# Predictors of Hospital Cost After Transcatheter Aortic Valve Implantation in the United States: From the Nationwide Inpatient Sample Database

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**We aimed to identify risk factors of high hospitalization cost after transcatheter aortic valve implantation (TAVI). TAVI expenditure is generally higher compared with surgical aortic valve replacement. We queried the Nationwide Inpatient Sample database from January 2011 to September 2015 to identify those who underwent endovascular TAVI. Estimated cost of hospitalization was calculated by merging the Nationwide Inpatient Sample database with cost-to-charge ratios available from the Healthcare Cost and Utilization Project. Patients were divided into quartiles (lowest, medium, high, and highest) according to the hospitalization cost, and multivariable regression analysis was performed to identify patient characteristics and periprocedural complications associated with the highest cost group. A total of 9,601 TAVI hospitalizations were identified. Median in-hospital costs of the highest and lowest groups were $82,068 and $33,966, respectively. Patients in the highest cost group were older and more likely women compared with the lowest cost group. Complication rates (68.4% vs 22.5%) and length of stay (median 10 days vs 3 days) were both approximately 3 times higher and longer, respectively, in the highest cost group. Co-morbidities such as heart failure, peripheral vascular disease, atrial fibrillation, anemia, and chronic dialysis as well as almost all complications were associated with the highest cost group. The complications with the highest incremental cost were acute respiratory failure requiring intubation ($28,209), cardiogenic shock ($22,401), and acute kidney injury ($16,974). Higher co-morbidity burden and major complications post-TAVI were associated with higher hospitalization costs. Prevention of these complications may reduce TAVI-related costs.** **© 2019 Elsevier Inc. All rights reserved.** **(Am J Cardiol 2019;123:1142−1148)**

Transcatheter aortic valve implantation (TAVI) is an attractive treatment method from a clinical standpoint, however, healthcare-related cost should be examined as value-based therapies, and cost containment measures are gaining increasing relevance. In 2012, the total expenditure for TAVI from Medicare was 215,770,200 US dollars for 4,083 TAVI procedures and the hospital costs were higher for TAVI compared with surgical aortic valve replacement (SAVR) (median $50,200 vs $45,500).[1] In addition, TAVI had higher hospitalization costs compared with SAVR when factoring readmission costs.[2] When procedure-related complications occur, this additional cost will further increase the hospital cost of TAVI and may make it a less attractive option compared with SAVR. Arnold et al have reported procedural costs associated with TAVI from the PARTNER trial.[3] However, the data were limited for initial TAVI experience in the United States. This study identifies baseline characteristics and periprocedural complications associated with high cost and also to calculate the incremental cost of major in-hospital complications after TAVI using the Nationwide Inpatient Sample (NIS) database.

## Methods

This study was conducted using the NIS database, which is part of the Healthcare Cost and Utilization Project (HCUP).[4] NIS is the largest all-payer inpatient admission database in the United States. It represents a 20% stratified sample of all discharges from community hospitals in the United States. Rehabilitation and long-term acute care hospitals are not included. The NIS includes data on primary and secondary discharge diagnoses, procedures, patient demographics, hospital characteristics, expected payment source, total hospitalization cost, discharge status, length of

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stay, and co-morbidities. International Classification of Diseases, Ninth Edition, Clinical Modification (ICD-9-CM) was used to identify the procedures and variables of interest related to the purposes of our study. This study was considered exempt from Institutional Review Board approval because HCUP-NIS contains de-identified patient data. The NIS database from January 2011 to September 2015 was queried to identify endovascular-TAVI admission with age ≥50 years using the ICD-9-CM codes (Supplementary Table 1). Because the current indication for TAVI is for symptomatic, severe aortic stenosis, we excluded patients with a diagnosis of aortic insufficiency without a diagnosis of aortic stenosis. In addition, for consistency, we used only ICD-9-CM codes for the study period. Hence, data for the last 3 months of 2015 were excluded given that NIS contained only ICD-10-CM codes after September 2015 and for the nonavailability of Elixhauser co-morbidity indicators in those months.[4] The following baseline patient-level characteristics were included: race (Whites, Non-Hispanic Blacks, Hispanics, Asians, and Others), gender (women and men), health insurance type (Medicare, Medicaid, Private, Self-pay and Others), elective versus nonelective admission, weekend admission, and income level based on the zip code (lowest quartile, second quartile, third quartile, and highest quartile). Variables for hospital-level factors such as region (Northeast, Midwest, South, and West), and hospital size (small, medium, and large sizes) conveyed in the NIS dataset were also included. Baseline characteristics and the procedure-related complications were captured from the ICD-9-CM procedure codes. The major perioperative complications included were stroke, acute myocardial infarction, percutaneous coronary intervention (PCI), major bleeding requiring transfusion, acute kidney injury (AKI), cardiogenic shock, fatal arrhythmia (ventricular fibrillation, ventricular tachycardia, or cardiac arrest), vascular injury, pacemaker implantation (PPM), and acute respiratory failure with intubation (Supplementary Table 1).

