

Supplementary materials

Supplemental Digital Contents:

- **Description of the matching process**
- **Plots and tables to compare the absolute standardized mean difference and statistics of covariate balance between the unweighted and weighted results.**
- **Missing data analysis**
- **Statistical package code for weighting and matching**

Matching process

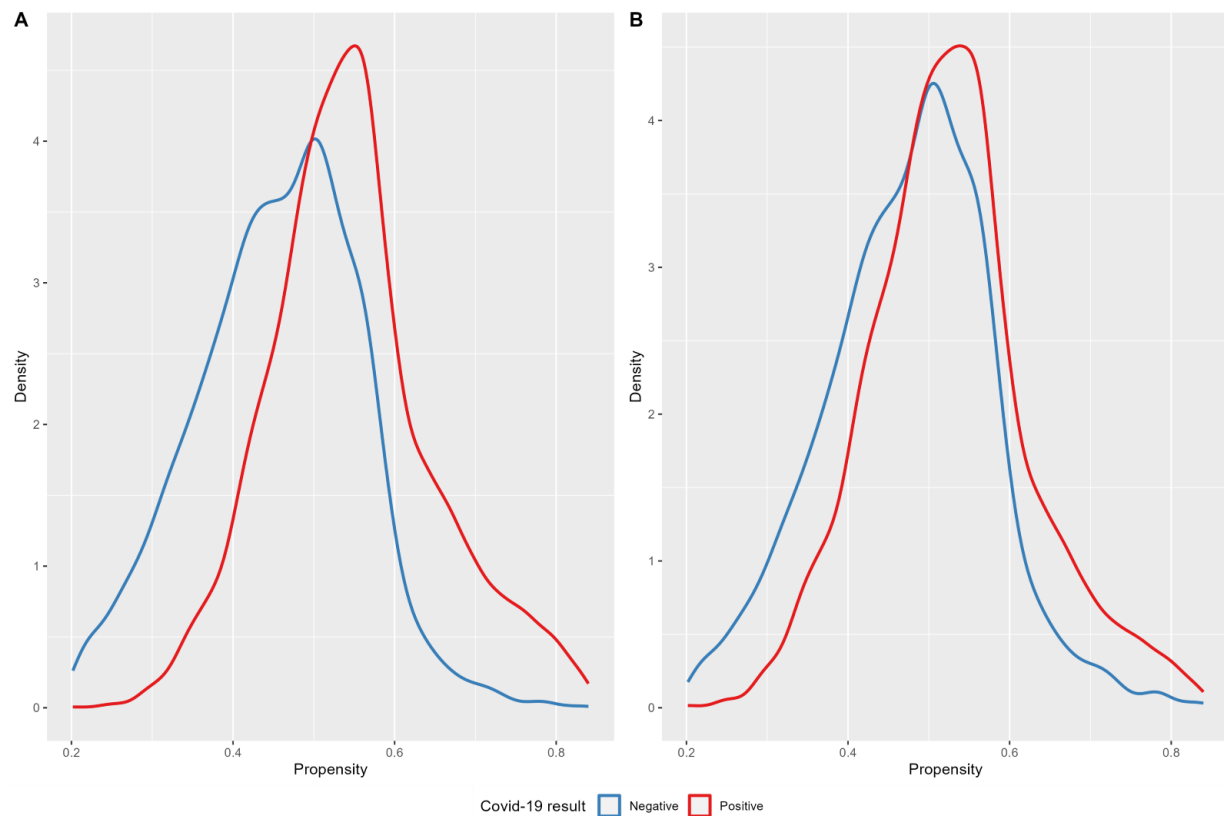
Prior to inverse probability weighting (IPW), we matched without replacement a cohort of patients with a negative Covid-19 diagnosis to a similar cohort of positive patients. Specifically, we used age **decile**, **race**, gender, **ASA classification**, solid tumor (without metastasis), and institution as our matching variables. 1:1 exact matching was used to create subclasses containing a positive-negative pair of patients who shared similar general characteristics. This process was repeated to create a matched cohort for the sensitivity analysis.

Propensity score — Inverse probability of treatment weighting

After initial matching, propensity scores (PS) were generated using a gradient boosted model from which the IPW was calculated. IPW has been shown to better balance baseline covariates while reducing patient exclusion while estimating the average treatment effect (ATE), compared with matching alone. Baseline covariates for the propensity score model included all prognostically important covariates. Balance was examined using the maximum absolute standard effect size between the COVID-19 exposure groups for each of the covariates. The weighted standard effect sizes were all close to 0 post-weighting. The density of the PSs between the positive and negative groups were also more similar after weighting. COVID-19

diagnosis was then added as the primary covariate in the model, with institution as a random effect. This process was repeated for each of the three outcomes (mortality, pulmonary complication, and AKI), and for each of the sensitivity analyses using an historical cohort. The results were similar to those of the primary analysis.

Supplement Digital Content 1. Mortality — Propensity scores



Supplemental Figure 1. Density plots of propensity scores unweighted (A) and weighted (B). The distribution of the propensity scores between patients diagnosed with Covid-19 (red) and those without known prior diagnosis (blue) were different in the unweighted sample, but more similar in the IPW-weighted sample.

Supplemental Table 1: Covariate Balance Mortality Outcome

Covariate Balance: Mortality (n = 4951)					
Covariate: Demographics	No. of Categories	Imbalance unweighted^a	X2 p-value unweighted^b	Imbalance weighted^c	X2 p-value weighted^d
ASA Class	4	0	1	0.002	0.999
Age	10	0	1	0.006	1
BMI Classification	6	0.082	0	0.022	0.873
Gender	2	0	1	0.008	0.685
Race	8	0	1	0.004	1
Covariate: Comorbidities	No. of Categories	Imbalance unweighted	X2 p-value unweighted	Imbalance weighted	X2 p-value weighted
AIDS HIV	2	0.02	0.296	0.006	0.729
Alcohol Abuse	2	0.031	0.107	0.012	0.487
Blood Loss Anemia	2	0.006	0.773	0.004	0.814
Cardiac Arrhythmia	2	0.038	0.049	0.014	0.485
Chronic Pulmonary Disease	2	0.053	0.006	0.007	0.725
Coagulopathy	2	0.1	0	0.024	0.21
Congestive Heart Failure	2	0.041	0.035	0.01	0.608
Depression	2	0.018	0.359	0.003	0.884
Diabetes with Complications	2	0.042	0.032	0.014	0.454
Diabetes without Complications	2	0.06	0.002	0.013	0.519
Drug Abuse	2	0.079	0	0.02	0.284
Fluid and Electrolyte Disorders	2	0.125	0	0.023	0.237
Hypertension with Complications	2	0.004	0.834	0.001	0.939
Hypertension without Complications	2	0.013	0.519	0.001	0.954
Hypothyroidism	2	0.01	0.602	0	0.988
Iron-Deficiency Anemia	2	0.042	0.033	0.011	0.583
Liver Disease	2	0.018	0.365	0.006	0.746
Lymphoma	2	0.017	0.37	0.008	0.617
Metastatic Cancer	2	0.005	0.801	0.003	0.886
Obesity	2	0.091	0	0.019	0.337
Other Neurological Disorders	2	0.087	0	0.019	0.319

Paralysis	2	0.025	0.202	0.009	0.602
Peptic Ulcer Disease Excluding Bleeding	2	0.014	0.459	0.003	0.871
Peripheral Vascular Disorders	2	0.011	0.57	0	0.998
Psychoses	2	0.025	0.202	0.009	0.602
Pulmonary Circulation Disorders	2	0.004	0.838	0	0.988
Renal Failure	2	0.019	0.323	0.002	0.898
Rheumatoid Arthritis Collagen	2	0.033	0.087	0.006	0.771
Solid Tumor without Metastasis	2	0	1	0.005	0.801
Valvular Disease	2	0.096	0	0.02	0.3
Weight Loss	2	0.073	0	0.016	0.391
Covariate: Procedure	No. of Categories	Imbalance unweighted	X2 p-value unweighted	Imbalance weighted	X2 p-value weighted
Body Region	19	0.122	0	0.028	0.998

