

**Article Title**

Racial Bias and Reproducibility in Pulse Oximetry Among General Care Medical and Surgical Inpatients in the Veterans Health Administration 2013-2019: A Cohort Study

**Authors**

Valeria S. M. Valbuena, MD, MSc<sup>\*1,2,3</sup>; Sarah Seelye, PhD<sup>\*2</sup>; Michael W. Sjoding, MD, MSc<sup>4</sup>; Thomas S. Valley, MD, MSc<sup>2,4</sup>; Robert P. Dickson, MD<sup>4</sup>; Steven E. Gay MD<sup>4</sup>; Dru Claar, MD<sup>4</sup>; Hallie C. Prescott, MD, MSc<sup>2,4</sup>; Theodore J. Iwashyna, MD, PhD<sup>2,3,4</sup>

\* These authors contributed equally to this work

**Affiliations**

<sup>1</sup> Department of Surgery, University of Michigan, Ann Arbor, Michigan

<sup>2</sup> Veterans Affairs Center for Clinical Management Research, Ann Arbor, Michigan

<sup>3</sup> National Clinician Scholars Program, University of Michigan, Ann Arbor, Michigan

<sup>4</sup> Department of Internal Medicine, University of Michigan, Ann Arbor, Michigan

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Supplemental analyses, tables, figures, and statistical code

**Corresponding Author**

Theodore J. Iwashyna, MD, PhD

VA CCMR

2800 Plymouth Road, NCRC Building 16, 3<sup>rd</sup> Floor

Ann Arbor, Michigan, 48104, USA

Email: [tiwashyn@umich.edu](mailto:tiwashyn@umich.edu)

Twitter: @iwashyna

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**Appendix 1. Comorbidities for patients with pairs of pulse oximetry and arterial oxygen saturation**

	Patients with 1 pair/day	Patients with 2 pairs/day	<i>p</i>
Total pairs, N	27,023	3,016	
SpO <sub>2</sub> median (IQR)	96 (93, 98)	95 (92, 98)	<0.001
SaO <sub>2</sub> , median (IQR)	94 (89.7, 96.9)	94 (89.8, 97.1)	0.186
Total patients, N	27,023	1,508	
Comorbidities, N (%)			
Congestive heart failure	9,479 (35.1)	513 (34.0)	0.401
Neurologic disease	3,328 (12.3)	179 (11.9)	0.608
Chronic pulmonary disease	14,290 (52.9)	758 (50.3)	0.048
Liver Disease	2,515 (9.3)	138 (9.2)	0.839
Diabetes without complication	6,882 (25.5)	397 (26.3)	0.456
Diabetes with complication	4,755 (17.6)	255 (16.9)	0.495
Non-metastatic cancer	2,867 (10.6)	166 (11.0)	0.625
Metastatic cancer	1,017 (3.8)	69 (4.6)	0.109
Renal disease	7,035 (26.0)	351 (23.3)	0.017
Cardiac arrhythmia	9,267 (34.3)	582 (38.6)	0.001
Valvular disease	2,029 (7.5)	134 (8.9)	0.049
Pulmonary circulation disorders	2,776 (10.3)	149 (9.9)	0.625
Peripheral vascular disorders	3,169 (11.7)	198 (13.1)	0.100
Paralysis	560 (2.1)	36 (2.4)	0.405
Hypertension with and with complication	18,769 (69.5)	1,030 (68.3)	0.344
Hypothyroidism	2,699 (10.0)	150 (10.0)	0.959
Peptic ulcer disease excluding bleeding	215 (0.8)	8 (0.5)	0.255
Lymphoma	420 (1.6)	27 (1.8)	0.472
Coagulopathy	1,722 (6.4)	112 (7.4)	0.104
Rheumatoid arthritis	535 (2.0)	23 (1.5)	0.215
Fluid and electrolyte disorders	10,042 (37.2)	543 (36.0)	0.367
Blood loss anemia	227 (0.8)	13 (0.9)	0.927
Deficiency anemia	1,969 (7.3)	91 (6.0)	0.068
Obesity	3,386 (12.5)	189 (12.5)	0.997
Weight loss	2,479 (9.2)	126 (8.4)	0.283
Alcohol abuse	2,838 (10.5)	154 (10.2)	0.721
Drug abuse	1,510 (5.6)	86 (5.7)	0.850
Depression	5,061 (18.7)	249 (16.5)	0.031
Psychosis	1,077 (4.0)	60 (4.0)	0.990

