THIRTY-DAY READMISSIONS AFTER EARLY VERSUS DELAYED DISCHARGE
AFTER UNCOMPLICATED TRANSCATHETER AORTIC VALVE REPLACEMENT:
INSIGHTS FROM THE NATIONWIDE READMISSION DATABASE

A THESIS IN
Bioinformatics

Presented to the Faculty of the University
Of Missouri-Kansas City in partial fulfillment of
The requirements for the degree

MASTER OF SCIENCE

By
MOHAMED OMER

M.D., University of Assiut, 2006

Kansas City, Missouri
2019
THIRTY-DAY READMISSIONS AFTER EARLY VERSUS DELAYED DISCHARGE AFTER UNCOMPLICATED TRANSCATHETER AORTIC VALVE REPLACEMENT: INSIGHTS FROM THE NATIONWIDE READMISSION DATABASE

Mohamed Omer, MD Candidate for the Master of Science Degree
University of Missouri-Kansas City, 2019

ABSTRACT

Early discharge after transcatheter aortic valve replacement (TAVR) has generally shown to be safe; however, studies have been limited to single centers or trial populations, making their generalizability unclear. This study sought to examine the rate of rehospitalization after early vs. late discharge following uncomplicated TAVR in an unselected population, to explore the variability in early discharge across sites, and to investigate factors associated with failure of early discharge.

Using the National Readmission Databases (1/2014-9/2015), we compared 30-day readmission rates between early (<3 days) vs late (≥3 days) discharges after uncomplicated transfemoral TAVR (propensity matched cohort) using Kaplan-Meier methods. Additionally, we examined factors associated with failure of early discharge using logistic regression and testing for interactions of patient factors with discharge strategy.

Among 4,955 hospitalizations for uncomplicated TAVR, 1857 (37%) were discharged early with substantial site-level variability (range 0-87%; median odds ratio 3.69). In the propensity matched cohort (n=3346), there were similar rates of 30-day readmission by discharge strategy (early vs. late: 10.3% vs. 10.6%; stratified log-rank p=0.555). There was a statistically significant interaction between discharge strategy and number of chronic
conditions (p=0.007), where readmission rates were lower in patients discharged early versus late.

In a matched cohort of real-world patients, early discharge after uncomplicated TAVR was not associated with a higher rate of 30-day rehospitalization, yet there was significant variability in early discharge across US hospitals. Furthermore, we were unable to identify any patients who appeared to benefit for longer inpatient monitoring. Novel strategies should be explored to safely increase the rate of early discharge after uncomplicated TAVR to improve patient outcomes.
The faculty listed below, appointed by the Dean of the School of Medicine, have examined a thesis titled “Thirty-Day Readmissions after Early versus Delayed Discharge after Uncomplicated Transcatheter Aortic Valve Replacement: Insights from the Nationwide Readmissions Database” presented by Mohamed Omer, candidate for the Master of Science degree, and certify that in their opinion it is worthy of acceptance.

Supervisory Committee

Kim Smolderen, Ph.D., Committee Chair
Department of Biomedical and Health Informatics

Suzanne Arnold, M.D., M.H.A
Department of Cardiovascular Medicine
Department of Biomedical and Health Informatics

Philip G. Jones, MS.
Department of Biomedical and Health Informatics
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ACKNOWLEDGEMENTS

I am forever grateful to my loving parents; whose love and support were essential in achieving any of my goals.

Thank you so much to Marwa, my wonderful wife, and our three children, Jana, Salma and Yusuf for your love, patience and support during this process.

I would like to thank my supervisory committee chair, Dr. Kim Smolderen, who worked so diligently and consistently with me to ensure that my thesis analyses and manuscript were completed in a timely fashion. It's hard to measure the impact you've had on my academic career, but I know it's been significant.

To Dr. Arnold, thank you for guiding me through one of my first primary manuscripts. I really appreciate your patience and your support not only in supervising my project, but also in being a great mentor whose advice has been invaluable.

To Dr. Spertus, I am so grateful that you supported my application for the Master degree program in Medical Bioinformatics and for placing your trust and confidence in my abilities to become a passionate cardiovascular researcher.

To Dr. Gaddis, Phil Jones and Kevin Kennedy, thank you for all the lessons that you taught us during last year. To say that it was a learning experience is not enough. I went from a student in biostatistics class to a national database analyst in two semesters.

Thank you to Nancy Hoover, for your assistance in formatting for the thesis manuscript.
Aortic stenosis (AS) is the most frequent valvular heart disease in developed countries and usually develops later in life (1,2). For people over the age of 75 years, the estimated prevalence of aortic stenosis is 3% (1). However, with the progressive aging of the population in the U.S. (3), the prevalence of AS is expected to double in the next two decades (1). Asymptomatic patients with AS have a relatively benign outcome (4,5), but once symptoms develop, the prognosis is poor (6,7). For many years, surgical aortic valve replacement (SAVR) was the only therapeutic intervention that was associated with significant improvement in symptoms and survival in patients with severe AS (8,9). As a result, the American and the European valvular heart disease guidelines recommended SAVR as a class I recommendation for most patients with symptomatic severe AS (10-12). Nevertheless, several studies have identified certain subgroups of patients (e.g., those with advanced age and multiple comorbidities) who are at increased risk for operative mortality and morbidity (13-15). Therefore, an alternative therapy was required for the management of these vulnerable patients.

