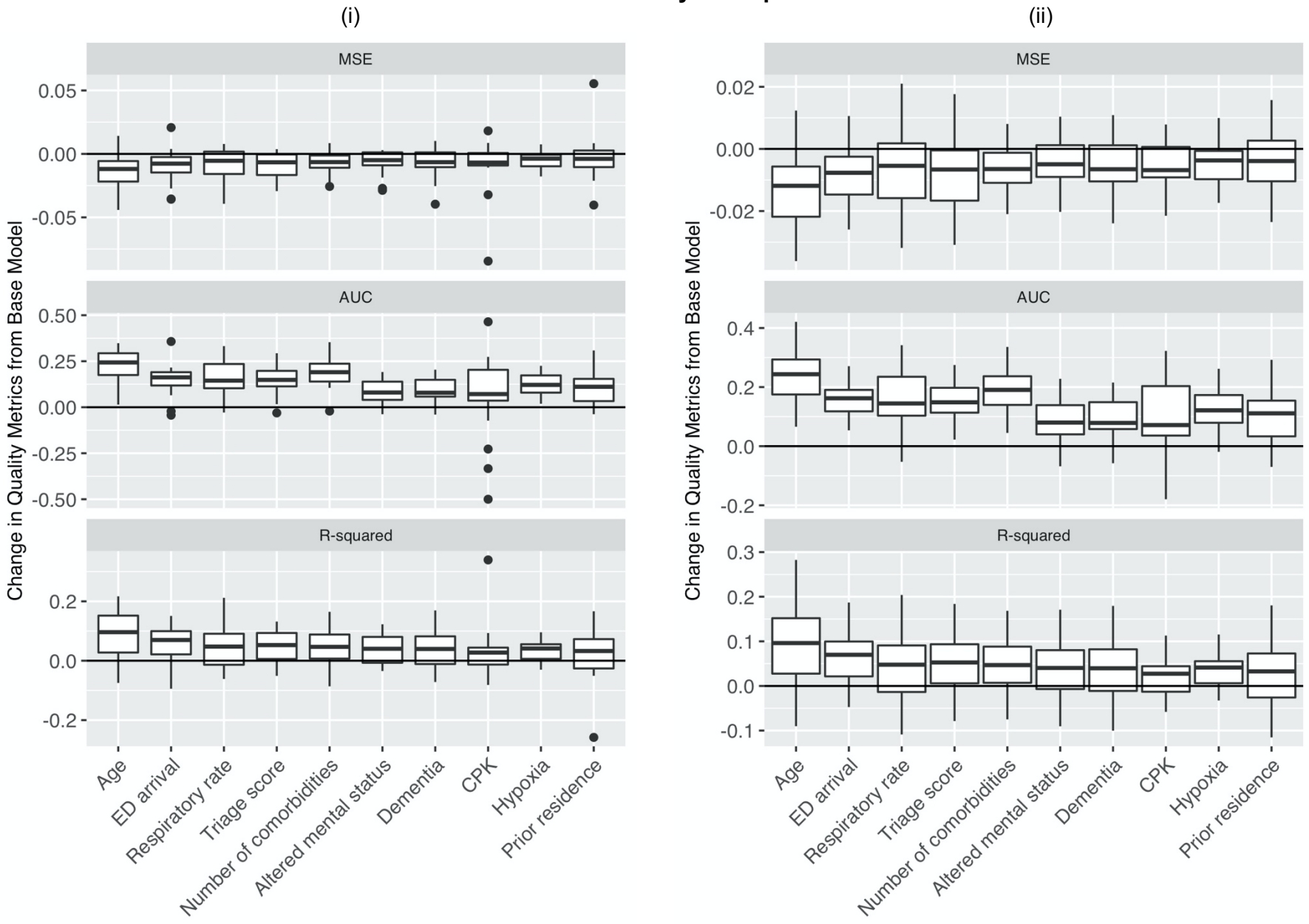
eAppendix A: Model selection details

FORWARD SELECTION STEP 1
Base Model: Mortality ~ Hospital



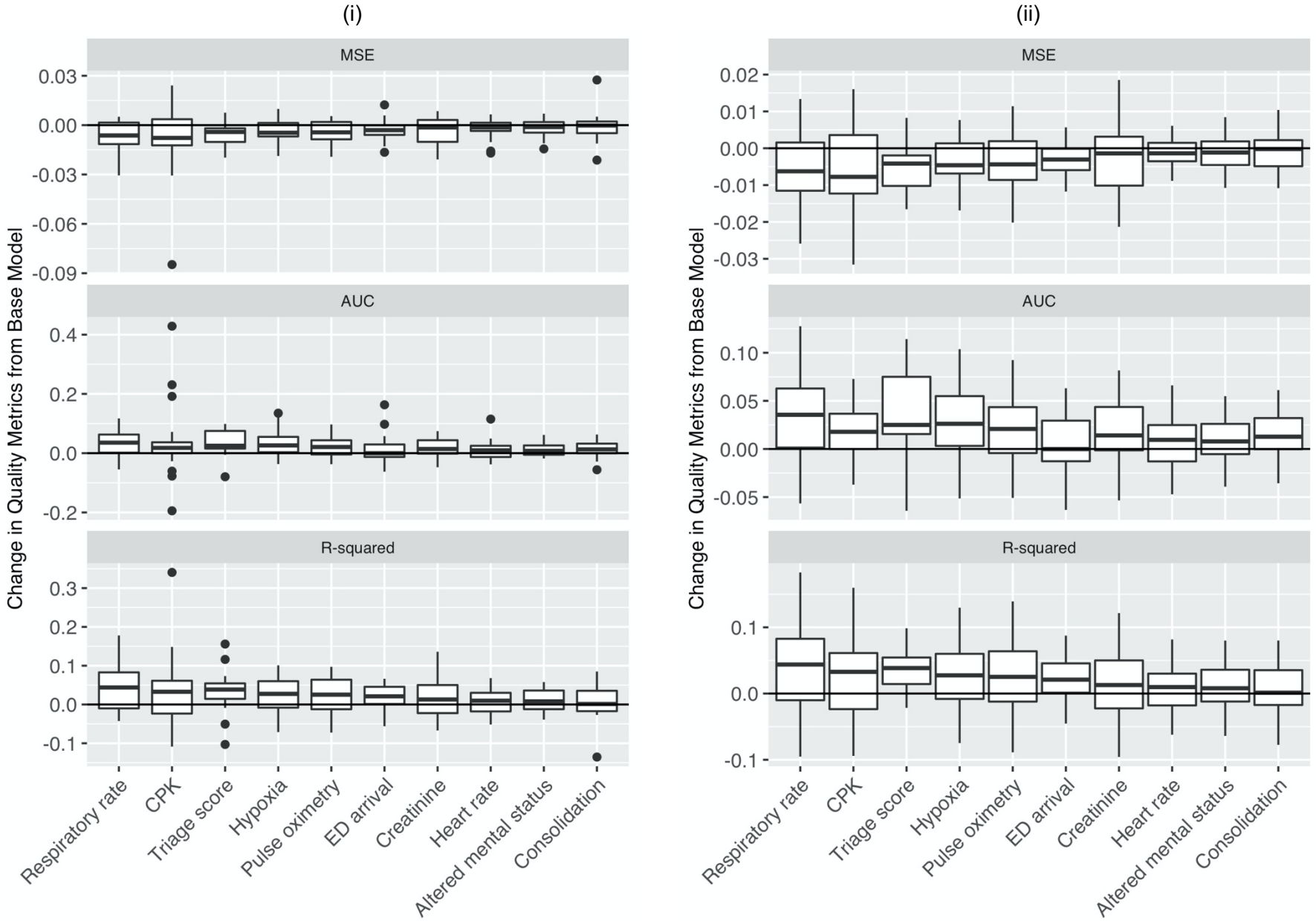
(iii)

		Change from Base Model Mortality ~ Hospital		
Variable	**N**	**MSE**	**AUC$^{(w)}$**	**R-squared**
Age	**1769**	**-0.013**	**0.220**	**0.081**
ED arrival	1659	-0.010	0.156	0.063
Respiratory rate	1734	-0.008	0.149	0.051
Triage score	1505	-0.007	0.147	0.047
Number of comorbidities	1769	-0.007	0.190	0.044
Altered mental status	1769	-0.006	0.087	0.038
Dementia	1769	-0.006	0.087	0.037
Creatine Phosphokinase (CPK)	447	-0.006	0.093	0.029
Hypoxia	1769	-0.005	0.127	0.031
Prior residence	1746	-0.004	0.108	0.025

eFigure 3a: Change in quality metrics for top 10 variables with most improved MSE when added to base model of in-hospital mortality from COVID-19 on hospital COVID-19 mortality rate. (i) Histograms of change in MSE, AUC$^{(w)}$ and R-squared for all 20 hospitals in the derivation set. (ii) Histograms of change in MSE, AUC$^{(w)}$ and R-squared for all 20 hospitals in the derivation set with outliers removed. (iii) Change in quality metrics for all derivation hospitals combined. Bolded variables were chosen for inclusion in the next step of forward selection.

Based on these results, we included age in the model for the next step of forward selection because it was the variable with the most improved MSE, AUC$^{(w)}$, and R-squared overall (iii) and showed improvement for almost all hospitals on these metrics (i and ii).

