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Effect of a lower target oxygen saturation range on the risk of hypoxaemia and elevated NEWS2 scores at a university hospital: a retrospective study

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ABSTRACT

Background The optimal target oxygen saturation (SpO_2) range for hospital inpatients not at risk of hypercapnia is unknown. The objective of this study was to assess the impact on oxygen usage and National Early Warning Score 2 (NEWS2) of changing the standard SpO_2 target range from 94–98% to 92–96%.

Methods In a metropolitan UK hospital, a database of electronic bedside SpO_2 measurements, oxygen prescriptions and NEWS2 records was reviewed. Logistic regression was used to compare the proportion of hypoxaemic SpO_2 values (<90%) and NEWS2 records ≥5 in 2019, when the target SpO_2 range was 94–98%; with 2022, when the target range was 92–96%.

Results In 2019, 218 of 224 936 (0.10%) observations on room air and 162 of 11 328 (1.43%) on oxygen recorded an SpO_2 <90%, and in 2022, 251 of 225 970 (0.11%) and 233 of 12 845 (1.81%), respectively (risk difference 0.04%, 95% CI 0.02% to 0.07%). NEWS2 ≥5 was observed in 3009 of 236 264 (1.27%) observations in 2019 and 4061 of 238 815 (1.70%) in 2022 (risk difference 0.43%, 0.36% to 0.50%; p<0.001). The proportion of patients using supplemental oxygen with hyperoxaemia (SpO_2 100%) was 5.4% in 2019 and 3.9% in 2022 (OR 0.71, 0.63 to 0.81; p<0.001).

Discussion The proportion of observations with SpO_2 <90% or NEWS2 ≥5 was greater with the 92–96% range; however, absolute differences were very small and of doubtful clinical relevance, in contrast to hyperoxaemia for which the proportion was markedly less in 2022. These findings support proposals that the British Thoracic Society oxygen guidelines could recommend a lower target SpO_2 range.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ It is uncertain whether the recommended target oxygen saturation (SpO_2) range for patients not at risk of hypercapnia should be between 94% and 98%, concordant with British Thoracic Society (BTS) and American Association for Respiratory Care guidelines, or between 92% and 96%, concordant with the Thoracic Society of Australia and New Zealand guidelines and the German National S3 guidelines.

WHAT THIS STUDY ADDS

⇒ This study found that the proportion of observations with SpO_2 <90% or a National Warning Score 2 (NEWS2) ≥5 was greater with the 92–96% range when compared with the 94–98% range; however, the absolute differences were very small and unlikely to be clinically relevant, whereas hyperoxaemia was markedly less prevalent when using a target range of 92–96% in 2022.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ These findings contribute to the evidence base supporting the proposal that the BTS oxygen guidelines recommend a lower SpO_2 target range of 92–96% for patients not at risk of hypercapnia.

INTRODUCTION

Oxygen therapy is common in hospital settings. Clinical guidelines recommend that oxygen is prescribed and delivered to achieve a particular oxygen saturation (SpO_2) target range.[1–4] The prescribed target range defines SpO_2 values that minimise clinical risks to patients with hypoxaemia, when saturation falls below range[5 6] or hyperoxaemia, when saturation rises above range.[7 8] Oxygen guidelines broadly align with advocating the use of two possible target ranges. First, a low target range prescribed for those at risk of hypercapnic respiratory failure. Second, a standard target range for those who are not at such risk. There is consensus that the low target range should be an SpO_2 between 88% and 92%.[1–4] There is less consensus about an appropriate standard range. The 2017 British Thoracic Society (BTS) and 2022 American Association for Respiratory Care guidelines recommend a standard SpO_2 target range of 94–98%,[2 3] whereas the 2015 Thoracic Society of Australia and New Zealand (TSANZ) and 2022 German National S3 guidelines recommend a target range of 92–96%.[1 4] The evidence suggesting a reduced clinical risk for the lower compared with higher standard target range[9–11] has led to a strong recommendation for maintaining SpO_2 of no more than 96% in acutely ill medical patients on supplemental oxygen.[11] Additionally, with oxygen conservation given increased priority during the COVID-19 pandemic, the 2020 UK National Health Service (NHS) recommendation was for a standard target range of 92–96% for all hospital patients;[12] while the 2020 WHO guidance was to target >94% during resuscitation, followed by >90% in non-pregnant adults with COVID-19 once stable.[13]