A transcatheter aortic valve is a bioprosthetic valve designed to be compressed into a small diameter catheter to displace and functionally replace the diseased native valve. Since its advent in 2002 in France, transcatheter aortic valve replacement (TAVR) has revolutionized the management of AS and become an accepted, less-invasive alternative for certain patients with an intermediate to high surgical risk AS (16,17). As a result, the number of TAVR procedures have increased exponentially in the U.S., from less than 5,000 in 2012 to nearly 50,000 in 2015 (18). Given the complexity of the novel procedure in the early years, the average length of stay (LOS) for TAVR hospitalization was 6 days in most landmark trials and registries (17,19-23). As the
technology evolved—from 24 French sheaths, general anesthesia, transesophageal echocardiography to a minimalist approach (24-26)—there has been an effort to reduce intensive care and total hospitalization LOS (27), both to reduce nosocomial complications and reduce costs (28). However, there is a reasonable concern that premature discharge before medical stability may result in an increased risk of readmission (15), which has potential clinical implications (16) in addition to being an important quality metric in the era of bundled fixed payment system (17,18).

Although small studies and recent meta-analysis demonstrated the safety of the early discharge strategy (29-33), data from a nationally representative cohort are still needed. Thus, our specific aims in this study were to use the Nationwide Readmissions Database (NRD) to:

Specific Aim 1: Examine the rate of readmission after uncomplicated TAVR in early vs late discharges.

Specific Aim 2: Explore the variability in early discharge across U.S. hospitals.

Specific Aim 3: Examine factors associated with failure of early discharge.

We hypothesize that early discharge will be associated with similar rate of readmission compared to late discharge, that there is homogeneity in the early discharge rate across different sites and that we would identify readmission risk factors which could be important to the TAVR team to reduce the burden of rehospitalization in the early discharge cohort.
CHAPTER 2

METHODS

Data Source

We used the NRD databases, which is one of several databases of all-payer hospital inpatient stays sponsored by the Agency for Healthcare Research and Quality as part of the Healthcare Cost and Utilization Project. The NRD was constructed from the State Inpatient Databases that contain reliable, verified patient linkage numbers that can be used to study multiple hospital visits for the same patient across hospitals within a State, while adhering to the Health Insurance Portability and Accountability Act strict privacy guidelines. The NRD includes data from 22 states that are geographically dispersed. The database includes all discharge records of patients treated in the US community hospitals excluding rehabilitation and long-term acute care facilities. In the unweighted sample, the NRD represents ~ 50 % of the US population and ~ 50 % of all US hospitalization. For the purpose of this study, we used NRD years 2014, and from January to September 2015 (the NRD started utilizing ICD-10 codes starting October 2015). This study was deemed exempt by the Saint Luke’s Hospital of Kansas City, MO’s Institutional Review Board as the NRD is a publicly available database that contains deidentified patient information.

Study Population

The NRD provides the list of diagnoses and procedures for each hospitalization record coded using the standard International Classification of Diseases-9th Edition-Clinical Modification (ICD-9-CM). We included hospitalizations for patients ≥18 years old with a primary procedure code of transfemoral TAVR (ICD-9-CM Procedure Code 35.05) between January 1, 2014 and September 30, 2015. We sought to identify uncomplicated TAVR
hospitalizations and therefore excluded hospitalizations where there was: 1) in-hospital death; 2) any complications (e.g. complete heart block (CHB), need for other cardiac procedure, major bleeding, acute kidney injury, myocardial infarction, sepsis); 3) LOS > 5 days (as these hospitalizations may have had a complication not identified by the ICD-9-CM codes); 4) discharge in December 2014 or September 2015 because of unavailability of 30-day follow-up data on these cases. Figure 1 shows the flowchart of the study. The Healthcare Cost and Utilization Project Clinical Classification Software (CCS) and International Classification of Diseases, Ninth Edition, Clinical Modification codes used to define these variables are listed in Supplemental Table 1. Based on the hospital LOS, patients were categorized into early discharge group (discharge < 3 days) or delayed discharge group (discharge ≥ 3 days).

Figure 1: Flow Chart of the Study Population
Definition of Outcomes

The primary outcome was 30-day all-cause unplanned readmission. If a patient had >1 readmission within 30 days of discharge, only the first readmission was included. The primary cause of readmission was identified based on the ICD-9 codes (Supplemental Table 2). The secondary outcomes were median hospital charges for the index hospitalization and median hospitalization LOS and hospital charges for the total 30-day episode of care (combined index admission and readmission).

Statistical Analysis

Among hospitals with annual TAVR volume ≥30, we first examined variability in the rates of early discharge. We constructed a multivariable hierarchical regression model, with hospital included as a random effect and adjusting for patient demographic and clinical factors. Site-level variability in early discharge, independent of patient factors, was quantified with a median odds ratio, which estimates the difference in odds of early discharge if a patient with identical characteristics was treated in one random hospital compared with another.

