Supplementary Online Content

Goto M, Schweizer ML, Vaughan-Sarrazin MS, et al. Association of evidence-based care processes with mortality in *Staphylococcus aureus* bacteremia in Veterans Health Administration Hospitals, 2003-2014. *JAMA Intern Med.* Published online September 5, 2017. doi:10.1001/jamainternmed.2017.3958

This supplementary material has been provided by the authors to give readers additional information about their work.

eMethod: Statistical Appendix

Model Building Process

To build a model to predict all-cause 30-day mortality, we started by assessing each candidate variable for missingness and bivariable associations with mortality. Patient characteristics were considered candidate variables for the risk adjustment model if they were possibly related ($p<.25$) to mortality in bivariable analyses and missingness before imputation was less than 10%. We fit a multivariable logistic regression with 30-day mortality as outcome. We also evaluated several interaction terms with potential clinical relevance, such as the interaction between a renal failure diagnosis and serum creatinine level, and between other risk-adjustment variables and place of bacteremia acquisition. We used a two-step approach to avoid overfitting the model and maintain prediction capability. First, variables were selected using a backward elimination strategy to minimize Akaike's information criterion (AIC). This variable selection was repeated 1500 times used a bootstrapping method proposed by Austin and Tu[1] to select only those variables identified as predictors in at least 90% of the bootstrap samples. Second, the final model was further assessed for prediction capability by randomly splitting the cohort (training dataset: 60%; validation dataset: 40%), and fitting the model in the training set with selected variables and applying it to validation set.[2,3] All models included a random intercept for hospitals to account for the grouping of patients within hospitals.

Recycled Prediction Methods for Estimating Proportion of Decline in Risk-Adjusted Mortality Attributable to Increasing Use of Care Processes

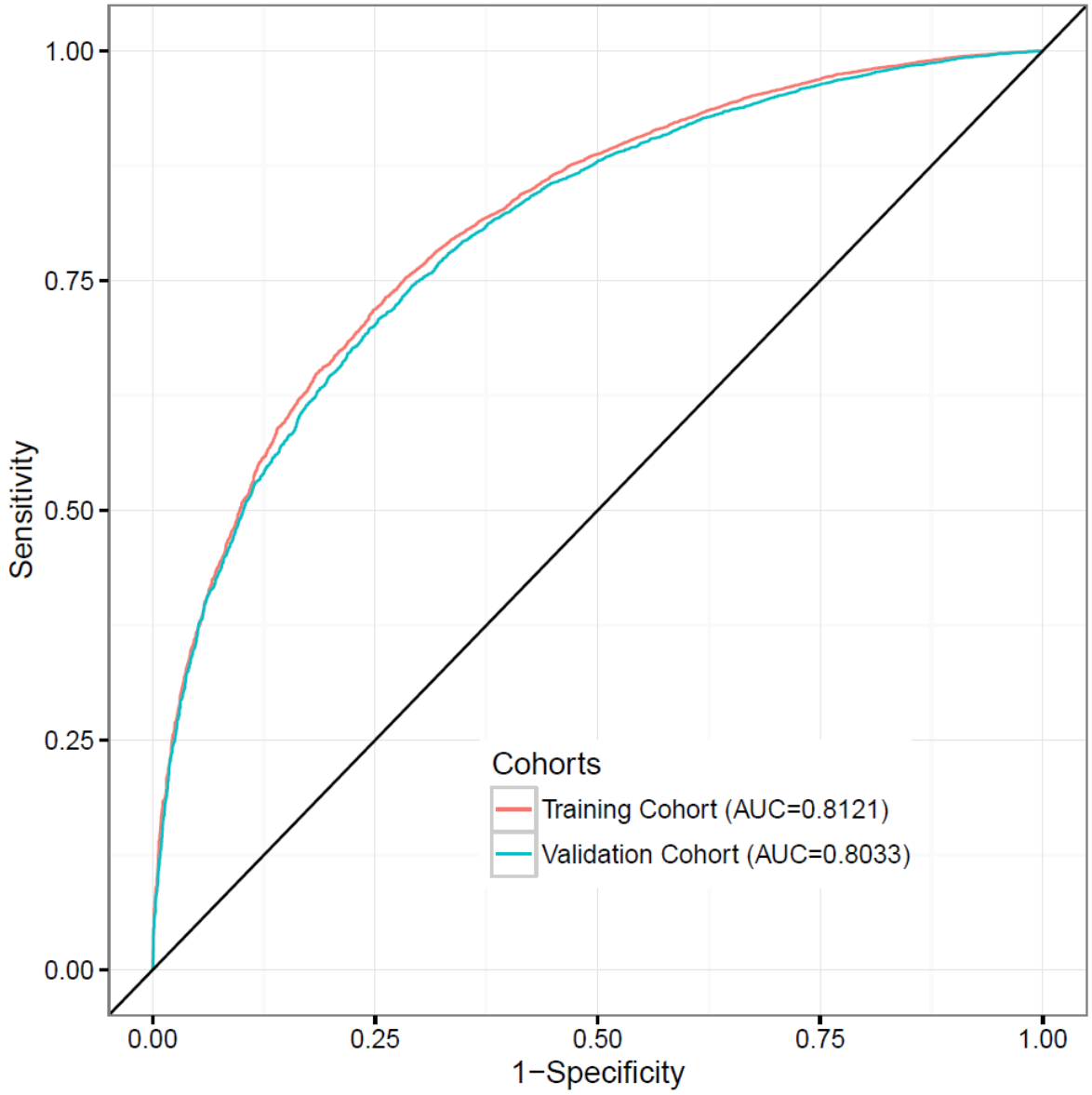
The method of recycled predictions uses marginal effects to measure the expected change in the dependent variable as a function of a change in a specific explanatory variable, while keeping all other covariates constant. This process used the method of recycled predictions to calculate marginal effects of use of increasing numbers of care processes on mortality, using estimated regression coefficients from the risk adjustment model that included an ordinal measure of the number of care processes each patient received, as well as a measure of time (in years), applied to a standardized patient sample. [4-6]

