Published in final edited form as:

J Am Coll Surg. 2011 May ; 212(5): 759–767. doi:10.1016/j.jamcollsurg.2010.12.050.

Primary Payer Status Affects Outcomes for Cardiac Valve Operations

Damien J LaPar, MD*, Castigliano M Bhamidipati, DO*, Dustin M Walters, MD*, George J Stukenborg, PhD†, Christine L Lau, MD, FACS*, Irving L Kron, MD, FACS*, and Gorav Ailawadi, MD, FACS*

*Department of Surgery, University of Virginia Health System, Charlottesville, VA

†Department of Public Health Sciences, University of Virginia Health System, Charlottesville, VA

Abstract

Background—Disparities in healthcare have been reported among various patient populations, and the uninsured and Medicaid populations are a significant focus of current healthcare reform. The objective of this study was to examine the influence of primary payer status on outcomes following cardiac valve operations in the United States.

Methods—From 2003–2007, 477,932 patients undergoing cardiac valve operations were evaluated using discharge data from the Nationwide Inpatient Sample (NIS) database. Records were stratified by primary payer status: Medicare (n=57,249, age=74.0±0.02 yrs), Medicaid (n=5,868, age=41.2±0.13 yrs), Uninsured (n=2,349, age=49.7±0.15 yrs), and Private Insurance (n=31,808, age=53.3±0.04yrs). Multivariate regression models were applied to assess the independent effect of payer status on in-hospital outcomes.

Results—Preoperative patient risk factors were more common among Medicare and Medicaid populations. Unadjusted mortality and complication rates for Medicare (6.9%, 36.6%), Medicaid (5.7%, 31.4%) and Uninsured (5.2%, 31.4%) patient groups were higher compared to Private Insurance groups (2.9%, 29.9%, p<0.001). Moreover, mortality was lowest for patients with Private Insurance for all types of valve operations. Medicaid patients accrued the longest unadjusted hospital length of stay and highest total hospital costs compared to other payer groups (p<0.001). Importantly, after risk adjustment, Uninsured and Medicaid payer status conferred the highest odds of risk adjusted mortality and morbidity compared to Private Insurance status and were higher than those for Medicare.

Conclusions—Uninsured and Medicaid payer status is associated with increased risk adjusted in-hospital mortality and morbidity among patients undergoing cardiac valve operations compared to Medicare and Private Insurance. Further, Medicaid patients accrued the longest hospital stays

© 2011 American College of Surgeons. Published by Elsevier Inc. All rights reserved.

Correspondence address: Gorav Ailawadi, MD, Assistant Professor of Surgery, Department of Surgery, University of Virginia School of Medicine, PO Box 800679, Charlottesville, VA 22908-0679, Fax: (434)-982-3885, Phone: (434)-924-5052, gorav@virginia.edu.

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

Disclaimer: The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Heart, Lung, And Blood Institute or the National Institutes of Health.

Presented at the American College of Surgeons 96th Annual Clinical Congress, Washington, DC, October 2010

Disclosure Information: Nothing to disclose.

This study was supported by Award Number 2T32HL007849-11A1 (DJL, CMB) from the National Heart, Lung, And Blood Institute and the Thoracic Surgery Foundation for Research and Education Research Grant (CLL, GA).

and highest total costs. Primary payer status should be considered as an independent risk factor during preoperative risk stratification and planning.

Keywords

Payer Status; Insurance; Cardiac Valve; Mortality; Outcomes

INTRODUCTION

The impact insurance type among patients in the United States has been a primary focus of recent health care reform and public scrutiny. From 2007 to 2008, the number of uninsured Americans rose from 45.7 to 46.3 million, the number of people covered by government-assistance insurance programs (Medicaid and Medicare) increased from 83.0 to 87.4 million, while the number of Americans covered by private insurance decreased from 202 to 201 million.¹ Medicaid and Uninsured patients have been shown to have worse outcomes compared to privately insured patients following medical admissions.^{2, 3} Recent efforts have been directed toward advancing initiatives for increased government-sponsored health care programs. However, disparities in surgical treatment and resource utilization may exist for patients with varying insurance types.

Cardiac valve disease remains a common condition for which surgical correction is often required. According to the Society of Thoracic Surgeons national database, approximately 17,000-20,000 isolated aortic valve replacements (AVR) are performed annually in addition to 3,700-4,700 mitral valve replacements (MVR) and 4,700-6,000 mitral valve repairs (MV Repair).⁴ Improvements in surgical techniques have resulted in the performance of both aortic and mitral valve operations with low morbidity and mortality. The operative mortality rates nationally for isolated AVR now approach 3.0% while the mortality for MVR and MV repair are approximately 5.0% and 1.7%, respectively.⁴ Furthermore, emerging technology has resulted in an increasing volume of transcatheter valve repair and replacement procedures.