In order to compare the rehospitalization rates between those with early versus delayed discharge, we used propensity score matching to account for the non-randomized nature of our exposure variable. We estimated the propensity for early discharge using non-parsimoneous multivariable logistic regression conditioned on multiple patient and site characteristics (Table 1). A 1:1 matching algorithm was used with a caliper width of 0.2 times the standard deviation of the logit of the propensity score(35). To assess acceptable covariate balance, characteristics of patients discharged early versus late were compared using standardized differences (>10% difference is considered clinically relevant(36) before and after matching. Time-to-readmission over 30 days after discharge was compared between groups using Kaplan-Meier curves and the
log-rank test. Median index hospitalization charges and median hospitalization LOS and hospital charges for the total 30-day episode of care were compared between groups using Wilcoxon rank-sum test.

Finally, we explored whether particular patient factors were associated with readmission differently according to discharge strategy (i.e., patients who may benefit from a longer length of stay). We constructed a hierarchical logistic regression model with multiple patient and hospital covariates and tested the interactions between discharge strategy and these factors. Factors included in the model were selected a priori based on clinical judgment and previous research(25,37) and included age, sex, atrial fibrillation, anemia, chronic lung disease, chronic kidney disease (CKD), home discharge, large bedsize hospital(38) and number of chronic conditions(39). Site was included as a random effect to account for clustering of patients within hospitals. Data were complete for all variables. Statistical analyses were conducted using SAS software version 9.4 (SAS Institute, Inc, Cary, NC), and 2-sided value of P<0.05 was set for statistical significance.
CHAPTER 3

RESULTS

Analytic Cohort

Of 18,535 index TAVR hospitalizations in the NRD database years 2014-2015; 4,995 were for uncomplicated transfemoral TAVR (Figure 1). The mean age was 81.3 ± 8.0 years, and 43.4% were women. Of these 4,995 uncomplicated TAVR hospitalizations, 1,857 (37.2%) were discharged early. Compared with the delayed discharge cohort, patients in the early discharge cohort were more likely to be men, lower prevalence of peripheral vascular disease, chronic pulmonary disease, chronic renal failure, coagulopathy, anemia, fluid and electrolyte disorders, and were more likely to be discharged home (Table 1).

Variability in early discharge strategy. Among hospitals with annual TAVR volume >30, the rate of early discharge varied widely, with a range from 0% to 87% (median 36.5%, interquartile range 18.2%-63.2%, Figure 2). After adjusting for differences in patient characteristics, the median odds ratio for early hospital discharge after TAVR across hospitals was 3.69 (95% confidence interval 3.17-4.22) suggesting that the odds of early hospital discharge after TAVR was 3.7 folds higher at 1 randomly selected hospital in comparison with a similar patient at another randomly selected hospital. There was no relation between the rate of early discharge and the institutional TAVR volume (R2 =0.014, p=0.43; Figure 3).

Readmission after early versus delayed discharge. After propensity score matching, our cohort consisted of 1673 matched pairs who were similar in terms of demographic and clinical characteristics, with all standardized differences <10% (Table 1). There was similar incidence of 30-day readmissions among patients discharged early versus delayed (KM-estimated rates: 10.3% vs 10.6%, stratified log rank p=0.55; Figure 4).
Figure 2: Variation in rates of early discharge among hospitals with annual TAVR volume >30.

Figure 3: Relationship between early discharge rate and institutional TAVR volume.
<table>
<thead>
<tr>
<th>Table 1. Baseline Characteristics and In-Hospital Outcomes of Patients with Early Versus Late Discharge Following Transcatheter Aortic Valve Replacement</th>
</tr>
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<tbody>
<tr>
<td><strong>Before matching</strong></td>
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<tr>
<td><strong>Early discharge (n= 1857)</strong></td>
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<tr>
<td>**Age, years **</td>
</tr>
<tr>
<td>**Women, **</td>
</tr>
<tr>
<td><strong>Comorbidities</strong>,</td>
</tr>
<tr>
<td><strong>Number of chronic conditions</strong></td>
</tr>
<tr>
<td><strong>Diabetes</strong></td>
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<tr>
<td><strong>Hypertension</strong></td>
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<td><strong>Smoking</strong></td>
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<tr>
<td><strong>Dyslipidemia</strong></td>
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<tr>
<td><strong>CAD</strong></td>
</tr>
<tr>
<td><strong>Prior myocardial infarction</strong></td>
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<tr>
<td><strong>Prior PCI</strong></td>
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<tr>
<td><strong>Atrial fibrillation</strong></td>
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<tr>
<td><strong>Prior pacemaker</strong></td>
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<tr>
<td><strong>Prior TIA/Stroke</strong></td>
</tr>
<tr>
<td><strong>Deficiency anemia</strong></td>
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<tr>
<td><strong>Chronic pulmonary disease</strong></td>
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<tr>
<td><strong>Coagulopathy</strong></td>
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<tr>
<td><strong>Chronic renal disease</strong></td>
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<tr>
<td><strong>Obesity</strong></td>
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<tr>
<td><strong>Hypothyroidism</strong></td>
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<tr>
<td><strong>Peripheral vascular disease</strong></td>
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<tr>
<td><strong>Median household income</strong></td>
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<tr>
<td><strong>0-25th percentile</strong></td>
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<tr>
<td><strong>26-50th percentile</strong></td>
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<tr>
<td><strong>51-75th percentile</strong></td>
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<tr>
<td><strong>76-100th percentile</strong></td>
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<tr>
<td><strong>Length of stay, days</strong></td>
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<tr>
<td><strong>Mean</strong></td>
</tr>
<tr>
<td><strong>Median</strong></td>
</tr>
<tr>
<td><strong>Disposition of patient</strong></td>
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<tr>
<td><strong>Home (self-care)</strong></td>
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<tr>
<td><strong>Short-term hospital</strong></td>
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<tr>
<td><strong>Skilled nursing facility</strong></td>
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<tr>
<td><strong>Home health care</strong></td>
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<tr>
<td><strong>Hospital characteristics</strong></td>
</tr>
<tr>
<td><strong>Bedsize</strong></td>
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</table>
Early discharge strategy had a significantly lower median hospital charges of the index hospitalization ($148,964 [IQR $115,306-$225,435] versus 160,665 [IQR $124,243-$227,415], p=<0.001). For the total episode of care (i.e., combined index admission and 30-day readmission), patients in the early discharge group had shorter median LOS in the hospital (2 [IQR 2-2] vs 4 [IQR 3-4], p=<0.001) and lower median hospital charges ($155,332 [IQR $117,286-$232,829] versus $166,303 [IQR $125,425-$233,074], p=0.001). The most frequent reasons for readmission after early discharge were cardiac (40%), infection (13%), and TIA/Stroke (8%; Figure 5).