Measurement of SpO_2 with pulse oximeters guides oxygen titration and safe oxygen delivery, but also contributes directly to assessment of physiological derangement and the risk of adverse patient outcomes. Consequently, SpO_2 has been widely adopted as a 'vital sign' and integrated into early warning scores (EWSs) that are used to standardise the assessment and responses to acute illness. Composite EWSs also include measurements of respiratory rate, systolic blood pressure, heart rate, temperature and level of consciousness, in addition to SpO_2 and supplemental oxygen use, and accurately predict important adverse outcomes, including in-hospital cardiac arrest[14] and death.[15] The National Early Warning Score 2 (NEWS2) is widely used in NHS trusts. It was revised in 2017 to distinguish between the low (88–92%) and standard (94–98%) SpO_2 target ranges.[16]

Until early 2020, Salford Royal Hospital (Salford, England) used a standard target range of 94–98%, concordant with 2017 BTS guidance. During oxygen shortages at some UK hospitals associated with the UK COVID-19 pandemic, and consistent with reports of harm reduction in some clinically defined patient groups,[10–12] Salford's standard SpO_2 target range was updated to 92–96%, concordant with 2015 TSANZ guidance. This change influenced oxygen delivery practices. In Salford, an integrated electronic medical record (EMR) allows for routine collection of oxygen prescription, SpO_2, vital signs and NEWS2 scores in an administrative dataset, allowing for large-scale automated audits of oxygen use and vital signs to be conducted instantaneously.[17] We were unable to identify other research describing cohort studies of the effect of oxygen prescribing and delivery practices on achieved SpO_2 and NEWS2 scores.

This study aims to investigate the association between the change in standard SpO_2 target range at Salford Royal Hospital and the distribution of documented SpO_2 values measured as part of routine NEWS2 scoring. This enquiry explores the hypothesis that implementing the change between the two different standard SpO_2 target ranges, in relation to patient cohorts before and after the change, was not associated with a prespecified clinically meaningful difference in risk of hypoxaemic events or NEWS2 scores prompting clinician review.

METHODS

Data collection

All data reported in this analysis arose from routine observations collected by hospital staff as part of usual care across more than 40 wards and units at a 900-bed NHS hospital in Greater Manchester. Salford Royal is a general hospital for the locality with regional facilities for major trauma, stroke, neurology and neurosurgery. It does not provide maternity or paediatric care. Most SpO_2 measurements in this study were documented on medical, elderly care and surgical wards. The emergency department accounted for 16.1% of measurements in 2019 and 23.6% in 2022. The critical care unit contributed 4.7% of the measurements in both years. All pulse oximeters in use at Salford Royal Hospital are CE certified (conforming to European standards) and are calibrated regularly by the hospital's medical physics team. Each ward orders its own medical equipment and there is no central inventory, so details of oximeter manufacturers and models are not available.

Data preparation

The overall dataset for SpO_2 observations and NEWS2 scores is available from the Salford Royal Hospital EMR, Sunrise-Altera, database, V.18. Relevant data were extracted from this dataset by the Salford Royal Hospital Business Information Team and anonymised prior to analysis.

Patient and public involvement

Patients and members of the public were not involved in the design or conduct of this study.