To calculate the hospitalization cost, the NIS data were merged with cost-to-charge ratios available from the HCUP. The hospitalization cost for each admission was estimated by multiplying the total hospital charge with cost-to-charge ratios. Inflation-adjusted cost for each year was calculated in terms of the 2017 cost based on the latest consumer price index data released by US government on January 30, 2018.[5] This enabled us to standardize the costs over the study period. The incremental cost for each complication was calculated as follows: [total amount of cost in patients with the complication] minus [median cost in patients with no complication × number of patients with the complication]. This method has been used in previous studies.[6] Hospital cost was expressed as median (interquartile range). As a sensitivity analysis, we compared the mean cost of TAVI procedures with or without each complication adjusting for co-morbidities, demographic, and hospital characteristics with multivariate regression analysis.

The patients were categorized into quartiles according to total hospitalization costs—lowest, medium, high, and highest cost. Descriptive statistics were presented and compared across different hospitalization cost levels. Chi-square test was used for categorical variables whereas analysis of variance was applied for normally distributed continuous variables. Kruskal-Wallis test was used for continuous variables with skewed distribution. We used hierarchical logistic-regression modeling to determine the independent predictors of high hospital cost using generalized linear mixed models. For hierarchical modeling, hospital-level random intercepts were assumed to be normally distributed to account for the clustering (nonindependence) of patients within the same hospital, permitting separation of within-hospital and between-hospital variation. The unique hospital identification number was used as a random effect in the model. The highest cost quartile (vs other 3 quartiles) was included as a dependent variable. The model included patient-level variables such as age, gender, complications, weekend admissions, elective admissions, year of procedure, co-morbidities as well as hospital-level variables such as hospital size (number of beds), hospital region, and teaching status. Covariates incorporated in the multivariate analyses were selected based on the plausibility that these could be associated with higher hospitalization cost. The results were expressed with odds ratio (OR) and 95% confidence intervals (CI). We obtained a remarkable C-statistics of 92.2% by computing the logistics regression of the predicted probabilities from the hierarchical model. Admissions with missing variables were excluded from the analysis, and a complete case analysis was performed. Statistical Analysis System (SAS V.9.4, SAS Institute Inc., Cary, North Carolina) was used for data extraction and analysis. A p value of <0.05 was considered significant. We performed our analyses based on the recommended method by the HCUP and checklist those proposed by Khera et al.[7]

## Results

A total of 9,601 (weighted 47,920) hospitalizations that had TAVI were identified. The overall cost of TAVI hospitalizations was $52,357 ($26,090), mean age was 81.6 ± 7.7 years old, complication rate was 39.1%, and in-hospital mortality was 3.3%. The costs for lowest, medium, high, and highest groups were $33,966 ($9,077), $46,879 ($5,449), $58,358 ($7,000), and $82,068 ($28,426), respectively. The highest cost group was older, more likely women, less frequently white, and had higher baseline co-morbidities such as atrial fibrillation, peripheral vascular disease, anemia, heart failure, renal failure, liver disease, and higher Elixhauser score. Conversely, the highest cost group had less previous myocardial infarction, PCI, coronary artery bypass graft (CABG), PPM, hypertension, hyperlipidemia, and smoking. Length of stay was approximately threefold (median 10 vs 3.0 days), the complication rate was also approximately 3 times higher (68.4% vs 22.4%), and in-hospital mortality (8.6% vs 1.1%) was roughly 8 times higher in the highest compared with the lowest cost group. Results are summarized in Table 1.

