unadjusted mortality rate for less affluent patients appears mostly related to their worse preoperative profiles.

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INTRODUCTION

Socioeconomic status has been identified as an important factor influencing health care quality [Schermerhorn 2008; Hardy 2009]. In cardiovascular medicine, much has been written about the disparity in outcomes of patients with acute myocardial infarction associated with socioeconomic status [Alter 1999; Philbin 2000; Chang 2007]. Patients from disadvantaged backgrounds are less likely to receive angiography, percutaneous transluminal coronary angioplasty or coronary artery bypass grafting (CABG) [Alter 1999; Philbin 2000]. Furthermore, patients who are less wealthy have a higher mortality rate following a myocardial infarction, even after adjustment for their higher comorbidity profiles [Alter 1999; Chang 2007].

Recently, some literature has emerged on the impact of socioeconomic status with respect to valve surgery. Using data from the UK Heart Valve Registry, Bagger et al found no difference in early mortality among patients who underwent valve replacement, whereas long-term mortality was worse for patients of lower socioeconomic status [Bagger 2008]. Using data from the Medicare database, Birkmeyer et al found socioeconomic status to be a significant predictor of operative mortality, for both aortic and mitral valve (MV) replacement, although the differences in mortality disappeared following adjustment for baseline comorbidities [Birkmeyer 2008]. Data on the impact of socioeconomic status on the procedure selected (repair versus replacement) for patients undergoing MV surgery are lacking. The question of procedure selection has become increasingly important in the field of MV surgery, because the superiority of MV repair over MV replacement has been well established [Perier 1984; Grossi 1998]. We sought to examine this issue with the largest all-payer database in the United States.

METHODS

Database

The Nationwide Inpatient Sample (NIS) represents a random sample (approximately 20%) of hospital admissions in the United States [Schermerhorn 2008]. To obtain a representative sample of US hospitals, the NIS collects data from

hospitals that are stratified by geographic region, urban/rural location, teaching status, and the number of hospital beds. The database is maintained by the Healthcare Cost and Utilization Project (HCUP) and deidentifies patients to protect the confidentiality of medical records. Records are coded by using up to 15 procedure and 15 diagnostic codes according to the International Classification of Diseases, Ninth Edition, Clinical Modification (ICD-9-CM). The NIS is the largest all-payer database in the United States and has been used for analyzing trends in health care utilization, access, charges, quality, and outcomes, not only for research but also for policy making [HCUP 2010].

Sample Selection

The study evaluated patients who underwent MV repair or replacement (ICD-9-CM codes 35.12, 35.23, 35.24) by using discharge data from the NIS database from 2005 through 2007. Patients <30 years of age were excluded. Patients were also excluded if they had undergone closed heart valvuloplasty, congenital heart disease, coronary revascularization, excision of a ventricular aneurysm, replacement of the thoracic aorta, an aortic fenestration procedure, and/or other valvular repair or replacement (except tricuspid). Specifically, patients who underwent concomitant tricuspid valve repair (ICD-9-CM code 35.14) or replacement (ICD-9-CM codes 35.27 and 35.28) and atrial septal defect/patent foramen ovale closure (ICD-9-CM 35.71) were not excluded from the analysis. We also excluded patients with additional diagnostic codes reflecting patients with congenital anomalies of the heart and circulatory system, as well as patients with a heart transplant or awaiting heart transplantation.

Data Variables

We used patient income level as a surrogate for socioeconomic status. The income quartiles in the NIS database are calculated using the median household income for the patient's ZIP Code. From 2005 through 2007, these income quartiles varied slightly, as follows: income quartile 1 (2005-2006, $1-$35,999; 2007, $1-$38,999), income quartile 2 (2005-2006, $36,000-$44,999; 2007, $39,000-$47,999), income quartile 3 (2005-2006, $45,000-$58,999; 2007, $48,000-$62,999), and income quartile 4 (2005-2006, $59,000; 2007, $63,000). We used the following baseline characteristics to compare patients from the 4 income levels: age, sex, race, urban versus rural patient residence status, insurance type, treatment at urban versus rural hospital, and teaching versus nonteaching hospital, admission status, and Charlson comorbidity index. The main outcomes of interest were the type of MV procedure (repair versus replacement) and hospital death.