Participants

The two annual cohorts of interest were extracted to avoid 'waves' of COVID-19 hospitalisation and so were chosen to be 1 January–31 December 2019 and 2022, with the change in the standard oxygen target range occurring in 2020. Within the dataset, we have analysed over half a million sets of bedside observations; ethnicity, skin colour and other demographics were not available for analysis. Salford Hospital patients are mostly from the Salford locality, within which, in the 2021 UK Census, 82.3% of residents described themselves as white, 6.1% identified as black, 5.5% identified as Asian, 2.0% identified as having mixed ethnicity and 2.9% selected 'other' as their ethnicity.[18]

The frequency of observations captured in the EMR differed by individual. To address the bias that would arise from individuals having a high frequency of observation sets per day contributing disproportionately to the final dataset, only a single observation set per individual, per day, was chosen for inclusion in the analysis. Most new admissions at the study hospital occur during the daytime, so to minimise the contribution of observation sets from newly admitted patients who might not yet have an oxygen prescription, only the final documented observation set per individual, per day (12:00–12:00), was included in the study dataset.

Outcomes

The primary variable of interest was individual observations of SpO_2 and particularly the number and proportions of observations that were hypoxaemic, where SpO_2 <90%.[1 2] Other categorisations of SpO_2 were treated as secondary outcome variables, as was the recorded NEWS2 score. The NEWS2 scores that are presented in this paper were calculated in accordance with the Royal College of Physicians (RCP) methodology.[16] The bedside NEWS scores in Salford since 2014 have been calculated using the Salford NEWS score which is identical to the RCP NEWS2 methodology apart from allocating one extra NEWS point to patients who are hyperoxaemic (SpO_2 99–100%) on supplemental oxygen therapy. The main explanatory variable was the year of observation: before, 2019, or after, 2022, with the change in the recommended standard oxygen prescription range occurring in 2020. The choice of the individual unit of observation as the unit of analysis was made because changes to oxygen prescription and the assessment of the NEWS2 score, and whether a clinician review was prompted, are in general made on the basis of the individual observations.

This dataset was very large so quite small differences in proportions could be identified as statistically significant. In the absence of a validated definition for clinical significance, the consensus of the study investigators was to use a predefined threshold for clinical significance as a difference in proportions of 1% which would require 100 additional observation sets to be made for one more event to be observed.

Statistical methods

For SpO_2, individual observations were the units of analysis. These were further categorised according to the oxygen range plan: low, standard or not stated; and by achieved SpO_2, categorised as: <85%, <88%, <90%, 92–93%, 97–98% and 100%. Of these possible 18 combinations, 10 were investigated. Additional categories included if the observation was made on room air or oxygen, and the year of observation: 2022 compared with 2019. The main interest was whether the probability of a particular SpO_2 observation was different in relation to year. However, because it was possible that this association was also related to whether the observation was made on room air or oxygen, the analysis also examined evidence for if the difference between years depended on whether the observation was made on room air or oxygen, as an interaction model, or was independent of this as a main effects model. Logistic regression was used to assess the associations. If p value for the interaction term was <0.05, then the differences between years, expressed as ORs, are reported within the strata of room air and oxygen. Otherwise, the differences between years expressed as ORs are reported as a main effect after adjustment for room air compared with oxygen. A second variable of interest was the proportion of NEWS2 scores made while on a standard oxygen target. The two categories of NEWS2 scores were total score ≥5 and the NEWS2 subscore between 3 and 5, which isolated highly scoring SpO_2 and supplemental O_2 parameters from the total NEWS2 score, so that the year effects of other vital signs were removed. For illustrative purposes, risk differences are reported for selected comparisons between years for SpO_2; however, these do not adjust for other effects in main effects models, or for interactions when these were identified. The analysis of NEWS2 scores was by estimation of risk differences and associated X^2 tests.

SAS V.9.4 was used for analysis.

RESULTS

The dataset for analysis was selected from a total pool of 377 222 datapoints in 2019 and 402 794 datapoints in 2022, with observation flow diagrams of eligible observations shown in online supplemental figures 1 and 2.

Summary data and associations between year of observation, SpO_2 category and oxygen prescription are shown in table 1. In 2019, 218 of 224 936 (0.10%) observations on room air and 162 of 11 328 (1.43%) on oxygen were associated with SpO_2 <90%. In 2022, these summary figures were 251 of 225 970 (0.11%) and 233 of 12 845 (1.81%), respectively. The OR (95% CI) for SpO_2 <90% for 2022 compared with 2019 was 1.20 (1.05 to 1.38), p=0.008 (risk difference (95% CI) 0.04% (0.02% to 0.07%) (table 2).