Using the regression coefficients, we estimated risk-standardized mortality for a standardized patients sample under three scenarios: 1) baseline year (2003) with baseline levels of care process utilization; 2) final year (2014) with baseline (2003) levels of care process utilization; and 3) final year (2014) with 2014 levels of care process utilization. The difference between (3) and (1) represents the overall change in risk-adjusted mortality from 2003 through 2014. The difference between (3) and (2) provides the change in risk-adjusted mortality that may be attributed to the increased use of care processes, while the difference between (2) and (1) provides the change in risk adjusted mortality over time due to other causes besides changes in care processes. Confidence intervals of attributable fractions were calculated by bootstrapping.

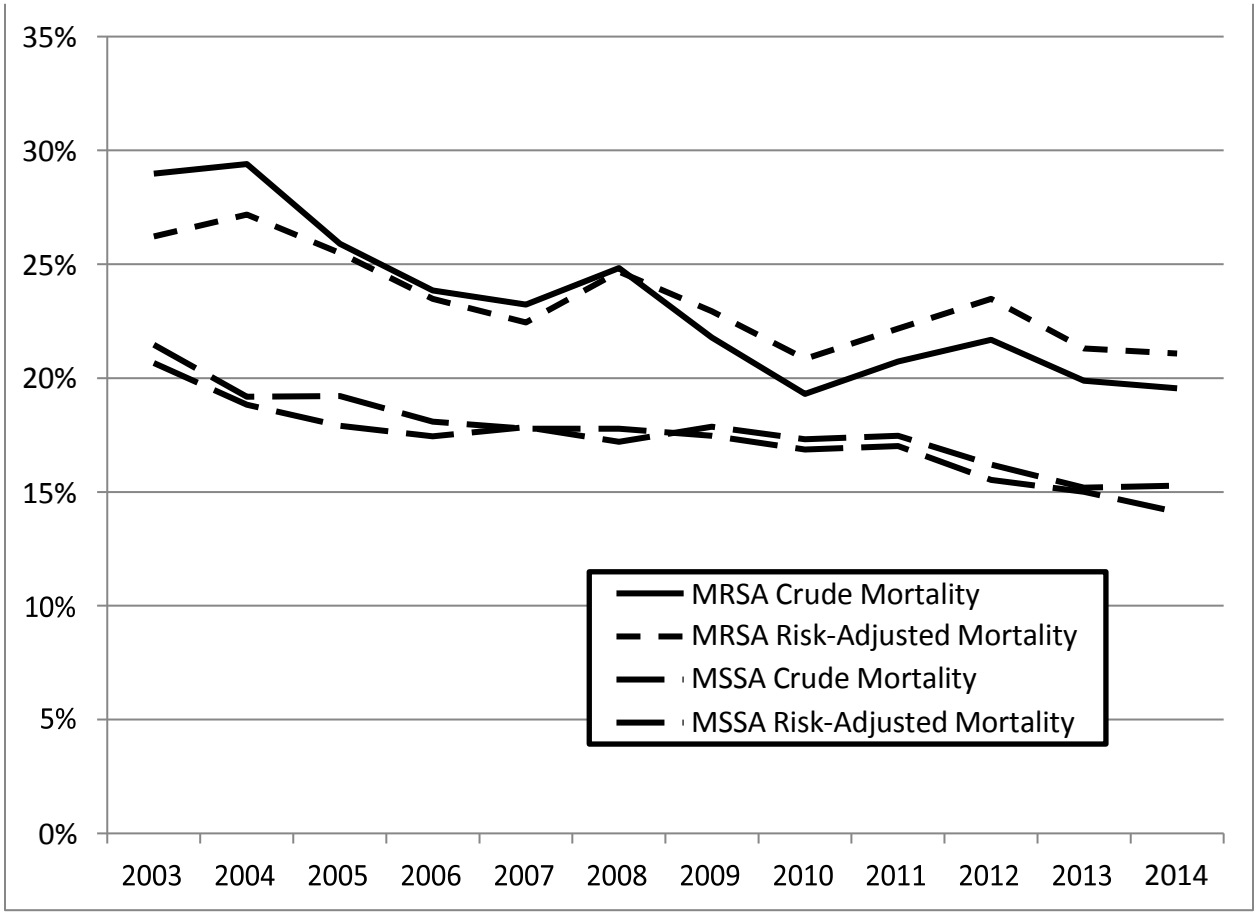
(Reference)