Previous studies have examined the impact of primary payer and insurance status within surgical populations in statewide databases or at individual centers. A recent study examining insurance status among vascular surgery patients in New York and Florida, demonstrated that insurance status predicts disease severity.⁵ Other studies have focused on disparate differences in allocation of surgical treatment as a function of payer status.^{6, 7} Moreover, differences in trauma care outcomes and resource utilization for Medicaid and uninsured patients have been demonstrated.⁸⁻¹⁰ However, no studies have examined the impact of primary payer status among patients undergoing cardiac valve procedures nor has it been evaluated in a national database. We hypothesized that primary payer status significantly influences patient outcomes in the United States.

METHODS

Data Source

The University of Virginia Institutional Review Board (IRB) did not perform a formal review of this study as it did not meet the regulatory definition of human subjects research due to the absence of patient identifiers and the fact that the data is collected for purposes other than research. Data for this study was obtained from the Nationwide Inpatient Sample (NIS) databases for the years 2003-2007. NIS is the largest, all-payer, inpatient care database that is publically available in the United States and is maintained by the Agency for Healthcare Research and Quality (AHRQ).¹¹ NIS methodology has been previously described,¹² and includes data representing an approximate 20% stratified random sample

of all hospital discharges in the United States. Data includes in-patient hospital discharge records collected for patients of all ages and sources of insurance. A discharge weight is included for each patient discharge record to represent the relative proportion of the total U.S. in-patient hospital population for each record.¹³ Therefore, the multi-institutional cohort represented in this study is broadly representative of individuals undergoing cardiac valve operations within the U.S.

Patients

Patients undergoing cardiac valve procedures were identified by using International Classification of Diseases-Ninth Revision, Clinical Modifications (ICD-9-CM) procedure codes:¹⁴ valve replacement (ICD-9-CM codes 352, 3520, 3521, 3522, 3523, 3524, 3525, 3526, 3527, 3528) and valve repair (ICD-9-CM codes 351, 3511, 3512, 3513, 3514). The anatomic location of a valve procedure was further identified for each patient discharge record. Concomitant CABG operations (ICD-9-CM codes 361, 3610, 3611, 3612, 3613, 3614, 3615, 3616) were identified where appropriate. Patients were stratified by primary payer status into four comparison groups: Medicare, Medicaid, Uninsured, and Private Insurance. The Uninsured payer group included both “no-charge” and “self-pay” patients.

Patient co-morbid disease was assessed using available AHRQ comorbidity categories, developed by Elixhauser et. al.¹⁵ The Elixhauser method has been demonstrated to provide effective adjustments for mortality risk among surgical populations.^{16, 17}

Hospitals

Hospital details reflect those included in the NIS database as well as within the Association of American Medical College’s Graduate Medical Education Tracking System. Cardiothoracic surgery teaching hospitals (CTH) were those hospitals where cardiothoracic surgery trainees from established Accreditation Council for Graduate Medical Education (ACGME) training programs obtained $\geq 50\%$ of their training. CTH status was established through linkage of NIS provided AHA identification numbers with the Association of American Medical College’s Graduate Medical Education Tracking System. Hospital operative volume was categorized into quartiles: Low ($<25^{\text{th}}$ percentile), Medium (26–49th percentile), High (50–74th percentile), and Very High ($>75^{\text{th}}$ percentile).

Outcomes Measured

All outcomes of interest were established *a priori* before data collection. Primary outcomes were risk-adjusted, in-hospital mortality and the odds of postoperative complications as a function of primary payer status. Secondary outcomes were hospital length of stay and total costs. In-hospital complications were categorized into eight classifications (wound, infections, urinary, pulmonary, gastrointestinal, cardiovascular, systemic and procedural) as previously described.¹⁸ In-hospital death, unadjusted mean length of stay and total costs were identified according to discharge records.

Statistical Analysis

Patient risk factors and outcomes were compared by univariate analyses using Pearson’s χ^2 for all categorical variables and analysis of variance (ANOVA) for continuous variables. All group comparisons were unpaired.

Multivariable logistic regression was performed to estimate adjusted odds ratios for the effect of primary payer status on risk-adjusted mortality and postoperative complications for all patients undergoing cardiac valve procedures. All risk factors entered as covariates (patient age, gender, race, elective operative status, mean income, hospital geographic region, cardiothoracic teaching hospital status, hospital operative volume, type of operation,

operative year, primary payer status, and categories for comorbid disease) were selected *a priori* as considered potential confounders for the effect of payer status among patients. All covariates were retained in each final model. All logistic regression models included appropriate adjustments for variance components estimated from the weighted study population.¹⁹ The statistical significance of the association between primary payer status and in-hospital death or complications was assessed using the Wald χ^2 test. The discrimination achieved by these models was assessed using the Area Under the Receiver Operating Characteristics Curve (AUC). The Hosmer-Lemeshow test was used to assess the statistical significance of differences in each model's calibration across deciles of observed and predicted risk.