Statistical Analysis

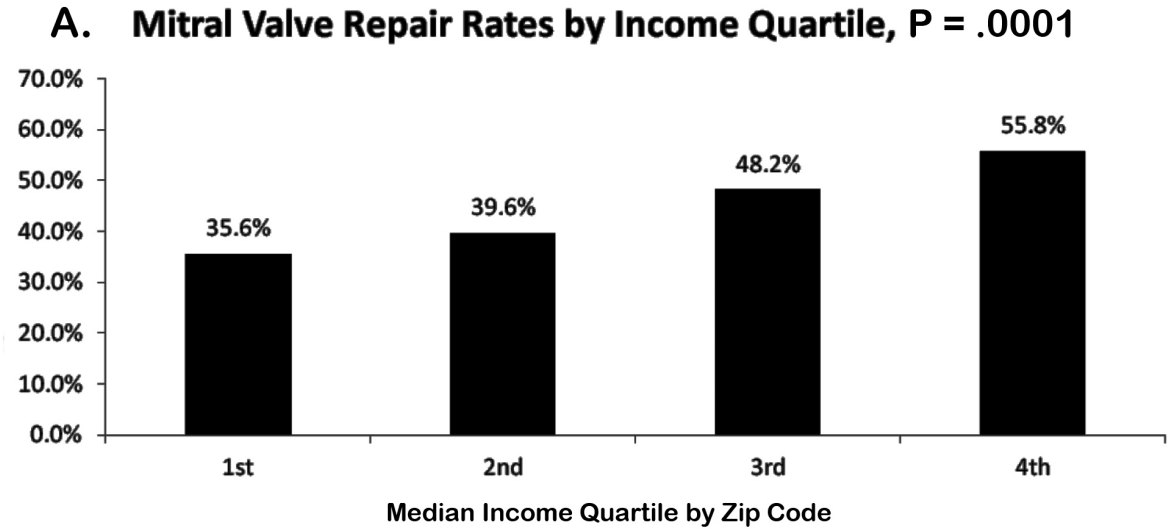
Chi-square tests of independence and analyses of variance were used to compare the groups with respect to baseline

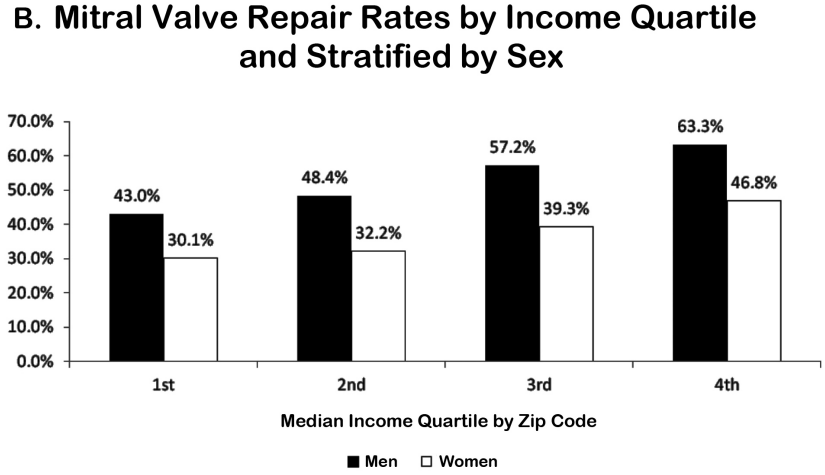
Baseline Characteristics by Income Quartile