Baseline characteristics associated with elevated risk of highest hospitalization costs were heart failure (OR 1.84, 95% CI 1.42 to 2.39, p <0.001), peripheral vascular disease (OR 1.57, 95% CI 1.34 to 1.83, p <0.001), atrial fibrillation (OR 1.26, 95% CI 1.1 to 1.45, p = 0.001), anemia (OR 1.12, 95% CI 1.01 to 1.40, p = 0.04), and end stage renal disease on hemodialysis (OR 2.37, 95% CI 1.61 to 3.49, p <0.001).

Table 1
Clinical and demographic data of patients stratified by TAVI cost

| Variables | Total | Quartile | | | | p value |
|---|---|---|---|---|---|---|
| | | 1 Lowest cost | 2 | 3 | 4 Highest cost | |
| No. of observation, Unweighted | 9,601 | 2,400 | 2,400 | 2,400 | 2,401 | |
| No. of observation, weighted | 47,920 | 11,976 | 11,982 | 11,983 | 11,979 | |
| Complication rate | 40.61% | 22.46% | 28.52% | 43.05% | 68.40% | <0.0001 |
| Median in-hospital cost (Interquartile) (dollars) | 52,357.15 (26,090.17) | 33,966.40 (9,076.95) | 46,878.78 (5,449.49) | 58,357.82 (6,999.88) | 82,068.29 (28,426.31) | |
| Age, mean (standard deviation) (Years) | 81.64 (7.71) | 81.30 (7.83) | 81.71 (7.55) | 81.97 (7.59) | 81.58 (7.87) | 0.0251 |
| Age (years) | | | | | | 0.027 |
| 50-59 | 1.59% | 1.75% | 1.54% | 1.46% | 1.62% | |
| 60-69 | 6.87% | 7.50% | 6.41% | 6.30% | 7.26% | |
| 70-79 | 23.01% | 23.63% | 22.30% | 22.51% | 23.60% | |
| 80-89 | 53.41% | 53.89% | 55.54% | 52.88% | 51.35% | |
| ≥90 | 15.12% | 13.23% | 14.20% | 16.86% | 16.18% | |
| Length of stay [median (interquartile)](days) | 5.00 (5.00) | 3.00 (3.00) | 4.00 (3.00) | 6.00 (4.00) | 10.00 (11.00) | <0.0001 |
| Female | 46.59% | 43.09% | 47.32% | 47.17% | 48.77% | 0.0007 |
| White | 87.56% | 89.22% | 87.81% | 88.37% | 84.87% | 0.006 |
| Black | 4.02% | 4.00% | 3.93% | 3.68% | 4.48% | |
| Hispanic | 3.68% | 3.11% | 3.49% | 3.33% | 4.77% | |
| Asia | 1.01% | 0.58% | 0.77% | 1.07% | 1.63% | |
| Others | 3.73% | 3.09% | 4.01% | 3.56% | 4.25% | |
| Dyslipidemia | 65.77% | 67.83% | 69.45% | 66.92% | 58.89% | <0.0001 |
| Prior myocardial infarction | 13.26% | 13.73% | 13.92% | 14.00% | 11.37% | 0.027 |
| Prior percutaneous coronary intervention | 20.64% | 21.27% | 23.95% | 20.42% | 16.93% | <0.0001 |
| Prior coronary bypass | 21.54% | 22.98% | 23.63% | 22.79% | 16.77% | <0.0001 |
| Prior pacemaker | 10.84% | 12.14% | 11.66% | 11.00% | 8.58% | 0.001 |
| Atrial fibrillation | 43.28% | 38.70% | 41.89% | 44.54% | 48.41% | <.0001 |
| Chronic obstructive pulmonary disease | 25.74% | 24.07% | 25.10% | 27.03% | 26.76% | 0.086 |
| Carotid artery disease | 6.88% | 7.00% | 6.74% | 7.00% | 6.80% | 0.981 |
| Cerebrovascular disease | 13.65% | 13.94% | 15.29% | 13.51% | 11.84% | 0.009 |
| Hypertension | 80.91% | 82.33% | 82.94% | 82.49% | 75.88% | <0.0001 |
| Peripheral vascular diseases | 27.33% | 23.55% | 24.79% | 28.05% | 32.92% | <.0001 |
| Diabetes mellitus | 35.74% | 34.61% | 35.65% | 37.18% | 35.53% | 0.318 |
| Obese | 15.07% | 14.42% | 15.92% | 14.97% | 14.98% | 0.586 |
| Anemia | 24.85% | 20.87% | 24.65% | 25.36% | 28.53% | <0.0001 |
| Heart failure | 8.68% | 6.64% | 8.01% | 8.64% | 11.45% | <0.0001 |
| Renal failure | 36.03% | 30.94% | 34.56% | 36.22% | 42.40% | <.0001 |
| Liver disease | 2.65% | 2.12% | 2.45% | 2.50% | 3.53% | 0.019 |
| Smoker | 29.36% | 30.40% | 31.56% | 29.75% | 25.73% | 0.0002 |
| Oxygen dependent | 6.38% | 5.33% | 6.36% | 7.31% | 6.50% | 0.048 |
| Maintenance dialysis | 2.90% | 2.41% | 2.04% | 2.80% | 4.34% | <0.0001 |
| Weekend admissions | 5.56% | 3.75% | 4.13% | 6.05% | 8.30% | <0.0001 |
| Non-elective admissions | 22.96% | 17.99% | 15.30% | 20.81% | 37.72% | <.0001 |
| Elixhauser score | | | | | | <.0001 |
| 0 | 1.58% | 1.67% | 1.79% | 1.51% | 1.37% | |
| 1-3 | 47.92% | 58.94% | 50.47% | 44.57% | 37.69% | |
| ≥4 | 50.50% | 39.39% | 47.74% | 53.93% | 60.94% | |
| In-hospital mortality | 3.29% | 1.12% | 1.21% | 2.21% | 8.64% | <0.0001 |
| Hospital bed size | | | | | | 0.087 |
| Small | 0.80% | 0.79% | 1.34% | 0.67% | 0.42% | |
| Medium | 8.94% | 8.72% | 10.39% | 8.87% | 7.80% | |
| Large | 90.26% | 90.49% | 88.32 | 90.46% | 91.78% | |
| Expected primary payer | | | | | | 0.125 |
| Medicare | 91.06% | 90.77% | 91.61% | 91.32% | 90.53% | |
| Medicaid | 0.91% | 0.67% | 0.75% | 0.84% | 1.37% | |
| Private | 6.331% | 6.94% | 6.22% | 6.34% | 5.84% | |
| Others | 1.70% | 1.63% | 1.42% | 1.50% | 2.25% | |
| Median household income in quartile | | | | | | <0.0001 |
| 1st | 25.07% | 22.94% | 21.62% | 19.12% | 18.97% | |
| 2nd | 20.91% | 28.65% | 24.57% | 24.05% | 22.22% | |
| 3nd | 25.70% | 25.97% | 25.10% | 26.32% | 25.41% | |

