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ORIGINAL RESEARCH

Economic Burden of Inpatient Care for Mitral Regurgitation in Maryland

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BACKGROUND: Mitral regurgitation (MR) is the most common valvular disease in the United States and increases the risk of death and hospitalization. The economic burden of MR in the United States is not known.

METHODS AND RESULTS: We analyzed inpatient hospitalization data from the 1 221 173 Maryland residents who had any in-state admissions from October 1, 2015, to September 30, 2019. We assessed the total charges for patients without MR and for patients with MR who underwent medical management, transcatheter mitral valve repair or replacement, or surgical mitral valve repair or replacement. During the study period, 26 076 inpatients had a diagnosis of MR. Compared with patients without MR, these patients had more comorbidities and higher inpatient mortality. Patients with medically managed MR incurred average total charges of $23 575 per year; MR was associated with $10 559 more in charges per year and an incremental 3.1 more inpatient days per year as compared with patients without MR. Both surgical mitral valve repair or replacement and transcatheter mitral valve repair or replacement were associated with higher charges as compared with medical management during the year of intervention ($47 943 for surgical mitral valve repair or replacement and $63 108 for transcatheter mitral valve repair or replacement). Annual charges for both groups were significantly lower as compared with medical management in the second and third years postintervention.

CONCLUSIONS: MR is associated with higher mortality and inpatient charges. Patients who undergo surgical or transcatheter intervention incur lower charges compared with medically managed MR patients in the years after the procedure.

Key Words: health care economics ■ mitral regurgitation ■ mitral valve surgery ■ transcatheter therapies

Valvular heart disease is a common group of cardiovascular disorders with significant associated morbidity and mortality. Aortic and mitral valve diseases affect 2.5% of US adults[1] and result in an incremental annual cost of $23.4 billion.[2] Mitral regurgitation (MR) is the most common valvular disease in US adults, with an estimated prevalence of 1.7%.[1,3] The incidence of MR increases with age, affecting 9.3% of US adults ≥75 years of age.[1,4,5] Numerous population-based studies have shown that even mild MR increases the risk of heart failure, hospitalization, and death, with risk that is proportional to disease severity.[6,7] However, only 15% of all patients with moderate to severe MR undergo surgical intervention, in part due to advanced age or comorbidities.[8] The growth of transcatheter aortic valve replacement volume by close to 50% per year in the past decade has increased interest in transcatheter mitral valve therapies for nonsurgical candidates with advanced MR. MitraClip (Abbott), a system for transcatheter edge-to-edge repair, obtained Food and Drug Administration approval in 2013 and was the only transcatheter device approved for the treatment of MR in the United States until the Pascal Precision system (Edwards) was approved in September 2022. The first in-human transcatheter mitral valve-in-valve, valve-in-ring, and valve-in-mitral annular calcification

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CLINICAL PERSPECTIVE

What Is New?

- Mitral regurgitation is associated with increased health care charges and increased mortality as compared with patients without mitral regurgitation.

What Are the Clinical Implications?

- Both surgical and transcatheter interventions are associated with increased health care charges over medical management in the index quarter of the procedure but are then associated with costs lower than those of long-term medical management.
- Addressing mitral regurgitation through surgical or transcatheter methods in selected patients, although associated with a higher upfront cost, may ultimately decrease health care expenditure.

Nonstandard Abbreviations and Acronyms

MM	medical management
MR	mitral regurgitation
SMVR	surgical mitral valve repair or replacement
TMVR	transcatheter mitral valve repair or replacement

replacements took place in 2009, 2011, and 2012, respectively.[9,10] Since that time, procedural volumes have grown steadily, although with a 30-day all-cause mortality of 8.5% to 29.7% in early studies.[10–12] Several clinical trials are currently underway to assess the efficacy of various transcatheter mitral valve replacement systems. With the rapid advance in transcatheter treatment options for MR, an accurate assessment of the cost of medical and operative/interventional management of mitral regurgitation is important in assessing these new mitral interventions.

METHODS

We conducted a retrospective analysis of state-wide inpatient data from Maryland. We obtained deidentified data sets from the Maryland Health Services Cost Review Commission, which contain demographic, clinical, and financial data on all inpatient visits in Maryland reported quarterly by hospitals to the state of Maryland by legal mandate. The Health Services Cost Review Commission outpatient data do not account for many nonregulated private outpatient practice spaces, resulting in significant deficiency of outpatient data; therefore, only inpatient data were used for this study. We felt this provided a sufficient representation of cost because most charges are incurred during inpatient admissions. We used the *International Classification of Diseases, Tenth Revision, Clinical Modification* (*ICD-10-CM*) codes to define diagnoses and *Procedure Coding System* (*ICD-10-PCS*) to define procedures. *Ninth Revision* (*ICD-9*) codes were not specific enough, because they did not differentiate surgical from transcatheter replacement and allowed for some codes that do not specify the exact valve disease or intervention. Our analysis therefore begins on October 1, 2015, when *ICD-10-CM* codes became the standard. The *ICD* codes do not specify MR severity and therefore include patients with any degree of MR. We included the following Charlson comorbidities[13]: myocardial infarction, heart failure, peripheral arterial disease, cerebrovascular disease, chronic obstructive pulmonary disease, liver disease, diabetes, chronic kidney disease. We additionally included obesity, aortic valve disease, tricuspid valve disease, and pulmonic valve disease. A complete list of diagnostic and procedural codes used to define the comorbidities included in the study are detailed in Table S1.