Factors associated with failure of early discharge. In the hierarchical logistic model, we found that the majority of patient and hospital factors were associated with readmission similarly in patients with early versus delayed discharge. We identified one significant interaction between discharge strategy and number of chronic conditions (p for interaction=0.007). To further examine this interaction, we categorized number of chronic conditions (0-4, 5-10, >10) and compared readmission rates by discharge strategy. Among 561 patients with 0-4 chronic conditions, readmission rates were significantly lower in patients who were discharged early vs late (4.3% vs 10.9%; P=0.04; Figure 6), whereas there were no differences in the readmission

<table>
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<th>Large</th>
<th>Medium</th>
<th>Small</th>
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<tr>
<td></td>
<td>1504 (81.0)</td>
<td>247 (13.3)</td>
<td>106 (5.7)</td>
</tr>
<tr>
<td>Teaching status</td>
<td></td>
<td></td>
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<tr>
<td>Metro teaching</td>
<td>1669 (89.9)</td>
<td>2774 (89.5)</td>
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</tr>
<tr>
<td>Metro non-teaching</td>
<td>186 (10.0)</td>
<td>304 (9.8)</td>
<td></td>
</tr>
<tr>
<td>Non-teaching</td>
<td>80 (4.3)</td>
<td>20 (0.6)</td>
<td></td>
</tr>
<tr>
<td>Ownership of the hospital</td>
<td></td>
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<tr>
<td>Governmental</td>
<td>148 (8.0)</td>
<td>367 (11.8)</td>
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</tr>
<tr>
<td>Private non-profit</td>
<td>1629 (87.7)</td>
<td>2546 (82.2)</td>
<td></td>
</tr>
<tr>
<td>Private invest-own</td>
<td>80 (4.3)</td>
<td>185 (6.0)</td>
<td></td>
</tr>
</tbody>
</table>

Data are presented as mean ± SD, median (IQR), and n (%)
*Variables which were entered in the propensity matched analysis.
rates between early vs late discharge strategy among patients with 5-10 (n=3063) or >10 (n=1331) chronic conditions (p=0.66 and 0.83, respectively).

Figure 4: Kaplan-Meier curves of 30-day hospital readmission for early versus late discharge cohorts.

Figure 5: Causes of 30-day readmissions in the early discharge cohort.
Figure 6: Bar chart showing the difference in the rate of 30-days readmission between early vs late discharge according to the number of chronic conditions.
CHAPTER 4
DISCUSSION

Multiple factors have contributed to pressure to reduce LOS after TAVR, including a high initial hospitalization cost. However, given the advanced age and comorbidities of the patients undergoing TAVR, there has been legitimate concern that early discharge might lead to increased risk of readmission. We found in a large unselected US cohort of patients undergoing uncomplicated TAVR (1) there were similar 30-day readmission rates after early versus delayed discharge; and, despite this apparent safety signal, (2) there is substantial site level variability in the practice of early discharge following TAVR among U.S. hospitals. Furthermore, we were unable to identify any patient factors that were associated with increased risk of readmission with early versus late discharge, meaning that, at least in uncomplicated cases, no patients appear to benefit from longer inpatient monitoring. Further efforts to improve standardization across hospitals and shared institutional knowledge of best practices may therefore improve patient outcomes and costs.

Our findings are consistent with several small studies that found no increased risk of 30 days readmission after TAVR between early and late discharge strategies (29-32), extending these prior results to a large, unselected population. Furthermore, our study is the first report that we are aware of to show substantial variability among US centers in the rate of early discharge after uncomplicated TAVR hospitalizations. Although hospital procedure volume was associated with early discharge in a prior study (27), we did not find this association to be significant.

Studies of other cardiac procedures have suggested that geographical location and certain hospital discharge policies can affect rate of early discharge (25,40). With a novel treatment where the technology of the procedure and care of the patient have changed substantially in the
past decade, it is not surprising that there has been differential uptake of a policy of early discharge after uncomplicated TAVR.

