SUPPLEMENTAL MATERIAL
Supplemental Methods

Data S1. Validation of Optum physician report of aortic stenosis

To validate Optum physician’s report of aortic stenosis, we leveraged the following approach:

- Among 26,438 patients with symptomatic severe aortic stenosis (ssAS) in the final cohort, we pulled the closest echocardiography readings to severe aortic stenosis (sAS) diagnosis identified by physicians’ notes
  - Echocardiography readings included aortic valve area (AVA), velocity, mean gradient, and left ventricular ejection fraction (LVEF)
  - The closest echocardiography readings in the seven days before sAS diagnosis from physicians’ notes were pulled. The LVEF is included only if it is on the same day of AVA/velocity/mean gradient. The completeness of echocardiography readings is shown in Table S1

- We restricted patients to those with each of three (AVA, velocity, and mean gradient) available measurements and to those who with four (AVA, velocity, mean gradient and LVEF) measurements available. We then compared the difference in sAS diagnoses using physician’s notes to the severity using AS definitions from the 3 or 4 echocardiography parameters. The differences are listed as below.
  o American Heart Association (AHA) guidelines were applied here to define the severity of AS by using AVA, velocity, or mean gradient
  o Echocardiography readings were categorized as mild, moderate or severe based on the 3, or 4, echocardiography parameters and agreement with patients identified as having severe AS with physicians’ notes are compared (see Table S2)

- The severity of AS by echocardiography readings stratified by LVEF level is shown in Table S3.

- The severity of AS by echocardiography readings stratified by left ventricular outflow tract velocity time integral (LVOT VTI) level is shown in Table S4.
Data S2. Sensitivity analysis of the core analysis focusing only on outpatient managing cardiologists

Similar trends were observed when restricting to patients with managing cardiologist classification based on outpatient visits only (n=23,013). In the subset of patients treated by these cardiologists, 36.1% of ssAS patients underwent AVR (13.8% TAVR, 22.3% SAVR). Rates of AVR within a year of diagnosis varied substantially by cardiologist, from 0% in the lowest quartile of treatment rates to 100% in the highest (median 30.0%, 25th–75th 16.7–47.4%). Among outpatient cardiologists, the association between the managing cardiologist and the odds of an alternative treatment strategy was similar to that observed in the overall cohort (adjusted MOR 2.21, 95% CI 2.10–2.33).
Data S3. Sensitivity analysis by using a claims-linked cohort.

1. To internally validate our results, we repeated the core analyses in Optum’s claims-linked patient set. The integrated patient set includes a substantially smaller subset of patients within the EHR who can also be linked to insurance claims via a distinct patient ID. Linkage to insurance claims allows for assessing to lower rates of missing data. After applying our inclusion and exclusion criteria to this cohort, a subset of 926 patients managed by 172 cardiologists were identified.

2. There are 33.4% of ssAS patients (n = 301) undergoing AVR in the first year after diagnosis. The median time between date of ssAS diagnosis and AVR was 48 days (25th-75th percentiles: 18-89 days), which stayed consistent compared to major analysis.

3. Rates of AVR within a year of the first ssAS diagnosis varied significantly by cardiologist from 1% in the lowest quartile of AVR rates to 100% in the highest (median 33.3%, 25th-75th percentiles 3.8-50%).

4. Patients had a 135% chance of receiving a different AVR treatment plan if they had seen a random managing cardiologist for AVR (MOR 2.35, 95% CI 1.72-2.94), which was similar to the pattern in the major set.
**Data S4. Subset analysis with lab data available.**

A complete case analysis was performed including only patients with available data for ejection fraction, creatinine, and body mass index to evaluate the potential impact of missing data for these variables on the risk-adjusted results.

1. Full multi-level logistic models for the likelihood of AVR (vs. no AVR) and the likelihood of TAVR (vs. SAVR), expressed a Median Odds Ratios (MOR) were conducted. The models included patient-level and clinician-level factors among patients with available values for ejection fraction, creatinine, and body mass index (Table S8). The clinician was one of the strongest determinants of ssAS. Similar patterns were observed when we restricted patients to those with available values for ejection fraction, creatinine, and body mass index.

2. Median odds ratios (MOR) for general cardiologists for the likelihood of AVR when stratified by region and time is shown below. The results stayed consistent compared to those in the main analysis (see Table S9).

   Similar trends were observed when restricting to patients with managing cardiologist classification based only on outpatient visits among complete sub-data set. The association between the managing cardiologist and the odds of an alternative treatment strategy was similar to that observed in the overall cohort (adjusted MOR 2.10, 95% CI 1.97-2.23).

3. Association between clinician 1-year treatment rate and 1-year all-cause mortality with clinician 1-year treatment rate was modeled as a restricted cubic spline with 4 degrees of freedom (See Figure S2). The hazard presented was adjusted for patient factors and demographics and demonstrates that a higher clinician 1-year treatment rate is associated with a significantly reduced 1-year mortality risk. The distribution of cardiologists by 1-year AVR rate is shown below the curve with each strike representing an individual clinician. The analysis is based on patients with the available values for ejection fraction, creatinine, and body mass index.
Data S5. Clinician 3-month AVR rate and 1-year all-cause mortality to evaluate the impact of immortal time bias.