We included all Maryland residents receiving medical care in the state of Maryland from October 1, 2015, to June 30, 2019. Mortality data include patients who were marked as deceased in the Health Services Cost Review Commission outpatient database, therefore accounting for some deaths that occurred outside of the hospital. Patients were enrolled into our study during the first quarter in which data for that patient were available; patients were included in the study until their death was recorded in the inpatient data set, or until the end of data availability (June 30, 2019). We excluded nonresidents of Maryland, patients with missing data, and patients who had undergone surgical mitral valve repair or replacement (SMVR) or transcatheter mitral valve repair or replacement (TMVR) if the quarter of service could not be identified. Patients were separated into 4 groups: those who had no diagnosis of MR at any time during the study period (non-MR), patients with MR who never underwent a mitral valve procedure (medical management [MM]), patients with MR who underwent SMVR, and patients with MR who underwent TMVR. The first quarter of enrollment was the index quarter for procedural patients and the quarter of first MR diagnosis code for MM patients; subsequent quarters were enumerated in relation to the quarter of enrollment, and there was no crossover among the 3 groups. Patients who underwent a repeat mitral valve procedure remained in the cohort of their index procedure regardless of the repeat procedure type, because the need for redo intervention was regarded as

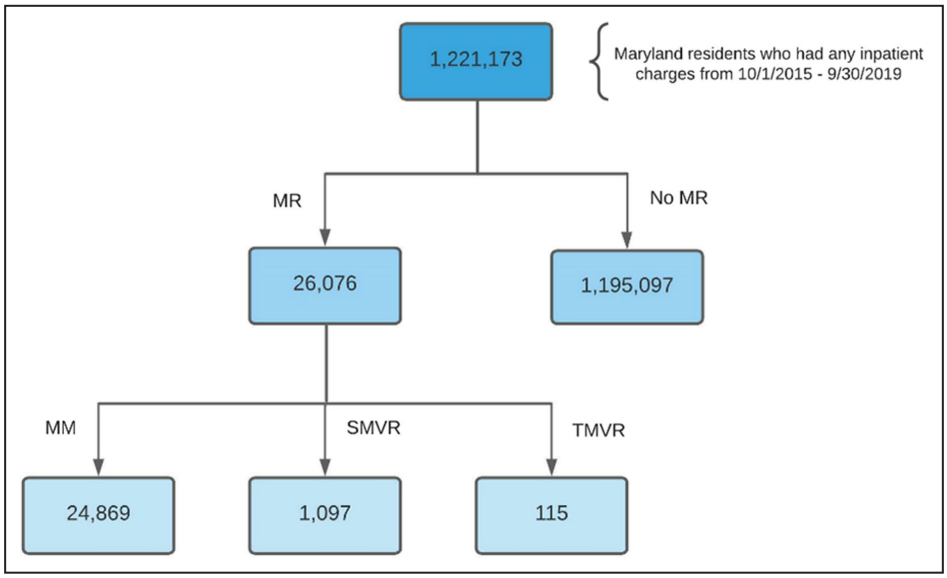

Figure 1. Patient cohorts used in the study.
Five patients received both SMVR and TMVR. MM indicates medical management; MR, mitral regurgitation; SMVR, surgical mitral valve repair or replacement; and TMVR, transcatheter mitral valve repair or replacement.

a complication or failure of the index procedure. All statistical analyses were conducted with these noncalendar quarters.

STATISTICAL ANALYSIS

We used standard descriptive statistics for comparisons of baseline characteristics. Because only a small percentage of patients with MR undergo hospitalization in any given quarter, the degree of skew in the data precluded meaningful use of median and interquartile range (IQR) in many of our analyses; therefore, mean and SD were primarily used to describe continuous variables. Statistical significance of differences in demographics between groups was assessed with the χ^2 test. Tests of association between exposure and outcome were conducted using linear regression models. To compensate for the noticeable difference in MR subgroups characteristics, we first used entropy balancing (Stata command: ebalance), a data-matching procedure that allows reweighting a data set such that the covariate distributions in the reweighted exposure group match the covariate moments in the control group.[14] We matched for the means of all aforementioned Charlson comorbidities, obesity, aortic valve disease, tricuspid valve disease, and pulmonic valve disease, as detailed in Tables S2–S4. Because the combined non-MR and MR data set exceeded 1.2 million patients, association of MR with mortality was tested using a confounder-controlled logistic regression model without propensity weighting. All statistical analyses in this study were performed using Stata statistical data analysis software (version 17; StataCorp). The study was deemed to be institutional review board exempt by the Johns Hopkins Institutional Review Board (institutional review board approval number: IRB00176693), and informed consent was not required. The data from this study can be obtained by applying to the Health Services Cost Review Commission; detailed methodology is available from the authors upon request.