There was no evidence of a difference in this association for the room air and oxygen strata. For an SpO_2 <85%, this was more likely in 2022 compared with 2019 for the oxygen group but not in the room air group.

The proportion of patients using supplemental oxygen with a standard prescribed target range who had hyperoxaemia (SpO_2 100%) was reduced from 5.4% in 2019 to 3.9% in 2022 (OR 0.71 (0.63 to 0.81), p<0.001).

In those observations with a low target oxygen prescription (target range 88–92% due to risk of hypercapnia), there was no evidence of a difference in years for SpO_2 <85% or <88%, and some evidence that SpO_2 >92% was more likely in 2022 compared with 2019, and there was no evidence of a difference in strata.

In those observations with a standard oxygen prescription, SpO_2 between 92% and 93% was more likely in 2022 compared with 2019 with no evidence of a difference in strata. SpO_2 between 97% and 98% was less likely in 2022 for both strata, although the association was stronger for those receiving oxygen.

In those observations with no oxygen range prescription, SpO_2 between 92% and 93% was more likely in 2022 compared with 2019 for those receiving oxygen and there was no association between year of observation for those receiving room air. In 2022, an SpO_2 between 97% and 98% was less likely for those receiving oxygen with no association for those receiving room air.

Table 1 Associations between year of observation and SpO_2 category and prescription

Oxygen target range strategy	N (%) 2019 Room air	2019 Oxygen	2022 Room air	2022 Oxygen	2022 vs 2019 OR (95% CI)	
Standard range	N=224 936	N=11 328	N=225 970	N=12 845		
SpO_2					**Main effect***	
<90%	218 (0.10)	162 (1.43)	251 (0.11)	233 (1.81)	1.20 (1.05 to 1.38) p=0.008	
					Oxygen†	**Room air†**
<85%	55 (0.02)	50 (0.44)	47 (0.02)	85 (0.66)	1.50 (1.06 to 2.13) p=0.023	0.85 (0.58 to 1.26) p=0.42
					Main effect*	
92–93%	1366 (0.61)	214 (1.89)	3975 (1.76)	737 (5.74)	2.96 (2.80 to 3.14) p<0.001	
					Oxygen†	**Room air†**
97–98%	99 961 (44.4)	3867 (34.1)	94 523 (41.7)	3573 (27.8)	0.74 (0.70 to 0.79) p<0.001	0.90 (0.88 to 0.91) p<0.001
100%	17 696 (7.9)	608 (5.4)	15 530 (6.9)	500 (3.9)	0.71 (0.63 to 0.81) p<0.001	0.86 (0.75 to 0.88) p<0.001
Low range						
SpO_2	N=25 373	N=6438	N=18 807	N=6932	**Main effect***	
<85%	59 (0.23)	51 (0.79)	51 (0.27)	57 (0.82)	1.10 (0.84 to 1.44) p=0.48	
>92%	18 518 (73.0)	2355 (36.6)	13 881 (73.8)	2594 (37.4)	1.04 (1.00 to 1.08) p=0.029	
<88%	195 (0.77)	120 (1.86)	162 (0.86)	123 (1.77)	1.05 (0.89 to 1.23) p=0.56	
No stated range						
SpO_2	N=88 601	N=860	N=119 839	N=1202	**Oxygen†**	**Room air†**
92–93%	437 (0.49)	18 (2.09)	606 (0.51)	58 (4.83)	2.37 (1.39 to 4.05) p=0.002	1.03 (0.91 to 1.16) p=0.69
97–98%	39 344 (44.4)	310 (36.0)	53 668 (44.8)	349 (29.0)	0.73 (0.60 to 0.88) p=0.001	1.02 (1.0 to 1.03) p=0.087

*Interaction p>0.05, main effect for 2022 vs 2019 after adjustment for room air versus oxygen.
†Interaction p<0.05, effects for 2022 vs 2019 within room air and oxygen stratum.
SpO_2, oxygen saturation.