In order to limit the impact of immortal time bias, we shortened the window from ssAS diagnosis to AVR treatment to 3-months.

1. Association between clinician managing cardiologists’ 3-month AVR treatment rate and 1-year all-cause mortality with clinician 3-month treatment rate was modeled as a restricted cubic spline with 4 degrees of freedom (Figure S3). The hazard presented was adjusted for patient factors and demographics and demonstrates that a higher clinician 3-month treatment rate is associated with a significantly reduced 1-year mortality risk. The distribution of cardiologists by 3-month AVR rate is shown below the curve with each strike representing an individual clinician.

2. Survival stratified by managing cardiologist 3-month treatment rate. Kaplan Meier curves for survival when stratified by managing cardiologist AVR treatment rate within a 3-month period (1 represents the lowest quartile of AVR rates, and 4 the highest) (Figure S4). Patients managed by cardiologists with higher AVR rates have a significantly higher survival at one year.

3. After adjusting for differences in patient characteristics, ssAS patients cared for by cardiologists in the lowest quartile of 3-month AVR rates experienced a higher associated risk of mortality than those treated by managing cardiologists in the highest quartile of 3-month AVR rates (adjusted HR 1.11, 95% CI 1.02–1.21). The results stayed consistent compared to that in the primary cohort.
To evaluate the relative impact of cardiologists with high AVR rates on patient mortality, a sensitivity analysis was conducted by removing patients treated by cardiologists with AVR intervention rates greater than 70%. The resulting median odds ratio (MOR) was 1.99 (95% CI: 1.90-2.08). While this value is somewhat lower compared to the full patient cohort (including patients treated by cardiologists with comprehensive AVR treatment rates) (MOR 2.25, 95% CI: 2.14-2.36), restricting the cohort to cardiologists with AVR rates ≤ 70% did not significantly impact our findings.
Data S7. Details on multiple imputation.

Imputation replaced 9%, 6%, 3%, 3%, 0.2%, and 0.2% of missing data for insurance, smoking, income, education, gender, and age, respectively; this rate of missing data is within previously reported ranges.20 Missing data for variables with more than 10% missing, including left ventricular ejection fraction (LVEF) (31%), creatinine (20%), and body mass index (11%) were coded as “unknown.”
Data S8. Sensitivity analysis: Adding the cardiologist case-load (both ssAS patients and AVR volume) to the main model.

To evaluate the impact of cardiologist case load, we conducted a sensitivity analyses by adding both ssAS patient volume and AVR volume to the main model. The median odds ratio of AVR for this model was 1.677 (95% CI 1.614-1.739), P<0.001, after adjustment for ssAS and AVR volume (tertiles). Although the MOR for AVR was lower compared to the model without case-load (MOR 2.25, 95% CI: 2.14–2.36), the results were still significant. Of note, the OR of AVR for provider ssAS volume (highest tertile vs. lowest tertile) 0.175 (0.147-0.210) P<0.001; OR of AVR for provider AVR volume (highest tertile vs lowest tertile) 27.123 (22.242-33.073) P<0.001.
Table S1. Completeness of echocardiography readings.

| Patients with available specific echocardiography readings | Completeness of data |
|-----------------------------------------------------------|----------------------|
| AVA                                                       | 8,032 (30.4%)        |
| Velocity                                                 | 3,323 (12.6%)        |
| Mean gradient                                            | 8,233 (31.1%)        |
| LVEF                                                      | 9,464 (35.8%)        |
| AVA + Velocity                                           | 1,490 (5.6%)         |
| AVA + Velocity + Mean gradient                           | 1,206 (4.6%)         |
| AVA + Velocity + Mean gradient + LVEF                    | 1,057 (4.0%)         |
Table S2. Echocardiography readings identified as severe AS.

| Classification by echocardiography Tests | Classification as severe by physicians' notes | Classification as severe by echocardiography tests |
|----------------------------------------|-----------------------------------------------|---------------------------------------------|
|                                        | Patients with all available echocardiography readings for AVA, velocity, and mean gradient | Patients with all available echocardiography readings for AVA, velocity, mean gradient, and LVEF |
| Mild AS                                | 17 (1.4%)                                     | 12 (1.1%)                                   |
| Moderate AS                            | 259 (21.5%)                                   | 192 (18.2%)                                 |
| Severe AS                              | 930 (7.1%)                                    | 853 (0.7%)                                  |
Table S3. Severity of AS by echocardiography readings stratified by LVEF.

| Level of LVEF | Mild AS | Moderate AS | Severe AS |
|---------------|---------|-------------|-----------|
| < 30%         | 0 (0.0%)| 19 (1.8%)   | 63 (6.0%) |
| 30% - 49%     | 3 (0.28%)| 26 (2.5%)   | 139 (13.2%)|
| ≥ 50%         | 9 (0.85%)| 147 (13.9%)| 651 (61.6%)|

Patients with all available echocardiography readings for AVA velocity, mean gradient, and LVEF. Data listed as n (% of whole)
Table S4. Severity of AS by echocardiography readings stratified by left ventricular outflow tract velocity time integral (LVOT VTI) level.