RESULTS

Medically Managed MR Versus the General Population

A total of 1 221 173 Maryland residents had at least 1 inpatient encounter in the state of Maryland during the predefined study period lasting 15 quarters, from October 1, 2015, to June 30, 2019. During this time, 26 076 patients (2.1%) had a diagnosis of MR (Figure 1). The remaining 1 195 097 formed the non-MR group. The demographics of these groups are detailed in Table 1. Patients with MR were significantly older, more likely to be men and White, and had a considerably higher prevalence of all Charleson comorbidities as compared with patients without MR.

The mean unadjusted charge for inpatient care during the first quarter was $5247 for patients with MR compared with $1685 for patients without MR; mean annual charges across the study were $23 575 and $7145, respectively. Mean unadjusted quarterly charges for these 2 cohorts through the duration of the study are shown in Figure S1. For the duration of

Table 1. Baseline Characteristics of Patients With and Without MR in the State of Maryland

Characteristic	No MR	Any MR	MM	TMVR	SMVR	*P* value (MR vs no MR)	*P* value (MM, TMVR, SMVR)
	N=1 195 097	N=26 076	N=24 869	N=113	N=1094		
Mean age, y (SD)	42.0 (27.9)	68.7 (16.3)	69.1 (16.3)	75.8 (9.8)	60.4 (14.8)	<0.001	<0.001
Median age, y [IQR]	42 [22–67]	72 [62–82]	72 [62–82]	77 [72–82]	62 [52–72]		
Sex						<0.001	<0.001
Men	39.9%	47.0%	46.4%	60.2%	58.3%		
Missing	0.1%	0%	0%	0%	0%		
Race						<0.001	<0.001
White	53.8%	62.9%	62.5%	72.6%	70.3%		
Black	31.5%	30.4%	30.8%	23.9%	21.8%		
Asian	12.4%	5.1%	5.1%	2.7%	5.2%		
Missing	2.3%	1.7%	1.7%	0.9%	2.7%		
Ethnicity						<0.001	0.76
Hispanic	8.5%	2.3%	2.4%	1.8%	2.1%		
Non-Hispanic	86.1%	94.7%	94.6%	97.3%	96.2%		
Missing	5.4%	3.0%	3.0%	0.9%	1.7%		
Myocardial infarction	3.5%	18.2%	18.5%	23.9%	9.8%	<0.001	<0.001
Congestive heart failure	6.0%	43.6%	43.9%	56.6%	35.7%	<0.001	<0.001
Peripheral vascular disease	2.5%	10.1%	10.2%	9.7%	8.0%	<0.001	0.07
Chronic obstructive pulmonary disease	0.5%	1.6%	1.6%	2.7%	0.7%	<0.001	0.053
Liver disease	2.0%	2.6%	2.6%	1.8%	1.2%	<0.001	0.012
Diabetes	8.9%	20.7%	21.1%	18.6%	11.2%	<0.001	<0.001
Renal disease	1.5%	7.0%	7.1%	3.5%	4.8%	<0.001	0.005
Obesity	11.5%	18.6%	18.8%	8.8%	15.4%	<0.001	<0.001
Aortic valve disease	1.6%	10.1%	10.2%	15.0%	8.2%	<0.001	0.024
Tricuspid valve disease	0.8%	12.9%	12.8%	21.2%	16.0%	<0.001	<0.001
Pulmonic valve disease	0.1%	1.6%	1.6%	3.5%	1.4%	<0.001	0.22

Data are presented as mean (SD) and median [IQR] for continuous measures, and percent for categorical measures. Any MR includes patients with any degree of MR, who are then subdivided as MM, SMVR, and TMVR.

IQR indicates interquartile range; MM, medical management; MR, mitral regurgitation; SMVR, surgical mitral valve repair or replacement; and TMVR, transcatheter mitral valve repair or replacement.

