UAMS Journal Club Summary
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Racial Bias in Pulse Oximetry Readings

Clinical Bottom Line

Pulse oximetry was created utilizing white/light skinned individuals and as a result this leads to higher rates of discrepancy between pulse oximetry readings and measured arterial oxygen saturation levels in darker skinned/black individuals compared with light skinned/white individuals. This discrepancy leads to higher rates of occult hypoxemia in black individuals compared to white individuals. This finding could have significant clinical implications including undiagnosed or late recognition of hypoxemia when physicians use pulse oximetry as the sole marker for oxygen saturation in black patients compared with white patients. This could potentially cause higher rates of morbidity and mortality in black patients as necessary clinical interventions for hypoxemia may be withheld or delayed.

PICO Question

Are there differences in rates of undiagnosed hypoxemia when utilizing pulse oximetry vary between patients of different racial/ethnic backgrounds?

P – Patients admitted to the hospital
I – Pulse oximetry readings
C – Arterial blood oxygen saturation on ABGs
O – Discrepancy in pulse oximetry and arterial blood oxygenation and racial differences in this discrepancy

Background

Pulse oximetry is a useful tool when assessing a patient's basic vital signs. There are different machines used to identify a patient's pulse ox. The US Food and Drug Administration (FDA) requires a root mean square accuracy within 2% for values between 70% and 100%. However, recently, there have been reports regarding discrepancies noted in pulse oximetry reading between different skin tones. Previously, studies have shown a discrepancy in critically-ill patient's pulse ox compared to their true hypoxia; however, there were limitations due to sample size. A study by Sjoding et al showed evidence of hidden hypoxemia rates almost 3 times higher in Black vs White patients. When making important clinical decisions for patient's clinical condition, it's vital to ensure that these discrepancies are further examined. The two following trials aim to address this concern by examining two different populations.

Trial 1

Valbuena VSM, Seelye S, Sjoding MW, Valley TS, Dickson RP, Gay SE, Claar D, Prescott HC, Iwashyna TJ. Racial bias and reproducibility in pulse oximetry among medical and surgical inpatients in general care in the Veterans Health Administration 2013-19: multicenter, retrospective cohort study. BMJ. 2022 Jul 6;378:e069775. doi: 10.1136/bmj-2021-069775. PMID: 35793817; PMCID: PMC9254870.

Link:
https://pubmed.ncbi.nlm.nih.gov/35793817/

The Basics:
This study was a multicenter, retrospective cohort study using electronic medical records from general care medical and surgical inpatients at over 100 VA hospitals in the US.

Inclusion Criteria:
Patients admitted to general medicine or surgical floors who had a pulse oximetry reading and a arterial blood gas lab draw within 10 min of each other.

Exclusion Criteria:
Any ICU level patients, or patients who received ICU level care while admitted. Any individuals who did not have pulse oximetry readings and arterial blood gas lab draws within 10min of each other. Excluded paired readings where more than one blood gas was drawn. SpO2 and SaO2 values less than 70% were removed to reduce possibility of mislabeled venous gases as arterial.

Primary Outcomes:
Rates of occult hypoxemia and whether this varied between races/ethnic groups.

Secondary Outcomes:
Rates of variability in pulse oximetry readings between measurements.

Results:
A total of 30,039 pairs of SpO2-SaO2 readings made within 10 minutes of each other were identified during the study. These pairs were predominantly among non-Hispanic white (21,918 (73.0%)) patients; non-Hispanic black patients and Hispanic or Latino patients accounted for 6498 (21.6%) and 1623 (5.4%) pairs in the sample, respectively. Among SpO2 values greater or equal to 92%, unadjusted probabilities of occult hypoxemia were 15.6% (95% confidence interval 15.0% to 16.1%) in white patients, 19.6% (18.6% to 20.6%) in black patients ($P<0.001$ *v* white patients, with similar P values in adjusted models), and 16.2% (14.4% to 18.1%) in Hispanic or Latino patients ($P=0.53$ *v* white patients, $P<0.05$ in adjusted models). This result was consistent in SpO2-SaO2 pairs restricted to occur within 5 minutes and 2 minutes. In white patients, an initial SpO2-SaO2 pair with little difference in saturation was associated with a 2.7% (95% confidence interval -0.1% to 5.5%)

probability of SaO2 <88% on a later paired SpO2-SaO2 reading showing an SpO2 of 92%, but black patients had a higher probability (12.9% (-3.3% to 29.0%)).