| Level of LVOT VTI | Classification by echocardiography Tests |
|-------------------|-----------------------------------------|
|                   | Mild AS | Moderate AS | Severe AS |
| < 18              | 5 (100.0%) | 9 (20.9%) | 61 (26.1%) |
| 18 - 22           | 0 (0.0%) | 11 (25.6%) | 60 (26.5%) |
| > 22              | 0 (0.0%) | 23 (53.5%) | 109 (47.4%) |

Patients with all available echocardiography readings for AVA, velocity, mean gradient, and LVEF. Data listed as n (% of column total).
Table S5. ICD-9-CM and ICD-10-CM procedure and diagnostic codes, and CPT codes.

| Condition                                      | ICD-9-CM          | ICD-10-CM                      | CPT               |
|------------------------------------------------|-------------------|--------------------------------|-------------------|
| Atrial fibrillation                            | 42731             | I480-I484, I489, I4891-I4892   |                   |
| Cancer                                         | 140-172, 174-194, 196-198, 190-1991, 200-208, 1950-1958 | C0-C1, C20-C26, C30-C34, C37-C41, C43, C45-C58, C60-C85, C88, C90-C97 |                   |
| Cardiac conduction disorders                   | 4260, 4261, 42611, 42612, 42613, 4262, 4263, 4264, 42650, 42651, 42652, 42653, 42654, 4266 | I440, I441, I442, I443, I4430, I4439, I450, I451, I4510, I4519, I452, I444, I445, I446, I4460, I4469, I447, I453 |                   |
| COPD                                           | 49, 500, 501, 502, 503, 504, 505 | I278, I279, J684, J701, J703, J40, J41, J42, J43, J44, J45, J46, J47, J60, J61, J62, J63, J64, J65, J66, J67 |                   |
| Dementia                                       | 290               | F051, G311, F00, F01, F02, F03, G30 |                   |
| Diabetes without complications                 | 2500, 2501, 2502, 2503, 2507 | E100, E101, E106, E108, E109, E110, E111, E116, E118, E119, E120, E121, E126, E128, E129, E130, E131, E136, E138, E139, E140, E141, E146, E148, E149 |                   |
| Diabetes with complications                    | 2504, 2505, 2506 | E102, E103, E104, E105, E107, E112, E113, E114, E115, E117, E122, E123, E124, E125, E127, E132, E133, E134, E135, E137, E142, E143, E144, E145, E147 |                   |
| Prior myocardial infarction                    | 410, 412          | I21, I22, I252                  |                   |
| Osteoarthritis (OA)                            | 715               | M15-M19                        |                   |
| Peripheral vascular disease (PVD)              | 4439, 441, 7854, V434 | I731, I738, I739, I771, I790, I792, K551, K558, K559, Z958, Z959, I70, I71 |                   |
| Heart failure (SDS terms)                     | 4282, 42820, 42821, 42822, 42823, 4283, 42830, 42831, 42832, 42833, 4284, 42840, 42841, 42842, 42843 | I502, I5020, I5021, I5022, I5023, I503, I5030, I5031, I5032, I504, I5040, I5041, I5042, I5043 |                   |
| Moderate to severe renal disease               | 582, 5830, 5831, 5832, 5833, 5834, 5835, 5836, 5837, 585, 586, 588 | I120, I131, N032, N033, N034, N035, N036, N037, N052, N053, N054, N055, N056, N057, N250, Z490, Z491, Z492, Z940, Z940, Z992, N18, N19 |                   |
| Supplemental oxygen use                        | V462              | Z9981                          | E1390, E1391, E0424, E0439, E1405, E1406, E0431, E0434, E1392, E0433, K0738, E0441, E0442, E0443, E0444, E0425, E0430, E0431, |
| Procedure Description                                      | Codes                                                                 | CPT Code(s)                  |
|-------------------------------------------------------------|-----------------------------------------------------------------------|------------------------------|
| Percutaneous cardiac procedures (including PCI, ablation, and transcatheter mitral) | 00.66, 36.06, 36.07, 37.26, 37.27, 37.33, 37.34, 35.97 | E0433, E0434, E0435, E0440, E0445, E0446 |
| Pacemaker/ICD                                                | 00.51, 00.54, 37.94, 37.95, 37.96, 37.80, 37.81, 37.82, 37.83 | 92937, 92941, 92943, 92920, 92924, 92928, 92933, 33418, 33419 |
| Hemodialysis                                                 | 39.95, 54.98                                                         | 90935, 90937, 90945, 90947, 4055F |
| Procedure | Codes | Description |
|-----------|-------|-------------|
| AVR       | 35.05, 35.06, 35.21, 35.22 | 02RFxxx |
|           |       | 3405-6, 33410-13; 33361-33366, 0265T, 0257T, 0318T |
| TAVR      | 35.05, 35.06 | 02RF37Z, 02RF38Z, 02RF3JZ, X2RF332, 0265T, 0257T, 0318T, 02RF3KZ, 02RF37H, 02RF38H, 02RF3JH, 02RF3KH |
|           |       | 33361-33366 |

COPD, chronic obstructive pulmonary disease; CPT, Current Procedural Terminology; ICD, implantable cardioverter defibrillator; ICD-9-CM, International Classification of Diseases, Ninth Revision, Clinical Modification; ICD-10-CM, International Classification of Diseases, Tenth Revision, Clinical Modification; PCI, percutaneous coronary intervention; SDS, signs, diseases, and symptoms
Table S6. Full, multi-level, logistic models for the likelihood of AVR (vs. no AVR) and the likelihood of TAVR (vs. SAVR) in patients with lab data.