(*continued*)

Table 1 (***Continued***)

| Variables | Total | Quartile | | | | p value |
|---|---|---|---|---|---|---|
| | | 1 Lowest cost | 2 | 3 | 4 Highest cost | |
| 4th | 28.52% | 21.44% | 28.71% | 30.52% | 33.39% | |
| Hospital region | | | | | | <0.0001 |
| Northeast | 26.37% | 21.44% | 23.86% | 28.54% | 31.72% | |
| Midwest | 21.57% | 23.00% | 24.88% | 21.47% | 16.89% | |
| South | 34.33% | 41.08% | 36.17% | 32.98% | 27.01% | |
| West | 17.73% | 14.49% | 15.09% | 17.01% | 24.39% | |

Anemia- ICD-9-CM codes: 280.1-281.9, 285.21-285.29, 285.9.
Obesity- ICD-9-CM codes: 278.0, 278.00, 278.01.
Dyslipidemia: Clinical classification code 53.

Conversely, previous PCI (OR 0.79, 95% CI 0.66 to 0.95, p = 0.011), previous CABG (OR 0.76, 95% CI 0.63 to 0.92, p = 0.004), and previous PPM (OR 0.75, 95% CI 0.59 to 0.94, p = 0.013) were identified as factors associated with lower costs. West region hospitals had the highest cost, followed by Northwest, Midwest, and South region hospitals. Patients with nonelective admissions (OR 2.95, 95% CI 2.49 to 3.50, p <0.001) and weekend admissions (OR 1.44, 95% CI 1.09 to 1.90, p = 0.010) both had elevated risk for having the highest costs. All complications were associated with elevated cost. Results are summarized in Table 2.