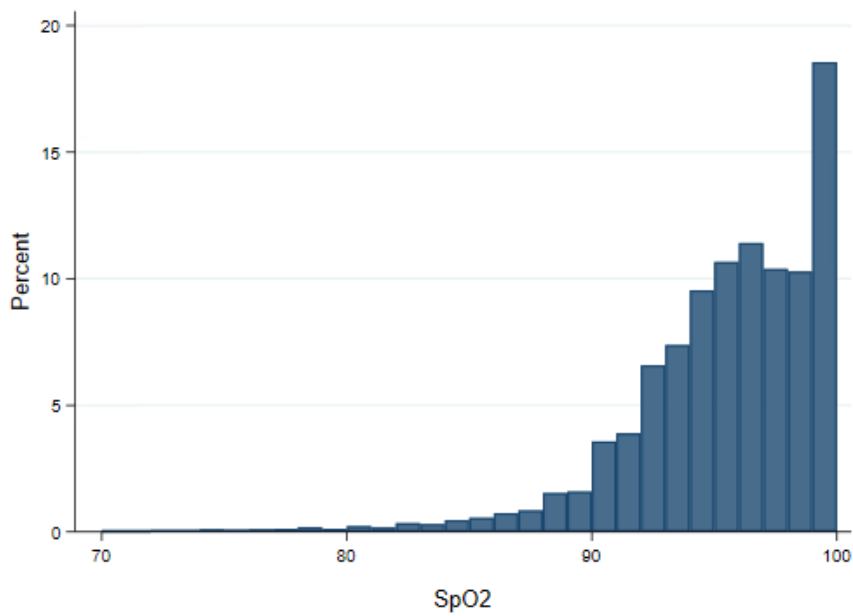
**Appendix 2.** Analytic code (see Supplemental file)

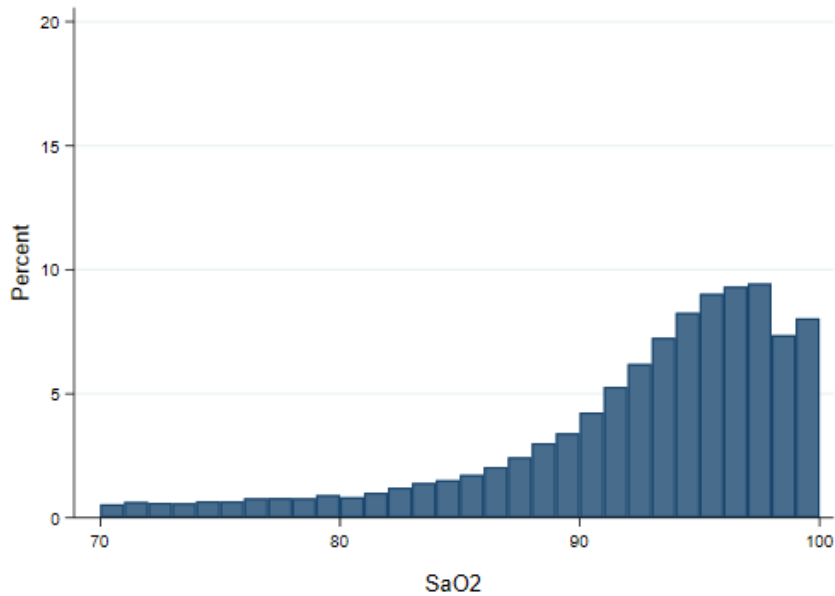
The stata .do files and a .log file for the results section are uploaded as additional text files.

All executable files are available in GitHub <https://github.com/CCMRcodes/RacialBias>

**Appendix 3.** Number of paired SpO<sub>2</sub>-SaO<sub>2</sub> measurements included in the study, stratified by race of Veterans and SpO<sub>2</sub> level and accompanying histograms of SpO<sub>2</sub> & SaO<sub>2</sub>

SpO <sub>2</sub> level	89	90	91	92	93	94	95	96	97	98	99	100
White	388	888	963	1619	1806	2303	2535	2571	2212	2035	1311	1765
Black	66	149	171	283	321	449	531	673	743	896	731	1225
Hispanic	24	35	35	73	88	114	138	185	166	159	165	378