| Patient Characteristics | AVR vs non-AVR | TAVR vs SAVR |
|-------------------------|----------------|--------------|
|                         | HR (95% CI)    | P-value      | HR (95% CI)    | P-value      |
| Gender                  |                |              |                |              |
| Male                    | Reference      | Reference    | Reference      | Reference    |
| Female                  | 0.75 (0.71, 0.80) | <.0001       | 1.46 (1.28, 1.65) | <.0001       |
| Age                     |                |              |                |              |
| <65                     | Reference      | Reference    | Reference      | Reference    |
| 65-79                   | 1.05 (0.95, 1.16) | 0.1940       | 3.90 (3.07, 4.93) | <.0001       |
| 80+                     | 0.56 (0.51, 0.63) | <.0001       | 20.83 (16.25, 26.69) | <.0001       |
| Race                    |                |              |                |              |
| Non-Hispanic white      | Reference      | Reference    | Reference      | Reference    |
| Non-Hispanic black      | 0.69 (0.58, 0.83) | 0.0001       | 1.06 (0.73, 1.53) | 0.7746       |
| Asian                   | 0.97 (0.63, 1.49) | 0.8842       | 1.12 (0.52, 2.40) | 0.7748       |
| Hispanic                | 0.91 (0.75, 1.10) | 0.3158       | 0.69 (0.47, 1.03) | 0.0630       |
| Other/unknown           | 0.79 (0.68, 0.93) | 0.0036       | 1.03 (0.74, 1.43) | 0.8624       |
| Division                |                |              |                |              |
| East North Central      | Reference      | Reference    | Reference      | Reference    |
| East South Central      | 2.20 (1.73, 2.81) | <.0001       | 1.33 (0.92, 1.92) | 0.1286       |
| Middle Atlantic         | 1.33 (1.07, 1.66) | 0.0105       | 1.87 (1.33, 2.64) | 0.0003       |
| Mountain                | 1.95 (1.49, 2.55) | <.0001       | 0.51 (0.33, 0.79) | 0.0025       |
| New England             | 0.82 (0.62, 1.09) | 0.1715       | 1.91 (1.16, 3.15) | 0.0109       |
| Pacific                 | 1.18 (0.94, 1.48) | 0.1537       | 1.31 (0.90, 1.89) | 0.1594       |
| South Atlantic/West South Central | 1.30 (1.10, 1.53) | 0.0020       | 1.55 (1.17, 2.03) | 0.0019       |
| West North Central      | 1.26 (1.09, 1.46) | 0.0018       | 0.75 (0.58, 0.96) | 0.0236       |
| Other/unknown           | 1.11 (0.89, 1.38) | 0.3505       | 0.96 (0.62, 1.49) | 0.8472       |
| Income level (quantiles)|                |              |                |              |
| <20th                   | Reference      | Reference    | Reference      | Reference    |
| 20th-40th               | 1.00 (0.88, 1.14) | 0.9908       | 0.96 (0.75, 1.23) | 0.7440       |
| 40th-60th               | 1.04 (0.92, 1.18) | 0.5315       | 1.14 (0.91, 1.43) | 0.2437       |
| 60th-80th               | 1.03 (0.91, 1.17) | 0.6700       | 1.15 (0.91, 1.46) | 0.2459       |
| 80th+                   | 1.07 (0.92, 1.24) | 0.3681       | 1.12 (0.85, 1.47) | 0.4133       |
| Education level (quantiles) |            |              |                |              |
| <20th                   | Reference      | Reference    | Reference      | Reference    |
| 20th-40th               | 1.04 (0.91, 1.18) | 0.5667       | 0.85 (0.67, 1.09) | 0.1979       |
| 40th-60th               | 0.85 (0.76, 0.96) | 0.0066       | 0.83 (0.66, 1.03) | 0.0838       |
| 60th-80th               | 0.90 (0.80, 1.02) | 0.0935       | 0.84 (0.68, 1.05) | 0.1283       |
|                  | 80th+     |          |          |          |
|------------------|-----------|----------|----------|----------|
|                  | 0.84 (0.74, 0.96) | 0.0102   | 1.01 (0.79, 1.30) | 0.9353   |
| **Insurance**    |           |          |          |          |
| Medicare         | Reference | Reference |          |          |
| Commercial       | 1.20 (1.09, 1.31) | 0.0002   | 0.77 (0.64, 0.93) | 0.0067   |
| Medicaid         | 0.93 (0.76, 1.13) | 0.4601   | 1.10 (0.71, 1.72) | 0.6588   |
| Uninsured        | 1.09 (0.87, 1.38) | 0.4591   | 0.93 (0.59, 1.48) | 0.7720   |
| Other or Unknown | 1.21 (1.12, 1.32) | <.0001   | 0.89 (0.76, 1.04) | 0.1328   |
| **Charlson Comorbidity Index** | |          |          |          |
| 0                | Reference | Reference |          |          |