FORWARD SELECTION STEP 2
Base Model: Mortality ~ Age + Hospital



(iii)

		Change from Base Model Mortality ~ Age + Hospital		
Variable	**N**	**MSE**	**AUC$^{(w)}$**	**R-squared**
Respiratory rate	**1734**	**-0.007**	**0.032**	**0.045**
Creatine Phosphokinase (CPK)	447	-0.006	0.041	0.031
Triage score	1505	-0.006	0.033	0.037
Hypoxia	1769	-0.004	0.035	0.028
Pulse oximetry	**1750**	**-0.004**	**0.021**	**0.024**
ED arrival	1659	-0.003	0.012	0.019
Highest creatinine	1737	-0.003	0.020	0.016
Heart rate	**1760**	**-0.003**	**0.010**	**0.016**
Altered mental status	1769	-0.002	0.014	0.010
Consolidation on chest x-ray	1684	-0.002	0.014	0.010

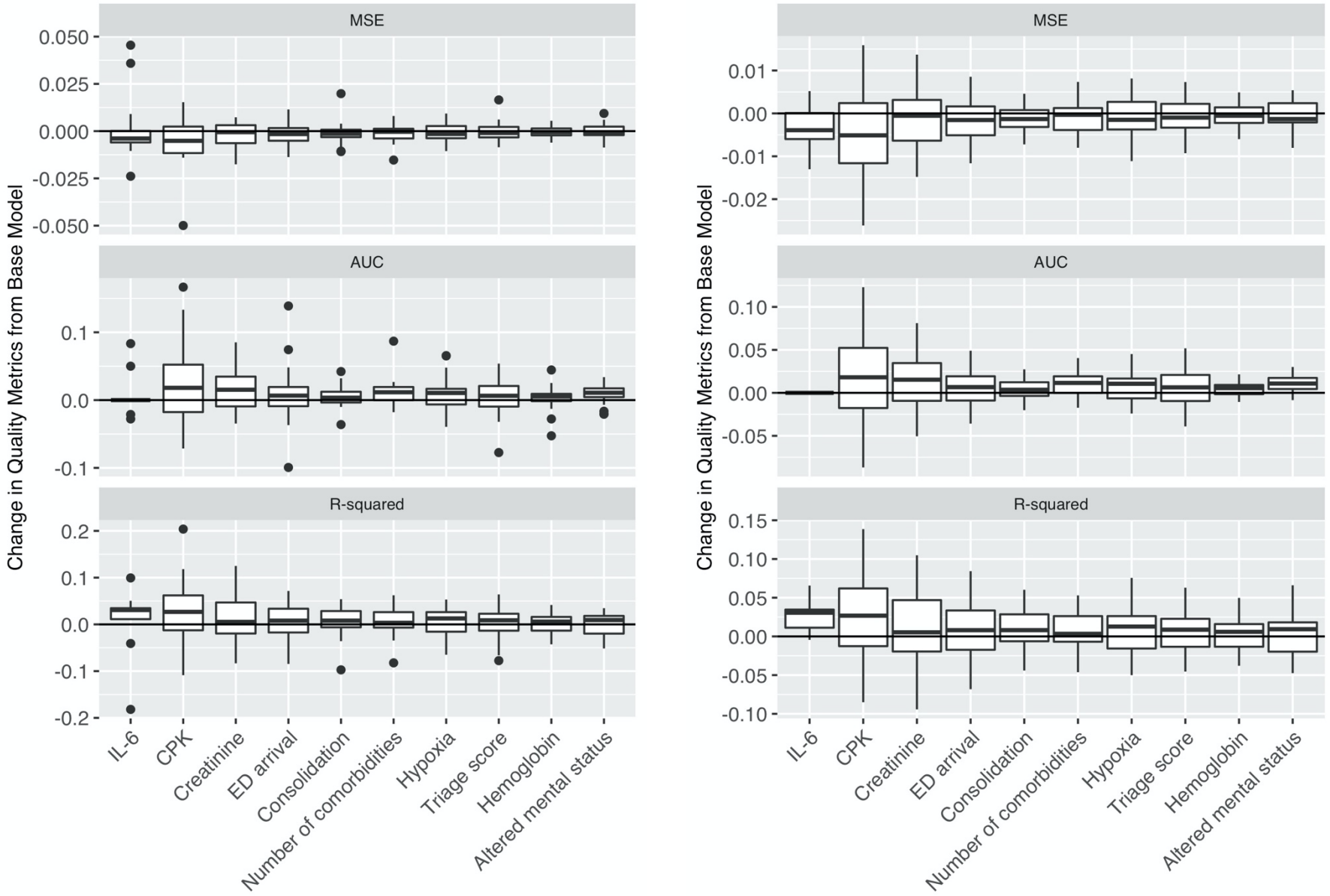
eFigure 3b: Change in quality metrics for top 10 variables with most improved MSE when added to base model of in-hospital mortality from COVID-19 on patient's age and hospital COVID-19 mortality rate. (i) Histograms of change in MSE, AUC$^{(w)}$ and R-squared for all 20 hospitals in the derivation set. (ii) Histograms of change in MSE, AUC$^{(w)}$ and R-squared for all 20 hospitals in the derivation set with outliers removed. (iii) Change in quality metrics for all derivation hospitals combined. Bolded variables were chosen for inclusion in the next step of forward selection.