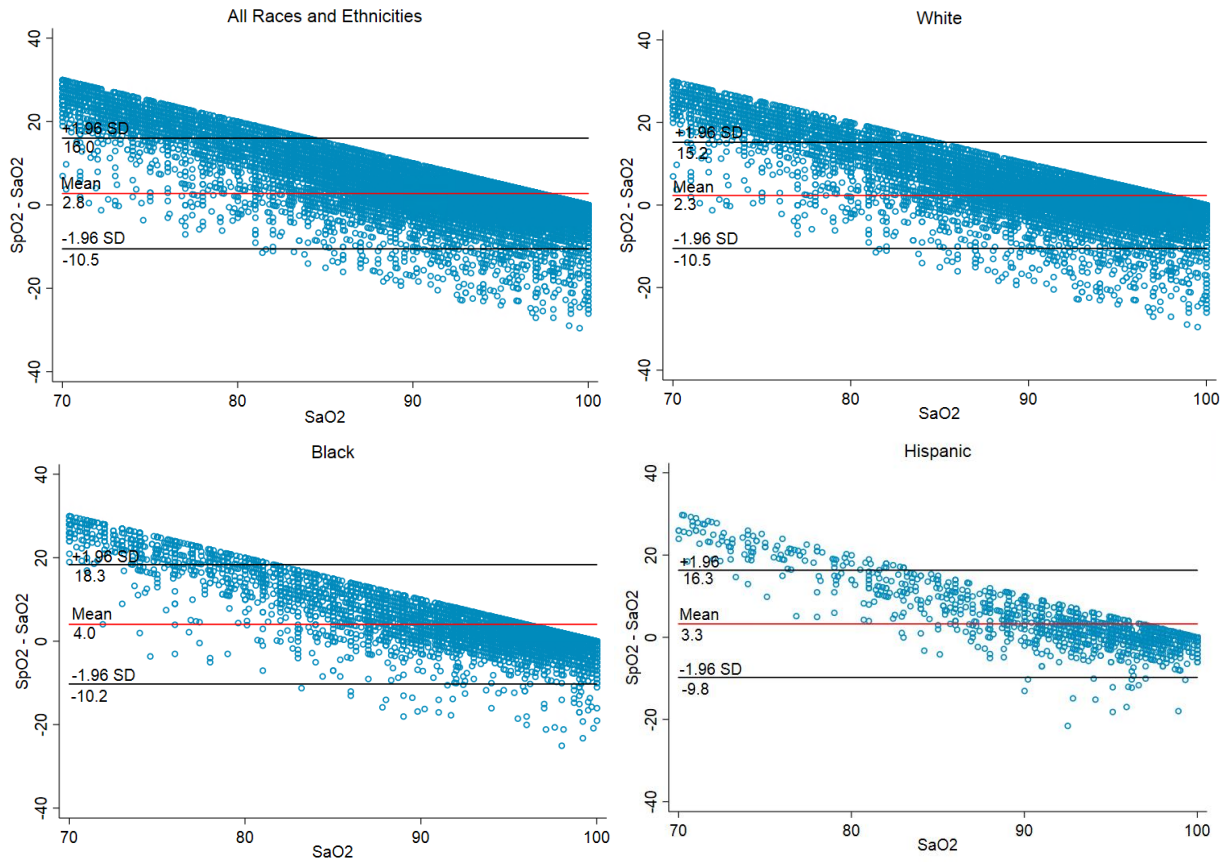


**Appendix 4.** Characteristics for total VAPD hospitalizations and those with available SpO<sub>2</sub>-SaO<sub>2</sub> pairs only

	SpO <sub>2</sub> -SaO <sub>2</sub> Pairs	VAPD
Total hospitalizations, N	27,427	3,644,559
Patient characteristics		
Age in years, median (IQR)	69 (63, 76)	67 (60, 74)
Male sex, N (%)	26,362 (96.1)	3,445,716 (94.5)
Race, N (%)		
Non-Hispanic White	20,134 (73.4)	2,607,137 (71.5)
Non-Hispanic Black	5,930 (21.6)	807,787 (22.2)
Hispanic/Latino	1,363 (5.0)	229,635 (6.3)
Primary Diagnoses, N (%)		
Chronic obstructive pulmonary disease	3,674 (13.4)	107,658 (3.0)
Respiratory failure	3,380 (12.3)	61,900 (1.7)
Septicemia	2,109 (7.7)	118,539 (3.3)
Pneumonia	1,914 (7.0)	95,402 (2.6)
Congestive heart failure	1,822 (6.6)	137,750 (3.8)
Coronary atherosclerosis	597 (2.2)	125,799 (3.5)
Diabetes with complication	536 (2.0)	69,488 (1.9)
Cardiac dysrhythmia	460 (1.7)	128,321 (3.5)
Renal failure	444 (1.6)	59,778 (1.6)
Acute myocardial infarction	328 (1.2)	50,356 (1.4)
Other	12,163 (44.4)	2,689,568 (73.8)
Comorbidities*, N (%)		
Congestive heart failure	9,620 (35.1)	752,698 (20.7)
Neurologic disease	3,350 (12.2)	277,895 (7.6)
Chronic pulmonary disease	14,569 (53.1)	926,811 (25.4)
Liver Disease	2,548 (9.3)	318,868 (8.8)
Diabetes without complication	7,020 (25.6)	851,028 (23.4)