the study, median total charges were $47 531 for patients with MR (IQR, $20 677–$100 124) and $10 774 for patients without MR (IQR, $5113–$26 158); skewness characteristics of the sample are depicted in Figure S2. Due to substantial differences in the baseline characteristics of each group, we used entropy-balanced models to assess the incremental impact of MR on charges. This resulted in a sufficient balance of means of covariates in patients with and without MR (Table S2). After rebalancing, in multiple linear regression adjusted for the aforementioned covariates, MR was associated with an incremental charge of $2581 in the first quarter (*P*<0.001 [95% CI, $2295–$2867]) or $10 559 in the first year (*P*<0.001 [95% CI, $9879–$11 239]) as compared with patients without MR. Patients with MR were admitted for an average of 1.70 days per quarter, >3 times more than patients without MR, who had an average 0.50 inpatient days per quarter. There was notable seasonal variation, although the number of days inpatients remained stable throughout the 15 quarters in this study (Figure S1). For the duration of the study, patients with MR had a mean 23 admission days (SD, 29 days) and a median 14 total inpatient days (IQR, 6–30 days). By contrast, patients without MR had a mean 7 days (SD, 13 days) and a median 3 total inpatient days (IQR, 2–6 days). MR was independently associated with an incremental 0.8 more inpatient days per patient per quarter (*P*<0.001 [95% CI, 0.68–0.82]) or 3.1 more inpatient days per patient per year (*P*<0.001 [95% CI, 2.96–3.31]) as compared with patients without MR despite controlling for the aforementioned confounding variables.

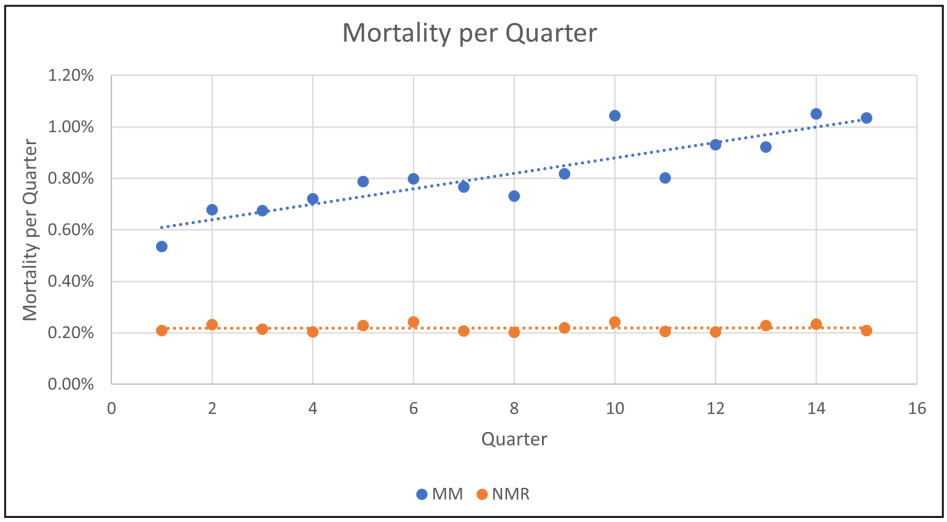

Figure 2. Mortality of patients with and without mitral regurgitation.
Unadjusted mortality rate per quarter. MM indicates medical management; and NMR, no mitral regurgitation.

During the first quarter of MR diagnosis, 0.53% of patients with MR died as compared with 0.21% of patients without MR. Over the subsequent quarters, there was a steady and sustained ris in mortality in the MR population and no change in the per-quarter mortality rate of patients without MR (Figure 2). Because the MR population had different demographics and comorbidities than the general population, we created a logistic regression model to control for these variables, and found that the diagnosis of MR was independently associated with death, with an odds ratio of 1.3 (P<0.001 [95% CI, 1.24–1.36]). There was no significant difference in the charges during the last quarter of life for patients who died with MR versus patients without MR ($49 603 versus $48 614; P=0.910).

Procedural Management of MR

Of the 26 076 patients diagnosed with MR, 24 869 were medically managed, 1097 underwent SMVR, and 115 underwent TMVR (Table 2). There were a total of 1540 SMVRs and 181 TMVRs during the study period, accounting for repeat procedures. The number of each SMVR and TMVR procedures performed for MR by chronological quarter (2015 quarter 4–2019 quarter 2) is shown in Figure 3. The demographics of these patients are summarized in Table 1. As compared with MM, patients who underwent SMVR were significantly younger, more likely to be men and White, and had fewer comorbidities of any kind than the overall population of patients with MR. Patients selected for TMVR were similarly more likely than MM patients to be men and White but were older than both other populations and more likely to have suffered from heart failure and a myocardial infarction; they were less likely than the MM cohort to have diabetes and liver or kidney disease. There was a trend toward fewer Hispanic patients undergoing SMVR or TMVR, although the differences were not statistically significant.

