

Black Patients 32% More Likely Than White Patients to Experience Occult Hypoxemia, Which May Result in Delayed Care

Team A: Sam Butler, MD; Joe Deckert, PhD; Zach Dezman, MD; Roderick King, MD, MPH

Team B: Jackie Gerhart, MD; Neil Sandberg; Joel Klein, MD; Joseph Wright, MD, MPH, Grace Wickerson

Last updated 20 March 2024 • Check for updates at EpicResearch.org

Key Findings:

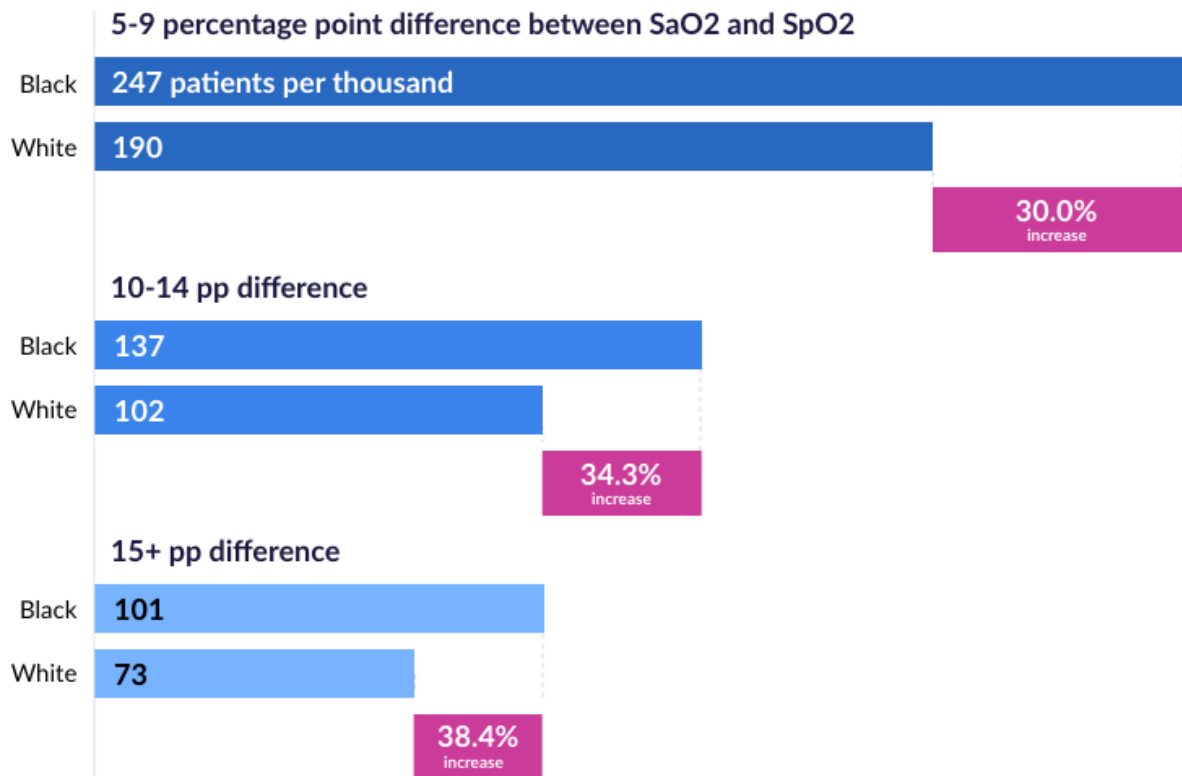
- Non-Hispanic Black patients are 32% more likely to have occult hypoxemia, which is an overestimation of a patient's blood gas by a pulse oximeter that can lead to delayed recognition of low oxygen levels than non-Hispanic White patients.
- Non-Hispanic Black patients are 39% more likely than non-Hispanic White patients to see a difference of 15 percentage points or more between their blood gas (SaO₂) and pulse oximeter (SpO₂) readings.

While it's well known that darker skin tone affects the accuracy of pulse oximeter readings¹, it's not known how far off those readings are from concurrent blood oxygen values or how often that discrepancy results in inadequate treatment.

To better understand the incidence and potential implications of inaccurate pulse oximeter oxygen saturation readings, we studied 13,483 patients hospitalized between January 1, 2016, and November 9, 2023, who had a documented pulse oximeter reading (SpO₂) followed by a blood gas oxygen saturation result (SaO₂) within five minutes. We stratified patients by race and compared the rates of inconsistent SpO₂ and SaO₂ readings.

The FDA currently states that pulse oximeters are considered meeting accuracy requirements if SpO₂ readings are within 2-4% of SaO₂ readings.² We found that 24.7% of non-Hispanic Black patients had SpO₂ readings that were at least five percentage points greater than their SaO₂ readings compared to 19.0% of non-Hispanic White patients. Additionally, 10.2% of non-Hispanic Black patients had SpO₂ readings at least 15 percentage points greater than their SaO₂ readings compared to 7.3% of non-Hispanic White patients.