Illustrative risk differences and associated number of observations needed to treat for selected comparisons are shown in table 2. For standard target range oxygen prescription, there would need to be a very large number of observations for one extra observation to have SpO_2 <90% (2500) or SpO_2 <85% (10 000) for 2022 compared with 2019.

Risk differences and associated number of observations needed to treat for NEWS2 scores in two categories are shown in table 3. Total NEWS2 scores reaching a threshold for clinician callout (NEWS2 ≥5) occurred more frequently in 2022 compared with 2019 with one additional clinician callout per 233 observations in 2022 compared with 2019, and one additional NEWS2 subscore (score for SpO_2 and oxygen use) between 3 and 5 per 152 observations.

The change in distribution of SpO_2 observations around the margins of the standard target range is shown in figure 1, where SpO_2 values of 92–93% were more frequent, and 97–98% less frequent in 2022. Figure 2 shows the change in distribution of SpO_2 values observed between years when no oxygen prescription was in place.

DISCUSSION

This study explores differences in routinely measured observations in cohorts of patients before and after Salford Royal Hospital reduced its standard SpO_2 target range. Changing the target range was associated with a statistically significant increase in the proportion of observations with SpO_2 <90% or NEWS2 score ≥5. However, the absolute risk differences were very small,

Table 2 Illustrative risk differences and numbers needed to treat for an extra event for selected oxygen prescriptions and SpO_2 by year

Oxygen target range strategy	N (%) 2019	N (%) 2022	Risk difference (95% CI)	Number of observations for one more event
Standard range	N=236 264	N=238 815		
SpO_2				
<90%	380 (0.16)	484 (0.20)	0.04 (0.02 to 0.07)	2500
<85%	105 (0.04)	132 (0.06)	0.01 (0.00 to 0.02)	10 000
Low range	N=31 811	N=25 739		
SpO_2				
<85%	110 (0.35)	108 (0.42)	0.07 (0.03 to 0.18)	1429
>92%	20 873 (65.6)	16 475 (64.0)	−1.61 (−2.39 to −0.82)	62
<88%	315 (0.99)	285 (1.11)	0.12 (−0.09 to 0.28)	833
Supplemental oxygen only				
Standard range	N=11 328	N=12 845		
SpO_2				
92–93%	214 (1.89)	737 (5.74)	3.85 (3.37 to 4.32)	26
97–98%	3867 (34.1)	3573 (27.8)	−6.32 (−7.49 to −5.15)	16
100%	608 (5.37)	500 (3.89)	−1.48 (−2.01 to −0.90)	68

SpO_2, oxygen saturation.

well below the prespecified clinically meaningful difference, and thus unlikely to be clinically relevant. These findings suggest that adopting a standard range of SpO_2, 92–96%, is unlikely to meaningfully influence patient exposure to hypoxaemia or the likelihood of having a high NEWS2 score mandating clinical review. In addition, the likelihood of overt hyperoxaemia, where SpO_2 was observed at 100% in the presence of supplemental oxygen, was significantly lower with the new target range in place. This difference in risk of hyperoxaemia between years was substantially greater than the prespecified clinically meaningful difference, and thus likely to be clinically relevant, inferring that the risks of overoxygenation are best mitigated when the standard target range is set between 92% and 96% rather than between 94% and 98%. Additional changes in the distribution of SpO_2 values at the boundaries of the new standard target range were observed. In 2022 compared with 2019, there was an increase in the proportion of observations of SpO_2 between 92% and 93% and a decrease in proportions for SpO_2 between 97% and 98%, which suggests that clinicians were using oxygen more conservatively in 2022.

In those observations made on patients at risk of hypercapnia who were prescribed the recommended target range of an SpO_2 between 88% and 92%, there was no difference in the proportion of observations with SpO_2 below range, <88%, or markedly below range, <85%. In patients for whom no target range was prescribed, there was an increase in the proportion of SpO_2 observations between 92% and 93% and a decrease in the proportions for SpO_2 between 97% and 98%. This is consistent with an institutional-level change in oxygen delivery practice.