Based on these results, we included respiratory rate, pulse oximetry, and heart rate in the model for the next step of forward selection. Respiratory rate was the variable with the most improved MSE and pulse oximetry and heart rate were two other vital signs that appeared to be predictive in the model overall (iii) and consistently across individual hospitals (i and ii). CPK was missing for a majority of patients and was unlikely to be widely available for COVID-19 patients. The triage score showed improvement, however, the other vital signs are included in the triage score. We also prioritized adding the vital signs over symptoms such as hypoxia. ED arrival described the manner in which a patient arrived at the hospital (such as "car," "ambulance," and "by foot"), which we did not expect to be widely available at all hospitals. Therefore, in the second step of forward selection, we decided to include the three most predictive vital signs. In the following steps, we could determine whether any of the other variables that appeared predictive in this step remained predictive after the vital signs were added to the model.

FORWARD SELECTION STEP 3

Base Model: Mortality ~ Age + Respiratory Rate + Pulse Oximetry + Heart Rate + Hospital

(i) (ii)



(iii)

		Change from Base Model Mortality ~ Age + Respiratory Rate + Pulse Oximetry + Heart Rate + Hospital		
Variable	**N**	**MSE**	**AUC$^{(w)}$**	**R-squared**
Highest interleukin 6 (IL-6)	130	-0.003	0.001	0.016
Creatine Phosphokinase (CPK)	438	-0.003	0.031	0.016
Highest creatinine	**1687**	**-0.002**	**0.016**	**0.015**
ED arrival	1610	-0.002	0.007	0.012
Consolidation on chest x-ray	1634	-0.001	0.006	0.007
Number of comorbidities	1716	-0.001	0.013	0.007
Hypoxia	1716	-0.001	0.011	0.006
Triage score	1458	-0.001	0.007	0.005
Highest hemoglobin (Hgb)	1698	-0.001	0.002	0.004
Altered mental status	1716	-0.001	0.009	0.004

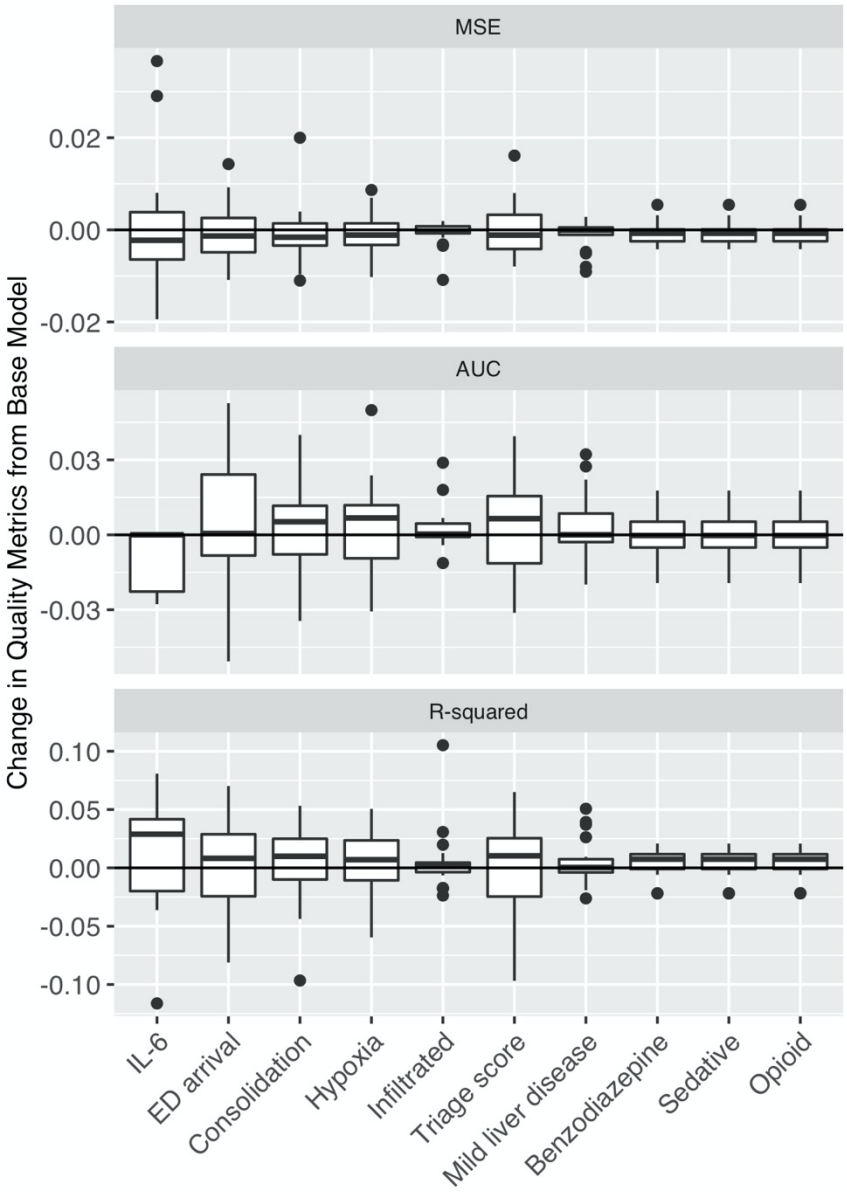
eFigure 3c: Change in quality metrics for top 10 variables with most improved MSE when added to base model of in-hospital mortality from COVID-19 on patient's age, respiratory rate on presentation, pulse oximetry on presentation, heart rate on presentation, and hospital COVID-19 mortality rate. (i) Histograms of change in MSE, AUC$^{(w)}$ and R-squared for all 20 hospitals in the derivation set. (ii) Histograms of change in MSE, AUC$^{(w)}$ and R-squared for all 20 hospitals in the derivation set with outliers removed. (iii) Change in quality metrics for all derivation hospitals combined. Bolded variables were chosen for inclusion in the next step of forward selection.