Diabetes with complication	4,843 (17.7)	494,273 (13.4)
Non-metastatic cancer	2,870 (10.5)	396,882 (10.9)
Metastatic cancer	1,050 (3.8)	133,121 (3.7)
Renal disease	7,128 (26.0)	749,215 (20.6)
Length of hospitalization in days, median (IQR)	6 (3, 10)	4 (2, 6)
Mortality		
In-hospital mortality, N (%)	1,390 (5.1)	55,013 (1.5)
30-d mortality, N (%)	2,764 (10.1)	152,051 (4.2)

## Appendix 5. Bland-Altman plots and calibration plots by race and ethnicity

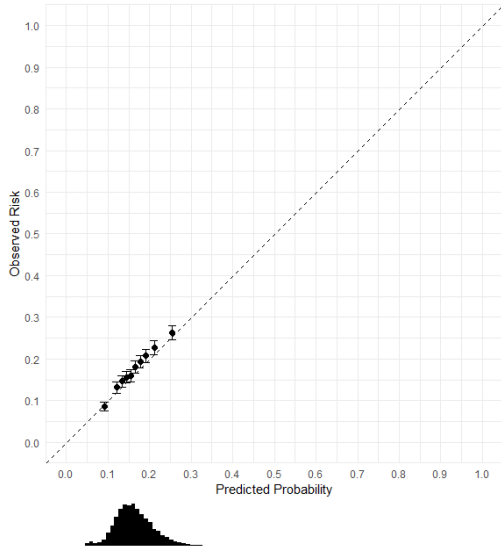


All Available SpO <sub>2</sub> -SaO <sub>2</sub> Pairs				
	All (N=30,039)	White (n=21,918)	Black (n=6,498)	Hispanic (n=1,623)
Bias, %	2.8	2.3	4.0	3.3
Precision, SD	6.8	6.6	7.3	6.7
Upper limit of agreement, %	16.0	15.2	18.3	16.3
Lower limit of agreement, %	-10.5	-10.5	-10.3	-9.8
Root mean square error, %	7.3	7.0	8.3	7.4