The most desirable standard target range is the option that offers the safest profile of clinical risk in the condition for which it is prescribed. Hypoxaemia is given primary consideration on account of its well-described

Table 3 Risk differences and number of observations needed to treat for an extra NEWS2 event by year for observations with a standard oxygen prescription

NEWS2 category	N (%) 2019	N (%) 2022	Risk difference (95% CI)	Number of observations for one more event
Standard range	N=236 264	N=238 815		
NEWS2 ≥5	3009 (1.27)	4061 (1.70)	0.43 (0.36 to 0.50) p<0.001	233
NEWS2 subscore 3–5 for SpO_2 and oxygen therapy	2905 (1.23)	4506 (1.89)	0.66 (0.59 to 0.73) p<0.001	152

NEWS2, National Early Warning Score 2; SpO_2, oxygen saturation.

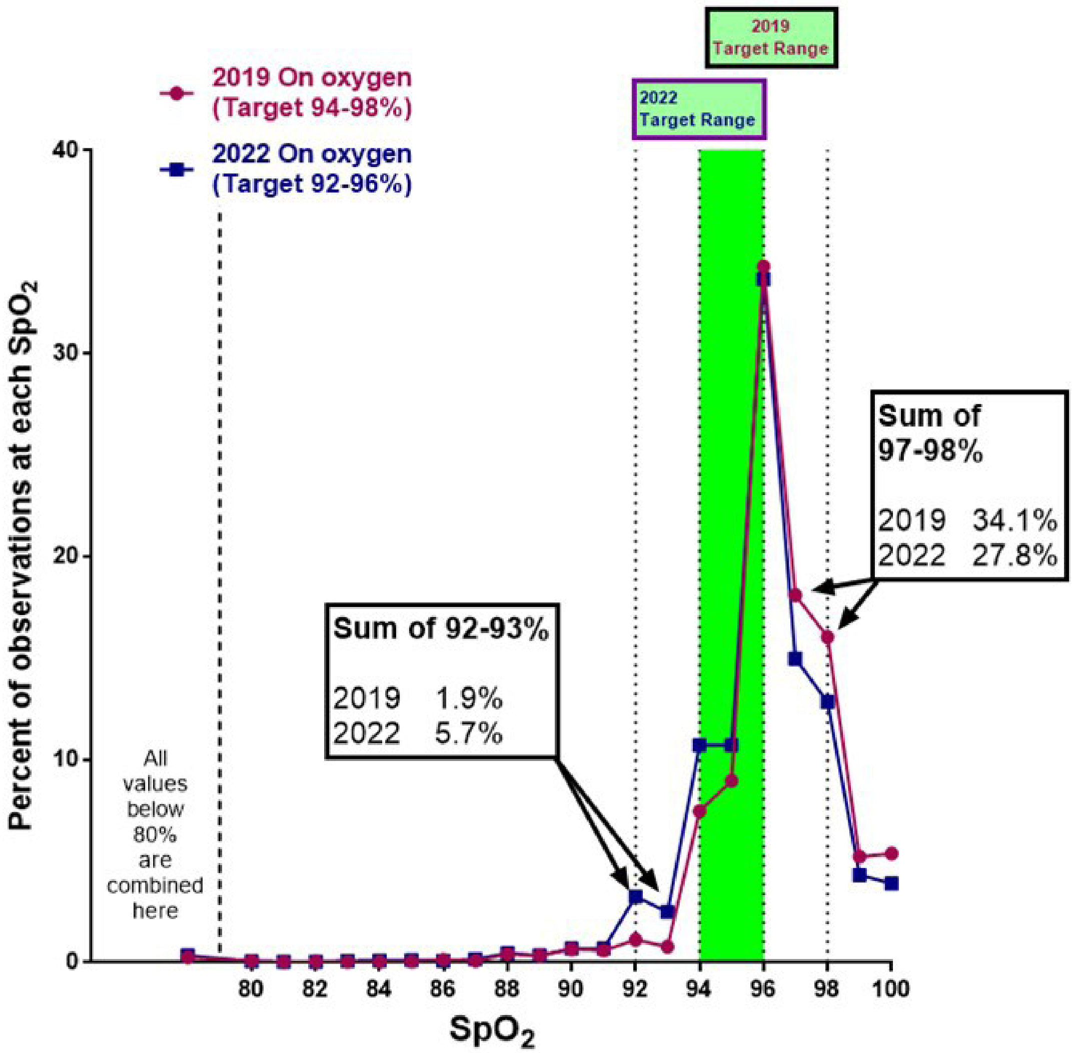

Figure 1 Distribution of SpO_2 values with oxygen supplemented and a standard oxygen prescription: 2022 (92–96%) vs 2019 (94 –98%). SpO_2, oxygen saturation.

physiological effect and because severe hypoxaemia has a clear association with harm, ranging from transient compromise of cellular function to severe tissue ischaemia, organ dysfunction and death.[19] The most common definition for hypoxaemia is an SpO_2 below 90%[2] and when a 90% threshold was used, no clinically relevant difference in the risk of hypoxaemia between the two standard target ranges was observed. The current 2017 BTS-recommended standard saturation range of between 94% and 98% has been justified on the premise that this range more closely reflects normal SpO_2 values in a healthy population and a 4% margin of safety is warranted to account for variability in saturation levels; yet as reflected in the results of this trial, a margin of 2% may be sufficient.