Pulse Oximeter Variability by Patient Race



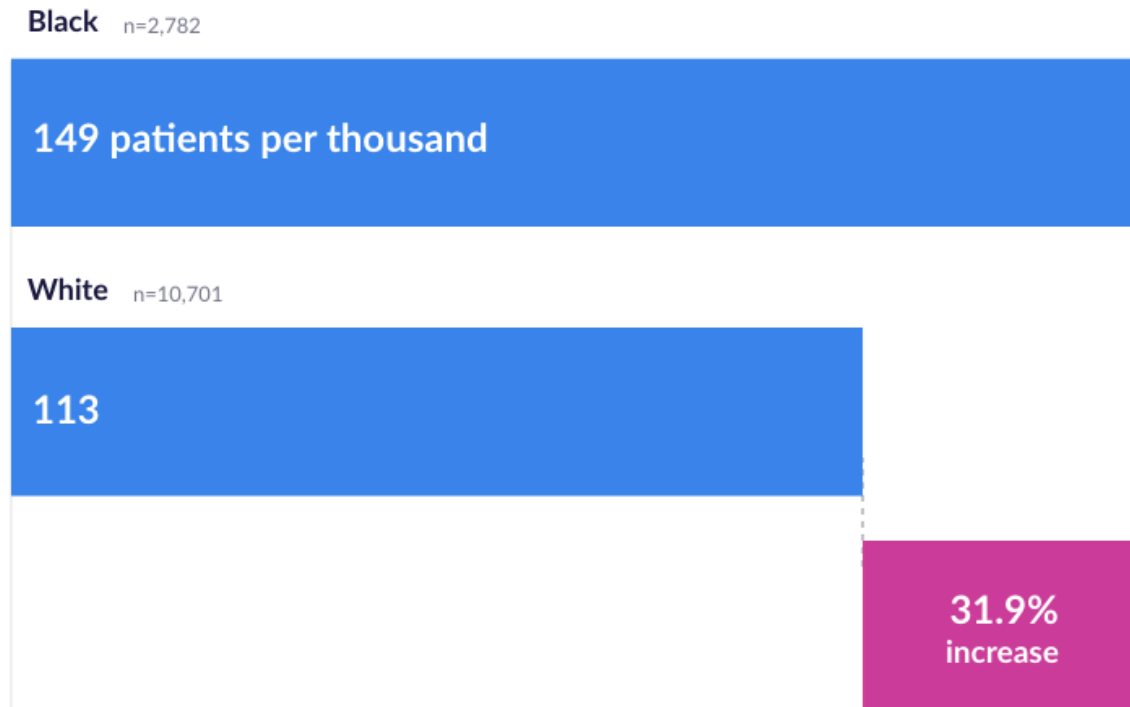
N=13,483 patients

"Pulse Oximeter Variability by Patient Race," 2024. EpicResearch.org

Figure 1. The rate of patients with SpO2 readings 5-9, 10-14, and 15+ percentage points different from SaO2 readings by patient race.

One of the primary concerns of inaccurate SpO2 readings is the potential for a delay in treatment. Providers often order supplemental oxygen or other treatment when oxygen saturation drops below 88%. If an SpO2 reading shows a value of 92% or greater but does not accurately reflect the patient's actual oxygen saturation, there may be a delay in potentially life-saving treatment, which could result in significant risk to the patient. For this study, we considered patients to have occult hypoxemia when the patient had an SaO2 value less than or equal to 88%, but an SpO2 value of 92% or greater. We compared the incidence of occult hypoxemia for non-Hispanic Black and White patients and found that Black patients are 31.9% more likely to experience occult hypoxemia than White patients, as shown in Figure 2.

Occult Hypoxemia Rate by Patient Race



N=13,483 patients

"Occult Hypoxemia Rate by Patient Race," 2024. EpicResearch.org

Figure 2. The rate of patients with occult hypoxemia by patient race.

These results support the need for further investigation of pulse oximeter accuracy to account for differences in patient skin pigmentation, race, and ethnicity as suggested by the FDA.¹

These data come from Cosmos, a collaboration of Epic health systems representing more than 238 million patient records from 1,345 hospitals and more than 28,000 clinics from all 50 states and Lebanon. This study was completed by two teams that worked independently and was completed in collaboration with researchers from the University of Maryland Medical System, University of Maryland School of Medicine, and Federation of American Scientists. The two teams came to similar conclusions. Graphics by Kayla Monnette.

References

1. Shuren J. CDRH takes steps to advance further discussions on pulse oximeters. U.S. Food and Drug Administration. Published November 17, 2023. <https://www.fda.gov/medical-devices/medical-devices-news-and-events/cdrh-takes-steps-advance-further-discussions-pulse-oximeters>. Accessed January 9, 2024.
2. Pulse oximetry. Yale Medicine. Published January 3, 2023. <https://www.yalemedicine.org/conditions/pulse-oximetry>. Accessed January 9, 2024.

Data Definitions

Term	Definition
Study period	1/1/2016 to 11/9/2023
Study population	SaO2 lab results and SpO2 reading pairs for comparison and non-Hispanic Black and White patients, where:

- The SaO2 lab and SpO2 reading were within five minutes of each other.
- The SaO2 result was over 50% and the SpO2 reading was over 80%.
- As more than 83% of SpO2 readings were documented at 15-minute intervals, likely due to rounding of documentation time, we excluded readings documented exactly at the :00, :15, :30, and :45 times to increase the confidence in the time between SpO2 and SaO2 readings.

SaO2 lab

A lab with a LOINC code 2708-6 or 2714-4.

Table 1. Pulse Oximeter Variability by Patient Race

Race	Total	Occult Hypoxemia Cases	Average difference (SpO2 - SaO2)	Difference between SaO2 and SpO2 5-9	Difference between SaO2 and SpO2 10-14	Difference between SaO2 and SpO2 >15
Black	2,782	415	4.596	687	381	282
White	10,701	1,205	3.049	2,038	1,089	778