	Quartile 1	Quartile 2	Quartile 3	Quartile 4	*P*
No. of patients	9784 (20.9%)	10,219 (21.8%)	12,430 (26.5%)	14,482 (30.9%)	
Age, y*	61.0, 62 (52-72)	62.3, 63 (53-73)	62.3, 63 (52-73)	62.1, 62 (52-73)	.0080
Age ≥ 65 y	43.3%	47.1%	46.2%	44.8%	.1158
Female sex	57.4%	54.5%	50.7%	46.2%	.0001
White race	64.5%	79.1%	79.9%	84.2%	.0001
Urban residency	64.8%	73.6%	90.7%	98.9%	.0001
Primary Payer					
Medicare	48.7%	49.9%	45.1%	41.4%	.0001
Medicaid	13.1%	6.2%	5.0%	2.0%	.0001
Private insurance	31.2%	37.5%	44.6%	53.4%	.0001
Self-pay	3.7%	2.8%	2.7%	1.0%	.0001
Other	3.3%	3.6%	2.6%	2.2%	.0483
Admission status					
Elective	60.1%	65.5%	67.7%	67.8%	.0104
Urgent/emergent	39.9%	34.5%	32.3%	32.2%	
Teaching hospital	69.4%	66.3%	68.5%	70.2%	.7655
Urban hospital	97.6%	97.2%	98.9%	>99.5%†	.0001
Charlson comorbidity index*	1.25, 1 (0-2)	1.07, 1 (0-2)	0.99, 1 (0-1)	0.88, 1 (0-1)	.0001

*Data are presented as the mean, median (interquartile range).

†Exact value not reported per HCUP (Healthcare Cost and Utilization Project) NIS (Nationwide Inpatient Sample) guidelines.





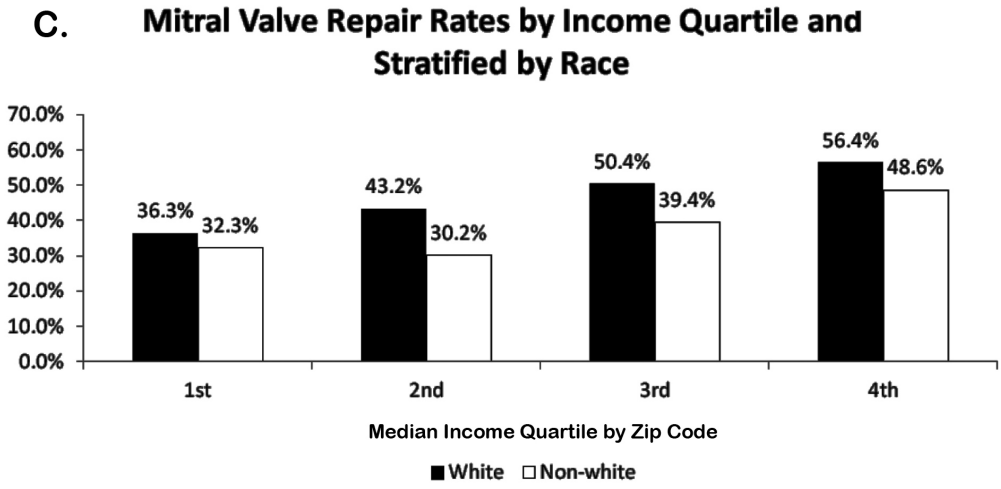


Figure 1. A, Mitral valve (MV) repair rates by income quartile. B, MV repair rates by income quartile and stratified by sex. C, MV repair rates by income quartile and stratified by race.