^aValues represent the maximum absolute standard effect size prior to IPW

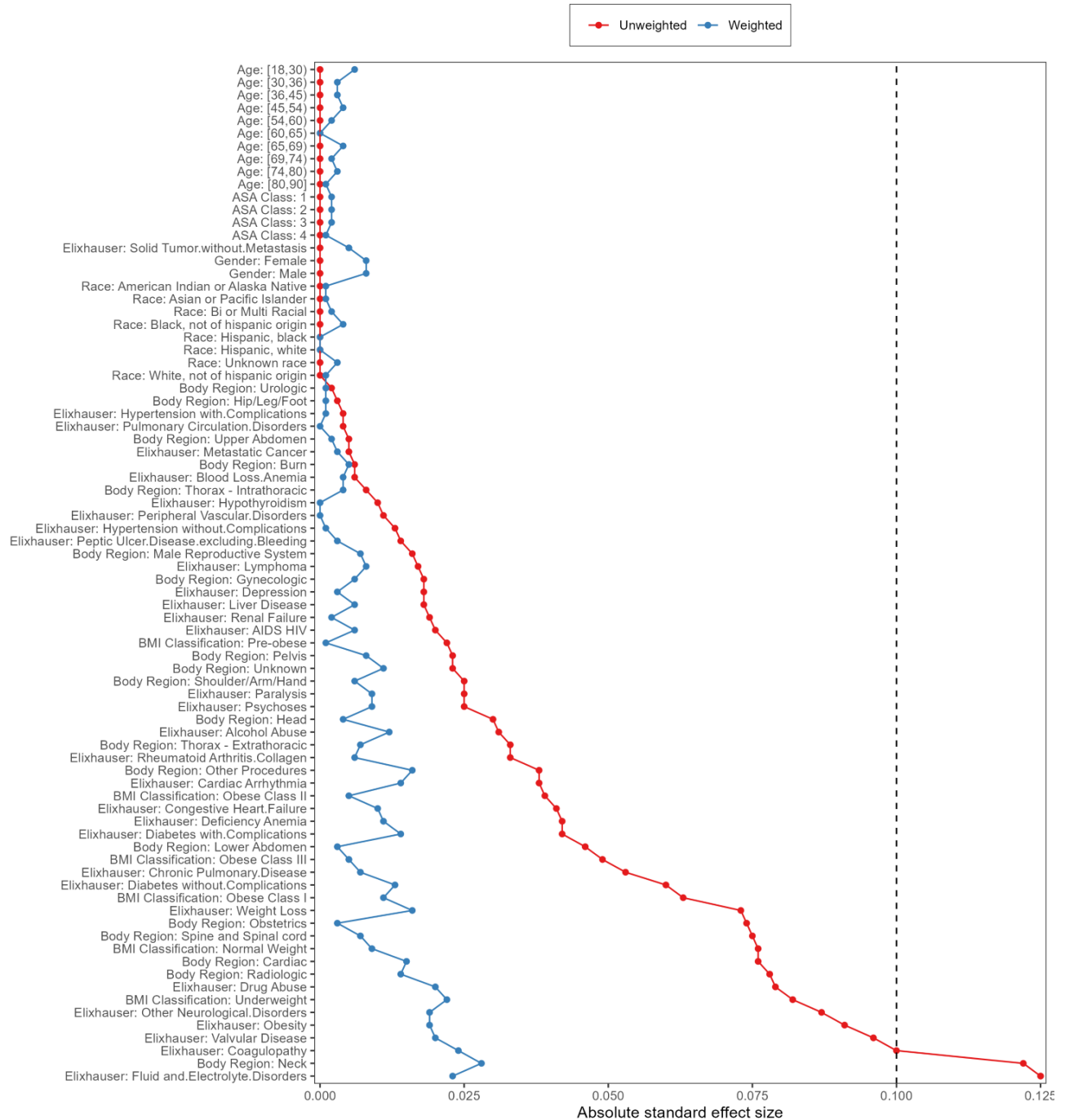
^bValues represent the X² p-value prior to IPW

^cValues represent the maximum absolute standard effect size after IPW

^dValues represent the X² p-value after IPW

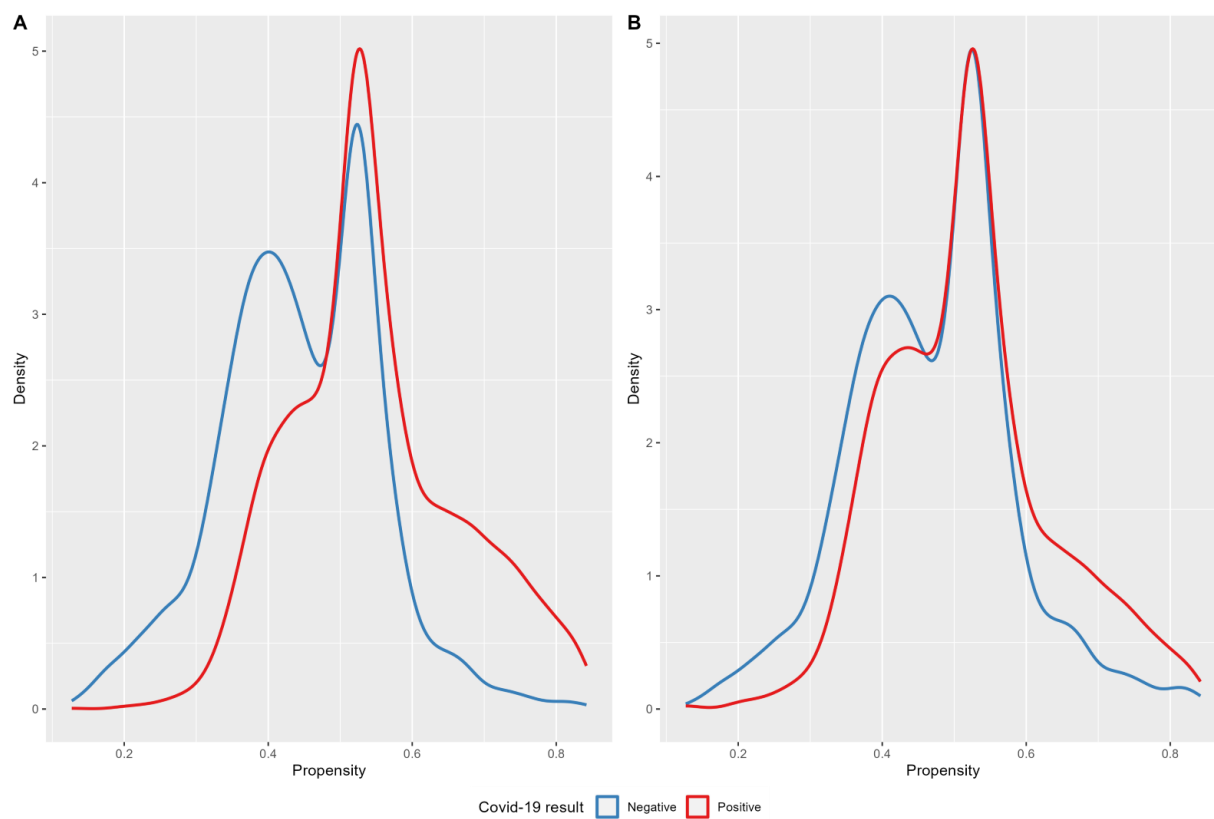
Supplemental Figure 1.2

Mortality covariate balance



Balance of individual covariates in the primary analysis of mortality in the unweighted and weighted samples

Supplement Digital Content 2. Mortality (sensitivity) — Propensity scores



Supplemental Figure 2. Density plots of propensity scores unweighted (A) and weighted (B) from the sensitivity (historical) analysis.

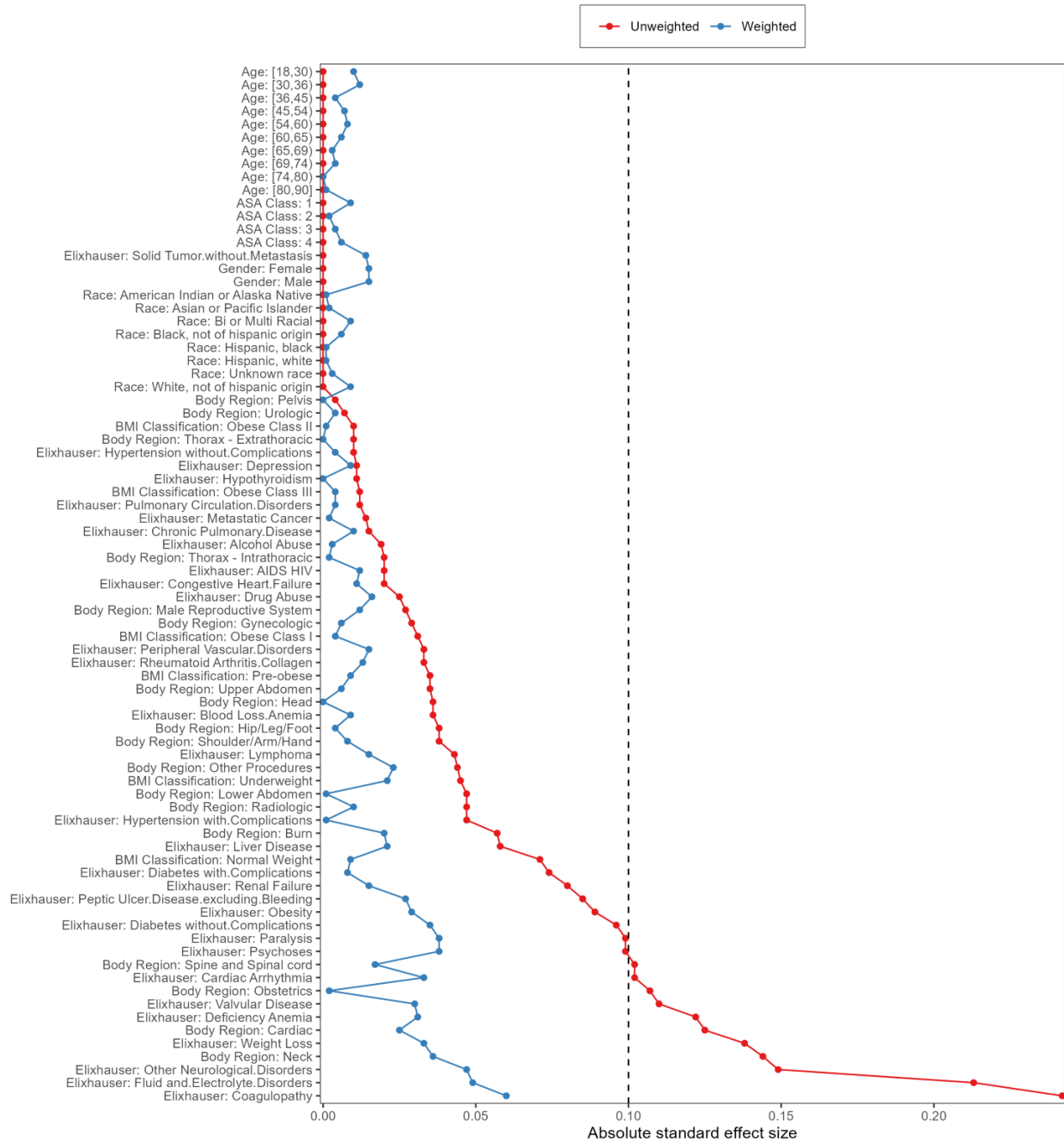
Supplemental Table 2: Covariate Balance Mortality Sensitivity Outcome