1. Austin PC, Tu JV. Bootstrap Methods for Developing Predictive Models. *The American Statistician.* 2004;58(2):131-137.
2. Hosmer DW, Lemeshow S, Sturdivant RX. *Applied Logistic Regression.* 3rd ed: Wiley; 2013.
3. James G, Witten D, Hastie T, Tibshirani R. *An introduction to statistical learning.* Vol 6: Springer; 2013.
4. Graubard BI, Korn EL. Predictive margins with survey data. *Biometrics.* 1999;55(2):652-659.
5. Basu A, Rathouz PJ. Estimating marginal and incremental effects on health outcomes using flexible link and variance function models. *Biostatistics.* 2004;6(1):93-109.
6. Li Z, Mahendra G. 272-2010 Using "Recycled Predictions" for Computing Marginal Effects. Paper presented at: SAS Global Forum 2010 Conference; April 11-14, 2010, 2010; Seattle, Washington.

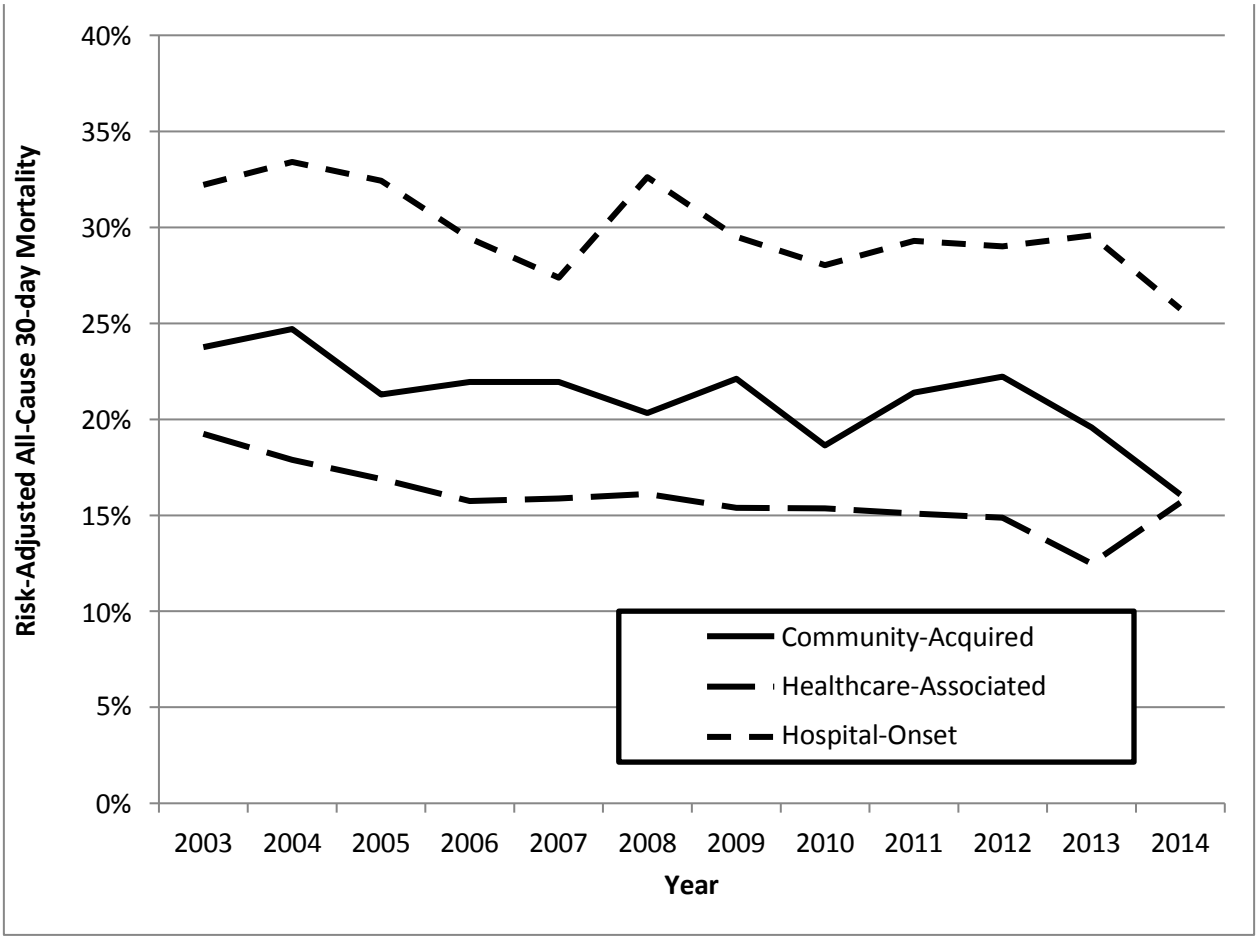
eFigure 1. Receiver Operating Characteristic Curves for Training and Validation Datasets