| 1                | 1.03 (0.94, 1.12) | 0.5566   | 1.26 (1.06, 1.51) | 0.0101   |
| 2                | 0.98 (0.88, 1.09) | 0.6881   | 1.56 (1.25, 1.94) | <.0001   |
| 3                | 0.96 (0.84, 1.09) | 0.5245   | 1.97 (1.51, 2.57) | <.0001   |
| 4+               | 0.82 (0.69, 0.97) | 0.0194   | 2.71 (1.93, 3.80) | <.0001   |
| Atrial fibrillation | 0.75 (0.70, 0.81) | <.0001   | 1.07 (0.93, 1.24) | 0.3271   |
| Cancer           | 0.90 (0.81, 1.01) | 0.0666   | 0.85 (0.68, 1.06) | 0.1438   |
| Conduction       | 0.92 (0.83, 1.03) | 0.1488   | 1.07 (0.87, 1.32) | 0.5020   |
| COPD             | 0.80 (0.71, 0.9)  | 0.0001   | 1.46 (1.16, 1.83) | 0.0011   |
| Dementia         | 0.32 (0.24, 0.42) | <.0001   | 1.82 (0.88, 3.75) | 0.1068   |
| Diabetes with complications | 1.01 (0.87, 1.16) | 0.9316   | 0.77 (0.59, 1.01) | 0.0625   |
| Diabetes without complications | 1.06 (0.98, 1.15) | 0.1256   | 1.01 (0.86, 1.17) | 0.9480   |
| Prior myocardial infarction | 1.00 (0.90, 1.12) | 0.9673   | 1.03 (0.83, 1.28) | 0.7939   |
| Osteoarthritis   | 0.94 (0.86, 1.03) | 0.2087   | 0.99 (0.84, 1.18) | 0.9384   |
| Peripheral vascular disease | 0.98 (0.89, 1.07) | 0.5856   | 0.93 (0.78, 1.11) | 0.4230   |
| Heart failure    | 0.99 (0.90, 1.08) | 0.8336   | 1.33 (1.12, 1.58) | 0.0012   |
| Moderate to severe renal disease | 0.92 (0.82, 1.03) | 0.1645   | 0.89 (0.71, 1.12) | 0.3158   |
| **Smoking status** |           |          |          |          |
| Previous         | Reference | Reference |          |          |
| Current          | 1.05 (0.95, 1.16) | 0.3217   | 0.80 (0.66, 0.98) | 0.0324   |
| Never            | 1.02 (0.95, 1.09) | 0.6307   | 0.88 (0.77, 1.00) | 0.0536   |
| Use of supplemental oxygen | 0.62 (0.52, 0.74) | <.0001   | 2.96 (2.00, 4.38) | <.0001   |
| Percutaneous coronary intervention | 1.09 (0.90, 1.32) | 0.3945   | 2.27 (1.57, 3.30) | <.0001   |
| Pacemaker        | 0.96 (0.72, 1.27) | 0.7686   | 1.36 (0.74, 2.50) | 0.3245   |
| Hemodialysis     | 0.84 (0.61, 1.17) | 0.3048   | 0.85 (0.39, 1.84) | 0.6715   |
| Dyspnea          | 1.65 (1.48, 1.84) | <.0001   | 1.24 (0.98, 1.58) | 0.0759   |
| Dyspnea on exertion | 1.51 (1.39, 1.65) | <.0001   | 1.03 (0.88, 1.21) | 0.7188   |
| Angina           | 1.13 (1.06, 1.21) | 0.0004   | 0.95 (0.84, 1.09) | 0.4752   |
| Syncope          | 0.94 (0.88, 1.01) | 0.0724   | 1.09 (0.96, 1.25) | 0.1863   |
| Ejection fraction |          |          |          |          |
| 50+              | Reference | Reference |          |          |
|          | Creatinine | BMI         | Year of diagnosis | Diagnosed in inpatient | Hospitalized in year prior | Median odds ratio for cardiologist |
|----------|------------|-------------|-------------------|------------------------|---------------------------|----------------------------------|
| <34      | 0.61 (0.54, 0.69) | <.0001 | 1.50 (1.16, 1.95) | 0.0021 | | |
| 35-49    | 0.79 (0.71, 0.88) | <.0001 | 1.44 (1.18, 1.77) | 0.0004 | | |
| <0.9     | Reference | | | | | |
| 1.0-1.4  | 0.93 (0.86, 1.00) | 0.0590 | Reference | | | |
| 1.5-1.9  | 0.69 (0.61, 0.79) | <.0001 | 2.01 (1.57, 2.59) | <.0001 | | |
| 2.0+     | 0.48 (0.41, 0.57) | <.0001 | 2.72 (1.93, 3.83) | <.0001 | | |
| 20.1-25.0| Reference | Reference | Reference | Reference | Reference | Reference |
| <20.0    | 0.71 (0.59, 0.84) | <.0001 | 2.11 (1.41, 3.15) | 0.0003 | | |
| 25.1-30.0| 1.34 (1.24, 1.46) | <.0001 | 0.87 (0.74, 1.04) | 0.1237 | | |
| 30.1+    | 1.54 (1.41, 1.68) | <.0001 | 0.94 (0.79, 1.11) | 0.4553 | | |
| 2011     | Reference | Reference | Reference | Reference | Reference | Reference |
| 2012     | 1.55 (1.35, 1.77) | <.0001 | 2.88 (1.87, 4.43) | <.0001 | | |
| 2013     | 1.71 (1.50, 1.95) | <.0001 | 6.51 (4.33, 9.79) | <.0001 | | |
| 2014     | 2.17 (1.91, 2.47) | <.0001 | 10.60 (7.08, 15.88) | <.0001 | | |
| 2015     | 2.52 (2.22, 2.86) | <.0001 | 15.58 (10.45, 23.25) | <.0001 | | |
| 2016     | 3.03 (2.66, 3.45) | <.0001 | 27.96 (18.66, 41.9) | <.0001 | | |
| Diagnosed in inpatient | 0.67 (0.61, 0.73) | <.0001 | 1.18 (1.00, 1.39) | 0.0541 | | |
| Hospitalized in year prior | 0.75 (0.68, 0.81) | <.0001 | 0.89 (0.75, 1.06) | 0.2028 | | |
| Median odds ratio for cardiologist | 2.25 (2.14, 2.36) | <.0001 | 2.41 (2.21, 2.61) | <.0001 | | |

