



Early View

Research Letter

A requirement for the use of supplementary oxygen to guide medical treatment decisions may introduce bias against non-White individuals

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A requirement for the use of supplementary oxygen to guide medical treatment decisions may introduce bias against non-White individuals

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To the Editor:

In England and Wales there was excess mortality from Covid-19 infection in individuals whose forebears originated outside the UK, often in Africa or South East Asia [1]. The reasons for this are still unclear. We suggest that the use of oxygen saturations derived from pulse oximetry to guide treatment may have been a contributory factor.

Pulse oximeters provide a non-invasive measure of blood oxygen saturation [2], and were commonly used during the Covid-19 pandemic. However, pulse oximetry is less accurate in patients with non-white skin [3, 4], leading to risks of misleadingly higher estimates of oxygen saturation. This could delay starting oxygen supplementation in patients with non-white skin. Given that guidelines for managing Covid-19 pneumonia state that corticosteroids should be prescribed to patients receiving supplementary oxygen [5, 6], any racial bias from pulse oximeters in patients with non-white skin also has the potential to delay prescription of corticosteroids, potentially deferring an intervention that reduces mortality by 18% [7].

We hypothesised that in patients admitted with Covid-19 infection, those of non-White ethnicity would have more severe respiratory failure, as defined as a higher respiratory rate compared to those of white Ethnicity, when their treatment was increased by starting supplemental oxygen therapy.

We conducted a cohort study using routinely collected electronic data for patients admitted to Nottingham University Hospitals NHS trust between 1 February 2020 and 31 December 2021 with Covid-19 infection. There were no data on oxygen use prior to arrival at hospital e.g., in an ambulance. Hence, there were two complementary analyses stratified by ethnic group. Firstly, the initial set of observations associated with a first use of supplemental oxygen during the hospital admission. Secondly, the last set of observations documented with no supplementary oxygen before receiving supplementary oxygen therapy in hospital.

A linear model predicting each measurement by ethnicity was fitted, adjusted for age (as a linear and a categorical variable <50 years 51-60 years, 61-70 years, 71-80 years and >80 years) and sex, for both analyses. All analyses were performed using version 4.2.2 of the R programming language.

Approval for this work was granted via an NUH Clinical Effectiveness Team audit (reference: 21-294C) and IRAS (REC: 20/WM/0142, project ID: 282490, amendment No. SA02 20/07/21).

Data were available from a total population of 7930 eligible adults who had a median age of 69 years. 5822 (73%) of these individuals were classified as being of White ethnicity. When initially recorded as starting supplementary oxygen, the median blood oxygen saturation derived from pulse oximetry was 96% for each of the White, Black and SE Asian ethnic groups in the 7810 patients with available data.

In the initial analysis that included patients at the first recorded use of supplemental oxygen during an admission to hospital, individuals with an ethnicity classified as either Black or SE Asian had a higher respiratory rate of +1.6 breaths/minute (95% confidence intervals CI: 0.9 to 2.3) and +1.3 (95% CI: +0.6 to +1.9) respectively than those classified as White (Table) after adjustment for age and sex. In the second analysis of patients who were documented as not initially requiring supplemental oxygen in hospital, before treatment was escalated to the prescription of supplementary oxygen, the adjusted association with Black ethnicity increased to 2.7 breaths/minute (95% confidence intervals CI: 0.2 to 5.2) compared to those of White ethnicity (Table), although the association with SE Asian ethnicity did not persist.

This is the first analysis to demonstrate that Covid-19 patients of Black ethnicity had increased respiratory rate prior to the initiation of supplementary oxygen compared to patients with White ethnicity. The most likely explanation for this observation is the differential error of oxygen saturation when measured by pulse oximeters in people with Black ethnicity.

The strengths of this analysis are the collection of data from all patients with a diagnosis of Covid-19 infection admitted to a busy UK teaching hospital. Data were recorded on ethnicity during the routine admission procedure. Data were collected on respiratory rate, oxygen saturation as measured by pulse oximetry and the presence or absence of supplemental oxygen as part of the routine clinical observations, and these data were electronically archived. A strength of the analysis is the availability of data on the patients who did not receive supplementary oxygen on arrival to hospital, but then required it.