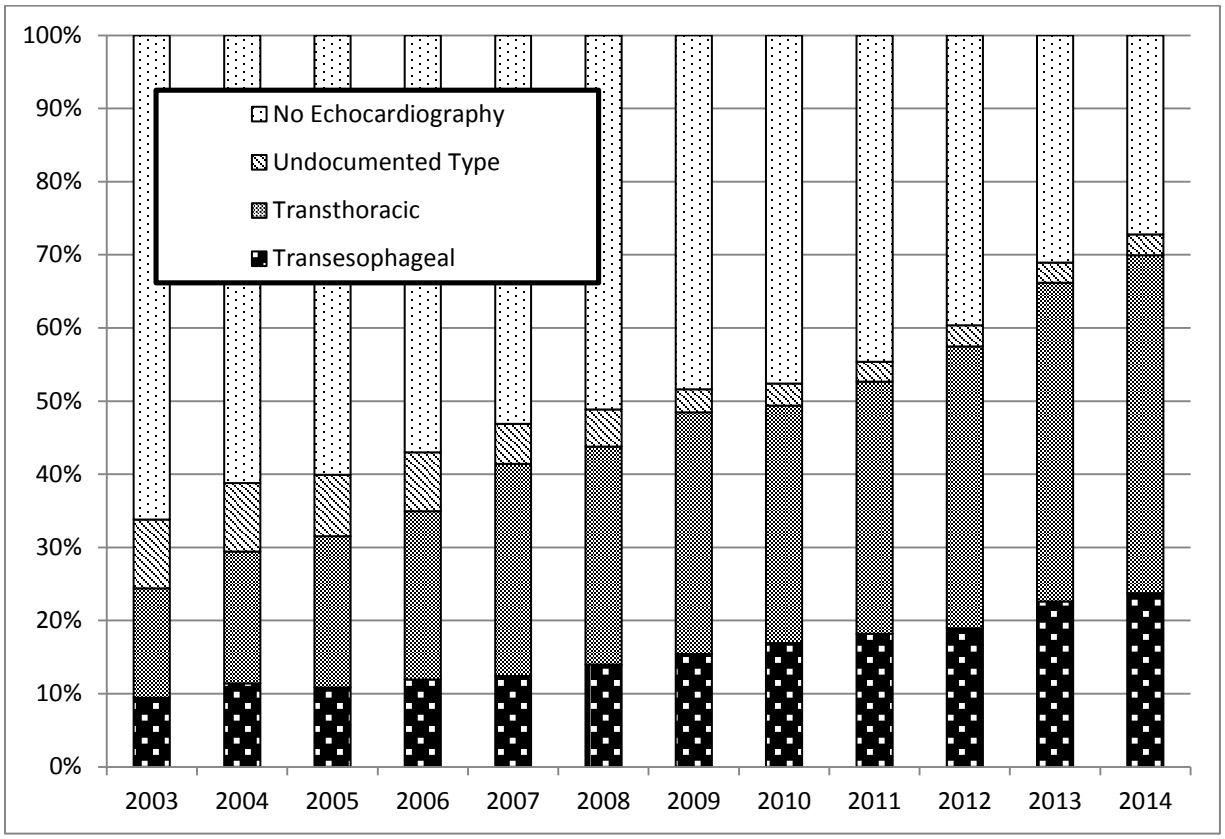
eFigure 2. Crude and Risk-Adjusted All-cause 30-day Mortality Rates of MRSA and MSSA