Based on these results, we included the patient's initial creatinine level in the model. The IL-6 and CPK lab values were available for very few patients. Creatinine was the factor with the most improvement in MSE and AUC$^{(w)}$ overall (iii) after these variables and it showed reasonably consistent improvement across hospitals (i and ii).

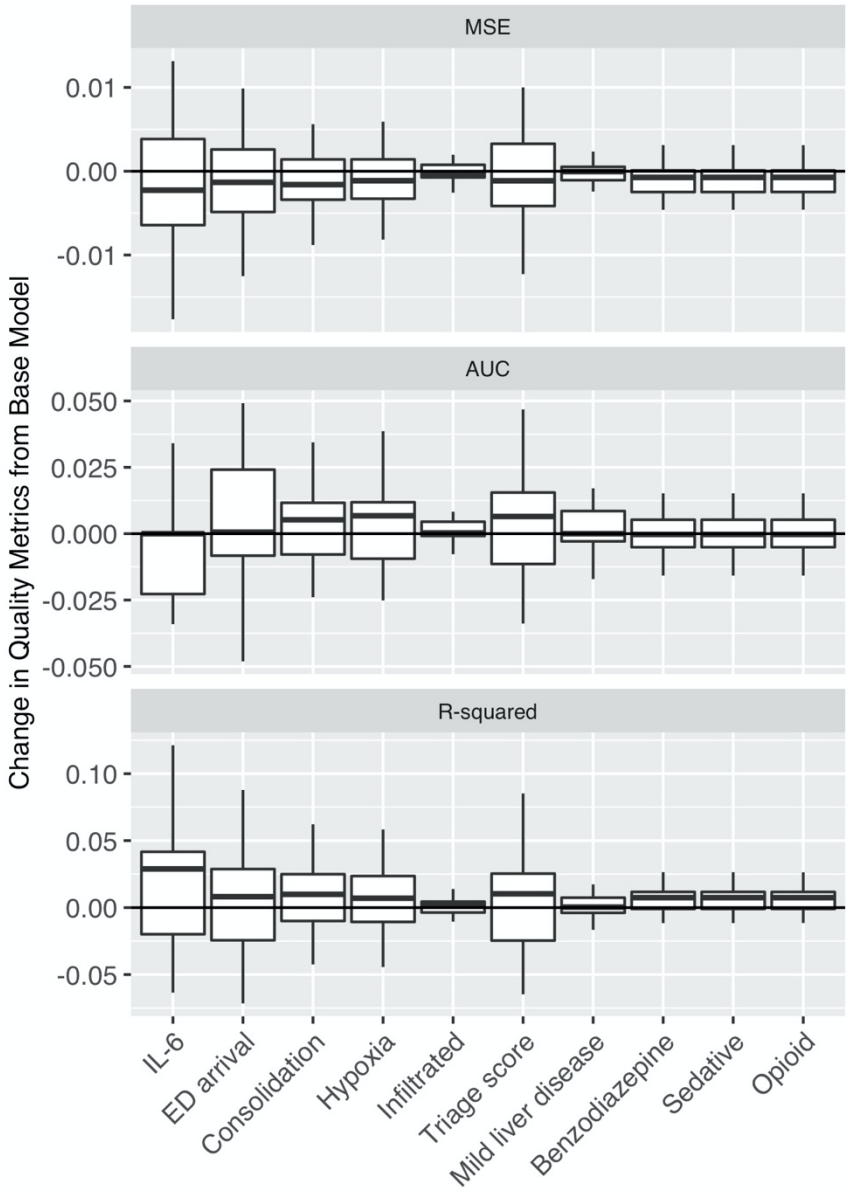
FORWARD SELECTION STEP 4

Base Model: Mortality ~ Age + Respiratory Rate + Pulse Oximetry + Heart Rate + Creatinine + Hospital

(i)



(ii)



(iii)