Covariate Balance: Mortality (Sensitivity) (n = 3473)					
Covariate: Demographics	No. of Categories	Imbalance unweighted	X2 p-value unweighted	Imbalance weighted	X2 p-value weighted
ASA Class	4	0	1	0.009	0.974
Age	10	0	1	0.012	1
BMI Classification	6	0.071	0.013	0.021	0.954
Gender	2	0	1	0.015	0.521
Race	8	0	1	0.009	1
Covariate: Comorbidities	No. of Categories	Imbalance unweighted	X2 p-value unweighted	Imbalance weighted	X2 p-value weighted
AIDS HIV	2	0.02	0.383	0.012	0.576
Alcohol Abuse	2	0.019	0.417	0.003	0.88
Blood Loss Anemia	2	0.036	0.12	0.009	0.676
Cardiac Arrhythmia	2	0.102	0	0.033	0.167
Chronic Pulmonary Disease	2	0.015	0.531	0.01	0.685
Coagulopathy	2	0.242	0	0.06	0.01
Congestive Heart Failure	2	0.02	0.397	0.011	0.625
Depression	2	0.011	0.642	0.009	0.702
Diabetes with Complications	2	0.074	0.001	0.008	0.723
Diabetes without Complications	2	0.096	0	0.035	0.136
Drug Abuse	2	0.025	0.291	0.016	0.473
Fluid and Electrolyte Disorders	2	0.213	0	0.049	0.036
Hypertension with Complications	2	0.047	0.042	0.001	0.955
Hypertension without Complications	2	0.01	0.682	0.004	0.853
Hypothyroidism	2	0.011	0.623	0	0.991
Iron-Deficiency Anemia	2	0.122	0	0.031	0.185
Liver Disease	2	0.058	0.013	0.021	0.357
Lymphoma	2	0.043	0.067	0.015	0.531
Metastatic Cancer	2	0.014	0.544	0.002	0.937
Obesity	2	0.089	0	0.029	0.226
Other Neurological Disorders	2	0.149	0	0.047	0.042

Paralysis	2	0.099	0	0.038	0.089
Peptic Ulcer Disease Excluding Bleeding	2	0.085	0	0.027	0.241
Peripheral Vascular Disorders	2	0.033	0.157	0.015	0.531
Psychoses	2	0.099	0	0.038	0.089
Pulmonary Circulation Disorders	2	0.012	0.603	0.004	0.868
Renal Failure	2	0.08	0.001	0.015	0.515
Rheumatoid Arthritis Collagen	2	0.033	0.162	0.013	0.569
Solid Tumor without Metastasis	2	0	1	0.014	0.567
Valvular Disease	2	0.11	0	0.03	0.203
Weight Loss	2	0.138	0	0.033	0.154
Covariate: Procedure	No. of Categories	Imbalance unweighted	X2 p-value unweighted	Imbalance weighted	X2 p-value weighted
Body Region	19	0.144	0	0.036	0.987

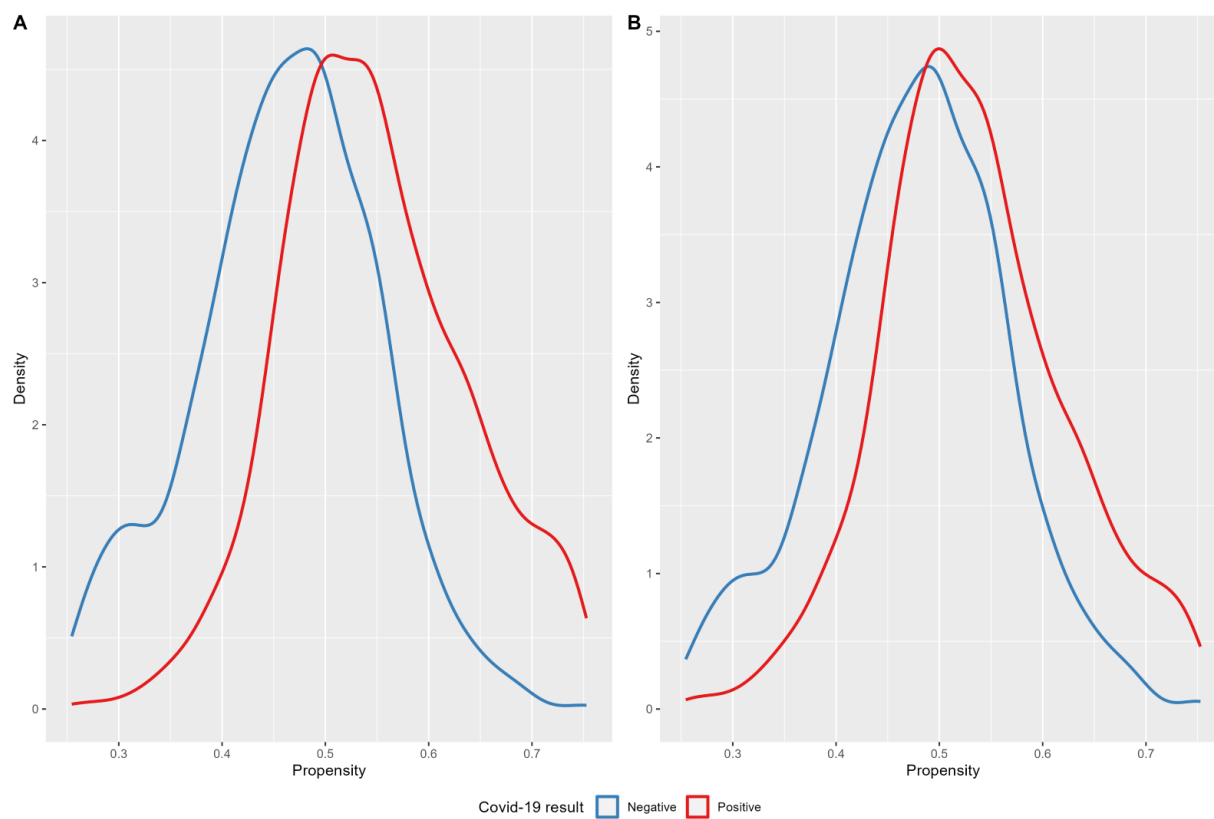
Supplemental Figure 2.2

Mortality covariate balance (Sensitivity)



Balance of individual covariates in the sensitivity (historical) analysis of mortality in the unweighted and weighted samples

Supplemental Digital Content 3. Pulmonary Complication — Propensity scores



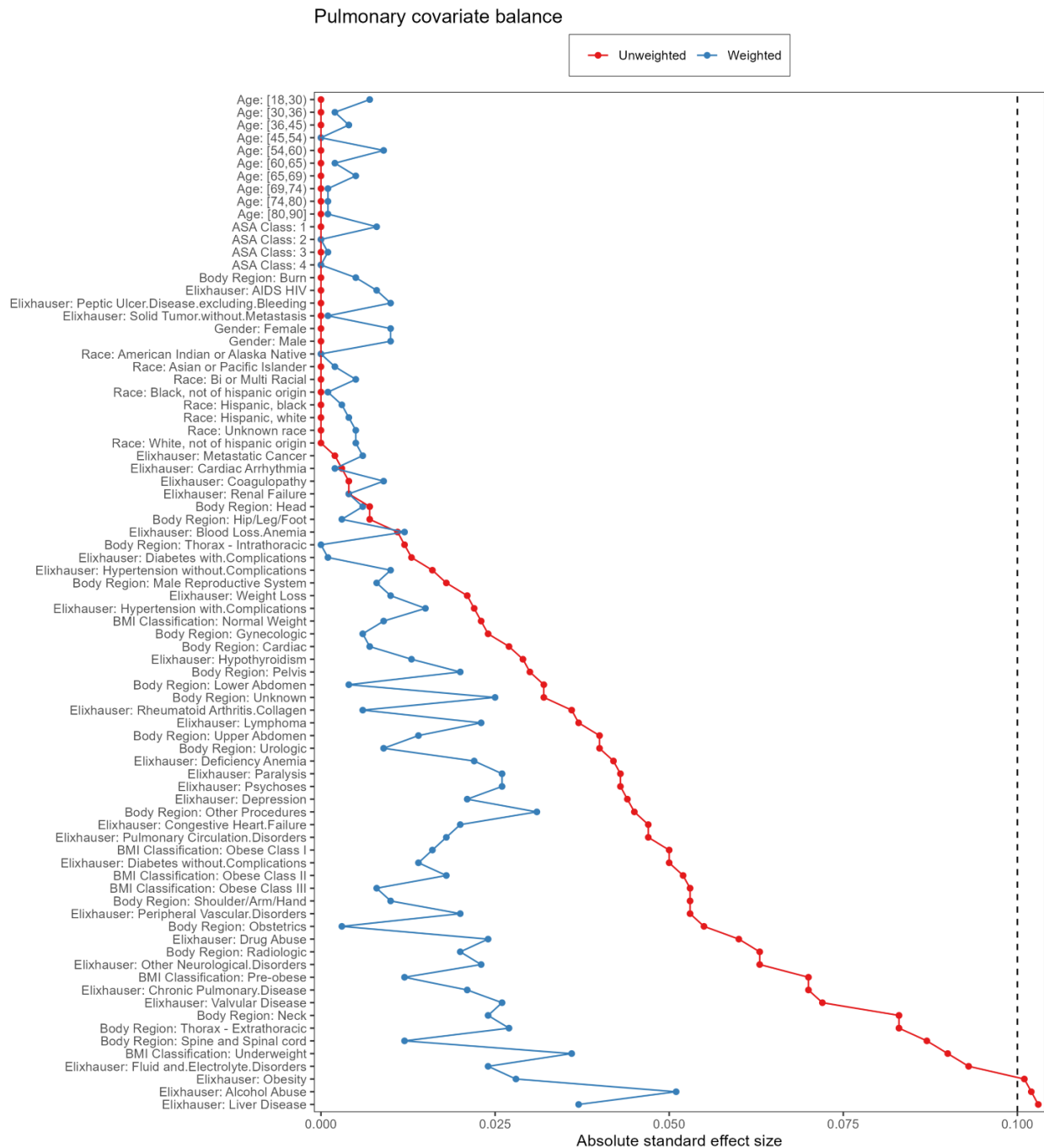
Supplemental Figure 3 Density plots of propensity scores unweighted (A) and weighted (B).