The incremental cost for each complication was highest for acute respiratory failure requiring intubation ($28,289), cardiogenic shock ($22,401), and AKI ($16,974). The incidence of each event is summarized in Figure 1. Other incremental cost for each complication is summarized in Figure 2. The results of adjusted costs with and without each complication are summarized in Supplementary Table 2.

## Discussion

TAVI complication rates were significantly higher in the high cost group, and therefore these are likely the main drivers of elevated hospitalization costs. Baseline characteristics identified in this study are therefore reflecting those at high risk of developing perioperative complications. Indeed, peripheral vascular disease, being on dialysis, and atrial fibrillation have been reported to be associated with increased risk of perioperative complications such as AKI, blood transfusion, stroke, vascular complications, new PPM, conversion to SAVR, and acute myocardial infarction.[8−10] Heart failure could be associated with AKI, acute respiratory failure, and cardiogenic shock. Previous PPM, PCI, and CABG were associated with lower risk of elevated costs. The decreased risk of elevated costs in previous PPM and PCI is plausible as these procedures were not needed to be performed during the index admission. Regarding those with previous CABG, one study reported significantly lower major bleeding, transfusion, and marginally lower major vascular complication (p = 0.052). Other similar, large size studies reported not statistically but numerically lower rates of bleeding and vascular complications that could partially explain the reduced costs.[11−13]

TAVI is associated with higher procedural costs related to TAVI equipment but nonprocedural costs are lower with TAVI than SAVR due to a lower risk of complications and a shorter hospital stay.[14−17] To reduce TAVI admission costs, in addition to avoidance of perioperative complications by obtaining vascular access under ultrasound guidance, using balloon-expandable valves for those at high risk for PPM, and use of moderate sedation, programs should also attempt to minimize intensive care unit stay, increase early ambulation, avoid urinary catheters, establish clinical pathways post-TAVI, and plan for early discharge in selected patients.

Table 2
Predictors of being in the highest cost group

| Variables | Adjusted OR | 95% CI | p value |
|---|---|---|---|
| Year 2011 (ref.) | | | |
| Year 2012 | 0.906 | 0.321-2.555 | 0.859 |
| Year 2013 | 0.678 | 0.243-1.889 | 0.460 |
| Year 2014 | 0.423 | 0.153-1.174 | 0.099 |
| Year 2015 | 0.484 | 0.175-1.335 | 0.162 |
| Female | 1.137 | 0.980-1.318 | 0.118 |
| Anemia | 1.119 | 1.008-1.395 | 0.040 |
| Heart failure | 1.843 | 1.422-2.387 | <0.0001 |
| Hypertension | 0.678 | 0.567-0.810 | <0.0001 |
| Peripheral vascular disease | 1.566 | 1.343-1.825 | <0.0001 |
| Prior percutaneous coronary intervention | 0.790 | 0.659-0.946 | 0.011 |
| Prior coronary bypass | 0.763 | 0.634-0.918 | 0.004 |
| Prior pacemaker | 0.745 | 0.589-0.943 | 0.013 |
| Atrial fibrillation | 1.261 | 1.097-1.450 | 0.0011 |
| Maintenance dialysis | 2.374 | 1.612-3.494 | <0.0001 |
| Non-elective admission | 2.953 | 2.493-3.498 | <0.0001 |
| Weekend admissions | 1.44 | 1.09-1.902 | 0.010 |
| Strokes | 3.014 | 2.028-4.480 | <0.0001 |
| Vascular complications | 3.532 | 2.345-5.319 | <0.0001 |
| Mechanical circulatory device | 3.988 | 2.372-6.706 | <0.0001 |
| Major bleeding | 2.256 | 1.812-2.808 | <0.0001 |
| Acute kidney injury | 4.148 | 3.451-4.985 | <0.0001 |
| Acute myocardial infarction | 1.531 | 1.067-2.196 | 0.015 |
| Percutaneous coronary intervention | 4.258 | 3.043-5.958 | <0.0001 |
| Respiratory failure with reintubation | 7.165 | 4.836-10.616 | <0.0001 |
| Fatal arrhythmia | 1.797 | 1.401-2.306 | <0.0001 |
| Pacemaker placement | 3.956 | 3.242-4.829 | <0.0001 |
| Hospital region | | | |
| Northeast (ref.) | – | – | – |
| Midwest | 0.553 | 0.375-0.816 | 0.003 |
| South | 0.519 | 0.371-0.726 | <0.0001 |
| West | 1.885 | 1.286-2.761 | 0.001 |

CI = confidence interval; OR = odds ratio.