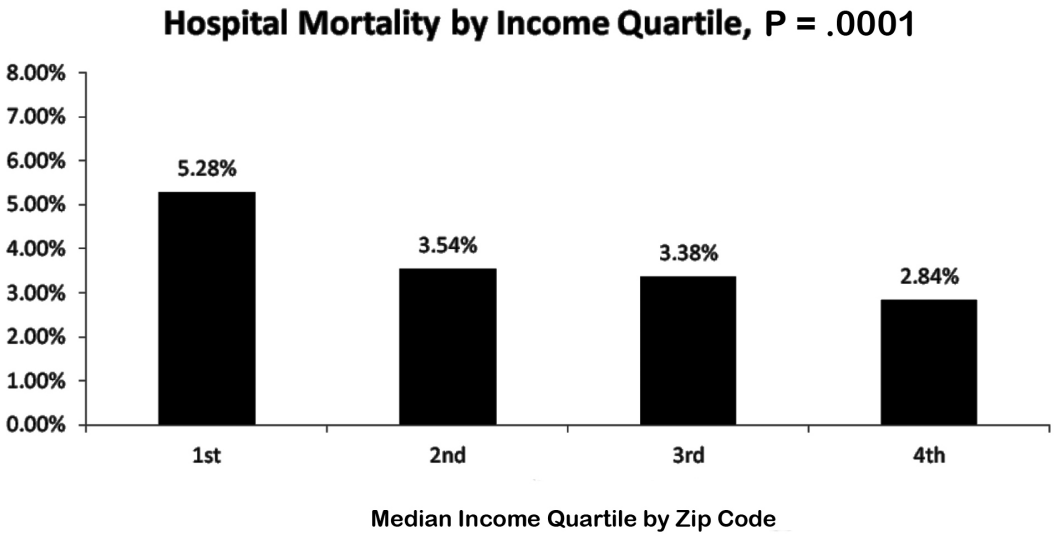


Figure 2. Hospital mortality by income quartile.

characteristics. Descriptive statistics reported included percentages, means, medians, and interquartile ranges. Logistic regression was used to examine the relationship of income quartile with procedure selection and mortality. Odds ratios (ORs) and their corresponding 95% confidence intervals (CIs) are reported for each group relative to the lowest income quartile. We also used logistic regression to assess these relationships after adjusting for baseline characteristics. We used SAS software (version 9.2; SAS Institute, Cary, NC, USA) in analyses to determine the weighting appropriate for reflecting the stratified sampling scheme used in the NIS.

RESULTS

We identified 22,454 observations that represented 111,111 admissions for MV repair or replacement. Of these observations, 2.25% (504) did not include income quartile information and were excluded. Subsequently, we applied all the prespecified exclusion criteria, as outlined in the Sample Selection section. This produced 9464 observations that represented 46,916 admissions. This set of observations constituted the final study population. Results are reported as the number of admissions.

Baseline Characteristics

The baseline characteristics of patients who underwent MV repair or replacement are summarized in the table. The overall patient population was distributed relatively evenly among the income quartiles (range, 20.9%-30.9%). The mean patient age was 62 years, and 45.3% of the patients were ≥ 65 years old. Women constituted 51.5% of patients, with the percentage decreasing as the income quartile increased (57.4% versus 54.5% versus 50.7% versus 46.2%, $P = .0001$). Whites constituted 77.9% of the patient population, with the percentage increasing as the income quartile increased (64.5% versus 79.1% versus 79.9% versus 84.2%, $P = .0001$). Our examination of insurance type revealed 45.8% of the patients were on Medicare and 6.0% of the patients were on Medicaid. As expected, Medicaid coverage decreased with increasing income quartile (13.1% versus 6.2% versus 5.0% versus 2.0%, $P = .0001$), whereas private insurance coverage increased with increasing income level (31.2% versus 37.5% versus 44.6% versus 53.4%, $P = .0001$). The majority of patients were treated at urban hospitals. There was no difference between teaching hospitals and nonteaching hospitals with respect to the number of treated patients in each income quartile. The mean Charlson comorbidity index for patients who underwent MV surgery was 1.03. There was a significant trend of decreasing Charlson comorbidity index as the income quartile increased (1.25 versus 1.07 versus 0.99 versus 0.88, $P = .0001$). Patients from lower income quartiles were admitted more often on an urgent/emergent basis (39.9% versus 34.5% versus 32.3% versus 32.2%, $P = .0104$).

Selection of MV Procedure

The selection of MV procedure by income quartile is presented in Figure 1A and is further stratified with respect to sex and race (Figure 1B and 1C, respectively). Overall, 46.0% of patients underwent MV repair. The relationship between valve repair and income level was significant, with the rate of repair increasing for patients in the higher income quartiles (35.6% versus 39.6% versus 48.2% versus 55.8%, $P = .0001$). When stratified by sex, the rate of MV repair increased with income quartile for men (43.05% versus 48.41% versus 57.25% versus 63.29%, $P = .0001$) and for women (30.1% versus 32.2% versus 39.3% versus 46.76%, $P = .0001$). Women, however, had lower rates of MV repair at every income quartile, compared with men: income quartile 1, 30.1% versus 43.05% ($P = .0001$); income quartile 2, 32.2% versus 48.41% ($P = .0001$); income quartile 3, 39.3% versus 57.25% ($P = .0001$); and income quartile 4, 46.76% versus 63.29% ($P = .0001$). Overall, the percentage of nonwhites who