Sensitivity analyses for each multivariable logistic regression model were performed to validate model performance and discrimination. Each model was re-estimated after removing the most statistically significant covariate as measured by the Wald statistic. The potential for spurious results is reduced if the originally observed effect is not substantially attenuated and remains statistically significant after re-estimation.²⁰ After removing this covariate from each logistic regression model, the effect of primary payer status on the estimated odds of each outcome were not significantly attenuated (<10%), validating the sensitivity of each original model.

Categorical variables are expressed as a percentage of the group of origin. Continuous variables are reported as means $\pm$ standard deviation. Odds ratios (OR) with a 95% confidence interval (CI) are used to report the results of logistic regression models. Reported *P*-values are two-tailed and were considered statistically significant if <0.05. Data analyses were performed using SPSS software, version 17 (SPSS, Chicago, IL).

RESULTS

Patient and Hospital Characteristics

During the six-year study period, a weighted estimate of 477,932 patients nationwide (97,274 discharge records) underwent cardiac valve operations. Frequencies of all patient characteristics stratified by the four primary payer groups are listed in Table 1. Patients with Medicare (58.8%) or Private Insurance (32.8%) represented the largest payer groups. Mean age was highest in the Medicare group (74.0 $\pm$ 0.02 years). Female gender was more frequent in Medicare (45.6%) and Medicaid (50.6%) payer groups. Regarding racial and ethnic differences, Medicare and Private Insurance groups included a higher proportion of White patients, while the Medicaid and Uninsured groups contained a higher percentage of Black and Hispanic patients. Medicaid (41.1%) and Uninsured (33.4%) patients were more likely to reside in low-income areas.

Isolated valve replacement (52.8%) was the most common procedure within all payer groups. The overall incidence of isolated aortic valve replacements (AVR) was 62.8%, mitral valve replacements (MVR) 21.8%, mitral valve repairs (MVP) 15.8%, pulmonary valve replacements (PVR) 1.4%, pulmonary valve repair 1.1%, tricuspid valve replacements (TVR) 0.9%, and tricuspid valve repairs 3.7%. Expectedly, Medicare patients underwent the highest proportion of AVR procedures, while MVR was more commonly performed among Medicaid and Uninsured groups. MVP was most common among Private Insurance groups. Concomitant CABG operations were most common among Medicare patients (42.7%). Elective operations occurred more commonly among Medicare (62.1%) and Private Insurance (70.3%) patients, while urgent/ emergent operations were more frequent in Medicaid and Uninsured patients.

Incremental differences in co-morbid disease existed across payer groups. The presence of chronic pulmonary disease (27.8%), diabetes (25.8%), renal failure (11.6%), and liver disease (1.6%) was most common among Medicaid patients, while alcohol and drug abuse, as well as the incidence of psychoses, was most frequent among the Medicaid and Uninsured groups. Medicare patients had the highest incidence of preoperative anemia (12.8%), coagulopathy (19.5%), hypertension (57.6%), and hypothyroidism (7.7%).

Hospital characteristics for all payer groups are displayed in Table 2. The large majority of cardiac valve operations occurred in the urban setting for all payer groups and within large bed size hospitals. Medicaid (30.3%) and Uninsured (21.1%) patients had the highest proportion of operations performed at CTH. Geographically, the Southern region performed the highest proportion of valve operations for all payer groups. Valve procedures were more commonly performed at large, high-volume (>75th percentile operative volume) centers ($P < 0.001$). The distribution of valve operations was similar across academic years for all payer groups.

Unadjusted Outcomes

Table 3 details the overall incidence of unadjusted outcomes for all primary payer groups. Private Insurance patients incurred the lowest incidence of overall, infectious, pulmonary and procedure related complications. Alternatively, Medicare patients incurred the highest composite incidence of postoperative complications (36.6%) as well as wound (2.2%), urinary (3.4%), pulmonary (15.5%), gastrointestinal (0.9%), cardiovascular (15.7%) and procedure related complications (7.3%). Medicaid patients accrued the highest unadjusted hospital length of stay (15.1 ± 0.1 days) and total costs (\$157,513 $\pm$ 883) followed by Uninsured patients. Mortality for Medicare (6.9%), Medicaid (5.7%) and Uninsured (5.2%) patient groups were higher compared to Private Insurance groups (2.9%, $p < 0.001$). Moreover, Private Insurance patients also had the lowest mortality for each operation (Table 4), and in-hospital mortality was highest for TVR (10.1%) and lowest for PVR (1.6%).