While the majority of patients appear to do well after early discharge, we attempted to identify factors associated with differential risk of readmission by discharge strategy in this cohort so as to potentially characterize patients who may benefit from longer inpatient monitoring. However, the only significant interaction we identified between early discharge and number of chronic conditions showed that patients with fewer comorbidities benefited even more from early discharge with no difference in readmissions rates among those with more comorbidities. While there may be some patients with a combination of factors who may benefit from longer inpatient monitoring, our results are reassuring that early discharge should be the goal in uncomplicated TAVR in the vast majority of patients. One potentially important consideration with early discharge after TAVR is post-discharge complete heart block,(41) which is an area of active study. Notably, rehospitalization for complete heart block was infrequent in our study, with heart failure being the most common cardiac reason for unplanned readmission. More investigation to identify patients who may benefit from longer in-hospital or outpatient rhythm monitoring after TAVR may be helpful to further improve outcomes.

Our results have several important implications. Efficient resource allocation for TAVR is critical in the current era of increasing health care expenditures and the adoption of bundled-care initiatives. Our study provides reassuring results that an early discharge strategy after uncomplicated TAVR is not associated with increased risk of 30-days readmission. Furthermore, our results showed marked, unexplained variation in the rate of early discharge after TAVR among U.S. hospitals, with a median odds ratio of 3.7. These data highlight the need for comparative effectiveness research to identify and reduce the factors contributing to this
unwarranted variation. Lastly, we found that higher number of chronic conditions is associated with high 30-days readmission after early TAVR discharge. This knowledge should promote appropriate follow up care to reduce the readmission rate for patients with higher number of comorbidities.

Our study should be interpreted in the context of several limitations. First, the NRD is an administrative dataset which lacks the ability to capture certain granular patient-level data, such as valve type and size, echocardiographic variables, and medication use. This potentially limited our propensity matching and the identification of factors associated with failure of early discharge. Second, mortality post-discharge is not available in NRD. While we cannot fully assess safety of early discharge without mortality, several studies have shown early discharge after TAVR is not associated with increased 30-days mortality (25,33). Finally, we excluded patients with LOS longer than 5 days, given concern that these hospitalizations had complications that were not captured in ICD-9 codes. However, it is likely that these hospitalizations are non-informative to the general cohort of uncomplicated TAVR admissions.
CHAPTER 5

CONCLUSION

In conclusion, in a large cohort of real-world patients, early discharge after uncomplicated TAVR was not associated with a higher rate of 30-day rehospitalization, yet there is significant variability in rates of early TAVR discharge across US hospitals. Novel strategies should be explored to safely increase the rate of early discharge after uncomplicated TAVR to improve patient outcomes.
Supplemental Table 1: The International Classification of Diseases, Ninth Edition, Clinical Modification (ICD-9 CM) codes used to identify relevant baseline comorbidities and complications

<table>
<thead>
<tr>
<th>Variable</th>
<th>ICD-9 code</th>
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<td><strong>Comorbidities</strong></td>
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<td>Smoking</td>
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<td>Known CAD</td>
<td>414.00-07</td>
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<tr>
<td>Prior stroke/TIA</td>
<td>V12.54</td>
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<td>Prior MI</td>
<td>412</td>
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<tr>
<td>Prior PCI</td>
<td>V45.82</td>
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<td>Prior CABG</td>
<td>V45.81</td>
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<td>Atrial fibrillation</td>
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<tr>
<td>Prior PPM</td>
<td>V45.01</td>
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<tr>
<td>Prior ICD</td>
<td>V45.02</td>
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<tr>
<td><strong>In-Hospital procedures and complications</strong></td>
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<tr>
<td>Surgical AVR</td>
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<td>PCI</td>
<td>00.66, 36.01, 36.02, 36.05, 36.06, 36.07</td>
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<tr>
<td>Complete heart block</td>
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<td>PPM placement</td>
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<td>AMI</td>
<td>410.x1, 411.1</td>
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<td>Cardiogenic shock</td>
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<tr>
<td>Cardiac arrest</td>
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<tr>
<td>AKI</td>
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<tr>
<td>Major bleeding</td>
<td>430, 431, 432.x, 336, 362.43, 362.81, 363.61, 363.62, 363.72, 364.41, 3736.32, 377.42, 379.23; 423.0 + 37.0; 923.x + 729.71, 924.x + 729.72, 922.2-9 + 729.73; 456.0, 456.20, 530.7, 530.82, 531.00, 531.01, 531.20, 531.21, 531.40, 531.41, 531.60, 531.61, 532.00, 532.01, 532.20, 532.21, 532.40, 532.41, 532.60, 532.61, 533.00, 533.01, 533.20, 533.21, 533.40, 533.41, 533.60, 533.61, 534.00, 534.01, 534.20, 534.21, 534.40, 534.41, 534.60, 534.61, 569.3, 578.0, 578.1, 578.9, 568.81, 599.70, 599.71, 719.1x, 784.7, 784.8, 459, 998.11, 998.12, 285.1 + 998.00, 998.09, 785.50, 785.59, 276.52 + 00.17 + 99.0x</td>
</tr>
<tr>
<td>Vascular complications</td>
<td>900-904, 998.2, 999.2, 997.7, 447.0, 868.04</td>
</tr>
</tbody>
</table>
Hypertension, diabetes mellitus, obesity, heart failure, peripheral vascular disease, anemia, chronic kidney disease, chronic lung disease, liver disease, coagulopathy, depression, hypothyroidism, fluid and electrolyte disorders, other neurological disorders, pulmonary circulation disorders, and cancer were identified from the 29 Elixhauser comorbidities included in the Nationwide Readmissions Database.