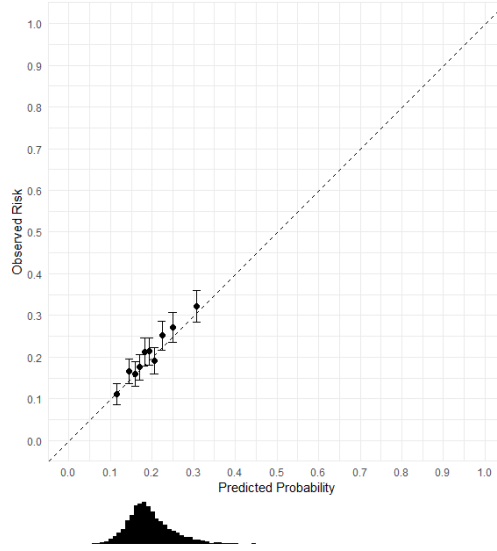


# Calibration plots by race and ethnicity

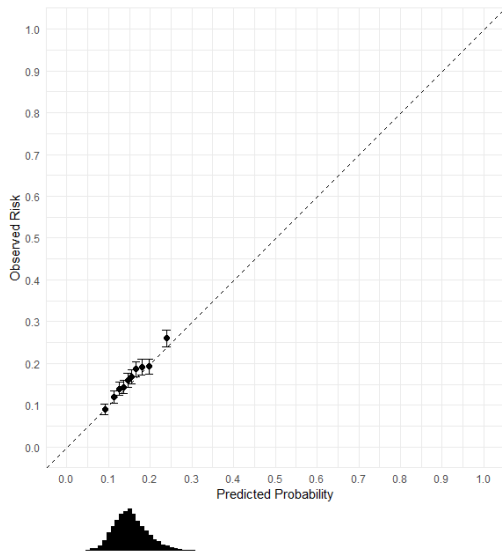
## All Races



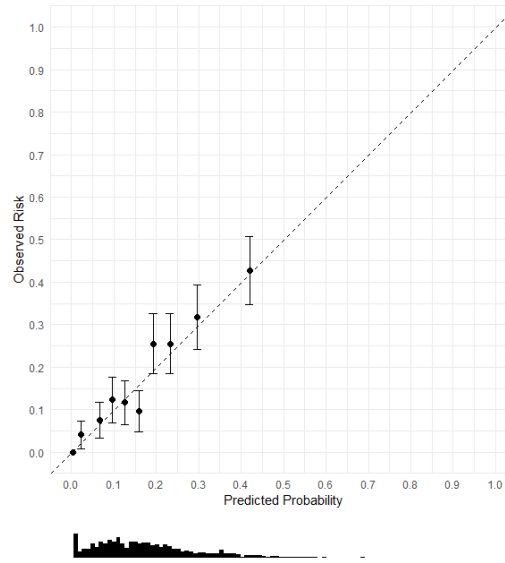
## Black



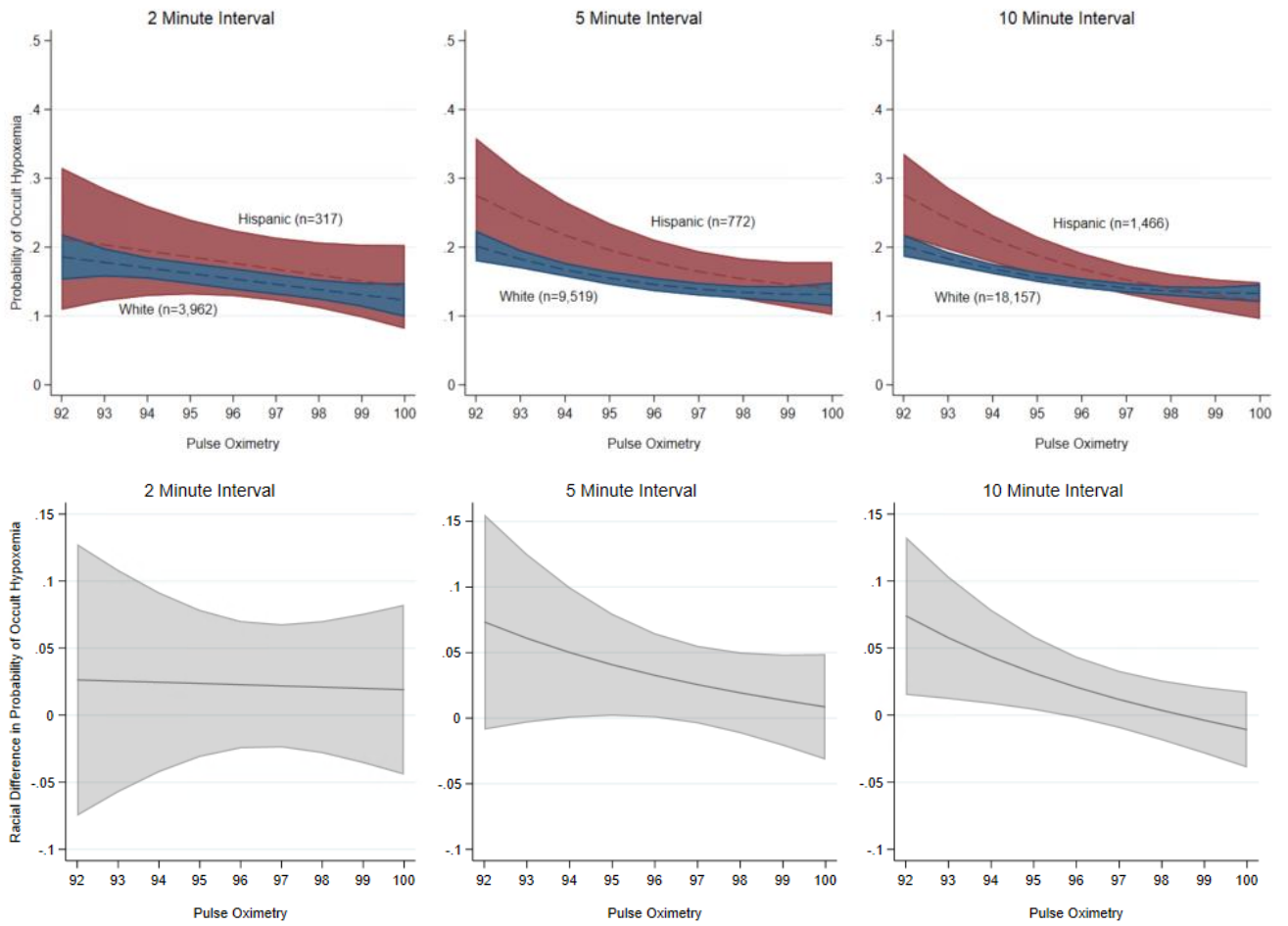
## White



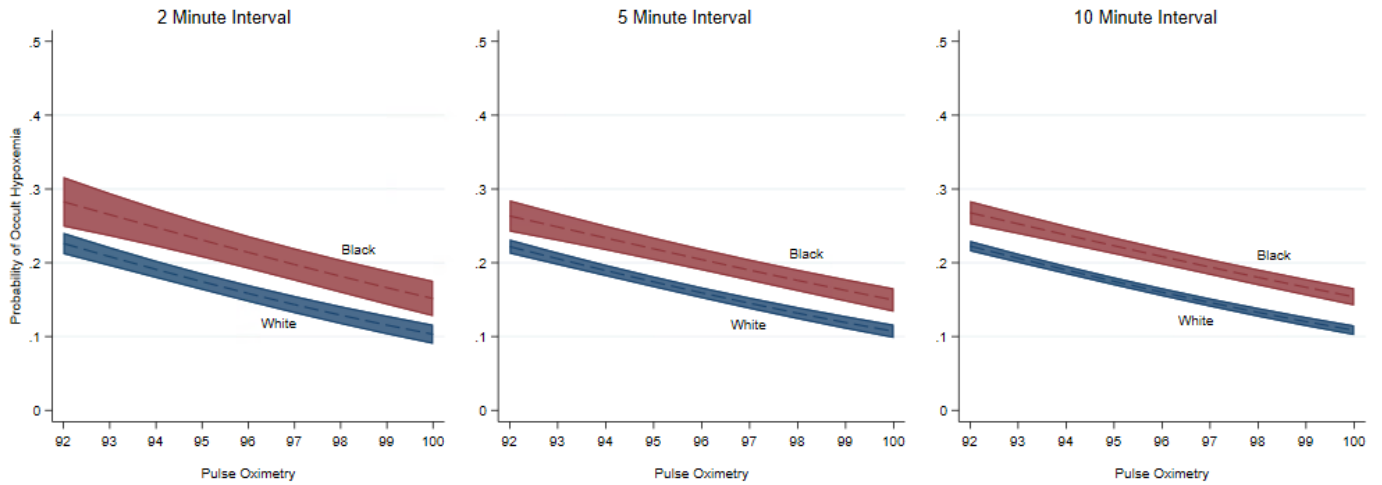