Adjusted Outcomes for the Effect of Primary Payer Status

As patients in each payer group had different demographics, income, and risk factors, risk adjustment was performed to identify the independent effect of payer status. Table 5 displays adjusted odds ratios for the effect of primary payer status on mortality and postoperative outcomes among patients undergoing cardiac valve procedures. After risk factor adjustment for the confounding effects of patient, hospital and operative factors, payer status remained a highly significant predictor of mortality ($P < 0.001$). Specifically, Uninsured, Medicaid, and Medicare status conferred a 100%, 70%, and 36% increase in the odds of in-hospital death, respectively, compared to Private Insurance

Multivariate analyses for postoperative complications further identified Uninsured, and Medicaid, and Medicare payer status as important independent predictors of morbidity (Table 5). Among payer groups, Uninsured payer status conferred the highest adjusted odds of any postoperative complication (OR=1.21) and for wound (OR=1.77) and cardiovascular complications (OR=1.12) compared to Private Insurance.

DISCUSSION

This study demonstrates that differences in payer/insurance status affect patient outcomes following cardiac valve procedures. These results reveal that Uninsured, Medicaid, and Medicare patients incur worse unadjusted and risk-adjusted outcomes compared to those with Private Insurance. More importantly, Uninsured and Medicaid payer status independently increases the risk of adjusted in-hospital mortality and the likelihood of

postoperative complications above that of Medicare status even after directly accounting for socioeconomic status as well as hospital related factors and several measures of co-morbid disease that are frequently encountered in low-income patient groups. In addition, significant differences in resource utilization were detected among payer groups, as Medicaid patients accrued the longest average hospital length of stay and highest total costs.

The relationship between insurance status and cardiac surgical outcomes remains ill-defined. Few studies have attempted to demonstrate disproportionate outcomes in cardiac surgery patients based on insurance status but are relatively small, single institution analyses.^{21, 22} To our knowledge, prospective evaluation of this trend within cardiac operations has not been previously performed. One of the largest series, conducted by Zacharias and colleagues (2005) at the Medical University of Ohio, retrospectively analyzed 6,377 patients, documenting worse long-term survival for Medicaid patients undergoing CABG operations at an urban, community hospital.²² Alternatively, Higgins et al. (1998) concluded that payer status and race was not associated with early mortality following CABG among a specific cohort of 2,776 black patients.²¹ These conflicting reports may be explained by a relatively small patient population relative to the present study.

The effect of insurance status has been performed in other types of subspecialty surgery. In a study of over 225,000 vascular surgery patients, Giacobelli et al (2008) demonstrated that insurance status predicted disease severity,⁵ and Kelz et al. (2004) reported that Medicaid and uninsured patients encountered worse postoperative outcomes following colorectal cancer resections.²³ In the later series of 13,415 patient records, Medicaid patients were found to incur a 22% increased risk of complications during hospital admission and a 57% increased risk of in-hospital death compared to those with private insurance. Recently, a comprehensive review of major surgical outcomes reported a 97% and 74% increase in the risk-adjusted odds of surgical mortality for Medicaid and Uninsured surgical patients, which included patients undergoing CABG operations.¹²

The findings of this study are likely multifactorial in origin and represent the interaction of several factors. First, elective operations were more commonly performed in patients with Medicare or Private Insurance, while Medicaid and Uninsured patients more commonly underwent non-elective (urgent and/or emergent) operations. The higher incidence of emergent operations among Medicaid and Uninsured populations and the presumed negative effect on outcomes is well documented.^{5, 24, 25} In our analyses, operative urgency status was accounted for in each predictive model, and the differences in payer groups remain significant. In addition, the confounding influence of inadequate preoperative resuscitation in the emergent setting may contribute to compromised outcomes for these patients. Secondly, the immeasurable influence of physician and healthcare system bias may negatively impact Medicaid and Uninsured patients. For many surgical patients, private insurance status often allows for referral to expert surgeons for their disease while referral patterns for Medicaid and Uninsured patients may have differed. For these complex operations, the impact of surgeon volume on outcomes has been well established, and expert surgeons have been shown to significantly impact outcomes.²⁶ Third, differences in comorbid disease may serve as a proxy for larger social and lifestyle influences between payer groups as Medicaid and Uninsured patients had the highest incidence of drug and alcohol abuse as well as depression and psychoses. Finally, deficits in access to care, poor health maintenance, and delayed diagnosis may have resulted in the presentation of more advanced valve disease among the Medicaid and Uninsured patient populations.