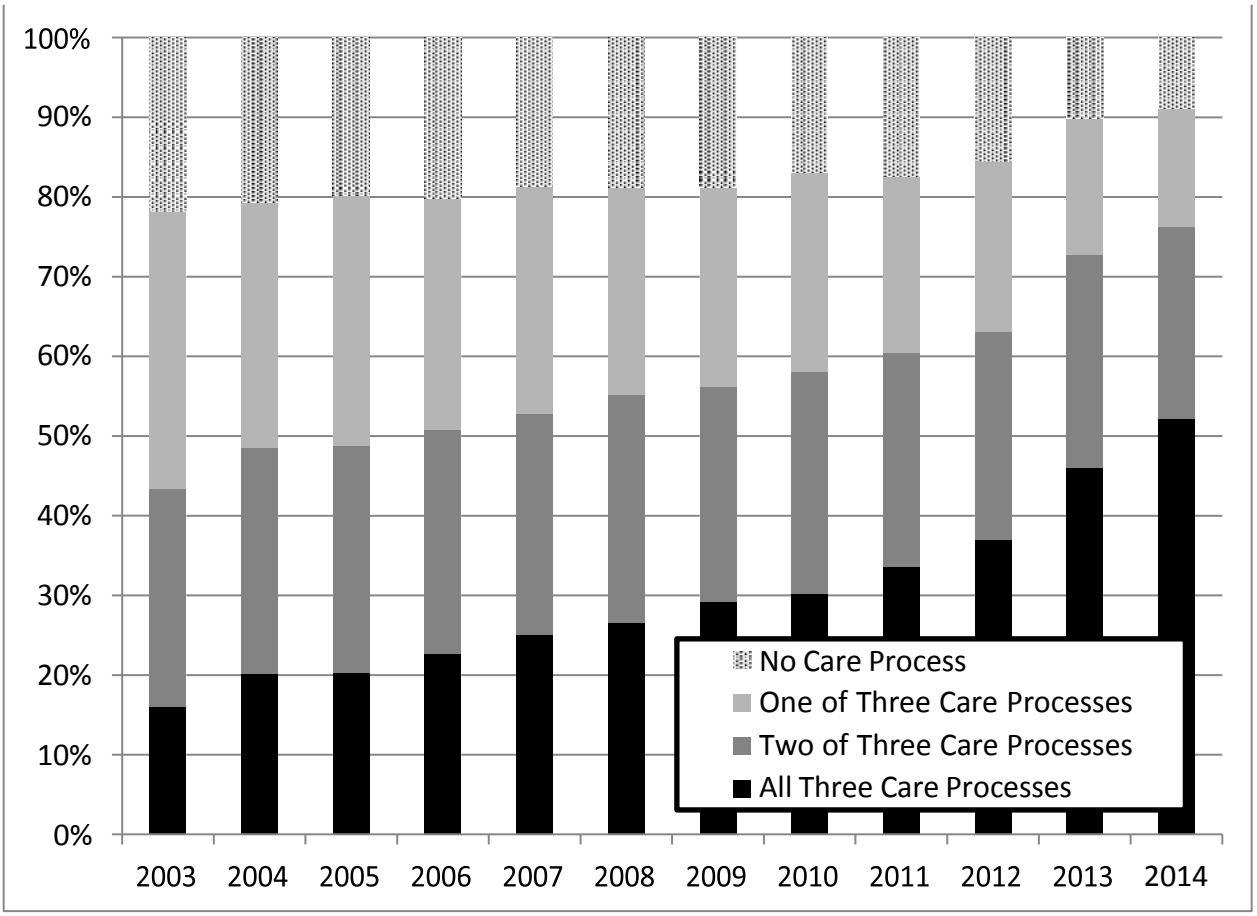
eFigure 3. Risk-Adjusted All-Cause 30-day Mortality Rates by Place of Acquisition



eFigure 4. Utilization of Echocardiography by Type of Procedure

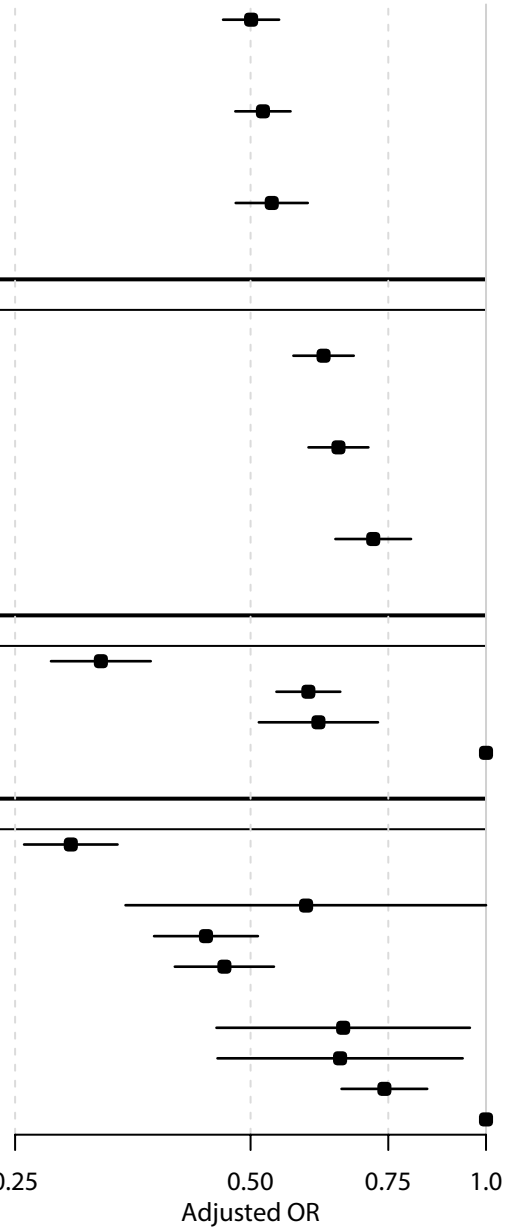


eFigure 5. Number of Care Processes Received, by Year



eFigure 6. Subgroup Analyses for Receipt of Care Processes and All-Cause 30-day Mortality for Patients with MRSA Bacteremia