## Hispanic



## Appendix 6. Probability of occult hypoxemia for White and Hispanic patients



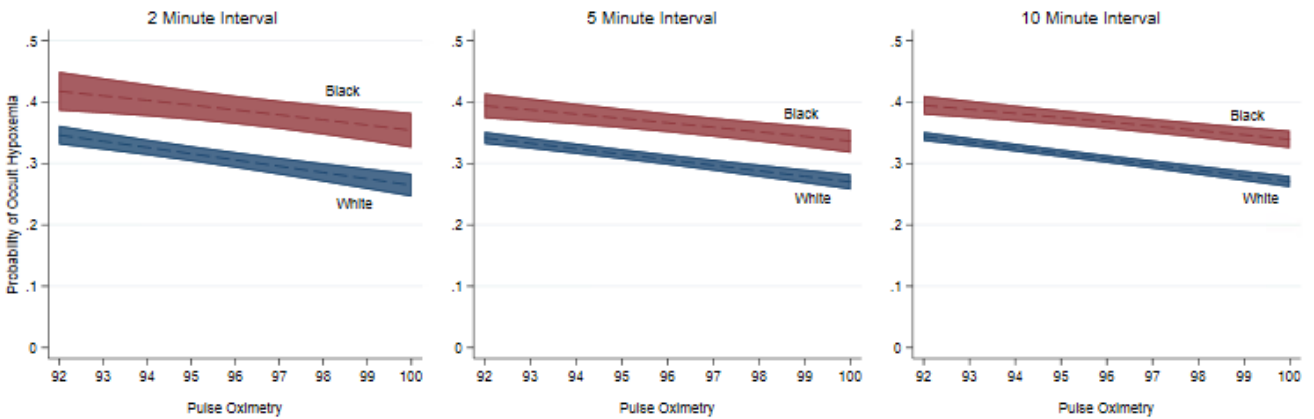
**Appendix 7.** Probability of occult hypoxemia for Black and White patients. All SpO<sub>2</sub> values included (i.e. not restricting model to SpO<sub>2</sub> ≤ 92%)