Supplemental Table 3: Covariate Balance: Pulmonary Outcome

Covariate Balance: Pulmonary (n = 1637)					
Covariate: Demographics	No. of Categories	Imbalance unweighted	X2 p-value unweighted	Imbalance weighted	X2 p-value weighted
ASA Class	4	0	1	0.008	0.996
Age	10	0	1	0.009	1
BMI Classification	6	0.09	0.002	0.036	0.835
Gender	2	0	1	0.01	0.764
Race	8	0	1	0.005	1
Covariate: Comorbidities	No. of Categories	Imbalance unweighted	X2 p-value unweighted	Imbalance weighted	X2 p-value weighted
AIDS HIV	2	0	1	0.008	0.795
Alcohol Abuse	2	0.102	0.001	0.051	0.047
Blood Loss Anemia	2	0.011	0.717	0.012	0.685
Cardiac Arrhythmia	2	0.003	0.92	0.002	0.94
Chronic Pulmonary Disease	2	0.07	0.026	0.021	0.514
Coagulopathy	2	0.004	0.891	0.009	0.77
Congestive Heart Failure	2	0.047	0.14	0.02	0.516
Depression	2	0.044	0.163	0.021	0.515
Diabetes with Complications	2	0.013	0.669	0.001	0.965
Diabetes without Complications	2	0.05	0.113	0.014	0.666
Drug Abuse	2	0.06	0.058	0.024	0.443
Fluid and Electrolyte Disorders	2	0.093	0.003	0.024	0.441
Hypertension with Complications	2	0.022	0.482	0.015	0.631
Hypertension without Complications	2	0.016	0.611	0.01	0.744
Hypothyroidism	2	0.029	0.357	0.013	0.668
Iron-Deficiency Anemia	2	0.042	0.18	0.022	0.468
Liver Disease	2	0.103	0.001	0.037	0.229
Lymphoma	2	0.037	0.246	0.023	0.381
Metastatic Cancer	2	0.002	0.949	0.006	0.858
Obesity	2	0.101	0.001	0.028	0.375

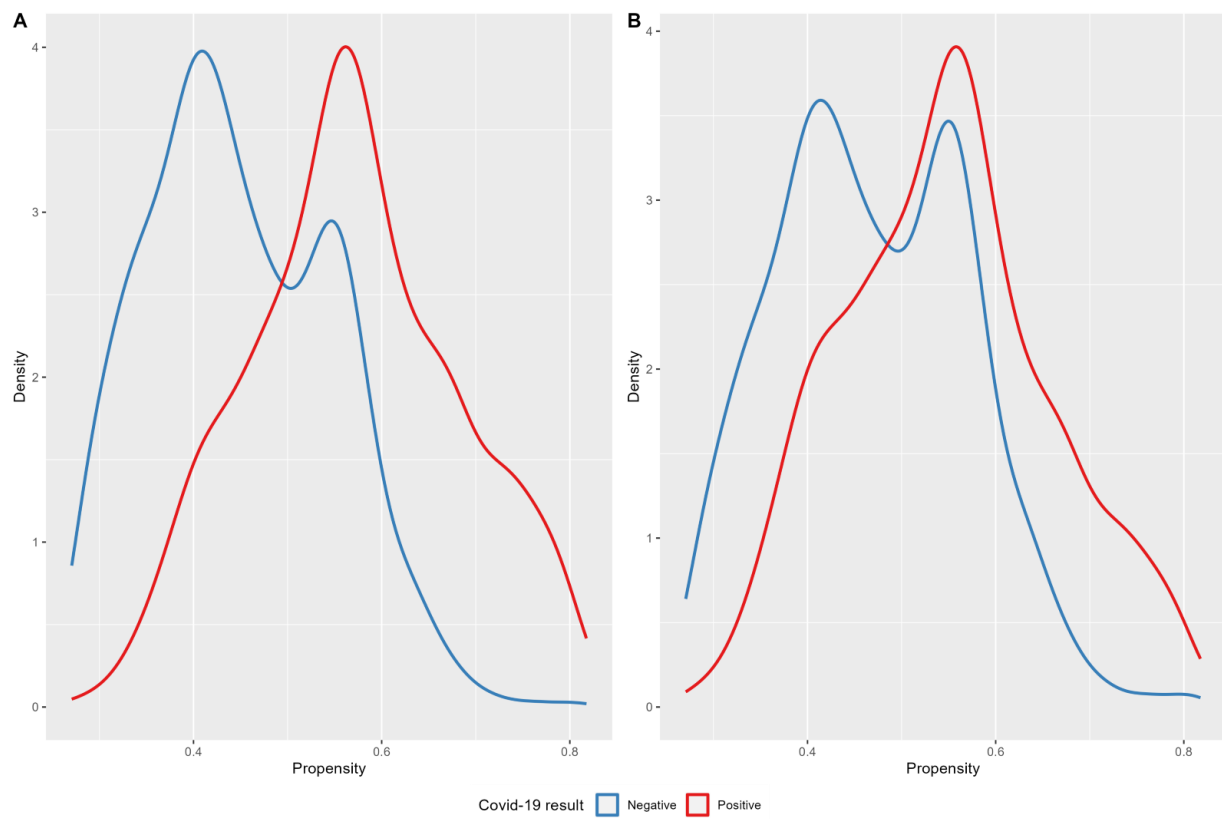
Other Neurological Disorders	2	0.063	0.045	0.023	0.453
Paralysis	2	0.043	0.169	0.026	0.363
Peptic Ulcer Disease Excluding Bleeding	2	0	1	0.01	0.733
Peripheral Vascular Disorders	2	0.053	0.093	0.02	0.504
Psychoses	2	0.043	0.169	0.026	0.363
Pulmonary Circulation Disorders	2	0.047	0.135	0.018	0.543
Renal Failure	2	0.004	0.91	0.004	0.907
Rheumatoid Arthritis Collagen	2	0.036	0.253	0.006	0.831
Solid Tumor without Metastasis	2	0	1	0.001	0.986
Valvular Disease	2	0.072	0.022	0.026	0.394
Weight Loss	2	0.021	0.501	0.01	0.74
Covariate: Procedure	No. of Categories	Imbalance unweighted	X2 p-value unweighted	Imbalance weighted	X2 p-value weighted
Body Region	19	0.087	0.003	0.031	0.998

Supplemental Figure 3.2.



Balance of individual covariates in the primary analysis of pulmonary complications in the unweighted and weighted sample