Other explanations for inherent differences between payer populations have been previously described. Studies have identified factors such as language barriers and low as well as poor nutrition and health maintenance.^{2, 27} However, payer status impacts several different areas

of health care delivery. Differences exist in not only access, but also in the type of primary care that patients receive. Prior studies have suggested that Medicaid and Uninsured patients receive the majority of primary care within Emergency Departments.^{28, 29} In fact, fewer diagnostic studies during emergency department visits and decreased in-patient hospitalizations following specialty consultations have been documented for these populations compared to private insurance patients.³⁰ Furthermore, Medicaid and Uninsured populations often present with more advanced disease compared to privately insured patients, and patient insurance type has been shown to affect access to cancer screening, treatment, and outcomes.^{31, 32} Payer status may also effect hospital discharge processes as discharge from the hospital may be delayed for Medicaid and Uninsured populations due to lack of support and resources to be cared for properly at home.

This study has several noteworthy limitations. First, the retrospective study design introduces inherent selection bias; however, the strict methodology and randomization of the NIS database reduces the influence of this bias. Second, NIS is a large, administrative database, and there exists a potential for unrecognized miscoding among diagnostic and procedure code. The performed data analyses allow us to comment upon statistical measures of association and do not establish a cause and effect relationship between payer status and risk adjusted outcomes. This study reports short-term outcomes as NIS records reflect inpatient admissions. Consequently, the results reported herein may underestimate the true incidence of perioperative mortality and morbidity following patient discharge. Certain assumptions regarding individual status may also impact data analyses as the potential for dual insurance eligibility and cross over between payer groups exists. However, NIS records reflect the primary payer status at the time of discharge, mitigating the effect of such scenarios. In addition, it is possible that a small percentage of Privately Insured patients may have “inadequate” coverage and may more closely resemble those without insurance with respect to poor health maintenance and advanced disease. In addition, we are unable to comment on the nature, etiology or degree of cardiac valve disease, which may impact perioperative morbidity and mortality rates. Finally, in our data analyses we are unable to include adjustments for other well-established cardiac surgical risk factors such as low preoperative albumin levels, poor nutritional status, preoperative cardiac functional status (NYHA Class), ventricular function, or cardiopulmonary bypass use and/or exposure times. However, as our sensitivity analyses proved resilient to the presence of a potentially unmeasured confounder, it is unlikely that inclusion of such factors in our analyses would change our primary results.

CONCLUSION

Compared to patients with private insurance, Uninsured and Medicaid payer status is associated with the highest risk-adjusted mortality and morbidity following performance of cardiac valve operations. Moreover, Medicaid patients accrue the longest hospital stays and highest total costs. These findings indicate that primary payer status should be considered as an independent risk factor during preoperative patient risk stratification and highlights complex socioeconomic and health system related factors that may be targeted to improve patient outcomes following cardiac valve operations.

REFERENCES

1. United States Census Bureau. Income, poverty, and health insurance coverage in the United States: 2008. [Accessed February 22, 2010]. <http://www.census.gov/prod/2009pubs/p60-236.pdf>
2. Lantz PM, House JS, Lepkowski JM, et al. Socioeconomic factors, health behaviors, and mortality: results from a nationally representative prospective study of US adults. *Jama*. 1998; 279(21):1703–8. [PubMed: 9624022]