		Change from Base Model Mortality ~ Age + Respiratory Rate + Pulse Oximetry + Heart Rate + Creatinine + Hospital		
Variable	**N**	**MSE**	**AUC$^{(w)}$**	**R-squared**
Highest interleukin 6 (IL-6)	129	-0.003	-0.015	0.017
ED arrival	1582	-0.001	0.004	0.008
Consolidation on chest x-ray	1609	-0.001	0.005	0.007
Hypoxia	1687	-0.001	0.005	0.006
New or worsening infiltrates on chest-xray	1609	-0.001	0.003	0.004
Triage score	1434	-0.001	0.004	0.004
Mild liver disease	1687	-0.001	0.002	0.004
Previously treated by a benzodiazepine	1687	-0.001	-0.001	0.004
Previoiusly treated by a sedative	1687	-0.001	-0.001	0.004
Previoiusly treated by an opioid	1687	-0.001	-0.001	0.004

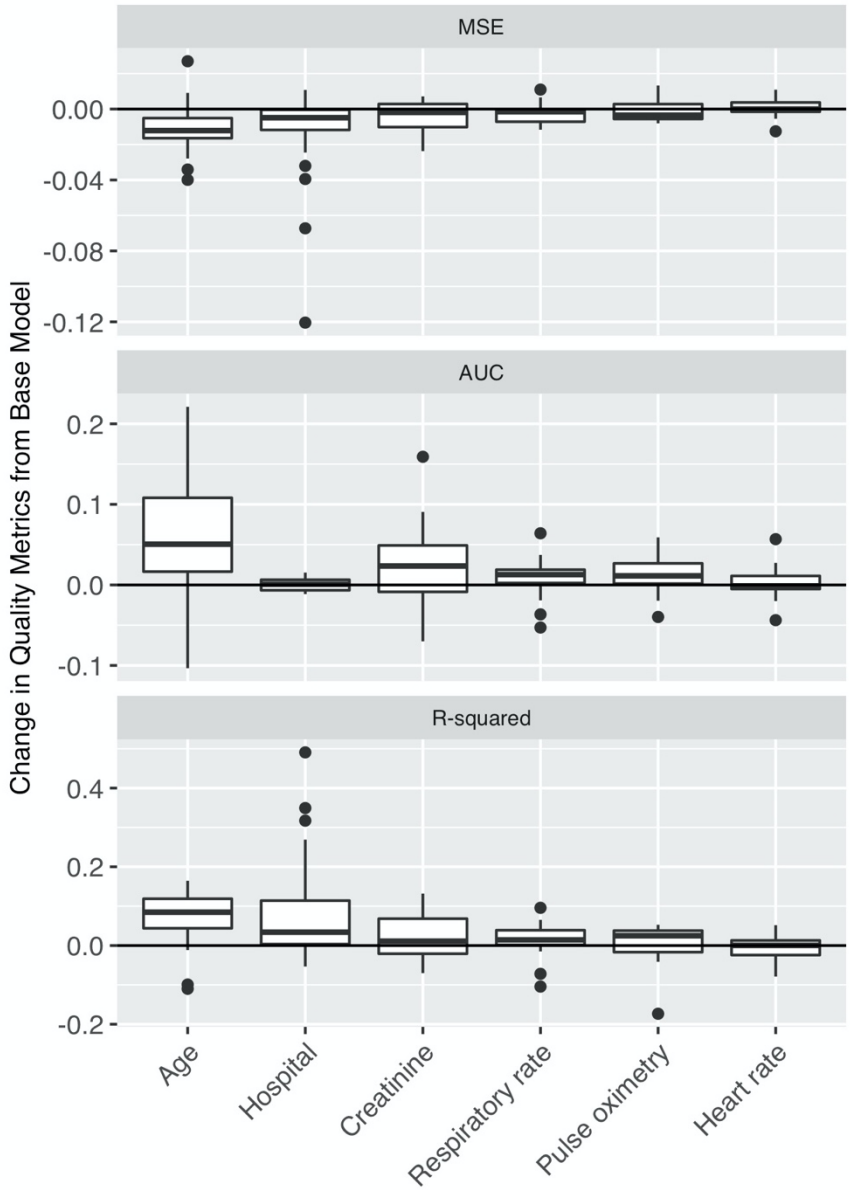
eFigure 3d: Change in quality metrics for top 10 variables with most improved MSE when added to base model of in-hospital mortality from COVID-19 on patient's age, respiratory rate on presentation, pulse oximetry on presentation, heart rate on presentation, creatinine on presentation, and hospital COVID-19 mortality rate. (i) Histograms of change in MSE, AUC$^{(w)}$ and R-squared for all 20 hospitals in the derivation set. (ii) Histograms of change in MSE, AUC$^{(w)}$ and R-squared for all 20 hospitals in the derivation set with outliers removed. (iii) Change in quality metrics for all derivation hospitals combined.

Based on these results, we did not include any further variables in the model. Th IL-6 lab values again were available for very few patients. After that, none of the other variables improved MSE, AUC$^{(w)}$, or R-squared overall enough to warrant inclusion (iii).