CAD = coronary artery disease, MI = myocardial infarction, PCI = percutaneous coronary intervention, CABG = coronary artery bypass grafting, TIA = transient ischemic attack, PPM = permanent pacemaker, ICD = implantable cardioverter defibrillator, AVR = aortic valve replacement, AKI = acute kidney injury
**Supplemental Table 2.** Causes of 30-Day Readmissions in the Early Discharge Cohort Categorized According to International Classification of Diseases, Ninth Edition, Clinical Modification (ICD-9-CM) Codes and/or Clinical Classifications Software (CCS) in the Primary Diagnosis Position*

<table>
<thead>
<tr>
<th>Causes of Readmission</th>
<th>CCS code(s)</th>
<th>ICD-9-CM code(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NON-CARDIAC</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respiratory</td>
<td>122, 124, 125, 127, 128, 129, 130, 131, 133, 134</td>
<td>415.19, 997.3x</td>
</tr>
<tr>
<td>Infections</td>
<td>2, 4, 135, 159, 197, 246</td>
<td>519.01, 780.62, 996.6x, 998.5x</td>
</tr>
<tr>
<td>Bleeding</td>
<td>60, 153</td>
<td>280.0, 537.83, 569.85–86, 599.7x, 998.1x</td>
</tr>
<tr>
<td>Peripheral vascular disease</td>
<td>114, 115, 116, 118, 248</td>
<td>415.11, 443.89, 997.2, 997.79</td>
</tr>
<tr>
<td>Renal</td>
<td>156, 157, 158, 160, 161, 163, 165, 166</td>
<td>403.91, 458.21, 997.5, 996.73, 996.76</td>
</tr>
<tr>
<td>Gastrointestinal</td>
<td>138, 140, 141, 143, 145, 146, 147, 149, 151, 152, 154, 155, 250, 251</td>
<td>996.82, 997.49</td>
</tr>
<tr>
<td>TIA/stroke</td>
<td>109, 112</td>
<td>—</td>
</tr>
<tr>
<td>Trauma</td>
<td>226, 229, 230, 231, 233, 235, 239, 242, 244</td>
<td>997.99, 998.32, 998.83</td>
</tr>
<tr>
<td>Hematological/neoplasms</td>
<td>59, 14, 32, 42, 44</td>
<td>790.92</td>
</tr>
<tr>
<td>Others</td>
<td>199, 204, 209, 211, 252, 253, 254, 257</td>
<td>—</td>
</tr>
<tr>
<td><strong>CARDIAC</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heart failure</td>
<td>108</td>
<td>402.91, 404.11, 404.91, 404.93, 429.4, 997.1</td>
</tr>
<tr>
<td>Dysrhythmias</td>
<td>106, 107</td>
<td>—</td>
</tr>
<tr>
<td>Complete heart block</td>
<td>105</td>
<td>426.0</td>
</tr>
<tr>
<td>Valve disorders</td>
<td>96</td>
<td>421.x, 996.02, 996.71, 996.72,</td>
</tr>
<tr>
<td>Causes of Readmission</td>
<td>CCS code(s)</td>
<td>ICD-9-CM code(s)</td>
</tr>
<tr>
<td>-----------------------</td>
<td>-------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Hypertension</td>
<td>98, 99</td>
<td>401.x</td>
</tr>
<tr>
<td>CAD</td>
<td>101, 104</td>
<td>—</td>
</tr>
<tr>
<td>AMI</td>
<td>100</td>
<td>—</td>
</tr>
<tr>
<td>Others</td>
<td>102, 245</td>
<td>416.8</td>
</tr>
</tbody>
</table>

*CCS and ICD-9-CM codes listed are NOT all inclusive for each category, but represent the primary diagnosis codes present in the discharge record of TAVR patients who experienced 30-day readmission in this study.

TIA = transient ischemic attack, CAD = coronary artery disease, AMI = acute myocardial infarction
SAS and SPSS program syntax delineating code for analysis