AVR, aortic valve replacement; BMI, body mass index; CI, confidence interval; COPD, chronic obstructive pulmonary disease; HR, hazard ratio; MOR, median odds ratio; SAVR, surgical aortic valve replacement; ssAS, symptomatic severe aortic stenosis; TAVR, transcatheter aortic valve replacement.
Table S7. Median odds ratios (MOR) for managing cardiologists for the likelihood of AVR when stratified by region and time in patients with lab data.

| Stratification          | MOR for AVR (95% CI) |
|-------------------------|-----------------------|
| **Region**              | **All patients**      |
| New England             | 2.58 (2.21, 2.96)     |
| Midwest                 | 2.10 (1.96, 2.24)     |
| South                   | 2.24 (2.02, 2.46)     |
| West                    | 2.41 (2.05, 2.76)     |
| **Year of diagnosis**   |                       |
| 2011-2012               | 2.28 (2.04, 2.51)     |
| 2013-2014               | 2.30 (2.13, 2.46)     |
| 2015-2016               | 2.29 (2.15, 2.42)     |

AVR, aortic valve replacement; CI, confidence interval; MOR, median odds ratio
Table S8. Full multi-level logistic models for the likelihood of AVR (vs. no AVR) and the likelihood of TAVR (vs. SAVR).