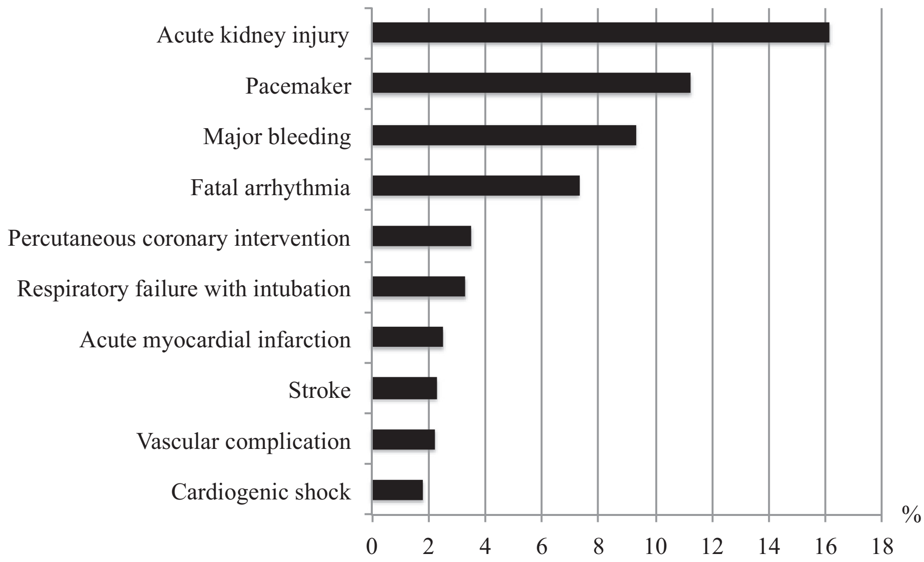


Figure 1. Incidence of each event.

Our analysis has several differences from the previous subgroup analysis from the PARTNER I trial (high-surgical risk cohort). First, we analyzed a larger sample size from a nationwide database of in-hospital outcomes. In addition, we examined outcomes such as respiratory failure and cardiogenic shock, not assessed in the previous PARTNER analysis by Arnold et al, that were important determinants of cost. Moreover, we identified baseline characteristics of patients who underwent TAVI associated with increased costs from an all-comer TAVI population and identified other unique risks such as nonelective and weekend admission as well as a regional variation.

There are several limitations that need to be acknowledged in this study. First, this was a retrospective study using an administrative database and is subject to miscoding. However, if analyzed properly, the NIS provides useful insights to certain clinical questions. We have used the analytical method recommended by the HCUP. Second, we were unable to obtain the cost details that could have impacted our results such as the cost of the different valves used, closure devices used, and other medical equipment. Third, the incremental cost was a crude estimate and was not adjusted for other variables. However, we adjusted for inflation using the consumer price index. Last, this was a cost estimation of only inpatient events and further study is required to evaluate outpatient costs before admission and during follow-up in patients with complications.

In conclusion, we identified clinical characteristics as well as key major perioperative complications that were