There was an average of 103 SMVRs performed for MR per quarter in Maryland during the study period. During the index quarter of the procedure, the average inpatient charge was $73 881 per patient, with an average of 13.5 inpatient days (Figure 4A). Both steadily decreased after the procedure, reaching a nadir at 1 year after surgery that sustained for the remainder of the study period. By comparison, the MM cohort had a per-quarter average charge of $5983 and average inpatient days of 1.7 during the study period. For patients with SMVR throughout the study, median total inpatient charges were $75 588 (IQR, $48 642–$136 561), and there were 12 median total inpatient days (IQR, 6–25). As noted previously, the data in this analysis include all degrees of MR. However, patients who undergo intervention are sicker and inherently have a higher degree of MR than most medically managed patients (exception for patients

Table 2. Patients Undergoing Medical, Surgical, and Transcatheter Management for Mitral Regurgitation

No. of procedures	MM	SMVR	TMVR	SMVR and TMVR
1	–	777	64	–
2	–	224	39	–
3+	–	96	12	–
Total	24 869	1097	115	5

For patients with SMVR and TMVR, the number shown is of patients undergoing 1, 2, or 3+ procedures during the study period.
MM indicates medical management; SMVR, surgical mitral valve repair or replacement; and TMVR, transcatheter mitral valve repair or replacement.

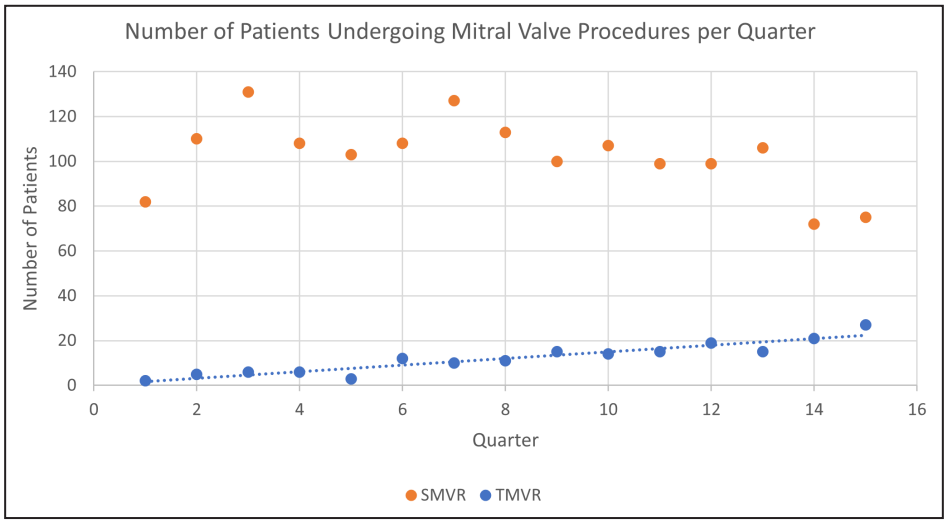

Figure 3. Number of mitral valve procedures performed per quarter.
Quarters are enumerated chronologically with quarter 1=2015 quarter 4, and quarter 15=2019 quarter 2. SMVR indicates surgical mitral valve repair or replacement; and TMVR, transcatheter mitral valve repair or replacement.

with severe MR who are not procedural candidates). To create a better comparison of the economic impact of intervention over MM, we used entropy balancing of patients with SMVR and MM patients, controlling for the aforementioned demographic variables and comorbidities. Balancing resulted in a sufficient balance of means of covariates in MM patients and patients with SMVR (Table S3). As compared with MM patients, during the index quarter of intervention, patients who were confounder-controlled and SMVR-equivalent had an additional incremental charge of $38 139 (*P*<0.001 [95% CI, $33 724–$42 554]) and an additional incremental 2.9 inpatient days (*P*<0.001 [95% CI, 2.09–3.66]) (Figure 5). During the year of surgery, defined as the quarter of surgery and 3 subsequent quarters, patients with SMVR incurred an incremental charge of $47 943 (*P*<0.001 [95% CI, $42 000–$53 887]) and an incremental 3.5 inpatient days (*P*<0.001 [95% CI, 2.28–4.74]) as compared with MM patients. In the second and third years after surgery, patients with SMVR had an incremental charge of −$1873 (*P*=0.175 [95% CI, −$4582 to $835]) and −$2344 (*P*<0.001 [95% CI, −$3321 to −$1366]) per year, respectively, and an incremental −0.9 (*P*<0.01 [95% CI, −1.56 to −0.31]) and −0.7 inpatient days (*P*<0.001 [95% CI, −0.95 to −0.40]), respectively, as compared with MM patients.