# Obtaining the study cohort from NRD 2014 database (SAS):

OPTIONS USER="/folders/myfolders/"
%let Path_="/folders/myfolders/";
libname sasdata "/folders/myfolders/";
libname nrd "/folders/myfolders/" access=readonly;
%let Obs_ = Max;
/* Format index and readmission event outcomes */
onlines FormChar='|----|+----|=|#/\<>*'
ods noptitle;
proc format;
value indexEvent
0 = '0: No TAVR index'
1 = '1: TAVR index'
value readmit
0 = '0: No TAVR readmit'
1 = '1: TAVR readmit'
run;
/* Identify TAVR index events */
Title "1 : Index Admissions"
data nrd_2014_indexEvents
ReadmCandidates ( drop=DISCWT LOS NRD_STRATUM IndexEvent )
set nrd.nrd_2014 ( obs= &obs_ 
keep= HOSP_NRD KEY_NRD DX1 DISCWT NRD_STRATUM
AGE DMONTH DIED LOS NRD_VISITLINK
NRD_DAYSTOEVENT DXCCS1 PR: PRCCS: )
attrib IndexEvent length=3 label='TAVR index event'
array Procedures $8 pr1-pr15;
IndexEvent = 0;
do i = 1 to 15;
   if Procedures in ("3505")
   IndexEvent = 1;
run;
and AGE ge 18
and 1 le DMONTH le 11
and DIED eq 0 then IndexEvent = 1;
end;
drop DX1 AGE DMONTH DIED;
* Retain index events only ;
if IndexEvent = 1 then output nrd_2014_indexEvents;
output ReadmCandidates ;
run;

Title "2 : 30-day All-Cause Readmission Events" ;
/* Select all readmissions within 30 days */
proc sql ;
create table readmissionsAll as
select i.HOSP_NRD as HOSP_NRD_Index
, i.KEY_NRD as KEY_NRD_Index
, r.*
from nrd_2014_indexEvents i /* Index Events */
inner join ReadmCandidates r /* Readmissions */
on i.NRD_VISITLINK = r.NRD_VISITLINK /* Link patients */
and i.KEY_NRD ne r.KEY_NRD /* Not a self join */
and r.NRD_DAYSTOEVENT - ( i.NRD_DAYSTOEVENT + i.LOS )
between 0 and 30
and i.indexEvent = 1
order by i.HOSP_NRD, i.KEY_NRD, r.NRD_DAYSTOEVENT; /* Sort by date */
quit ;
/* Identify closest readmission if there are multiple readmission events */
data readmissionsClosest;
set readmissionsAll ( rename=(HOSP_NRD=HOSP_NRD_Readmit
HOSP_NRD_Index=HOSP_NRD
KEY_NRD = KEY_NRD_Readmit

23
KEY_NRD_Index=KEY_NRD));
by HOSP_NRD KEY_NRD;
if first.KEY_NRD;
run;

/*/ Merge readmissions and index events */
data readmissions_sql;
merge nrd_2014_indexEvents ( drop=DXCCS1 PR: PRCCS:)
readmissionsClosest ( in=inR
rename=( NRD_DAYSTOEVENT=DaysToReadmission )
drop=NRD_VisitLink ) ;
by HOSP_NRD KEY_NRD;
attrib Readmit length = 3 label='Readmission within 30 days (0/1)';
Readmit = inR;
label DaysToReadmission = 'Readmission date';
run ;

Table 1 Data (SPSS)

Parametric Tests

CROSSTABS
/TABLES=Disch_Status BY NE_readmit30 FEMALE AGE HOSP_BEDSIZE H_CONTRL
HOSP_UR_TEACH NCHRONIC DISPUNIFORM PAY1 PL_NCHS ZIPINC_QRTL CM_CHF
CM_CHRN Lung CM_COAG CM_DM CM_DMCX CM_HTN_C CM_OBESE
CM_PERIVASC CM_RENFLAIL HOSP_BEDSIZE H_CONTRL Afib
HX_SMOKING Old_MI Hx_TIA DLD prior_PCI Prior_PM CAD
/FORMAT=AVALUE TABLES
/STATISTICS=CHISQ
/CELLS=COUNT
/COUNT ROUND CELL.
Propensity Matching Analysis (SPSS + R)

DATASET ACTIVATE DataSet1.

PSMATCHING3

/VARS

   TREAT = Early_Discharge
   COVS = AGE FEMALE NCHRONIC DISPUNIFORM PAY1 PL_NCHS ZIPINC_QRTL CM_CHF CM_CHRNLng CM_COAG
   CM_DM CM_DMCX CM_HTN_C CM_OBESE CM_PERIVASC CM_RENLFAIL HOSP_BEDSIZE H_CONTRL HOSP_UR_TEACH Afib
   HX_SMOKING Old_MI Hx_TIA DLD prior_PCI Prior_PM CAD

/MATCHIT

   MATCH=NEAREST
   EST =LOGIT
   DISCARD = NONE
   MORDER = LARGEST
   RATIO = 1
   CALIPER = .2

/PLOT HISTPLOT HISTBAL DOTPLOT RESOLUTION = 96

/OUTPUT PAIRED MATCHED_CASES_ONLY.

Calculation of Median Odds Ratio (SAS)