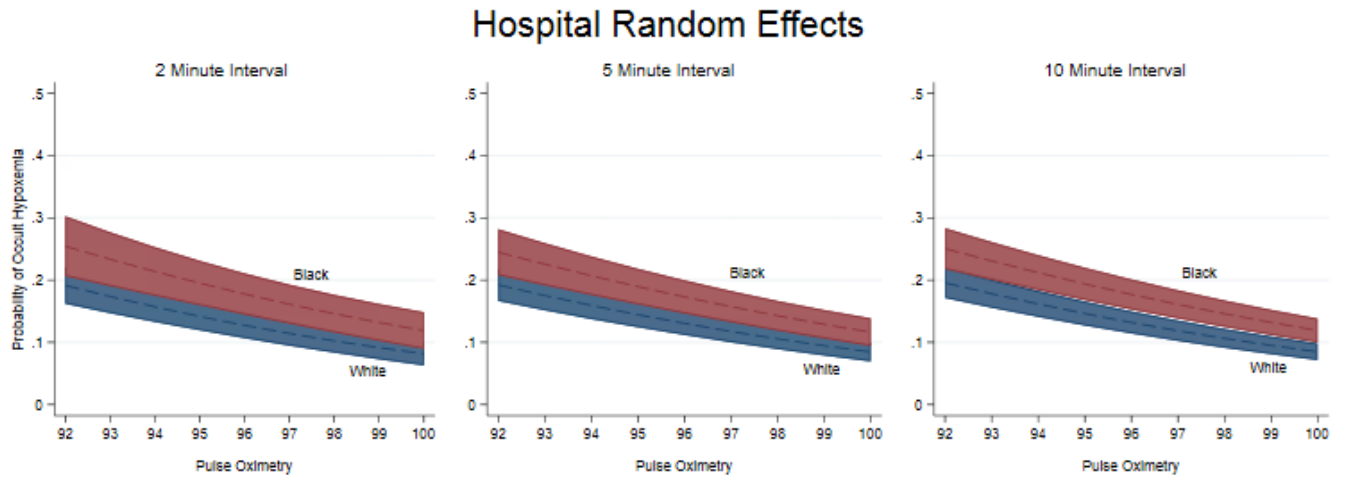
Note: When we include **all** SpO<sub>2</sub> values, in the 10-minute interval, 22.8% of Black patients and 18.1% of White patients had SaO<sub>2</sub><88%. This is a 4.6% difference (CI=3.3%, 6.0%).

Probability of occult hypoxemia for Black and White patients. All SpO<sub>2</sub> and SaO<sub>2</sub> values included (i.e. not dropping SpO<sub>2</sub> or SaO<sub>2</sub> < 70%)