During the study period, there was an average of 12 TMVRs per quarter; however, there was significant ramp-up with 2 TMVRs during the first quarter and 27 TMVRs during the last quarter. During the index quarter of the procedure, the average patient incurred a charge of $70 929 with 7.8 inpatient days, with a steady decline in both in subsequent quarters (Figure 4B). Due to the recent introduction of TMVR in Maryland, there are limited follow-up data past 6 quarters after the procedure. For patients with TMVR throughout the study, the median total inpatient charge was $104 247 (IQR, $74 170–$148 934), and there were 10 median total inpatient days (IQR, 4–22). We used entropy balancing of patients with TMVR and MM patients, controlling for the aforementioned demographic variables and comorbidities, which resulted in a sufficient balance of means of covariates in MM patients and patients with TMVR (Table S4). In a regression model after entropy balancing, patients who underwent TMVR incurred an additional incremental charge of $42 283 (*P*<0.001 [95% CI, $34 048–$50 519]) over MM in the index quarter. There was no statistically significant difference in the number of inpatient days between the 2 groups (β=−0.506, *P*=0.513 [95% CI, −2.02 to −1.01) during that time period (Figure 5). During the year of the procedure, patients with TMVR incurred an incremental charge of $63 108 (*P*<0.001 [95% CI, $53 131–$73 086]), with no difference between the number of inpatient days (β=−0.564, *P*=0.643 [95% CI, −2.94 to 1.81]). In the second and third years after the procedure, patients with TMVR had an incremental charge of −$4008 (*P*<0.01 [95% CI, −$6705 to −$1311]) and −$3270 (*P*<0.001 [95% CI, −$4171 to −$2368]), respectively, and an incremental −1.5 (*P*<0.001 [95% CI, −2.26 to −0.70]) and −0.8 inpatient days (*P*<0.001 [95% CI, −1.16 to −0.55]), respectively, as compared with MM patients.

DISCUSSION

The expanding arsenal of mitral valve interventions has increased the number of patients who can receive

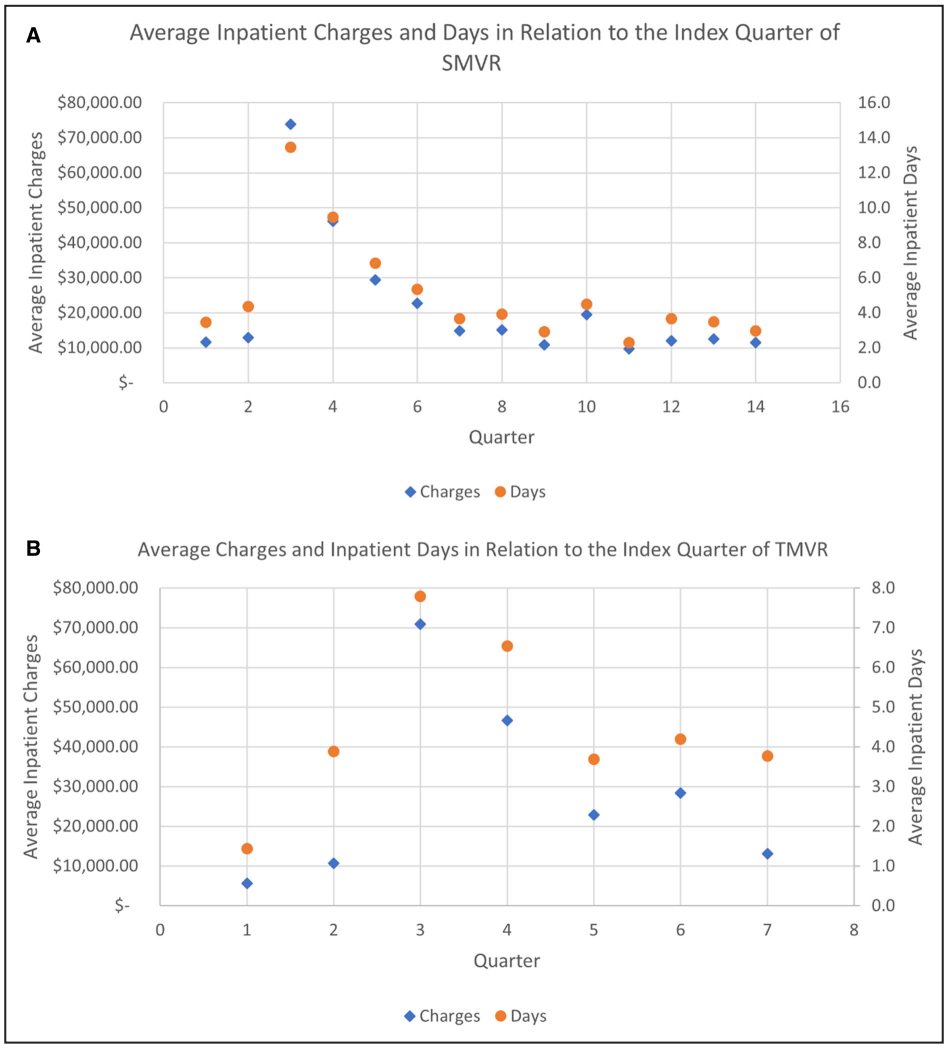

Figure 4. Inpatient charges and days for patients who underwent intervention.
Indexed by quarter of intervention, with 2 quarters before and 11 quarters following the intervention for SMVR (**A**) and 2 quarters before and 4 quarters following the intervention for TMVR (**B**). SMVR indicates surgical mitral valve repair or replacement; and TMVR transcatheter mitral valve repair or replacement.

interventional therapy; however, there are only limited data available on the financial burden of MR. We analyzed a state-wide database of inpatient charges, and found that MR is associated with a 3-fold increase in charges and inpatient days. Both surgical and transcatheter intervention for MR are associated with significant cost during the index quarter, but appear to result in cost savings in subsequent years.