RANDOM INTERCEPT/SUBJECT=HOSP_NRD;
estimate 'Elective Admission' elective 1/exp cl;
estimate 'Age +10' age 10/exp cl;
estimate 'Female' female 1/exp cl;
estimate 'Home DC' home 1/exp cl;
estimate 'CM Anemia' cm_anemdef 1/exp cl;
estimate 'CM CHF' cm_chf 1/exp cl;
estimate 'CM Chrn Lung Dz' cm_chrnlng 1/exp cl;
estimate 'CM Coag' cm_coag 1/exp cl;
estimate 'CM DM' cm_dm 1/exp cl;
estimate 'CM HTN' cm_htn_c 1/exp cl;
estimate 'CM Hypothy' cm_hypothy 1/exp cl;
estimate 'CM Liver' cm_liver 1/exp cl;
estimate 'CM Lymph' cm_lymph 1/exp cl;
estimate 'CM Lytes' cm_lytes 1/exp cl;
estimate 'CM Neuro' cm_neuro 1/exp cl;
estimate 'CM Obese' cm_obese 1/exp cl;
estimate 'CM Para' cm_para 1/exp cl;
estimate 'CM Perivasce' cm_perivasce 1/exp cl;
estimate 'CM Pulm Circ' cm_pulmcirc 1/exp cl;
estimate 'CM Renal Fail' cm_renlfail 1/exp cl;
estimate 'CM Ulcer' cm_ulcer 1/exp cl;
estimate 'CM Valve' cm_valve 1/exp cl;
estimate 'CM Wght Loss' cm_wghtloss 1/exp cl;
estimate 'Smoking' smoking 1/exp cl;
estimate 'Dyslip' dyslip 1/exp cl;
estimate 'CAD' cad 1/exp cl;
estimate 'Prior MI' prior_mi 1/exp cl;
estimate 'Prior PCI' prior_pci 1/exp cl;
estimate 'Prior Cabg' prior_cabg 1/exp cl;
estimate 'TIA/STK' tia_stk 1/exp cl;
estimate 'Afib/Flutter' afib_flutter 1/exp cl;
estimate 'Prior PPM' prior_ppm 1/exp cl;
estimate 'Prior ICD' prior_icd 1/exp cl;
estimate 'Carotid Dz' carotid_disease 1/exp cl;

ods output estimates=est;
QUIT;
data est;
set est;
combo=compress(round(ExpEstimate,.01)!!'('!!round(ExpLower,.01)!!','!!round(expupper,.01)!!')');
label combo='Adjusted Odds Ratios, 95% CI predicting Early DC';
run;
ods rtf file="&output/Predictors of Early DC &sysdate..rtf";
proc print data=est label;
var label combo probt;
run;
ods rtf close;
data new;
label='Median Odds Ratio';
variance=1.87;
stderr=.2069;
lower = variance-1.96*StdErr;
upper = variance+1.96*StdErr;
mu=exp(sqrt(2*variance)*probit(.75));
lowermu=exp(((2* lower)**0.5)*probit(0.75));
uppermu=exp(((2* upper)**0.5)*probit(0.75));
run;
proc print data=new;
run;

**Logistic regression analysis for 30 days readmission (SPSS)**

(Main effect + interaction between Early discharge and number of chronic conditions)

DATASET ACTIVATE DataSet2.
LOGISTIC REGRESSION VARIABLES NE_readmit30

/METHOD=ENTER AGE FEMALE NCHRONIC Afib Home_Discharge Large_Bedsize CM_ANEMDEF CM_CHRNLUNG

CM_RENLFAIL Early_Discharge Early_Discharge*NCHRONIC

/CONTRAST (FEMALE)=Indicator(1)

/CONTRAST (Afib)=Indicator(1)

/CONTRAST (Home_Discharge)=Indicator(1)

/CONTRAST (Large_Bedsize)=Indicator(1)

/CONTRAST (CM_ANEMDEF)=Indicator(1)

/CONTRAST (CM_CHRNLUNG)=Indicator(1)

/CONTRAST (CM_RENLFAIL)=Indicator(1)

/CONTRAST (Early_Discharge)=Indicator(1)

/PRINT=GOODFIT

/CRITERIA=PIN(0.05) POUT(0.10) ITERATE(20) CUT(0.5).
REFERENCE LIST

31. Sud M, Qui F, Austin PC et al. Short Length of Stay After Elective Transfemoral Transcatheter Aortic Valve Replacement is Not Associated With Increased Early or Late Readmission Risk. J Am Heart Assoc 2017;6.


VITA

Mohamed Omer was born on January 1st, 1982 in Assiut, EGYPT and lived there with his parents and siblings until graduating from El Mosher Ahmed Ismail secondary school in 1998. He attended Assiut University medical school from 1998 to 2004 and obtained A Bachelor of Medicine and Surgery (MBBCh) in 2005. After finishing internship in 2006, he began Cardiovascular fellowship at Assiut University Hospitals in Assiut, Egypt. During his fellowship years, Mohamed finished the United States Medical Licensing Examinations. He then relocated to the United States in 2011.

He began internal medicine residency at University of Missouri – Kansas City in 2013 and completed his residency in 2016. Following completion of his internal medicine residency, Mohamed began his Cardiovascular fellowship at Saint Luke’s Mid America Heart Institute and the University of Missouri-Kansas City. During his fellowship, he elected to pursue a Master of Science through the Bioinformatics Program at the University of Missouri-Kansas City.

Upon completion of his research fellowship and his degree requirements, Dr. Omer will begin his interventional cardiology fellowship at Minneapolis Heart Institute in Minneapolis, MN. Following this fellowship, Dr. Omer plans to pursue additional training in complex coronary intervention and structural cardiology as well as to engage in cardiovascular research.

Dr. Omer is a member of the American College of Cardiology, the American Heart Association, the American Medical Association, and is certified by the American Board of Internal Medicine, American Board of Echocardiography and American Board of Nuclear Cardiology.