underwent repair ranged from 32.3% in income quartile 1 to 48.6% in income quartile 4, compared with a range of 36.3% to 56.4% for whites. When the influence of race on procedure selection was examined in each income quartile, there was a significant disparity in repair rates for income quartile 2 (43.2% for whites versus 30.2% for nonwhites, $P = .0002$) and income quartile 3 (50.4% for whites versus 39.4% for nonwhites, $P = .0008$). Interestingly, patients in income quartile 1 underwent repair less often, regardless of race, whereas in income quartile 4 the influence of race was mitigated by the higher income level (56.4% for whites versus 48.6% for nonwhites, $P = .0775$).

Even after adjustment for baseline, the selection of MV procedure showed a significant difference according to quartiles of patient income. Patients in the lower 2 quartiles had significantly lower rates of MV repair than patients in the higher 2 quartiles ($P = .0004$): quartile 1 versus quartile 3: OR, 0.70 (95% CI, 0.58-0.86); quartile 1 versus quartile 4: OR, 0.58 (95% CI, 0.42-0.79); quartile 2 versus quartile 3: OR, 0.76 (95% CI, 0.64-0.92); quartile 2 versus quartile 4: OR, 0.62 (95% CI, 0.47-0.83).

Hospital Mortality

The overall hospital mortality rate was 3.64%. The rate of hospital death was significantly higher for patients in the lower income quartiles (5.28% versus 3.54% versus 3.38% versus 2.84%, $P = .0001$) (Figure 2); however, this difference was no longer statistically significant after adjusting for baseline characteristics ($P = .5533$).

DISCUSSION

There has been an ongoing trend of valve repair as the procedure of choice for the surgical correction of MV disease. The advantages of MV repair include lower operative mortality, improved long-term survival, better preservation of both early and late ventricular function, and fewer valve-related complications, including thromboembolism, endocarditis, anticoagulation-related bleeding events, and late prosthesis dysfunction [Perier 1984; Grossi 1998]. The main finding of our investigation is that the utilization of MV repair is significantly lower for patients with a lower socioeconomic status, as examined by using income level. This disparity, which persisted even following adjustments for important baseline characteristics, has important implications for health care quality. According to the 2 largest population-based studies, MV regurgitation is the most common valvular abnormality, and regurgitation equal to or greater than moderate severity affects 2% to 3% of the general population [Singh 1999; Jones 2001]. A myxomatous etiology is the leading cause of isolated MV regurgitation requiring surgical intervention in the United States [Freed 1999]. The vast majority of degenerative MVs are repairable, with success rates as high as 90% reported by some investigators [Gillinov 2003]. Patients in the first 3 income quartiles, which constitute 69.2% of the total population, underwent MV repair at rates of <50%. Although others have reported a salutary trend of valve repair as the procedure of choice for surgical correction of the MV, our study raises the possibility that patients with lower incomes may be disproportionately less likely to receive the benefits of MV repair, a procedure with an established superiority compared with MV replacement [Perier 1984; Grossi 1998; Gillinov 2003].

Other procedures have been noted to be underutilized in patients with lower income levels. Less affluent patients do not undergo cardiac catheterization, PTCA, and CABG as often as their more affluent counterparts [Philbin 2000]. Although patient preferences regarding the use of invasive procedures may differ with respect to coronary revascularization, this factor is less likely to play a role in the selection of surgical procedure. However, a lower education level, which is commonly associated with lower income, may be related to a decreased likelihood to seek out or inquire about MV repair.