Limitations/Bias:
This study was done at VA hospitals so the population is overwhelmingly male and the age of the population studied is much older than the average population. This limits the generalizability of results. Additionally, they utilized self reported demographic information, there was no stratification of individuals on skin color/tone itself.

Trial 2

An-Kwok Ian Wong, MD, PhD et al; Analysis of Discrepancies Between Pulse Oximetry and Arterial Oxygen Saturation Measurements by Race and Ethnicity and Association With Organ Dysfunction and Mortality. Multicenter, retrospective study. JAMA Network Open. 2021;4(11):e2131674. doi:10.1001/jamanetworkopen.2021.31674 (Reprint) PMID: 34730820 PMCID: PMC9178439

Link:
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9178439/

The Basics:
This is a multicenter, retrospective, cross-sectional study which included 3 publicly available databases from 200+ hospitals and 380+ ICUs from which 87,000+ patients with first ABG measurements and SpO2 at least 88% within 5 minutes before the ABG test were included.

Inclusion Criteria:
SpO2 range for inclusion was 88-100% with a first ABG and a SpO2 documented within 5 mins of that ABG. Self identified race and ethnicity of Asian, Black, Hispanic, or White were included.

Exclusion Criteria:
If there was not a SpO2 documented within 5 mins of first ABG, patients were excluded. Measurements less than 88% were not measured due to low prevalence. Patient who did not have their self-reported race a Asian, Black, Hispanic, or White were not included. If patient's chart did not have certain data listed, such as age, ethnicity, race, CVSOFA score, etc, listed, then the charts were excluded from the data.

Primary Outcomes:
Rates of hidden hypoxemia among different racial/ethnic groups

Secondary Outcomes:
Effect on clinical outcomes including in-hospital mortality, length of stay, organ dysfunction

Results:
Out of the 3 databases analyzed, 141600 encounters had ABGs and Spo2 and Sao2 pairs within 30 mins of each other. Further restricting to Sp02 within 5 minutes of an ABG and selecting the first ABG in an encounter led to a total of 87,971 patient encounters being analyzed. The first pairs of Spo2 and Sao2 were taken with a 42.9% of the population being women. With the above mentioned inclusion and exclusion criteria, the patients analyzed were placed in 4 subgroups based on ethnicity - 1919 Asian patients (2.7%), 26032 Black patients (29.6%), 2397 Hispanic patients (2397) and 57623 White patients (65.5%). Additionally, besides oxygen saturation measurements, patient's SOFA scores, in-hospital mortality, lactate levels were also analyzed. Overall, hidden hypoxemia was found in all subgroups with varying incidence (Black at 6.8%, Hispanic at 6.0%, Asian at 4.8%, and White at 4.9%). Hidden hypoxemia was also associated with greater organ dysfunction 24hrs after ABG measurement, as seen in higher SOFA scores. There was also higher in-hospital mortality associated with hidden hypoxemia in addition to higher lactate levels/less lactate clearance.

Limitations/Bias:
In this retrospective study, there was limitation based on the study criteria where patients with measurements of Spo2 and ABG that were more than 5 minutes apart were not analyzed, limiting the number of patients analyzed. Additionally, different brands of Spo2 measurement machines may have been used, which was not recorded in the EMR, thus it was unable to be assessed. Patients used in this study were also in a critical care setting, with no data analysis for non-critically ill floor patients and finding evidence of hidden hypoxemia. Additionally, this was a retrospective study, reflecting associations; however, further studies should be developed to assess causality between hidden hypoxemia and patient outcomes.