Routinely collected data on ethnic group as categorised by skin pigmentation may be susceptible to measurement error, however, it is likely that individuals labelled as White, SE Asian and Black ethnicity are from broadly recognisable phenotypes. Respiratory rate is often manually measured by healthcare staff [8], and this can also introduce measurement error that may reduce the precision and size of the differences observed. However, this would likely decrease any differences observed as a result of regression dilution bias [9].

The problem of differential error of oxygen saturation as measured by pulse oximetry in individuals with Black skin has been known for at least three decades [10], and subsequently reported in larger populations in the USA [3] and in patients from our institution [4]. These data are consistent with our prior observation that at the time of transfer to intensive care, those patients of Black ethnicity had substantially more severe respiratory failure with increased respiratory rates and decreased oxygen saturation as measured by arterial blood gases, yet similar oxygen saturation as measured by pulse oximeters [11]; again this would be consistent with the hypothesis that differential error of oxygen saturation as measured by pulse oximeters is associated with delays in the escalation of treatment in patients with non-white skin compared to those with white skin.

These data provide further evidence that differential measurement error of oxygen saturation in patients with non-white skin may contribute to the excess mortality from Covid-19 infections [1]. As such, it highlights the need for further analysis of other large datasets, as these findings could have important implications for clinical decision making. Datasets that have access to concurrent electronic prescribing data would be particularly useful, as these could allow evaluation of the timing of the initiation of therapies such as corticosteroids with the physiological measurements of disease severity. These potential analyses could also explore other key data elements in detail such as patient clinical characteristics, medical management strategies, and outcome data that we were unable to analyse in our dataset.

Pulse oximeters are used to assess patients in primary care, ambulances, emergency departments, in hospitals both as part of both direct clinical care and also the early warning score safety net surveillance system [12], and in virtual wards at home after discharge from hospital [13]. This problem is compounded if the initiation of effective treatments that reduce mortality, such as the prescription of corticosteroids in Covid-19 infection, is linked to disease severity as defined by the requirement for supplemental oxygen which is a decision that is often based on pulse oximetry measurements.

When designing guidelines in respiratory disease, awareness of the differential measurement error of oxygen saturation, as measured by pulse oximeters, across different ethnic groups may modify thresholds for starting oxygen is an important consideration, particularly if the use of supplemental oxygen is linked to starting disease modifying treatments. This may be particularly important in the context of future pandemics.

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Patient and Public Involvement

There was no patient or public involvement in this analysis.

Competing interests

No competing interests

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Table. Respiratory rate of patients with Covid-19 infection at time of commencing supplemental oxygen stratified by reported ethnicity

	<i>N</i>	Respiratory rate at first recorded use of supplementary oxygen during admission	<i>p</i>	<i>N</i>	Respiratory rate on air prior to first initiation of supplementary oxygen during admission	<i>p</i>
		<i>Adjusted difference in respiratory rate, breaths/minute. (95% CI)</i>			<i>Adjusted difference in respiratory rate, breaths/minute. (95% CI)</i>	
Age (years)	7930	0.00 (-0.01 to 0.01)	0.609	579	-0.01 (-0.04 to +0.01)	0.277
White	5822	<i>Reference</i>		414	<i>Reference</i>	
Asian	373	+1.25 (+0.60 to +1.89)	<0.001	22	+0.51 (-1.94 to +2.97)	0.680
Black	298	+1.62 (+0.90 to +2.33)	<0.001	21	+2.70 (+0.21 to +5.18)	0.033
Other	171	+1.64 (+0.70 to +2.57)	0.001	18	+3.86 (+1.16 to +6.55)	0.005
Unknown	1266	+0.69 (+0.31 to +1.06)	<0.001	104	+0.15 (-1.08 to +1.37)	0.816
Male	4202	<i>Reference</i>		300	<i>Reference</i>	
Female	3728	-0.46 (-0.73 to -0.18)	0.001	279	+0.19 (-0.73 to +1.12)	0.678

Analysis using multivariate linear regression
CI = confidence intervals