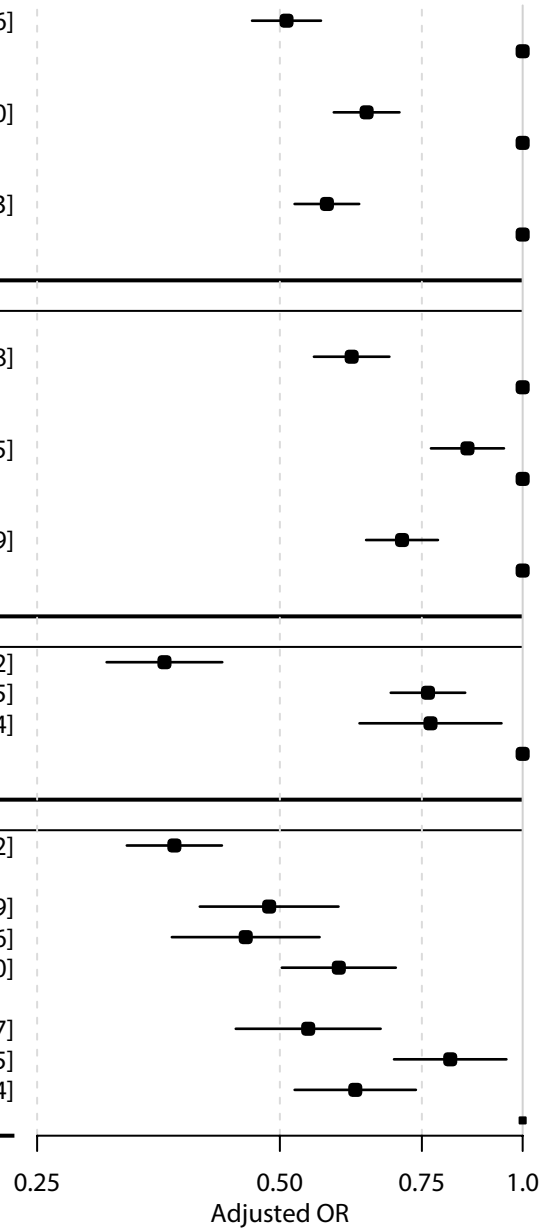
Process Measures (Not Adjusted for Other Care Processes)*	N (%)	Adjusted OR [95% CI]
ID Consultation during Hospitalization		
ID Consult	8997 (46.6%)	0.50 [0.46–0.54]
No ID Consult	10328 (53.4%)	
Echocardiography during Hospitalization		
Echocardiography	9160 (47.4%)	0.52 [0.48–0.56]
No Echocardiography	10165 (52.6%)	
Appropriate Therapy during Hospitalization		
Appropriate Therapy	16895 (87.4%)	0.53 [0.48–0.59]
Other Therapy	2430 (12.6%)	
Process Measures (Adjusted for Other Care Processes)**		
ID Consultation during Hospitalization		
ID Consult	8997 (46.6%)	0.62 [0.57–0.68]
No ID Consult	10328 (53.4%)	
Echocardiography during Hospitalization		
Echocardiography	9160 (47.4%)	0.65 [0.59–0.71]
No Echocardiography	10165 (52.6%)	
Appropriate Therapy during Hospitalization		
Appropriate Therapy	16895 (87.4%)	0.72 [0.64–0.80]
Other Therapy	2430 (12.6%)	
Types of Echocardiography*		
TEE	2673 (13.8%)	0.32 [0.28–0.37]
TTE	5378 (27.8%)	0.59 [0.54–0.65]
Undocumented Type	1109 (5.7%)	0.61 [0.51–0.73]
No Echocardiography	10165 (52.6%)	1 (Reference)
Combination of Care Processes*		
All Three Care Processes	5905 (30.6%)	0.29 [0.26–0.34]
Two of Three Care Processes		
ID Consultation and Echocardiography	108 (0.6%)	0.59 [0.35–1.00]
ID Consultation and Appropriate Therapy	2776 (14.4%)	0.44 [0.38–0.51]
Echocardiography and Appropriate Therapy	2936 (15.2%)	0.46 [0.40–0.54]
One of Three Care Processes		
ID Consultation Only	205 (1.1%)	0.66 [0.45–0.95]
Echocardiography Only	211 (1.1%)	0.65 [0.45–0.93]
Appropriate Therapy Only	5278 (27.3%)	0.74 [0.65–0.84]
No Care Process	1906 (9.9%)	1 (Reference)



* Care process indicator variables included individually in risk adjustment models with all variables in Table 2; ** All variables in Table 2 and three care processes were entered to the model simultaneously