3. Committee on the Consequences of Uninsurance I. Care without Coverage: Too Little, Too Late. National Academy Press; Washington, DC: 2002.
4. National Adult Cardiac Surgery Database Executive Summary. Society of Thoracic Surgeons. 2009
5. Giacobelli JK, Egorova N, Nowygrod R, et al. Insurance status predicts access to care and outcomes of vascular disease. *J Vasc Surg.* 2008; 48(4):905–11. [PubMed: 18586449]
6. Vogel TR, Cantor JC, Dombrovskiy VY, et al. AAA repair: sociodemographic disparities in management and outcomes. *Vasc Endovascular Surg.* 2008; 42(6):555–60. [PubMed: 18697755]
7. Wallace AE, Young-Xu Y, Hartley D, Weeks WB. Racial, Socioeconomic, and Rural-Urban Disparities in Obesity-Related Bariatric Surgery. *Obes Surg.* 2010
8. Haider AH, Chang DC, Efron DT, et al. Race and insurance status as risk factors for trauma mortality. *Arch Surg.* 2008; 143(10):945–9. [PubMed: 18936372]
9. Rosen H, Saleh F, Lipsitz SR, et al. Lack of insurance negatively affects trauma mortality in US children. *J Pediatr Surg.* 2009; 44(10):1952–7. [PubMed: 19853754]
10. Salim A, Ottochian M, DuBose J, et al. Does insurance status matter at a public, level I trauma center? *J Trauma.* 68(1):211–6. [PubMed: 20065777]
11. Healthcare Cost and Utilization Project Nationwide Inpatient Sample. Agency for Health Care Research and Quality; Rockville, MD: 2003-2007.
12. LaPar DJ, Bhamidipati CM, Mery CM, et al. Primary payer status affects mortality for major surgical operations. *Ann Surg.* 2010; 252(3):544–50. discussion 550-1. [PubMed: 20647910]
13. Whalen, D.; Houchens, R.; Elixhauser, A. HCUP Nationwide Inpatient Sample (NIS) Comparison Report. HCUP Methods Series Report #2007-03 online. U.S. Agency for Healthcare Research and Quality. March 7. 2010 2004 Available at: <http://www.hcup-us.ahrq.gov/reports/methods/jsp>
14. Public Health Service. Clinical Modification (ICD-9-CM). United States Department of Health and Human Services; Washington, DC: 1991. Health Care Financing Administration International Classification of Diseases, 9th Revision.
15. Elixhauser A, Steiner C, Harris DR, Coffey RM. Comorbidity measures for use with administrative data. *Med Care.* 1998; 36(1):8–27. [PubMed: 9431328]
16. Southern DA, Quan H, Ghali WA. Comparison of the Elixhauser and Charlson/Deyo methods of comorbidity measurement in administrative data. *Med Care.* 2004; 42(4):355–60. [PubMed: 15076812]
17. Stukenborg GJ, Wagner DP, Connors AF Jr. Comparison of the performance of two comorbidity measures, with and without information from prior hospitalizations. *Med Care.* 2001; 39(7):727–39. [PubMed: 11458137]
18. Guller U, Hervey S, Purves H, et al. Laparoscopic versus open appendectomy: outcomes comparison based on a large administrative database. *Ann Surg.* 2004; 239(1):43–52. [PubMed: 14685099]
19. Rao JNK, Shao J. Modified balanced repeated replication for complex survey data. *Biometrika.* 1999; 86:403–415.
20. Lin DY, Psaty BM, Kronmal RA. Assessing the sensitivity of regression results to unmeasured confounders in observational studies. *Biometrics.* 1998; 54(3):948–63. [PubMed: 9750244]
21. Higgins RS, Paone G, Borzak S, et al. Effect of payer status on outcomes of coronary artery bypass surgery in blacks. *Circulation.* 1998; 98(19 Suppl):II46–9. discussion II49-50. [PubMed: 9852879]
22. Zacharias A, Schwann TA, Riordan CJ, et al. Operative and late coronary artery bypass grafting outcomes in matched African-American versus Caucasian patients: evidence of a late survival-Medicaid association. *J Am Coll Cardiol.* 2005; 46(8):1526–35. [PubMed: 16226179]
23. Kelz RR, Gimotty PA, Polsky D, et al. Morbidity and mortality of colorectal carcinoma surgery differs by insurance status. *Cancer.* 2004; 101(10):2187–94. [PubMed: 15382089]
24. Boxer LK, Dimick JB, Wainess RM, et al. Payer status is related to differences in access and outcomes of abdominal aortic aneurysm repair in the United States. *Surgery.* 2003; 134(2):142–5. [PubMed: 12947310]
25. Shen JJ, Washington EL. Disparities in outcomes among patients with stroke associated with insurance status. *Stroke.* 2007; 38(3):1010–6. [PubMed: 17234983]

26. Birkmeyer JD, Stukel TA, Siewers AE, et al. Surgeon volume and operative mortality in the United States. *N Engl J Med*. 2003; 349(22):2117–27. [PubMed: 14645640]
27. Wallace LS, Cassada DC, Rogers ES, et al. Can screening items identify surgery patients at risk of limited health literacy? *J Surg Res*. 2007; 140(2):208–13. [PubMed: 17509266]
28. Cohen JW. Medicaid policy and the substitution of hospital outpatient care for physician care. *Health Serv Res*. 1989; 24(1):33–66. [PubMed: 2497086]
29. Cornelius, L.; Beauregard, K.; Cohen, J. Usual sources of medical care and their characteristics. Agency for Health Care Policy and Research; Rockville, MD: 1991. AHCPR Publication No. 91-0042
30. White FA, French D, Zwemer FL Jr, Fairbanks RJ. Care without coverage: is there a relationship between insurance and ED care? *J Emerg Med*. 2007; 32(2):159–65. [PubMed: 17307625]
31. de Bosset V, Atashili J, Miller W, Pignone M. Health insurance-related disparities in colorectal cancer screening in Virginia. *Cancer Epidemiol Biomarkers Prev*. 2008; 17(4):834–7. [PubMed: 18398024]
32. Roetzheim RG, Pal N, Gonzalez EC, et al. Effects of health insurance and race on colorectal cancer treatments and outcomes. *Am J Public Health*. 2000; 90(11):1746–54. [PubMed: 11076244]

Table 1

Patient Characteristics for All Patients Undergoing Cardiac Valve Operations by Primary Payer Group (n=97,274)