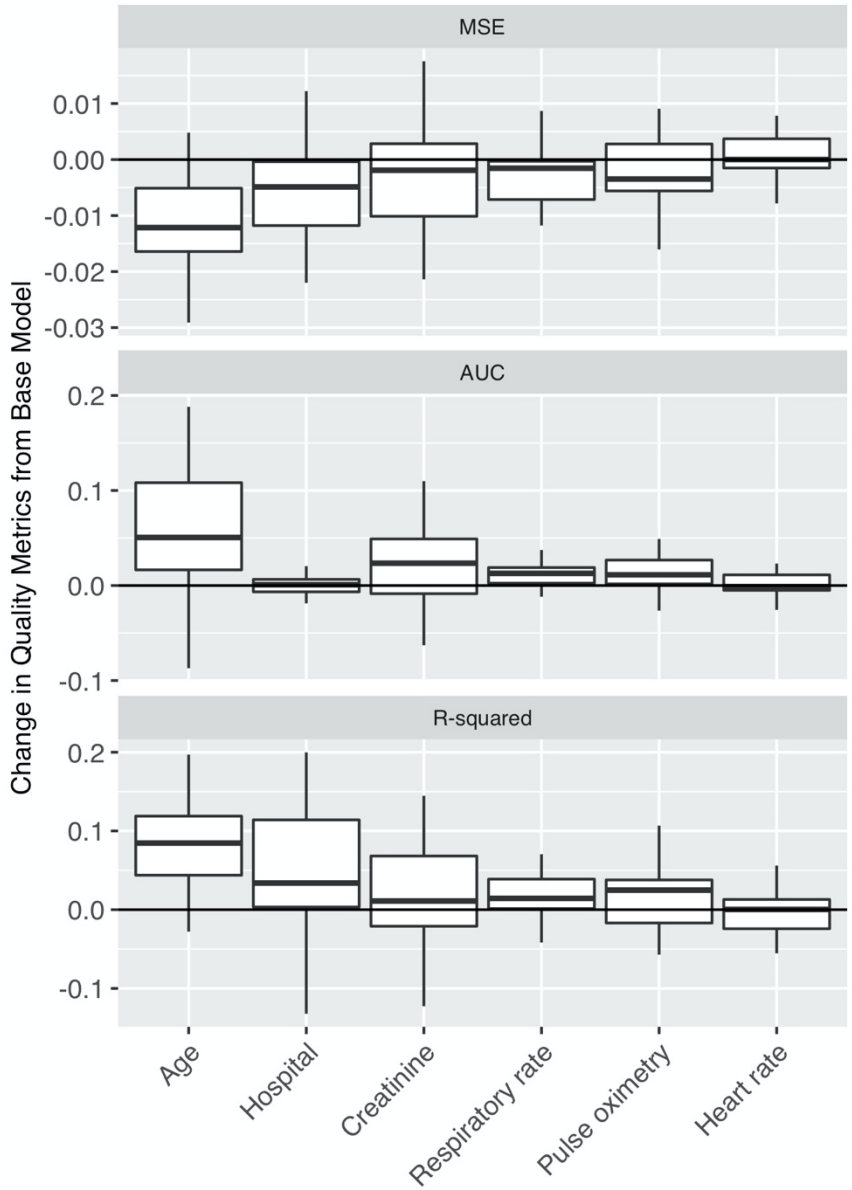
BACKWARD SELECTION STEP 1

Base Model: Mortality ~ Age + Respiratory Rate + Pulse Oximetry + Heart Rate + Creatinine + Hospital

(i)



(ii)