Supplement Digital Content 4. Pulmonary (sensitivity) — Propensity scores



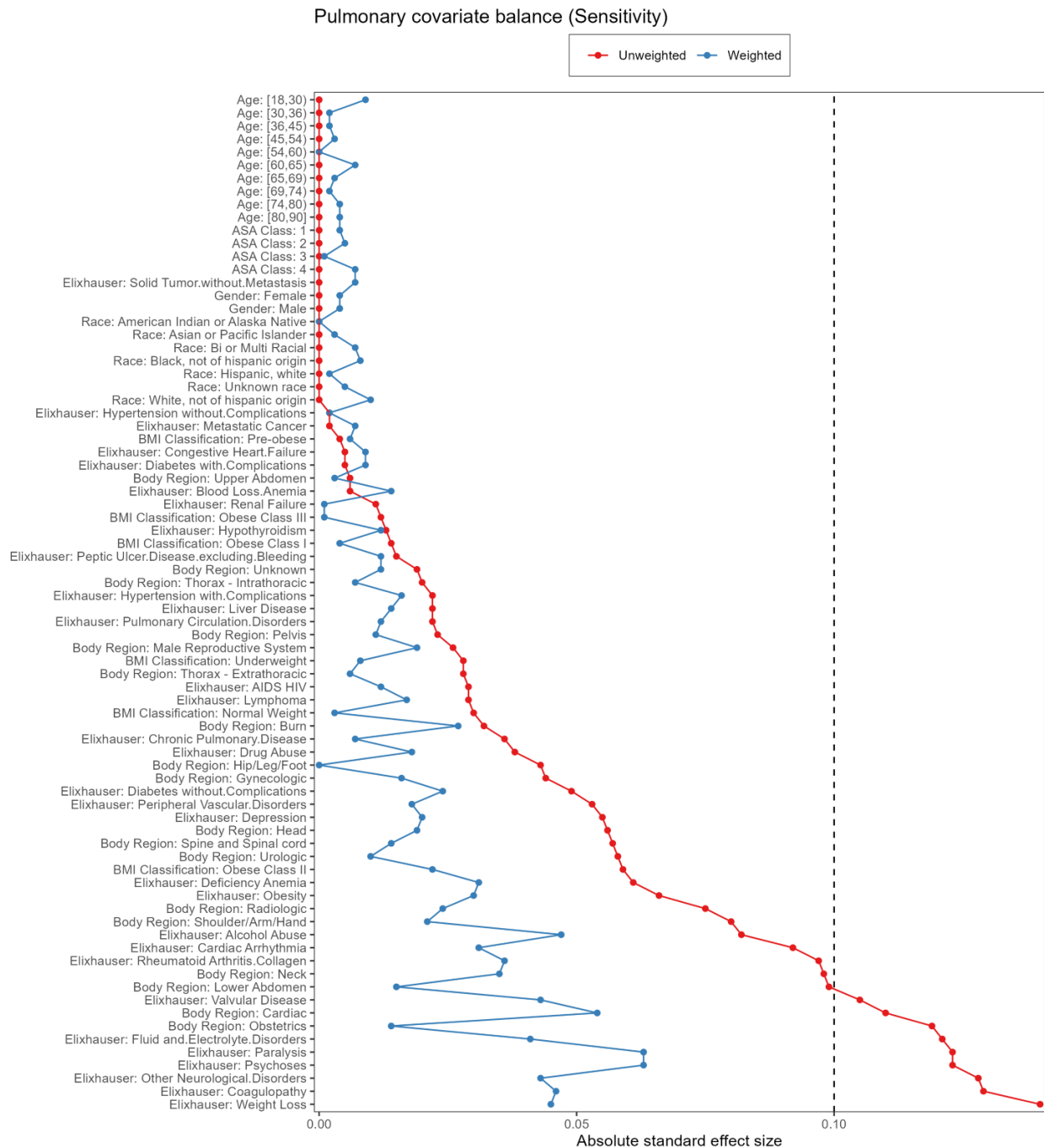
Supplemental Figure 4. Density plots of propensity scores unweighted (A) and weighted (B).

Supplemental Table 4: Covariate Balance Pulmonary Sensitivity Outcome

Covariate Balance: Pulmonary (Sensitivity) (n = 1516)					
Covariate: Demographics	No. of Categories	Imbalance unweighted	X2 p-value unweighted	Imbalance weighted	X2 p-value weighted
ASA Class	4	0	1	0.007	0.995
Age	10	0	1	0.009	1
BMI Classification	6	0.059	0.467	0.022	0.991
Gender	2	0	1	0.004	0.909
Race	8	0	1	0.01	1
Covariate: Comorbidities	No. of Categories	Imbalance unweighted	X2 p-value unweighted	Imbalance weighted	X2 p-value weighted
AIDS HIV	2	0.029	0.365	0.012	0.693
Alcohol Abuse	2	0.082	0.011	0.047	0.052
Blood Loss Anemia	2	0.006	0.859	0.014	0.657
Cardiac Arrhythmia	2	0.092	0.004	0.031	0.334
Chronic Pulmonary Disease	2	0.036	0.256	0.007	0.835
Coagulopathy	2	0.129	0	0.046	0.132
Congestive Heart Failure	2	0.005	0.875	0.009	0.788
Depression	2	0.055	0.084	0.02	0.537
Diabetes with Complications	2	0.005	0.888	0.009	0.778
Diabetes without Complications	2	0.049	0.124	0.024	0.458
Drug Abuse	2	0.038	0.232	0.018	0.57
Fluid and Electrolyte Disorders	2	0.121	0	0.041	0.21
Hypertension with Complications	2	0.022	0.5	0.016	0.621
Hypertension without Complications	2	0.002	0.948	0.002	0.957
Hypothyroidism	2	0.013	0.685	0.012	0.696
Iron-Deficiency Anemia	2	0.061	0.056	0.031	0.309
Liver Disease	2	0.022	0.488	0.014	0.648
Lymphoma	2	0.029	0.374	0.017	0.571
Metastatic Cancer	2	0.002	0.95	0.007	0.832
Obesity	2	0.066	0.039	0.03	0.352

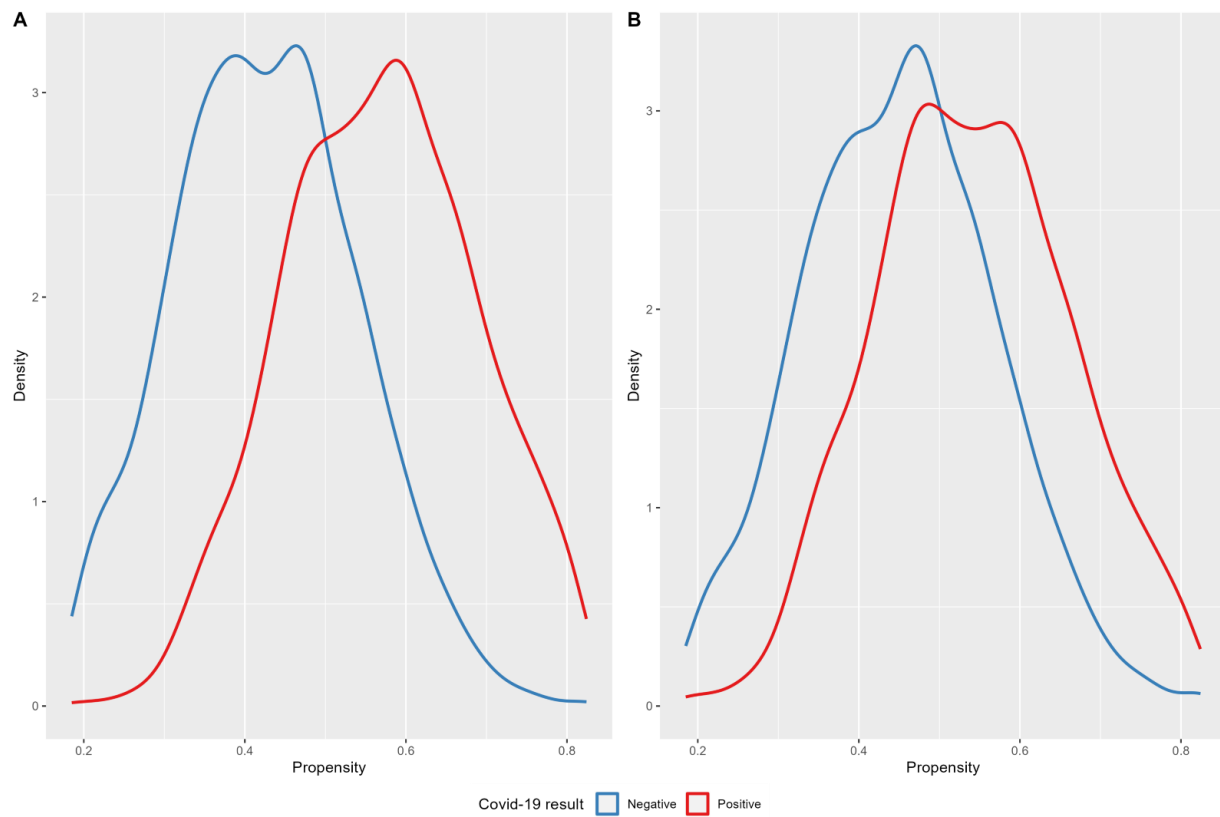
Other Neurological Disorders	2	0.128	0	0.043	0.181
Paralysis	2	0.123	0	0.063	0.026
Peptic Ulcer Disease Excluding Bleeding	2	0.015	0.642	0.012	0.695
Peripheral Vascular Disorders	2	0.053	0.099	0.018	0.557
Psychoses	2	0.123	0	0.063	0.026
Pulmonary Circulation Disorders	2	0.022	0.484	0.012	0.688
Renal Failure	2	0.011	0.732	0.001	0.978
Rheumatoid Arthritis Collagen	2	0.097	0.002	0.036	0.262
Solid Tumor without Metastasis	2	0	1	0.007	0.836
Valvular Disease	2	0.105	0.001	0.043	0.163
Weight Loss	2	0.14	0	0.045	0.152
Covariate: Procedure	No. of Categories	Imbalance unweighted	X2 p-value unweighted	Imbalance weighted	X2 p-value weighted
Body Region	19	0.119	0	0.054	0.94

Supplemental Figure 4.2.