The bulk of existing literature on the financial burden of MR originates outside of the United States. In France, a large retrospective review of patients with severe MR reported an annual cost of €12 200 ($13 000) for MM MR, compared with €29 700 ($31 700) for the year starting with SMVR and €21 900 ($23 400) after MitraClip repair.[15] An American longitudinal retrospective study examining the health care costs of mitral valve disease from 1996 to 2011 reported an average annual cost of $5200 and $1800 per patient per year for symptomatic and asymptomatic mitral valve disease, respectively.[2] Other Canadian[16,17] and European[18–20] models have reported a wide range of predicted charges, estimating costs of CAD $21 900 to $35 600 (USD $16 800–$27 300) and €8600 to €18 900 (USD $9200–$20 200) for MM compared with CAD $40 600 to $52 500 (USD $31 200–$40 300), €25 500 to €36 700 (USD $27 200–$39 200) for MitraClip. Overall, these studies reported greater costs for MitraClip over MM, but also reported improved quality of life and life-years gained with MitraClip over MM (quality-adjusted life year [QALY], 1.13–2.76; incremental cost-effectiveness ratio [ICER]: USD $16 600–$24 800/QALY gained).

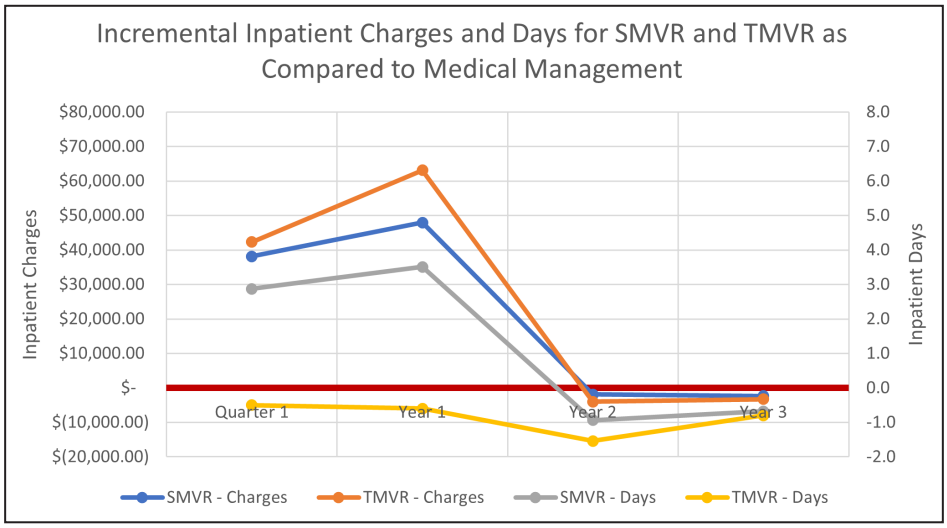

Figure 5. Incremental inpatient charges and days for SMVR and TMVR as compared with MM.

Output from linear regression models of SMVR or TMVR in relation to MM in the quarter and year of intervention, as well as years 2 and 3 following intervention. MM indicates medical management; SMVR, surgical mitral valve repair or replacement; and TMVR, transcatheter mitral valve repair or replacement.

US studies have been limited, using small data sets, often within the context of clinical trials. The mean costs of isolated surgical mitral valve repair and replacement were reported to be $72 761 and $78 216, respectively.[21] The cumulative 2-year cost of the MitraClip has been reported at $73 416 (including $48 198 for the index hospitalization) compared with $38 325 for medically managed patients.[22] Another study reported similar mean Medicare charges per patient pre- and post-MitraClip, but for patients who survived 1 year, the mean annual costs were significantly decreased in the following year ($18 100 versus $11 700).[23]

In this study we examined health care charges in the largest US cohort to date using a database of inpatient admissions in the state of Maryland over a period of >3 years. During that time, 2.2% of patients were assigned the diagnosis of MR. This is slightly higher than the previously reported estimated US prevalence of 1.7%, likely because this is an inpatient sample. There were several important findings in our analysis of demographic data. The average age of patients with MR was higher than patients without MR, an expected finding given that the risk of MR increases with age. There was a slightly higher share of women with MR than men, consistent with prior data[24]; however, men are significantly more likely to undergo a procedure for MR. There was also underrepresentation of Hispanic patients with MR as compared with the 2019 Census data from the state of Maryland.[25] Furthermore, there is an unfortunate disparity in the patients who are selected for SMVR and TMVR, both of which favor White patients, bringing to focus a well-known bias in medicine with ongoing barriers for non-White and female patients.