The secondary consideration when assessing safety of the saturation target range is the risk posed by exposure to hyperoxaemia. This was defined in this study as SpO_2 equal to 100% in the presence of supplemental oxygen. This occurred more frequently when the standard target range of between 94% and 98% was used. This definition characterises the most extreme scenario of hyperoxaemia. The SpO_2 threshold for which the use of supplemental oxygen is likely to increase risk of mortality is estimated to lie close to 96%.[10 11] The most compelling evidence for risk of harm of hyperoxaemia comes from the IOTA systematic review/meta-analysis,[10] reporting increased in-hospital mortality (relative risk (95% CI) 1.14 (1.01 to 1.29)) and 30-day mortality (1.10 (1.00 to 1.20)) for liberal oxygenation compared with more conservative oxygenation. The IOTA study reported that the risk of mortality progressively increased with increasing SpO_2 above 96%. These findings were operationalised into clinical practice guidelines by Siemieniuk and colleagues[11] who make the strong recommendation that for most acutely unwell patients, SpO_2 should be maintained no higher than 96%, based on moderate certainty evidence, and estimated 11 fewer deaths per 1000 people when the target range upper limit is ≤96% as compared with ≥97%. The generalisability of this guideline has been questioned, as the mortality events were derived mostly from studies assessing patients hospitalised for cardiac,[20]