Balance of individual covariates in the sensitivity (historical) analysis of pulmonary complications in the unweighted and weighted samples

Supplement Digital Content 5. Acute kidney injury (AKI) — Propensity scores



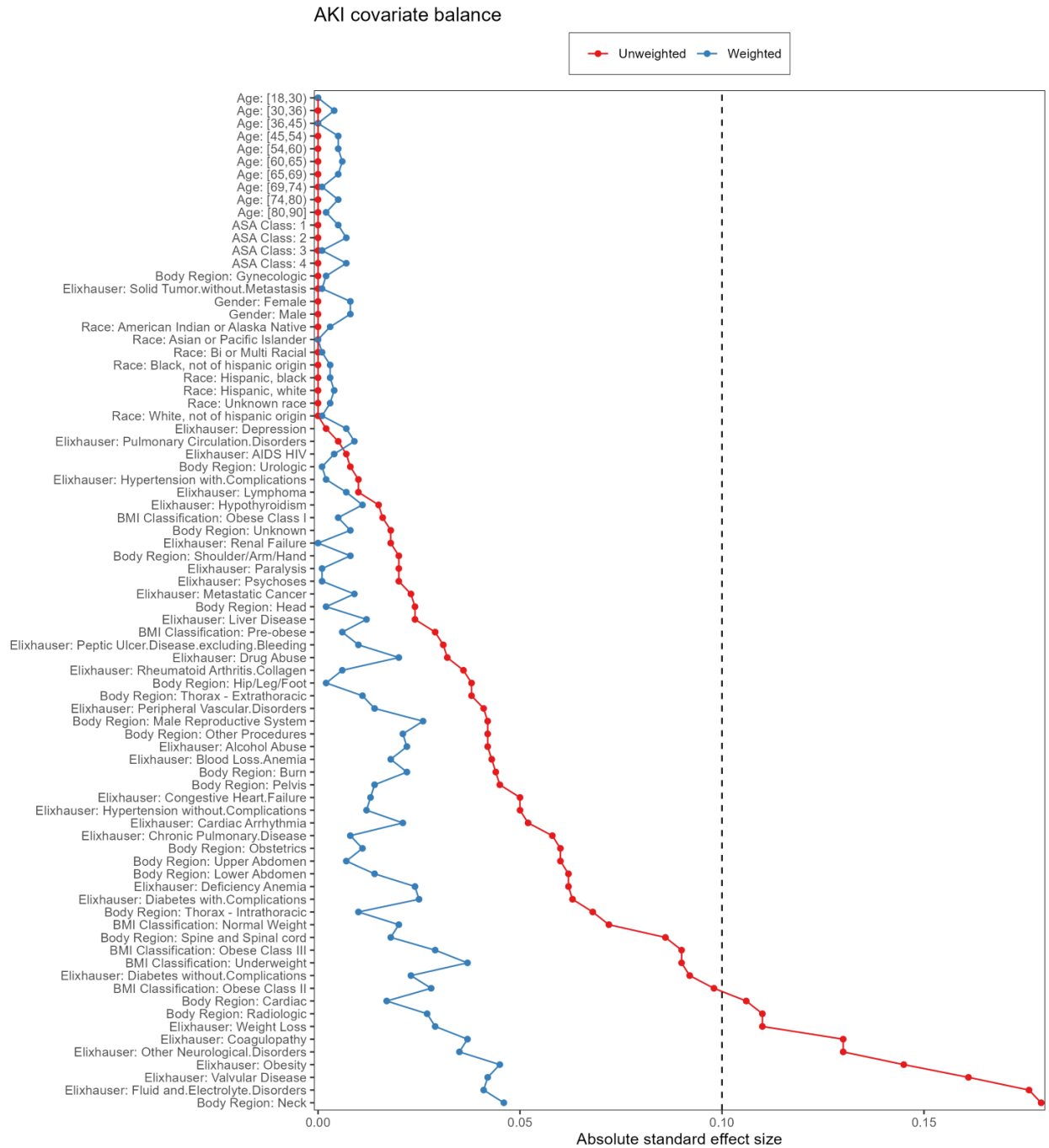
Supplemental Figure 5. Density plots of propensity scores unweighted (A) and weighted (B).

Supplemental Table 5: Covariate Balance AKI

Covariate Balance: AKI (n = 1814)					
Covariate: Demographics	No. of Categories	Imbalance unweighted	X2 p-value unweighted	Imbalance weighted	X2 p-value weighted
ASA Class	4	0	1	0.007	0.99
Age	10	0	1	0.006	1
BMI Classification	6	0.098	0	0.037	0.634
Gender	2	0	1	0.008	0.811
Race	8	0	1	0.004	1
Covariate: Comorbidities	No. of Categories	Imbalance unweighted	X2 p-value unweighted	Imbalance weighted	X2 p-value weighted
AIDS HIV	2	0.007	0.818	0.004	0.892
Alcohol Abuse	2	0.042	0.176	0.022	0.423
Blood Loss Anemia	2	0.043	0.161	0.018	0.519
Cardiac Arrhythmia	2	0.052	0.093	0.021	0.506
Chronic Pulmonary Disease	2	0.058	0.061	0.008	0.804
Coagulopathy	2	0.13	0	0.037	0.229
Congestive Heart Failure	2	0.05	0.108	0.013	0.691
Depression	2	0.002	0.94	0.007	0.824
Diabetes with Complications	2	0.063	0.042	0.025	0.415
Diabetes without Complications	2	0.092	0.003	0.023	0.47
Drug Abuse	2	0.032	0.3	0.02	0.504
Fluid and Electrolyte Disorders	2	0.176	0	0.041	0.197
Hypertension with Complications	2	0.01	0.737	0.002	0.96
Hypertension without Complications	2	0.05	0.107	0.012	0.716
Hypothyroidism	2	0.015	0.618	0.011	0.727
Iron-Deficiency Anemia	2	0.062	0.046	0.024	0.423
Liver Disease	2	0.024	0.443	0.012	0.706
Lymphoma	2	0.01	0.756	0.007	0.819
Metastatic Cancer	2	0.023	0.456	0.009	0.78
Obesity	2	0.145	0	0.045	0.156
Other Neurological Disorders	2	0.13	0	0.035	0.262

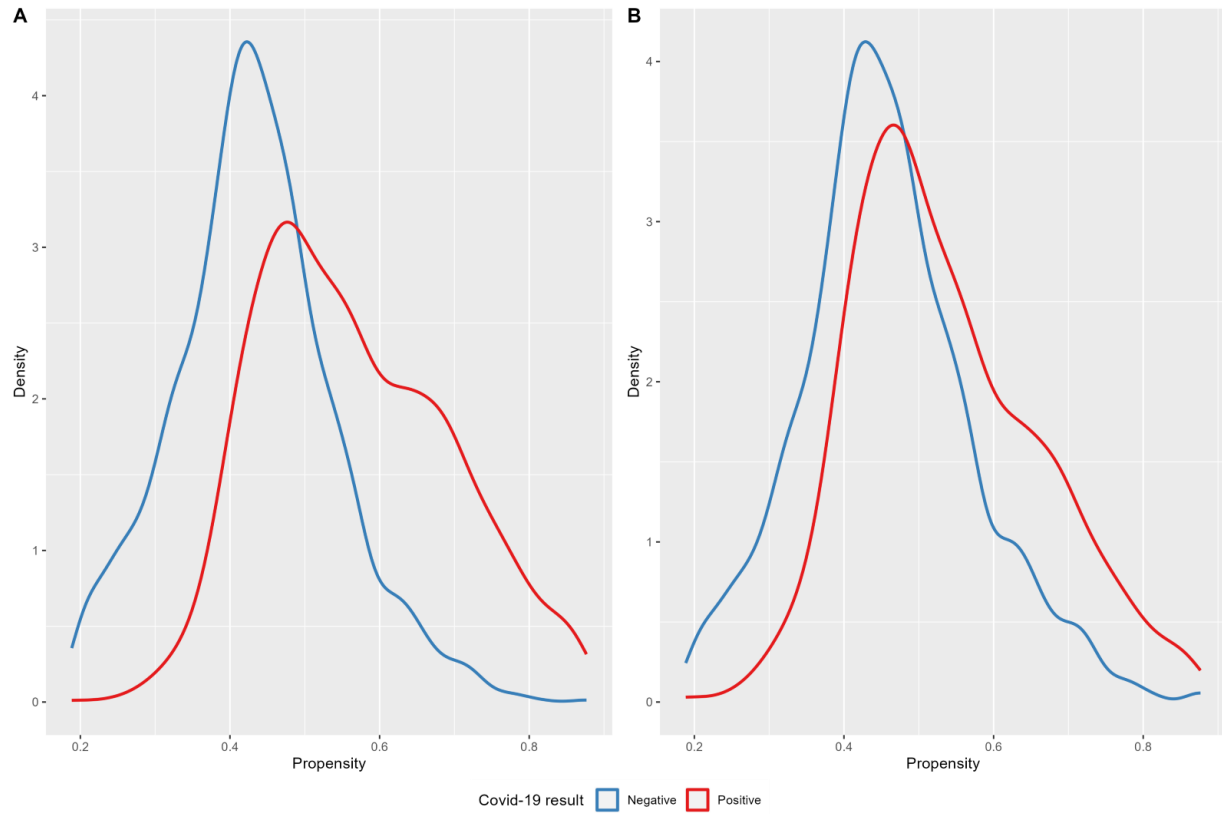
Paralysis	2	0.02	0.523	0.001	0.984
Peptic Ulcer Disease Excluding Bleeding	2	0.031	0.312	0.01	0.728
Peripheral Vascular Disorders	2	0.041	0.186	0.014	0.664
Psychoses	2	0.02	0.523	0.001	0.984
Pulmonary Circulation Disorders	2	0.005	0.867	0.009	0.768
Renal Failure	2	0.018	0.566	0	0.989
Rheumatoid Arthritis Collagen	2	0.036	0.242	0.006	0.846
Solid Tumor without Metastasis	2	0	1	0.001	0.967
Valvular Disease	2	0.161	0	0.042	0.188
Weight Loss	2	0.11	0	0.029	0.335
Covariate: Procedure	No. of Categories	Imbalance unweighted	X2 p-value unweighted	Imbalance weighted	X2 p-value weighted
Body Region	19	0.179	0	0.046	0.991

Supplemental Figure 5.2



Balance of individual covariates in the primary analysis of acute kidney injury in the unweighted and weighted samples

Supplement Digital Content 6. AKI (sensitivity) — Propensity scores



Supplemental Figure 6. Density plots of propensity scores unweighted (A) and weighted (B).