| Patient Characteristics  | AVR vs non-AVR | TAVR vs SAVR |
|--------------------------|----------------|--------------|
|                          | HR (95% CI)    | P-value      | HR (95% CI)    | P-value      |
| Gender                   |                |              |                |              |
| Male                     | Reference      | Reference    |                |              |
| Female                   | 0.76 (0.70, 0.83) | <.0001      | 1.46 (1.28, 1.65) | <.0001      |
| Age                      |                |              |                |              |
| <65                      | Reference      | Reference    |                |              |
| 65-79                    | 1.01 (0.88, 1.17) | 0.1940      | 3.90 (3.07, 4.93) | <.0001      |
| 80+                      | 0.52 (0.45, 0.61) | <.0001      | 20.83 (16.25, 26.69) | <.0001      |
| Race                     |                |              |                |              |
| Non-Hispanic white       | Reference      | Reference    |                |              |
| Non-Hispanic black       | 0.72 (0.57, 0.91) | 0.0070      | 1.06 (0.73, 1.53) | 0.7746      |
| Asian                    | 0.66 (0.35, 1.26) | 0.2064      | 1.12 (0.52, 2.40) | 0.7748      |
| Hispanic                 | 0.93 (0.71, 1.22) | 0.5975      | 0.69 (0.47, 1.03) | 0.0630      |
| Other/unknown            | 0.86 (0.69, 1.07) | 0.1690      | 1.03 (0.74, 1.43) | 0.8624      |
| Division                 |                |              |                |              |
| East North Central       | Reference      | Reference    |                |              |
| East South Central       | 2.01 (1.52, 2.66) | <.0001      | 1.28 (0.81, 2.02) | 0.2933      |
| Middle Atlantic          | 1.31 (0.99, 1.74) | 0.0626      | 1.74 (1.10, 2.74) | 0.0173      |
| Mountain                 | 2.01 (1.47, 2.75) | <.0001      | 0.53 (0.32, 0.9)  | 0.0176      |
| New England              | 0.72 (0.52, 1.01) | 0.0575      | 1.82 (0.96, 3.45) | 0.0685      |
| Pacific                  | 0.95 (0.74, 1.24) | 0.7266      | 1.25 (0.80, 1.96) | 0.3272      |
| South Atlantic/West South Central | 1.24 (1.02, 1.49) | 0.0267      | 1.43 (1.04, 1.97) | 0.0298      |
| West North Central       | 1.19 (1.01, 1.41) | 0.0391      | 0.80 (0.60, 1.08) | 0.1395      |
| Other/unknown            | 1.05 (0.8, 1.39)  | 0.7221      | 0.89 (0.51, 1.56) | 0.6939      |
| Income level (quantiles)*|                |              |                |              |
| <20th                    | Reference      | Reference    |                |              |
| 20th-40th                | 0.97 (0.82, 1.14) | 0.7060      | 0.99 (0.73, 1.36) | 0.9701      |
| 40th-60th                | 1.06 (0.90, 1.24) | 0.4766      | 1.14 (0.86, 1.51) | 0.3665      |
| 60th-80th                | 1.02 (0.87, 1.21) | 0.7798      | 1.19 (0.88, 1.62) | 0.2662      |
| 80th+                    | 1.13 (0.93, 1.36) | 0.2191      | 1.20 (0.84, 1.71) | 0.3217      |
| Education level (quantiles) |            |              |                |              |
| <20th                    | Reference      | Reference    |                |              |
| 20th-40th                | 1.10 (0.93, 1.30) | 0.2718      | 0.87 (0.64, 1.19) | 0.3910      |
| 40th-60th                | 0.92 (0.79, 1.07) | 0.2694      | 0.76 (0.58, 1.01) | 0.0577      |
| 60th-80th                | 0.95 (0.82, 1.10) | 0.4815      | 0.82 (0.62, 1.08) | 0.1517      |
| 80th+                    | 0.90 (0.76, 1.07) | 0.2302      | 0.95 (0.69, 1.31) | 0.7581      |
| Insurance                |                |              |                |              |
| Medicare                 | Reference      | Reference    |                |              |
| Commercial               | 1.24 (1.09, 1.41) | 0.0007      | 0.81 (0.64, 1.03) | 0.0911      |
| Medicaid          | 0.91 (0.71, 1.18) | 0.4850 | 1.32 (0.78, 2.25) | 0.3010 |
|-------------------|-------------------|--------|-------------------|--------|
| Uninsured         | 1.10 (0.83, 1.46) | 0.5212 | 0.99 (0.57, 1.71) | 0.9606 |
| Other or Unknown  | 1.27 (1.15, 1.42) | <.0001 | 1.01 (0.83, 1.22) | 0.9559 |
| Charlson Comorbidity Index       |   |        |                    |       |
| 0                  | Reference         | Reference | Reference         |        |
| 1                  | 1.02 (0.90, 1.16) | 0.7559 | 1.26 (0.98, 1.61) | 0.0693 |
| 2                  | 0.98 (0.85, 1.14) | 0.7946 | 1.65 (1.24, 2.20) | 0.0006 |
| 3                  | 0.94 (0.79, 1.11) | 0.4568 | 1.84 (1.31, 2.57) | 0.0004 |
| 4+                 | 0.81 (0.66, 1.00) | 0.0463 | 2.43 (1.61, 3.67) | <.0001 |
| Atrial fibrillation| 0.74 (0.68, 0.81) | <.0001 | 1.02 (0.85, 1.21) | 0.8640 |
| Cancer             | 0.94 (0.82, 1.08) | 0.3595 | 0.97 (0.75, 1.27) | 0.8347 |
| Conduction         | 0.96 (0.85, 1.09) | 0.5248 | 0.98 (0.76, 1.25) | 0.8550 |
| COPD               | 0.82 (0.72, 0.94) | 0.0047 | 1.21 (0.93, 1.59) | 0.1608 |
| Dementia           | 0.33 (0.23, 0.46) | <.0001 | 1.58 (0.70, 3.57) | 0.2686 |
| Diabetes with complications | 1.02 (0.87, 1.21) | 0.7862 | 0.87 (0.63, 1.19) | 0.3695 |
| Diabetes without complications | 1.00 (0.91, 1.11) | 0.9602 | 1.04 (0.86, 1.26) | 0.6675 |
| Prior myocardial infarction | 0.95 (0.84, 1.08) | 0.4717 | 1.14 (0.88, 1.47) | 0.3142 |
| Osteoarthritis     | 0.99 (0.89, 1.11) | 0.9189 | 0.91 (0.74, 1.12) | 0.3742 |
| Peripheral vascular disease | 0.94 (0.84, 1.05) | 0.2565 | 0.89 (0.72, 1.10) | 0.2676 |
| Heart failure      | 0.96 (0.86, 1.07) | 0.4753 | 1.35 (1.10, 1.66) | 0.0040 |
| Moderate to severe renal disease | 0.88 (0.77, 1.01) | 0.0754 | 0.76 (0.58, 1.00) | 0.0465 |
| Smoking status     |                     |        |                    |       |
| Previous           | Reference         | Reference | Reference         |        |
| Current            | 1.05 (0.93, 1.20) | 0.4339 | 0.84 (0.65, 1.09) | 0.1990 |
| Never              | 1.00 (0.92, 1.10) | 0.9229 | 0.85 (0.72, 1.01) | 0.0621 |
| Use of supplemental oxygen | 0.63 (0.52, 0.77) | <.0001 | 3.35 (2.14, 5.27) | <.0001 |
| Percutaneous coronary intervention | 1.05 (0.85, 1.31) | 0.6539 | 2.28 (1.50, 3.47) | 0.0001 |
| Pacemaker          | 0.98 (0.72, 1.34) | 0.8858 | 1.22 (0.63, 2.38) | 0.5566 |
| Hemodialysis       | 0.81 (0.56, 1.17) | 0.2628 | 0.78 (0.32, 1.88) | 0.5742 |
| Dyspnea            | 1.65 (1.40, 1.94) | <.0001 | 1.16 (0.83, 1.62) | 0.3778 |
| Dyspnea on exertion | 1.46 (1.31, 1.63) | <.0001 | 1.12 (0.92, 1.35) | 0.2671 |
| Angina             | 1.22 (1.12, 1.33) | <.0001 | 0.89 (0.76, 1.05) | 0.1717 |
| Syncope            | 0.90 (0.82, 0.98) | 0.0153 | 1.13 (0.96, 1.34) | 0.1388 |
| Ejection fraction  |                     |        |                    |       |
| 50+                | Reference         | Reference | Reference         |        |
| <34                | 0.66 (0.58, 0.76) | <.0001 | 1.40 (1.05, 1.86) | 0.0213 |
| 35-49              | 0.80 (0.72, 0.90) | 0.0002 | 1.42 (1.13, 1.78) | 0.0022 |
| Creatinine         |                     |        |                    |       |
| <0.9               | Reference         | Reference | Reference         |        |
| 1.0-1.4            | 0.95 (0.87, 1.04) | 0.2960 |                    |        |
| 1.5-1.9            | 0.73 (0.63, 0.84) | <.0001 | 2.44 (1.81, 3.28) | <.0001 |
| 2.0+               | 0.50 (0.41, 0.60) | <.0001 | 3.40 (2.28, 5.08) | <.0001 |
| BMI                |                     |        |                    |       |
| Year of diagnosis | Diagnosed in inpatient | Hospitalized in year prior | Median odds ratio for cardiologist |
|-------------------|-------------------------|---------------------------|----------------------------------|
| 2011              | Reference               | Reference                 | Reference                        |
| 2012              | 1.61 (1.34, 1.93)       | <.0001                    | 3.19 (1.71, 5.98)                | .0003 |
| 2013              | 1.98 (1.67, 2.36)       | <.0001                    | 8.61 (4.81, 15.44)               | <.0001|
| 2014              | 2.28 (1.92, 2.71)       | <.0001                    | 14.36 (8.04, 25.64)              | <.0001|
| 2015              | 2.90 (2.45, 3.43)       | <.0001                    | 23.24 (13.06, 41.33)             | <.0001|
| 2016              | 3.52 (2.97, 4.19)       | <.0001                    | 39.34 (22.01, 70.32)             | <.0001|
| <20.0             | Reference               | Reference                 | Reference                        |
| 2011              | 0.65 (0.52, 0.81)       | 0.0001                    | 1.99 (1.20, 3.32)                | 0.0080 |
| 2012              | 1.36 (1.22, 1.51)       | <.0001                    | 0.88 (0.71, 1.09)                | 0.2436|
| 2013              | 1.52 (1.37, 1.70)       | <.0001                    | 0.98 (0.79, 1.22)                | 0.8903|