The Charlson comorbidity index was used to adjust risk among income quartiles in our study population to avoid the limitation of missing comorbidity data [Deyo 1992]. This index was initially developed as a way to measure the prognostic impact of patient comorbidities and was subsequently validated for its ability to predict the risk of death from comorbid disease [Charlson 1987]. This index had been validated for use with large administrative databases [Deyo 1992; D'Hoore 1996]. Although patient ages were similar, patients in the lower income quartiles had significantly higher Charlson comorbidity index values compared with those in higher income quartiles. Our results are consistent with those of others [Pilote 2007; Agabiti 2008; Bagger 2008]. Among patients presenting with acute myocardial infarction and patients presenting for valve surgery, patients with lower incomes had more comorbidities than their counterparts with higher incomes [Pilote 2007; Agabiti 2008; Bagger 2008]. Possible reasons for these findings for less affluent patients include less access to preventive health care services, lack of education about nutrition and exercise, and financial constraints that limit risk-modification behaviors [Clark 2010]. The higher comorbidity index of patients in the lower income quartiles may have influenced surgeon comfort in attempting MV repair to correct the disease pathology. Moreover, patients with lower incomes presented for surgery on an urgent/emergent basis more often than patients with higher incomes, and perhaps this fact was also influential in selecting the MV procedure. It is important to note, however, that even after controlling for admission status and Charlson comorbidity index (and other baseline characteristics), we still observed a significant disparity in the likelihood of receiving MV repair with respect to income quartile. It is possible that less affluent patients present for evaluation to hospitals that offer less surgical expertise in MV repair. A hospital's annual MV volume of <40 cases per year has been associated with lower rates of MV repair [Vassileva 2012].

Women and nonwhites were overrepresented in the lower income quartiles. Female sex has been shown to independently decrease the likelihood of receiving MV repair [Vassileva 2011b]. Nonwhites have also been shown to receive MV repair less frequently, which appears to be related to their worse preoperative profiles [Vassileva 2011a]. Patients in the lower income quartiles more often were on Medicaid or were uninsured, and it is possible that primary payer and

issues related to reimbursement influenced procedure selection. For example, patients with Medicare or private insurance are more likely to receive angiography, angioplasty, and bypass grafting, compared with uninsured patients [Wenneker 1990]. Alternatively, a worse preoperative profile may be a surrogate for a different disease process that ultimately may be less suited for repair. It is possible that patients in the lower income quartiles had a higher incidence of rheumatic valve disease, which may have influenced the surgeon's decision to perform MV repair or replacement.

MV surgery is safe, as evidenced by an overall hospital mortality rate of 3.64%. Nevertheless, patients in the lowest income quartile had a mortality rate more than twice as high as those in the highest income quartile. Others have reported that survival after CABG is lower for less affluent patients [Boscarino 1999; Agabiti 2008]. Bagger et al. found that the long-term outcomes of patients undergoing isolated valve surgery were significantly related to socioeconomic status, with lower survival rates among patients with a disadvantaged social background [Bagger 2008]. The NIS database contains only data on the initial hospitalization, and therefore follow-up information is not available. In our investigation, the mortality difference with respect to income level was no longer evident after adjustment for baseline characteristics, suggesting income may not be an independent predictor of mortality in this patient subset. It is important to note, however, that unadjusted differences in mortality according to income level reflect the current reality in surgical practice and point to an important area for future improvement in the care of patients with valvular heart disease.

This study has several limitations. Although there are other indicators of socioeconomic position, such as education and occupation, income was a more sensitive indicator of socioeconomic status and therefore optimal for health research [Duncan 2002]. We used median household income by ZIP Code as a means of assessing economic status. Stratifying income by ZIP Code is not perfect, as reflected by the presence of a few patients on Medicaid in the highest income quartile. In addition, there is a possibility of income variations for individual patients above or below the median in their ZIP Code. The NIS is a stratified probability sample, and therefore our conclusions are based on the effectiveness of the method by which the NIS weighs hospitals. The purpose of administrative databases is to gather data for billing purposes, and these databases can be limited by erroneous coding. However, HCUP has quality control measures in place that should minimize these possibilities [HCUP 2008]. Furthermore, the NIS is the largest all-payer database in the United States, and some of its limitations are offset by large patient volumes, hard clinical end points, and the opportunity to explore real-world community data, making our findings widely applicable across hospitals in the United States.

In conclusion, lower income patients presenting for MV surgery are less likely to undergo repair, even after adjustment for important differences in baseline characteristics. In view of the established superiority of MV repair over replacement, future investigations should focus on the factors responsible for this disparity. The unadjusted mortality rate for less affluent patients undergoing MV surgery was higher, and this difference appeared to be mainly related to the worse preoperative profiles of patients with lower income levels. Nevertheless, this disparity reflects current reality in surgical practice and identifies another important area for the future improvement in the care of patients with valvular heart disease.

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