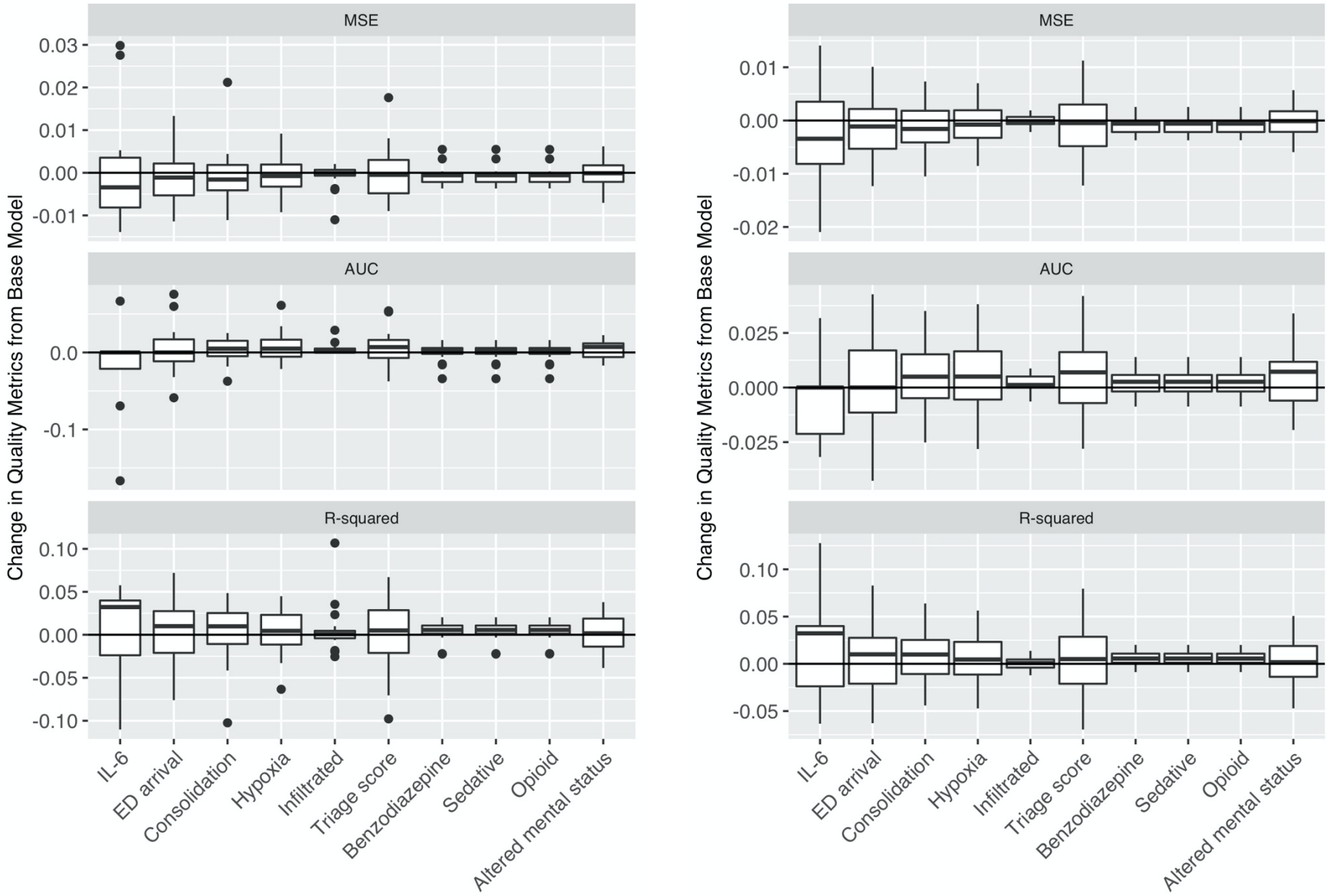
eFigure 3e: Change in quality metrics for backward selection when removed from base model of in-hospital mortality from COVID-19 on patient's age, respiratory rate on presentation, pulse oximetry on presentation, heart rate on presentation, creatinine on presentation, and hospital COVID-19 mortality rate. (i) Histograms of change in MSE, $AUC^{(w)}$ and R-squared for all 20 hospitals in the derivation set. (ii) Histograms of change in MSE, $AUC^{(w)}$ and R-squared for all 20 hospitals in the derivation set with outliers removed.

Based on these results, we decided to remove heart rate on presentation from the model because removing it from the model actually consistently improved MSE and R-squared across individual hospitals (i and ii). All other variables were kept in the model, because removing them from the model hurt the quality metrics across individual hospitals.

FORWARD SELECTION STEP 5

Base Model: Mortality ~ Age + Respiratory Rate + Pulse Oximetry + Creatinine + Hospital

(i) (ii)



(iii)

		Change from Base Model Mortality ~ Age + Respiratory Rate + Pulse Oximetry + Creatinine + Hospital		
Variable	**N**	**MSE**	**AUC$^{(w)}$**	**R-squared**
Highest interleukin 6 (IL-6)	130	-0.004	-0.017	0.021
ED arrival	1585	-0.001	0.004	0.009
Consolidation on chest x-ray	1611	-0.001	0.004	0.006
Hypoxia	1690	-0.001	0.008	0.005
New or worsening infiltrates on chest-xray	1611	-0.001	0.004	0.004
Triage score	1437	-0.001	0.007	0.004
Previously treated by a benzodiazepine	1690	-0.001	<0.001	0.003
Previoiusly treated by a sedative	1690	-0.001	<0.001	0.003
Previoiusly treated by an opioid	1690	-0.001	<0.001	0.003
Altered mental status	1690	<0.001	0.004	0.003

eFigure 3f: Change in quality metrics for top 10 variables with most improved MSE when added to base model of in-hospital mortality from COVID-19 on patient's age, respiratory rate on presentation, pulse oximetry on presentation, creatinine on presentation, and hospital COVID-19 mortality rate. (i) Histograms of change in MSE, AUC$^{(w)}$ and R-squared for all 20 hospitals in the derivation set. (ii) Histograms of change in MSE, AUC$^{(w)}$ and R-squared for all 20 hospitals in the derivation set with outliers removed. (iii) Change in quality metrics for all derivation hospitals combined.

Based on these results, we did not include any further variables in the model. The IL-6 lab values again were available for very few patients. After that, none of the other variables improved MSE, AUC$^{(w)}$, or R-squared overall enough to warrant inclusion (iii).