We analyzed charge data from inpatient admissions during the study period and found 3-fold higher per-quarter charges ($5247 versus $1685) and inpatient days (1.7 versus 0.5, respectively) for patients with MR compared with patients without MR. The diagnosis of MR was associated with $2581 more in charges per quarter or $10 559 more per year and an incremental 0.8 more inpatient days per quarter or 3.1 more inpatient days per year in our regression models. These charge data are comparable to data for medically managed MR reported by European and Canadian groups as discussed above. Over the 15-quarter period, there remained a significant difference in per-patient charges between the 2 cohorts, with notable seasonal variation resulting in highest charges and inpatient days during the winter months and lowest charges during the summer months (Figure S1).

A notable finding of our analysis was the higher mortality rate in patients with MR, which was more than double that of the general population at the start of the analysis (0.53% versus 0.21%) and sustained a steady rise over the subsequent quarters. Even after controlling for demographics and comorbidities, the diagnosis of MR was independently associated with death, with a risk that increased the longer a patient was followed. This is in line with existing literature showing that even mild MR increases mortality.[6,7] Age was the only other comorbidity or demographic characteristic in our analysis that was independently associated with increased mortality risk; race, sex, and ethnicity did not have a statistically significant association with

mortality. Medical care in the months before death in this population carried a significant cost, an incremental $45 400 for patients who died in a given quarter, which may offset some of the savings gained from early and appropriate intervention.

We analyzed the trends, economics, and associated outcomes of procedural management of MR. During the index quarter of the procedure, patients with SMVR and TMVR incurred a charge of $73 881 and $70 929 (13.5 and 7.8 inpatient days), respectively, compared with an average charge of $5983 (1.7 inpatient days) for MM patients. These data are similar to the previously reported cost for SMVR[21] and the MitraClip[22]; the cost of the MitraClip device has been reported to be $30 000.[22] In both intervention cohorts, inpatient charges and days dramatically drop in the quarters after the intervention. Because this study includes patients with any degree of MR, we used regression models constructed after propensity weighting to better define associated differences between intervention and MM. In these models, SMVR was associated with an increase in charge of $47 943 and an incremental 3.5 inpatient days in the year of intervention as compared with MM, but this fell below the baseline of MM in years 2 and 3 after the procedure (–$1873 and –0.9 days, and –$2344 and –0.7 days, respectively). TMVR was associated with an increase in charge of $63 108, with no statistically significant difference between the number of inpatient days during the year of the procedure. Observed again was a decrease below the MM baseline in years 2 and 3 after TMVR (–$4008 and –1.5 days, and –$3270 and –0.8 days, respectively). These data demonstrate that despite higher upfront charges, SMVR and TMVR are associated with decreased charges in the years after the procedure that at least partially offset the cost of the procedure.

In this study we present the most comprehensive financial analysis of mitral valve regurgitation and its associated interventions in the United States to date. The data were explicitly collected for analysis of inpatient charges and were controlled for several confounders. Rather than a sample population, these data include all inpatient hospitalizations for the state of Maryland regardless of payer type. It therefore presents an unbiased assessment of charges. This can be used in cost-effectiveness analyses for the rapidly emerging interventions for MR. Further understanding of costs is also important in rate setting for these interventions by US payers, including hospitals, insurance providers, and Medicare/Medicaid.

LIMITATIONS

There are several limitations to our study. Due to the nature of the data set, we were restricted in using only inpatient charges. Although we believe that these represent the bulk of charges accrued by patients over the study period, this limits the full scope of data and naturally exaggerates the average annual charge incurred by patients with mitral valve regurgitation. Although we extracted death data from both inpatient and outpatient databases, these may not fully include all patients who were deceased during the study timeframe. Because our diagnoses are based on *ICD-10-CM* codes, we cannot differentiate the varying degrees of MR nor the causes. Our study is limited to 3 years due to the recent change in *ICD* codes, but more long-term data, especially as TMVR volumes increase, will be critical in understanding the long-term economic impact of these procedures and the cost as compared with quality-adjusted life-years.

CONCLUSIONS

The high prevalence of MR and new interventional therapeutic options have created a need for better understanding of the economics and patient selection for procedural management. In this study we present the first US state-wide longitudinal analysis of the inpatient economic burden of mitral regurgitation across all types of management, and the relative impact of interventional strategies over MM from propensity-weighted confounder-adjusted regression models. In Maryland, patients who were admitted to a hospital during our study period, MR was associated with significantly more in charges, inpatient days, and higher mortality as compared with patients without MR. Procedural intervention for MR with either SMVR or TMVR was more frequent in patients who were men and White compared with patients who were medically managed, suggesting a possible bias in procedural selection. Patients who did undergo intervention incurred a higher relative inpatient charge during the year of intervention as compared with MM, but patients in both procedural arms had significantly lower annual charges as compared with MM patients at 1 and 2 years postintervention. An extended analysis is warranted to better understand the lifetime economic impact of such interventions.

ARTICLE INFORMATION

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Supplemental Material

Data S1

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