*Income is available within the dataset at the zip code level, and not at the patient level.

AVR, aortic valve replacement; BMI, body mass index; CI, confidence interval; COPD, chronic obstructive pulmonary disease; HR, hazard ratio; MOR, median odds ratio; SAVR, surgical aortic valve replacement; ssAS, symptomatic severe aortic stenosis; TAVR, transcatheter aortic valve replacement.
Table S9. Median odds ratio (MOR) for general cardiologists for the likelihood of AVR when stratified by region and time.

| Stratification          | MOR for AVR (95% CI) | Patients with available values for ejection fraction, creatinine, and body mass index |
|-------------------------|-----------------------|--------------------------------------------------------------------------------------|
| Region                  |                       |                                                                                      |
| New England             | 2.38 (2.13, 2.63)     |                                                                                      |
| Midwest                 | 2.00 (1.84, 2.15)     |                                                                                      |
| South                   | 2.16 (1.89, 2.42)     |                                                                                      |
| West                    | 2.16 (1.76, 2.54)     |                                                                                      |
| Year of diagnosis       |                       |                                                                                      |
| 2011-2012               | 2.16 (1.76, 2.54)     |                                                                                      |
| 2013-2014               | 2.14 (1.94, 2.33)     |                                                                                      |
| 2015-2016               | 2.20 (2.03, 2.36)     |                                                                                      |

AVR, aortic valve replacement; CI, confidence interval; MOR, median odds ratio
Figure S1. Kaplan-Meier curves for survival when stratified by severity of aortic stenosis.

AS, aortic stenosis
Figure S2. Association between clinician 1-year treatment rate and 1-year all-cause mortality in patients with lab data
The distribution of cardiologists by 1-year AVR rate is shown below the curve with each strike representing an individual clinician.
Figure S3. Histogram showing the AVR intervention rate by cardiologist within 1 year
Figure S4. Cardiologist AVR treatment rate stratified by quartile
Cardiologists were ranked by treatment rate with cardiologist quartiles indicated by color (1 represents the lowest quartile of cardiologists in terms of AVR rate and 4 the highest).
Figure S5. Clinician’s AVR rate compared to TAVR rate for ssAS patients

Scatter plot for a cardiologist’s AVR rate as compared to their TAVR rate for ssAS patients. There was a significant correlation between AVR rate and TAVR rate. The smoothing curve was applied to the data to better visualize trends.
AVR, aortic valve replacement; ssAS, symptomatic severe aortic stenosis; TAVR, transcatheter aortic valve replacement
Figure S6. Association between managing cardiologists’ 3-month AVR treatment rate and 1-year all-cause mortality with clinician 3-month treatment.
Figure S7. Kaplan-Meier curves for survival when stratified by managing cardiologist 3-month AVR treatment rate