Variable	Medicare	Medicaid	Uninsured	Private Insurance
No. of cases (unweighted)	57,249	5,868	2,349	31,808
National estimate of cases (weighted)	281,186	28,729	11,380	156,637
Age, y	74.0±0.02	41.2±0.13	49.7±0.15	53.3±0.04
Female	45.6%	50.6%	37.7%	34.4%
Race				
White	86.4%	47.1%	59.6%	81.9%
Black	4.8%	17.6%	14.1%	6.2%
Hispanic	4.9%	24.1%	16.8%	5.5%
Asian or Pacific Islander	1.4%	4.4%	2.2%	2.4%
Native American	0.2%	1.4%	0.8%	0.4%
Other	2.3%	5.4%	6.5%	3.6%
Elective Operation	62.1%	51.4%	42.2%	70.3%
Operation				
Isolated Valve Replacement	49.8%	57.5%	59.5%	56.7%
Isolated Valve Repair	7.5%	23.0%	14.9%	19.0%
Concomitant CABG	42.7%	19.5%	25.6%	24.3%
Aortic Valve Replacement	68.8%	41.5%	52.0%	56.7%
Mitral Valve Replacement	21.3%	28.6%	29.9%	20.8%
Mitral Valve Repair	13.3%	15.5%	16.8%	20.4%
Pulmonary Valve Replacement	0.1%	6.2%	2.2%	2.9%
Pulmonary Valve Repair	<0.1%	3.9%	0.6%	0.7%
Tricuspid Valve Replacement	0.6%	2.9%	2.2%	0.9%
Tricuspid Valve Repair	2.2%	6.4%	3.7%	2.4%
AHRQ Comorbidity				
AIDS	0.0%	0.5%	0.0%	0.1%
Alcohol abuse	1.2%	4.6%	5.0%	2.3%
Deficiency anemia	12.8%	11.4%	12.0%	11.8%
Arthritis/collagen vascular disorder	1.8%	1.3%	0.5%	1.4%
Chronic blood loss anemia	1.8%	1.2%	1.5%	1.5%
Congestive heart failure	2.2%	2.6%	0.6%	1.2%
Chronic pulmonary disease	23.1%	27.8%	26.7%	20.5%
Coagulopathy	19.5%	16.1%	11.8%	15.4%
Depression	2.8%	4.1%	2.2%	3.1%
Diabetes Mellitus (uncomplicated)	21.8%	25.8%	19.6%	21.4%
Diabetes Mellitus (complicated)	3.8%	5.7%	3.0%	3.6%

Variable	Medicare	Medicaid	Uninsured	Private Insurance
Drug abuse	0.2%	4.6%	3.2%	0.4%
Hypertension	57.6%	52.1%	50.5%	56.9%
Hypothyroidism	7.7%	3.5%	3.2%	5.7%
Liver disease	0.6%	1.6%	1.0%	1.0%
Lymphoma	0.5%	0.5%	1.0%	0.7%
Fluid and Electrolyte Disorder	21.3%	20.9%	18.5%	19.0%
Metastatic cancer	0.2%	0.0%	0.2%	0.1%
Neurologic Disorder (not CVA)	2.7%	3.6%	2.9%	2.2%
Obesity	5.4%	8.1%	6.2%	9.2%
Paralysis	1.2%	0.9%	0.9%	0.7%
Peripheral vascular disease	13.1%	13.9%	10.4%	14.1%
Psychoses	1.0%	2.6%	2.1%	0.8%
Pulmonary circulation disorder	0.2%	0.4%	0.2%	0.1%
Renal failure	11.6%	11.9%	6.7%	7.2%
Solid tumor (without metastasis)	1.1%	0.6%	1.6%	0.8%
Peptic ulcer disease (non-bleeding)	0.0%	0.1%	0.1%	0.1%
Weight loss	2.7%	1.9%	1.8%	1.6%
Median household income national quartile for patient ZIP code				
I (\$1-24,999)	21.6%	41.1%	33.4%	15.9%
II (\$25,000-34,999)	25.6%	26.9%	26.3%	22.0%
III (\$35,000-44,999)	25.7%	20.3%	23.7%	28.3%
IV (> \$45,000)	27.2%	11.7%	16.7%	33.8%

Table 2

Hospital Characteristics for All Patients Undergoing Cardiac Valve Operations by Primary Payer Group

Variable	Medicare, %	Medicaid, %	Uninsured, %	Private insurance, %
Rural location	2.8	1.9	3.5	1.7
Cardiothoracic teaching hospital	15.1	30.3	21.1	19.5
Hospital bed size				
Small	5.9	7.0	9.3	6.2
Medium	19.7	17.1	18.4	19.9
Large	74.3	75.9	72.2	73.9
Hospital region				
Northeast	24.6	22.9	22.9	22.1
Midwest	23.0	19.4	19.4	23.9
West	19.3	22.1	9.2	22.9
South	33.2	35.6	48.4	31.0
Hospital operative volume				
Low	3.1	3.3	5.6	2.8
Medium	9.4	13.2	10.3	9.8
High	21.5	20.5	16.1	23.6
Very high	66.0	63.0	68.0	63.8
Admission year				
2003	20.4	19.8	19.0	19.4
2004	18.5	18.4	21.7	19.2
2005	19.7	23.6	19.6	20.4
2006	21.8	20.2	20.6	21.7
2007	19.6	18.1	19.0	19.2