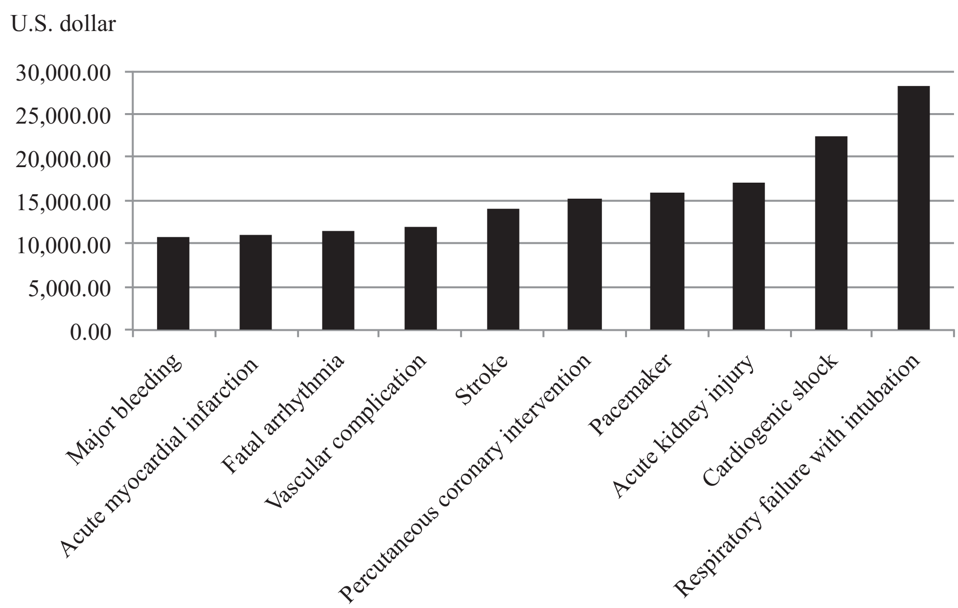


Figure 2. Incremental cost for each complication.

associated with higher hospitalization costs in patients who underwent TAVI. Careful patient and access site selection as well as hospital measures to identify and address early signs of periprocedural complications may help decrease TAVI hospital costs.

## Disclosures

Dr. Deepak L. Bhatt discloses the following relations: Advisory Board: Cardax, Elsevier Practice Update Cardiology, Medscape Cardiology, Regado Biosciences; Board of Directors: Boston VA Research Institute, Society of Cardiovascular Patient Care, TobeSoft; Chair: American Heart Association Quality Oversight Committee; Data Monitoring Committees: Baim Institute for Clinical Research (formerly Harvard Clinical Research Institute, for the PORTICO trial, funded by St. Jude Medical, now Abbott), Cleveland Clinic, Duke Clinical Research Institute, Mayo Clinic, Mount Sinai School of Medicine (for the ENVISAGE trial, funded by Daiichi Sankyo), Population Health Research Institute; Honoraria: American College of Cardiology (Senior Associate Editor, Clinical Trials and News, ACC.org; Vice-Chair, ACC Accreditation Committee), Baim Institute for Clinical Research (formerly Harvard Clinical Research Institute; RE-DUAL PCI clinical trial steering committee funded by Boehringer Ingelheim), Belvoir Publications (Editor in Chief, Harvard Heart Letter), Duke Clinical Research Institute (clinical trial steering committees), HMP Global (Editor in Chief, *Journal of Invasive Cardiology*), *Journal of the American College of Cardiology* (Guest Editor; Associate Editor), Population Health Research Institute (for the COMPASS operations committee, publications committee, steering committee, and USA national co-leader, funded by Bayer), Slack Publications (Chief Medical Editor, Cardiology Today's Intervention), Society of Cardiovascular Patient Care (Secretary/Treasurer), WebMD (CME steering committees); Other: Clinical Cardiology (Deputy Editor), NCDR-ACTION Registry Steering Committee (Chair), VA CART Research and Publications Committee (Chair); Research Funding: Abbott, Amarin, Amgen, AstraZeneca, Bayer, Boehringer Ingelheim, Bristol-Myers Squibb, Chiesi, Eisai, Ethicon, Forest Laboratories, Idorsia, Ironwood, Ischemix, Lilly, Medtronic, PhaseBio, Pfizer, Regeneron, Roche, Sanofi Aventis, Synaptic, The Medicines Company; Royalties: Elsevier (Editor, Cardiovascular Intervention: A Companion to Braunwald's Heart Disease); Site Co-Investigator: Biotronik, Boston Scientific, St. Jude Medical (now Abbott), Svelte; Trustee: American College of Cardiology; Unfunded Research: FlowCo, Merck, Novo Nordisk, PLx Pharma, Takeda. The other authors report no disclosures.

## Supplementary materials

Supplementary material associated with this article can be found, in the online version, at https://doi.org/10.1016/j.amjcard.2018.12.044.


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