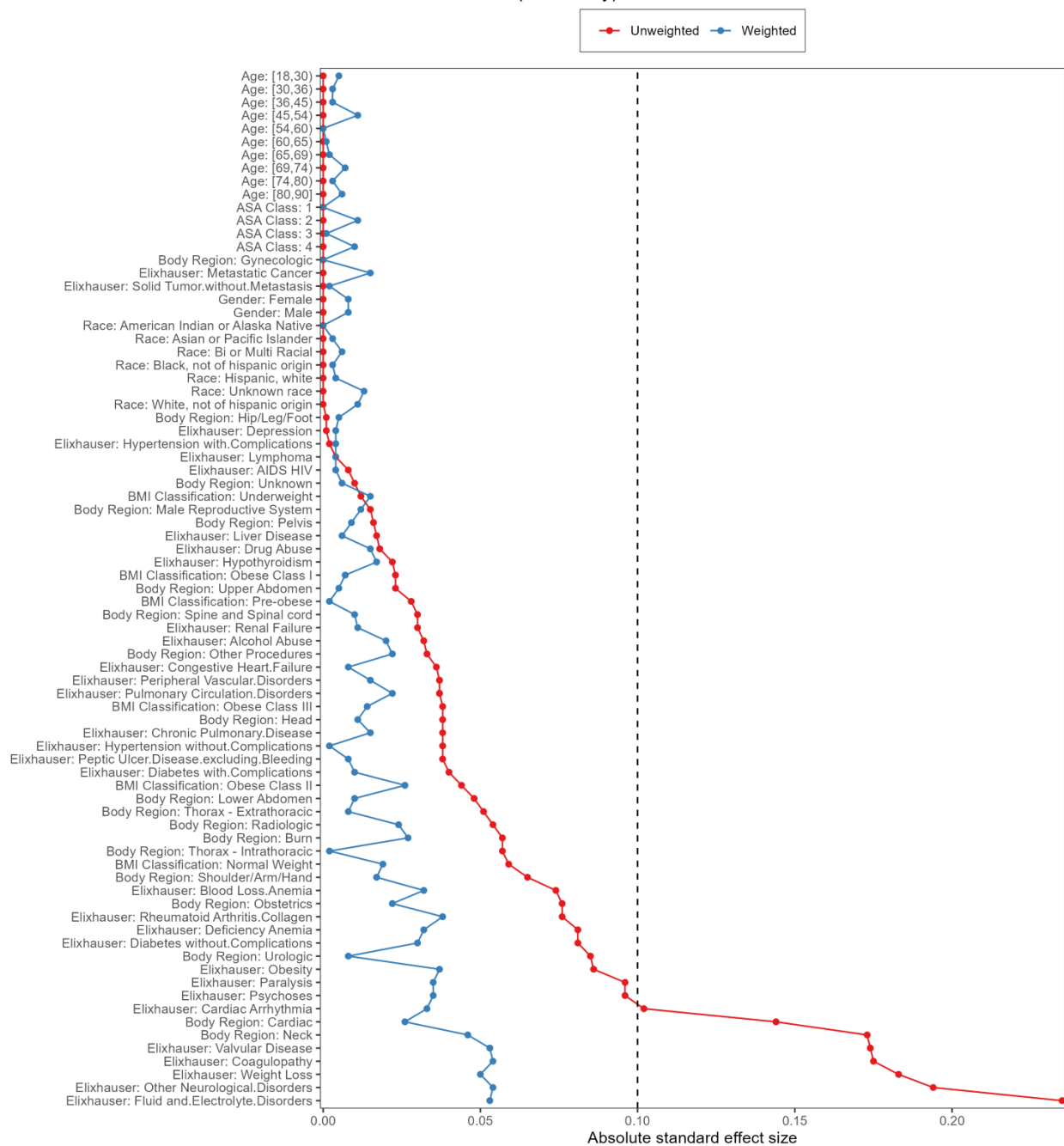
Supplemental Table 6: Covariate Balance AKI Sensitivity Outcome

Covariate Balance: AKI (Sensitivity) (n = 1621)					
Covariate: Demographics	No. of Categories	Imbalance unweighted	X2 p-value unweighted	Imbalance weighted	X2 p-value weighted
ASA Class	4	0	1	0.011	0.986
Age	10	0	1	0.011	1
BMI Classification	6	0.059	0.295	0.026	0.949
Gender	2	0	1	0.008	0.804
Race	8	0	1	0.013	1
Covariate: Comorbidities	No. of Categories	Imbalance unweighted	X2 p-value unweighted	Imbalance weighted	X2 p-value weighted
AIDS HIV	2	0.008	0.818	0.004	0.901
Alcohol Abuse	2	0.032	0.328	0.02	0.526
Blood Loss Anemia	2	0.074	0.025	0.032	0.301
Cardiac Arrhythmia	2	0.102	0.002	0.033	0.324
Chronic Pulmonary Disease	2	0.038	0.252	0.015	0.657
Coagulopathy	2	0.175	0	0.054	0.099
Congestive Heart Failure	2	0.036	0.279	0.008	0.804
Depression	2	0.001	0.968	0.004	0.904
Diabetes with Complications	2	0.04	0.232	0.01	0.766
Diabetes without Complications	2	0.081	0.015	0.03	0.368
Drug Abuse	2	0.018	0.579	0.015	0.641
Fluid and Electrolyte Disorders	2	0.235	0	0.053	0.121
Hypertension with Complications	2	0.002	0.943	0.004	0.895
Hypertension without Complications	2	0.038	0.247	0.002	0.964
Hypothyroidism	2	0.022	0.506	0.017	0.604
Iron-Deficiency Anemia	2	0.081	0.015	0.032	0.327
Liver Disease	2	0.017	0.603	0.006	0.843
Lymphoma	2	0.004	0.913	0.004	0.893
Metastatic Cancer	2	0	1	0.015	0.672
Obesity	2	0.086	0.01	0.037	0.27

Other Neurological Disorders	2	0.194	0	0.054	0.104
Paralysis	2	0.096	0.004	0.035	0.294
Peptic Ulcer Disease Excluding Bleeding	2	0.038	0.248	0.008	0.81
Peripheral Vascular Disorders	2	0.037	0.262	0.015	0.664
Psychoses	2	0.096	0.004	0.035	0.294
Pulmonary Circulation Disorders	2	0.037	0.259	0.022	0.515
Renal Failure	2	0.03	0.359	0.011	0.757
Rheumatoid Arthritis Collagen	2	0.076	0.022	0.038	0.252
Solid Tumor without Metastasis	2	0	1	0.002	0.957
Valvular Disease	2	0.174	0	0.053	0.115
Weight Loss	2	0.183	0	0.05	0.131
Covariate: Procedure	No. of Categories	Imbalance unweighted	X2 p-value unweighted	Imbalance weighted	X2 p-value weighted
Body Region	19	0.173	0	0.046	0.996

Supplemental Figure 6.2

AKI covariate balance (Sensitivity)



Balance of individual covariates in the sensitivity (historical) analysis of acute kidney injury in the unweighted and weighted samples

Supplemental Table 7. Missing data analysis

Characteristic	Complete N = 241,347*	Missing, N = 16,219*	P-value†
Age			<0.001
(18,30)	26,802 (11%)	2,647 (16%)	
(30,36)	24,809 (10%)	2,182 (13%)	
(36,45)	24,756 (10%)	1,993 (12%)	
(45,54)	24,965 (10%)	1,608 (9.9%)	
(54,60)	24,099 (10.0%)	1,444 (8.9%)	
(60,65)	24,814 (10%)	1,382 (8.5%)	
(65,69)	21,395 (8.9%)	1,211 (7.5%)	
(69,74)	25,280 (10%)	1,377 (8.5%)	
(74,80)	22,872 (9.5%)	1,248 (7.7%)	
(80,90)	21,555 (8.9%)	1,127 (6.9%)	
Race			<0.001
White, not of Hispanic origin	174,059 (72%)	11,770 (73%)	
Black, not of Hispanic origin	34,893 (14%)	1,671 (10%)	
Unknown race	18,012 (7.5%)	1,613 (9.9%)	
Hispanic, white	4,579 (1.9%)	388 (2.4%)	
Asian or Pacific Islander	8,030 (3.3%)	578 (3.6%)	
American Indian or Alaska Native	1,167 (0.5%)	163 (1.0%)	
Hispanic, black	432 (0.2%)	20 (0.1%)	
Bi or Multi Racial	175 (<0.1%)	16 (<0.1%)	
BMI Classification			<0.001
Underweight	6,713 (2.8%)	169 (2.6%)	
Obese Class III	24,783 (10%)	802 (12%)	
Pre-obese	71,476 (30%)	1,801 (27%)	
Obese Class I	51,251 (21%)	1,459 (22%)	
Normal Weight	58,955 (24%)	1,515 (23%)	
Obese Class II	28,169 (12%)	808 (12%)	
Unknown	0	9,665	
Gender			<0.001
Female	142,694 (59%)	9,915 (61%)	
Male	98,653 (41%)	6,304 (39%)	
ASA Class			<0.001
1	3,822 (1.6%)	495 (3.1%)	
2	76,911 (32%)	5,842 (36%)	
3	132,268 (55%)	8,016 (49%)	
4	28,346 (12%)	1,866 (12%)	
AIDS HIV	910 (0.4%)	53 (0.3%)	0.3
Alcohol Abuse	3,175 (1.3%)	160 (1.0%)	0.001