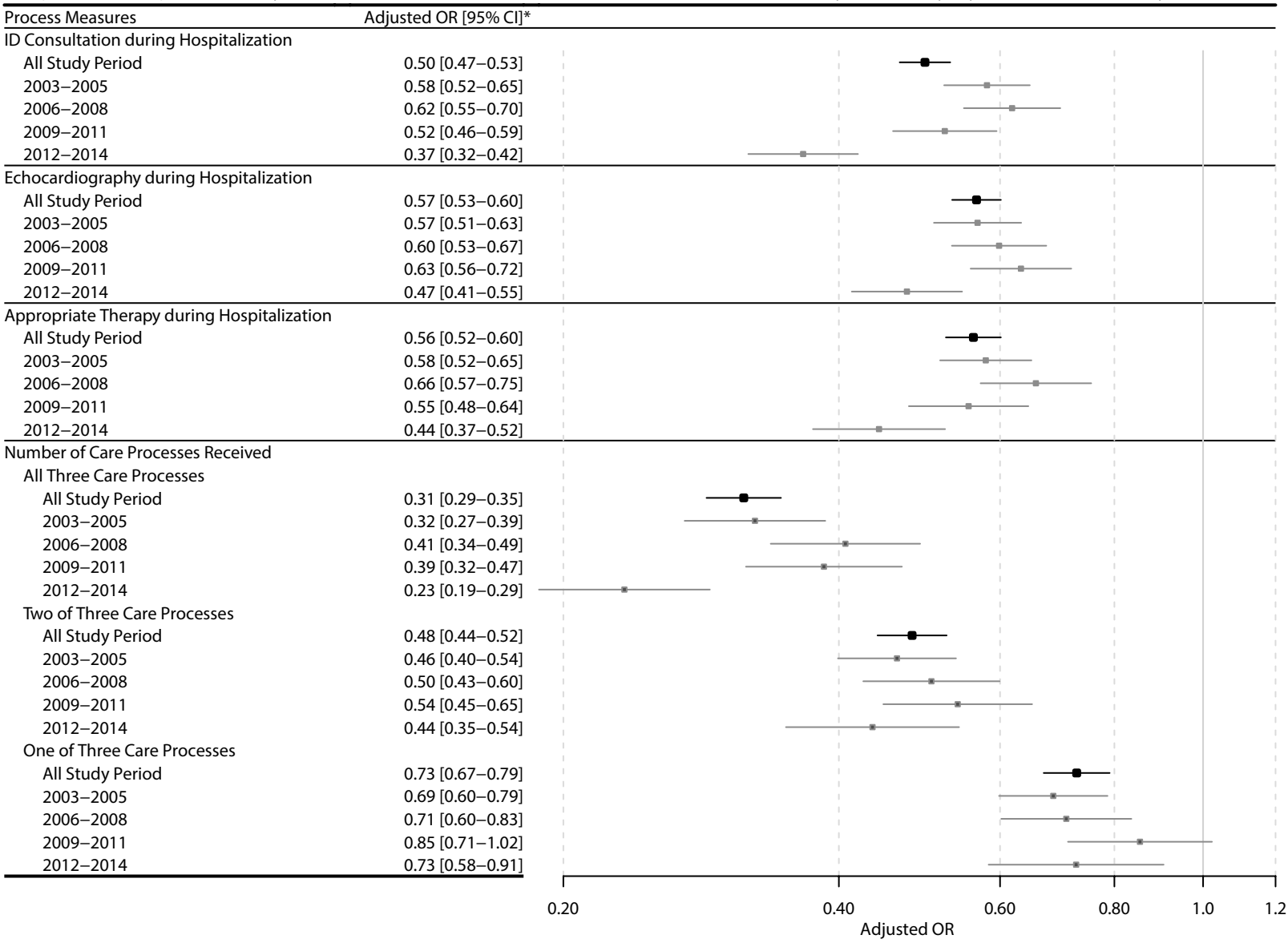
eFigure 7. Subgroup Analyses for Receipt of Care Processes and All-Cause 30-day Mortality for Patients with MSSA Bacteremia

Process Measures (Not Adjusted for Other Care Processes)*	N (%)	Adjusted OR [95% CI]
ID Consultation during Hospitalization		
ID Consult	8292 (47.3%)	0.51 [0.46–0.56]
No ID Consult		1 (Reference)
Echocardiography during Hospitalization		
Echocardiography	9185 (52.4%)	0.64 [0.58–0.70]
No Echocardiography		1 (Reference)
Appropriate Therapy during Hospitalization		
Appropriate Therapy	9142 (52.1%)	0.57 [0.52–0.63]
Other Therapy		1 (Reference)
Process Measures (Adjusted for Other Care Processes)**		
ID Consultation during Hospitalization		
ID Consult	8292 (47.3%)	0.61 [0.55–0.68]
No ID Consult		1 (Reference)
Echocardiography during Hospitalization		
Echocardiography	9185 (52.4%)	0.85 [0.77–0.95]
No Echocardiography		1 (Reference)
Appropriate Therapy during Hospitalization		
Appropriate Therapy	9142 (52.1%)	0.71 [0.64–0.79]
Other Therapy		1 (Reference)
Types of Echocardiography*		
TEE	2849 (16.2%)	0.36 [0.30–0.42]
TTE	5391 (30.7%)	0.76 [0.69–0.85]
Undocumented Type	945 (5.4%)	0.77 [0.63–0.94]
No Echocardiography	8358 (47.6%)	1 (Reference)
Combination of Care Processes*		
All Three Care Processes	4703 (26.8%)	0.37 [0.32–0.42]
Two of Three Care Processes		
ID Consultation and Echocardiography	1274 (7.3%)	0.48 [0.40–0.59]
ID Consultation and Appropriate Therapy	1236 (7.0%)	0.45 [0.37–0.56]
Echocardiography and Appropriate Therapy	1756 (10.0%)	0.59 [0.50–0.70]
One of Three Care Processes		
ID Consultation Only	1053 (6.0%)	0.54 [0.44–0.67]
Echocardiography Only	1452 (8.3%)	0.81 [0.69–0.95]
Appropriate Therapy Only	1447 (8.2%)	0.62 [0.52–0.74]
No Care Process	4622 (26.3%)	1 (Reference)