Table 3
Unadjusted In-Hospital Outcomes for All Patients Undergoing Cardiac Valve Operations by Primary Payer Group

Outcome	Medicare	Medicaid	Uninsured	Private insurance	p Value
In-hospital mortality	6.9%	5.7%	5.2%	2.9%	<0.001
Any in-hospital complications	36.6%	31.4%	31.4%	29.9%	<0.001
Wound complications	2.2%	1.9%	1.7%	1.4%	<0.001
Infectious complications	1.3%	1.7%	1.0%	0.9%	<0.001
Urinary complications	3.4%	1.8%	1.7%	1.8%	<0.001
Pulmonary complications	15.5%	13.8%	12.3%	12.1%	<0.001
Gastrointestinal complications	0.9%	0.6%	0.6%	0.7%	<0.001
Cardiovascular complications	15.7%	11.9%	13.6%	13.1%	<0.001
Systemic complications	1.2%	1.4%	1.4%	1.4%	<0.001
Procedure related complications	7.3%	6.8%	6.8%	6.1%	<0.001
Length of stay, d	12.96±0.02	15.07±0.10	13.91±0.12	9.66±0.03	<0.001
Total cost, \$	145,026±218	157,513±833	142,869±1,121	121,643±254	<0.001

Table 4
In-Hospital Mortality for All Patients Undergoing Cardiac Valve Operations by Primary Payer Status

Outcomes	Medicare, %	Medicaid, %	Uninsured, %	Private insurance, %	p Value
Isolated valve replacement	6.9	5.5	4.9	2.8	<0.001
Isolated valve repair	5.9	4.8	3.3	1.8	<0.001
Concomitant CABG	7.0	7.4	7.1	4.0	<0.001
Aortic valve replacement	6.0	6.2	5.6	3.0	<0.001
Mitral valve replacement	10.8	7.0	5.6	4.2	<0.001
Mitral valve repair	6.2%	3.6	3.6	1.8	<0.001
Pulmonary valve replacement	3.3	2.2	0.0	1.3	0.001
Pulmonary valve repair	11.1	4.8	<0.1	1.7	<0.001
Tricuspid valve replacement	14.1	7.7	9.4	6.6	<0.001
Tricuspid valve repair	10.5	8.0	4.5	4.2	<0.001

Table 5

Adjusted Odds Ratios and Means for the Effect Of Primary Payer Status on Outcomes among Patients Undergoing Cardiac Valve Operations

Outcomes	Medicare	Medicaid	Uninsured	Private Insurance	AUC
In-hospital mortality	1.36 (1.26-1.47) *	1.71 (1.49-1.95) *	2.01 (1.70-2.39) *	1.0	0.88
Any hospital complications	1.04 (1.01-1.08) *	1.10 (1.02-1.18) *	1.21 (1.10-1.33) *	1.0	0.78
Wound complications	1.34 (1.19-1.51) *	1.48 (1.18-1.85) *	1.77 (1.34-2.33) *	1.0	0.73
Infectious complications	1.08 (0.95-1.24)	1.28 (0.99-1.64)	1.25 (0.87-1.78)	1.0	0.76
Urinary complications	0.87 (0.79-0.96) *	0.98 (0.79-1.21)	1.05 (0.77-1.42)	1.0	0.81
Pulmonary complications	0.97 (0.92-1.01)	0.95 (0.86-1.04)	1.14 (1.01-1.28)	1.0	0.78
Gastrointestinal complications	0.81 (0.68-0.97) *	0.72 (0.45-1.15)	1.52 (0.95-2.45)	1.0	0.68
Cardiovascular complications	1.07 (1.02-1.13) *	1.13 (1.02-1.24) *	1.26 (1.11-1.44) *	1.0	0.84
Systemic complications	0.80 (0.70-0.93) *	1.22 (0.94-1.58)	0.78 (0.52-1.18)	1.0	0.79
Procedure related complications	1.13 (1.06-1.21) *	1.09 (0.95-1.25)	1.01 (0.84-1.21)	1.0	0.77

Reference group, primary payer status (private insurance). Outcomes adjusted for patient age, gender, race, operative status, mean income, hospital geographic region, cardiothoracic surgery teaching hospital status, type of valve operation, primary payer status, and categories for co-morbid disease.

AUC, area under receiver operator curve.

* p<0.05. In-hospital mortality and postoperative complications reported as Adjusted Odds Ratios (95% Confidence Interval).