Characteristic	Complete N = 241,347*	Missing, N = 16,219*	P-value†
Unknown	0	347	
Blood Loss Anemia	5,783 (2.4%)	317 (2.0%)	<0.001
Cardiac Arrhythmia	67,762 (28%)	3,579 (23%)	<0.001
Unknown	0	347	
Chronic Pulmonary Disease	50,178 (21%)	3,005 (19%)	<0.001
Unknown	0	347	
Coagulopathy	22,984 (9.5%)	1,500 (9.5%)	0.8
Unknown	0	347	
Congestive Heart Failure	33,041 (14%)	1,901 (12%)	<0.001
Unknown	0	347	
Deficiency Anemia	16,445 (6.8%)	1,147 (7.2%)	0.048
Unknown	0	347	
Depression	43,767 (18%)	3,342 (21%)	<0.001
Unknown	0	347	
Diabetes with Complications	19,244 (8.0%)	1,190 (7.5%)	0.033
Unknown	0	347	
Diabetes without Complications	32,964 (14%)	2,175 (13%)	0.4
Drug Abuse	11,609 (4.8%)	883 (5.6%)	<0.001
Unknown	0	347	
Fluid and Electrolyte Disorders	58,896 (24%)	4,164 (26%)	<0.001
Unknown	0	347	
Hypertension with Complications	46,529 (19%)	2,645 (17%)	<0.001
Unknown	0	347	
Hypertension without Complications	97,811 (41%)	5,487 (35%)	<0.001
Unknown	0	347	
Hypothyroidism	32,421 (13%)	2,081 (13%)	0.3
Unknown	0	347	
Liver Disease	18,849 (7.8%)	1,140 (7.2%)	0.004
Unknown	0	347	
Lymphoma	3,558 (1.5%)	239 (1.5%)	0.8
Unknown	0	347	
Metastatic Cancer	21,112 (8.7%)	1,121 (7.1%)	<0.001
Unknown	0	347	
Obesity	59,667 (25%)	4,183 (26%)	<0.001
Unknown	0	347	
Other Neurological Disorders	24,252 (10%)	1,697 (11%)	0.010
Unknown	0	347	
Paralysis	2,736 (1.1%)	185 (1.2%)	0.7
Unknown	0	347	
Peptic Ulcer Disease excluding Bleeding	5,080 (2.1%)	243 (1.5%)	<0.001

Characteristic	Complete N = 241,347*	Missing, N = 16,219*	P-value†
Unknown	0	347	
Peripheral Vascular Disorders	23,003 (9.5%)	1,239 (7.8%)	<0.001
Unknown	0	347	
Psychoses	2,736 (1.1%)	185 (1.2%)	0.7
Unknown	0	347	
Pulmonary Circulation Disorders	11,874 (4.9%)	849 (5.2%)	0.076
Renal Failure	38,258 (16%)	2,206 (14%)	<0.001
Unknown	0	347	
Rheumatoid Arthritis Collagen	9,147 (3.8%)	585 (3.6%)	0.2
Solid Tumor without Metastasis	43,910 (18%)	2,298 (14%)	<0.001
Valvular Disease	21,360 (8.9%)	1,082 (6.7%)	<0.001
Weight Loss	21,873 (9.1%)	1,575 (9.7%)	0.006
Body Region			<0.001
Head	14,129 (5.9%)	809 (8.3%)	
Hip/Leg/Foot	33,999 (14%)	1,203 (12%)	
Spine and Spinal cord	16,792 (7.0%)	723 (7.4%)	
Lower Abdomen	20,835 (8.6%)	732 (7.5%)	
Shoulder/Arm/Hand	7,204 (3.0%)	375 (3.8%)	
Upper Abdomen	42,240 (18%)	1,179 (12%)	
Thorax - Intrathoracic	16,965 (7.0%)	587 (6.0%)	
Obstetrics	38,171 (16%)	2,263 (23%)	
Neck	9,035 (3.7%)	328 (3.4%)	
Urologic	13,941 (5.8%)	543 (5.6%)	
Cardiac	4,635 (1.9%)	92 (0.9%)	
Thorax - Extrathoracic	8,814 (3.7%)	326 (3.3%)	
Pelvis	1,578 (0.7%)	115 (1.2%)	
Radiologic	7,902 (3.3%)	227 (2.3%)	
Gynecologic	2,819 (1.2%)	121 (1.2%)	
Male Reproductive System	469 (0.2%)	32 (0.3%)	
Other Procedures	227 (<0.1%)	11 (0.1%)	
Burn	921 (0.4%)	51 (0.5%)	
Unknown	0	6,474	
Institution			<0.001
1	11,733 (4.9%)	365 (2.3%)	
4	2,541 (1.1%)	2,110 (13%)	
7	11,221 (4.6%)	695 (4.3%)	
8	3,198 (1.3%)	168 (1.0%)	
15	5,327 (2.2%)	68 (0.4%)	
19	7,701 (3.2%)	105 (0.6%)	
22	677 (0.3%)	57 (0.4%)	

Characteristic	Complete N = 241,347*	Missing, N = 16,219*	P-value†
23	5,467 (2.3%)	156 (1.0%)	
27	1,198 (0.5%)	12 (<0.1%)	
30	1,680 (0.7%)	103 (0.6%)	
31	1,931 (0.8%)	122 (0.8%)	
32	2,516 (1.0%)	5 (<0.1%)	
35	0 (0%)	6,260 (39%)	
36	16,236 (6.7%)	340 (2.1%)	
37	10,503 (4.4%)	215 (1.3%)	
40	6,202 (2.6%)	504 (3.1%)	
46	2,403 (1.0%)	223 (1.4%)	
48	4,037 (1.7%)	272 (1.7%)	
53	4,913 (2.0%)	37 (0.2%)	
56	6,289 (2.6%)	234 (1.4%)	
57	608 (0.3%)	6 (<0.1%)	
58	14,165 (5.9%)	254 (1.6%)	
59	1,296 (0.5%)	111 (0.7%)	
67	11,269 (4.7%)	157 (1.0%)	
68	14,975 (6.2%)	330 (2.0%)	
69	12,844 (5.3%)	142 (0.9%)	
70	5,763 (2.4%)	137 (0.8%)	
74	843 (0.3%)	54 (0.3%)	
75	11,760 (4.9%)	222 (1.4%)	
78	2,966 (1.2%)	721 (4.4%)	
80	1,707 (0.7%)	101 (0.6%)	
82	807 (0.3%)	68 (0.4%)	
83	6,103 (2.5%)	282 (1.7%)	
84	12,542 (5.2%)	545 (3.4%)	
86	4,907 (2.0%)	49 (0.3%)	
88	47 (<0.1%)	12 (<0.1%)	
91	4,631 (1.9%)	81 (0.5%)	
96	6,995 (2.9%)	294 (1.8%)	
97	1,623 (0.7%)	170 (1.0%)	
98	5,234 (2.2%)	160 (1.0%)	
99	3,168 (1.3%)	82 (0.5%)	
101	11,321 (4.7%)	190 (1.2%)	

* n (%)

† Pearson's Chi-squared test

Supplement Table 8. Statistical package code for weighting and matching

```
library(tidyverse)
library(MatchIt)

library(twang)

# 1:1 exact matching
exact_matching <-
  matchit(Covid19_result ~ Age_decile + Race + ASA_Class + Gender + Solid_Tumor_without_Metastasis +
    Institution,
    data      = covid_data,
    method    = "cem",
    k2k       = TRUE,
    estimand  = "ATE",
    cutpoints = 0)

matched_data <- match.data(exact_matching)

# Obtain relevant variables
matched_subset <-
  matched_data %>%
  select(MPOG_Patient_ID, MPOG_Case_ID, Covid19_result, subclass, Age_decile, Race, BMI_Classification,
    Gender, ASA_Class, starts_with("Elix"), Body_Region) %>%
  mutate(Covid19_01 = ifelse(Covid19_result == "Negative", 0, 1)) %>%
  drop_na()

# Form right-hand side of the propensity score equation
ps_form_rhs <-
  paste(
    colnames(
      matched_subset[, names(matched_subset) %in% c("Age_decile", "Race", "BMI_Classification", "Gender",
        "ASA_Class", starts_with("Elix"), "Body_Region")]
    ),
    collapse = " + "
  )
```

```

# Create PS formula
ps_form <- formula(paste("Covid19_01 ~ ", ps_form_rhs, sep = ""))

# Use generalized boosted regression model for propensity scores
# Set n.trees large enough to find optimal number of iterations
set.seed(12345)

twangGBM <- ps(formula      = ps_form,
               data         = data.frame(matched_subset),
               n.trees      = 130000,
               shrinkage    = 0.0005,
               interaction.depth = 4,
               stop.method  = "es.mean")

# Get propensity scores and inverse probability weights
matched_subset$propensity <- twangGBM$ps[, 1]
matched_subset$IPW       <- get.weights(twangGBM, stop.method = "es.mean")

# Join data to subset
ps_data <- right_join(matched, matched_subset)

# Find range of common support
mini <- min(ps_data$propensity[ps_data$Covid19_result == "Positive"])
maxi <- max(ps_data$propensity[ps_data$Covid19_result == "Negative"])

ps_data_trimmed <-
  ps_data %>%
  filter(propensity >= mini) %>%
  filter(propensity <= maxi)

# Patients who no longer have a match after PS trimming
unmatched_patients <-
  ps_data_trimmed %>%
  count(subclass) %>%

```

```

filter(n != 2) %>%
pull(subclass)

# Remove singular patients
ps_data_balanced <-
  ps_data_trimmed %>%
  filter(!(subclass %in% unmatched_patients))

# Find Institutions that have >= 20 positive cases
cases_by_institution <-
  ps_data_balanced %>%
  count(Institution, Covid19_result) %>%
  pivot_wider(names_from = Covid19_result, values_from = n)

keep_institutes <-
  cases_by_institution %>%
  filter(Positive >= 20) %>%
  pull(Institution)

# Keep Institutions that have >=20 cases
final_matched <- ps_data_balanced %>% filter(Institution %in% keep_institutes)

```