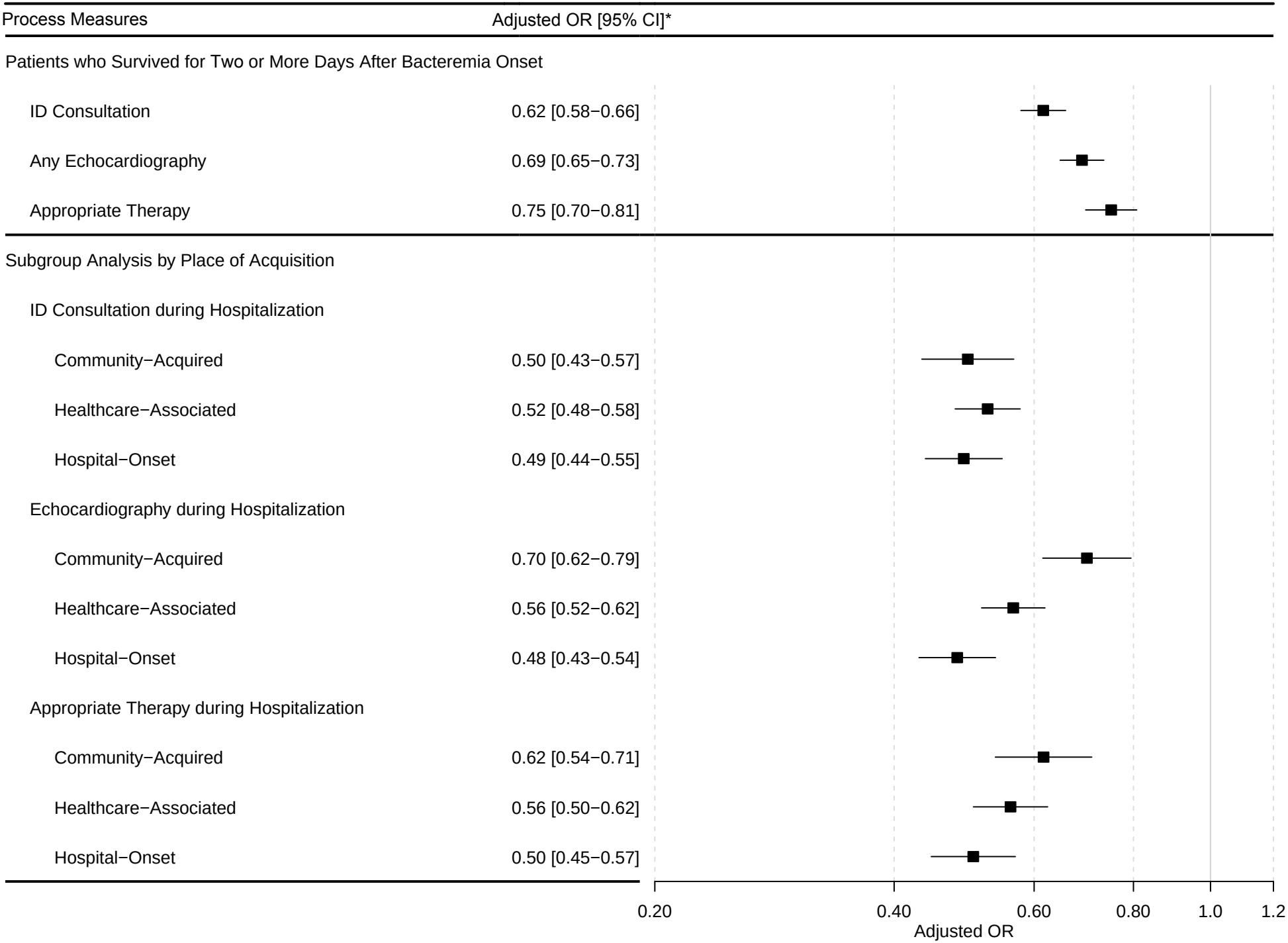
* Care process indicator variables included individually in risk adjustment models with all variables in Table 2; ** All variables in Table 2 and three care processes were entered to the model simultaneously

eFigure 8. Subgroup Analyses for Receipt of Care Processes and All-Cause 30-day Mortality by Quarters of Study Period



* Adjusted for all variables in Table 2

eFigure 9. Subgroup Analyses for Receipt of Care Processes and All-Cause 30-day Mortality for Patients who Survived for Two or More Days and by Places of Acquisition



*Adjusted for all variables in Table 2