**Black and White - Including all SpO<sub>2</sub>s and SaO<sub>2</sub>s <70**



**Appendix 8.** Probability of occult hypoxemia for White and Black patients including a hospital-level random effect.



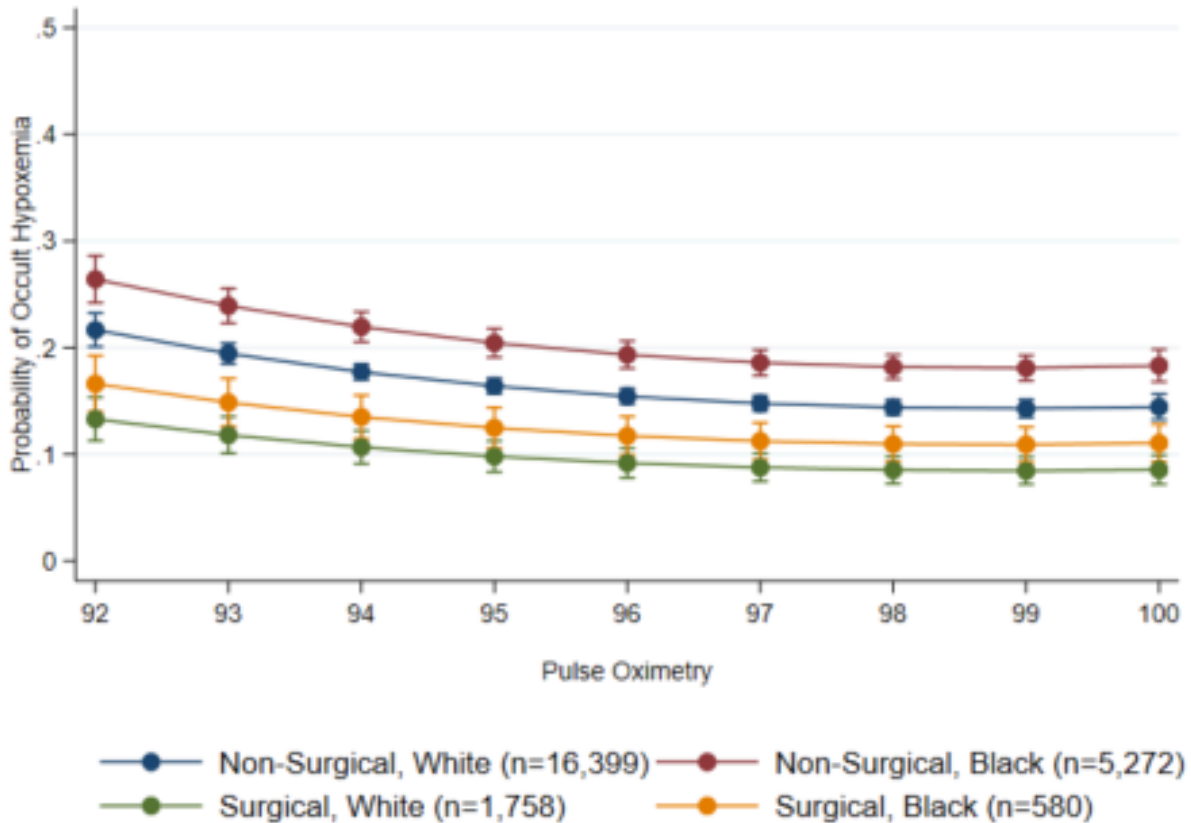
## Appendix 9. Post Hoc analysis of surgical vs non-surgical patients

Of the SaO<sub>2</sub>-SpO<sub>2</sub> pairs, only 580 pairs—approximately 10%—from Black patients and 1,758 pairs from White patients occur on surgical services on patient-days outside the ICU.

In the interacted analysis, there was no large difference between surgical and non-surgical patients:

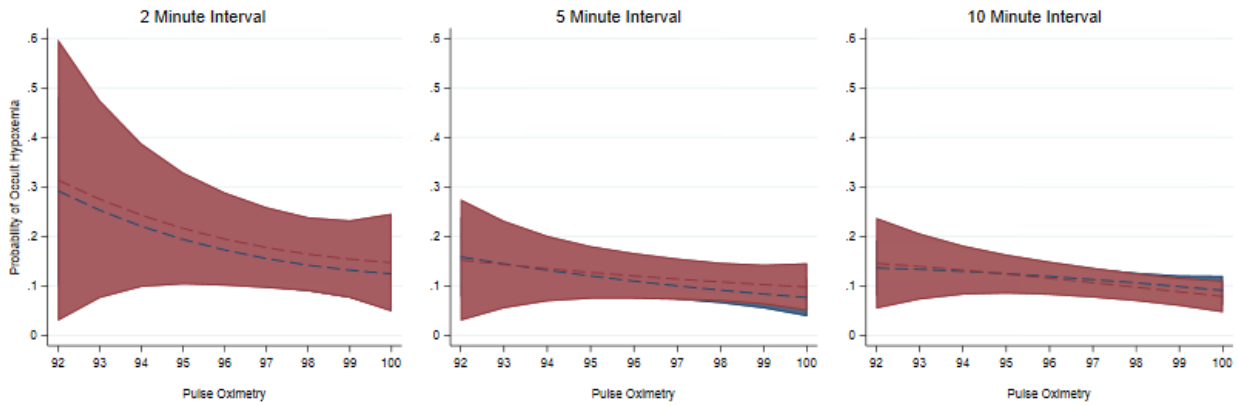
Non-surgical patients: Black patients have a 4.0% greater chance of hypoxemia than White patients ( $p < 0.001$ , CI 2.7%, 5.4%)

Surgical patients: Blacks have a 2.7% greater chance of hypoxemia than Whites ( $p < 0.001$ , CI= 1.7%, 3.6%)



However, in fully stratified analyses in this small, post-hoc population, it appears there is no difference in occult hypoxemia by race—the point estimates and confidence intervals overlap:

### White and Black Surgical Patients



At the same subset of VA hospitals that perform surgeries, a racial differential was present in non-surgical patients:

### White and Black Non-surgical Patients in Hospitals with Surgeries