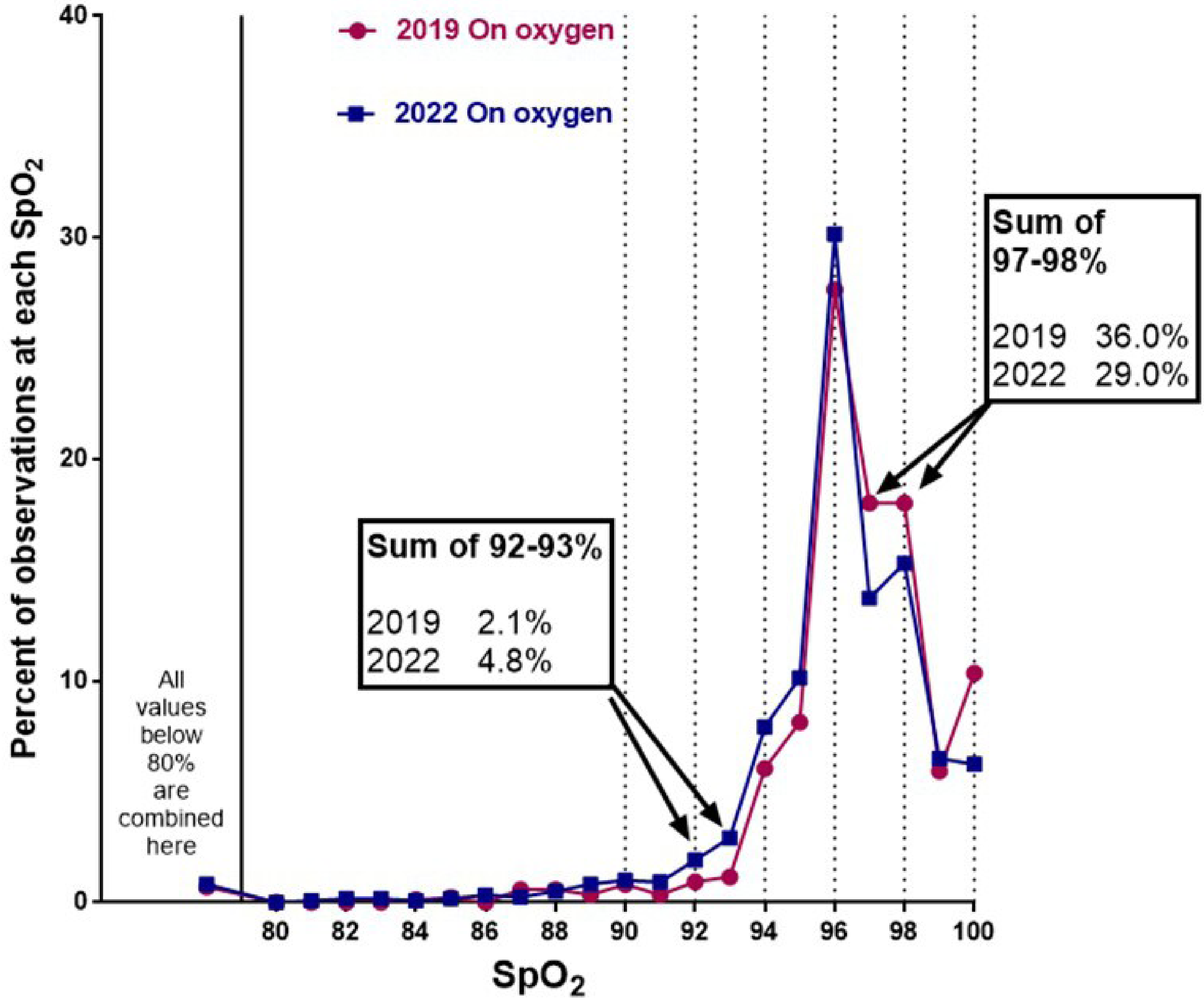

Figure 2 Distribution of SpO_2 values with oxygen supplemented and no oxygen prescription: 2022 vs 2019. SpO_2, oxygen saturation.

neurological[21 22] and critical care[23] conditions, and subsequent critical care trials imply that there is likely a heterogeneous association between hyperoxaemia and mortality depending on the clinical condition studied.[24 25] Nonetheless, with respect to what is currently known about the risks of hyperoxaemia outside of a critical care environment, the standard target range associated with the least harm is likely to be 92–96%.

SpO_2 is included in the NEWS2 risk stratification system, so it is important to characterise how changing the SpO_2 target range influences NEWS2 scores. In this study, the group with a standard SpO_2 target range had an increased proportion of observations in 2022 compared with 2019 with NEWS2 score ≥5 that would warrant a clinician callout. However, this association was modest with 233 additional observations required for one more NEWS2 ≥5 in 2022 compared with 2019. This increase in clinician workload is considered by the investigators to be of limited significance and balanced by the potential benefit of recognising the deteriorating patient earlier. Furthermore, many of these NEWS2 scores ≥5 would be repeated high scores which might not require further clinical review.

Healthcare facilities worldwide experienced critical oxygen shortages during the COVID-19 pandemic.[26] Guidelines recommended lower than usual SpO_2 targets to preserve oxygen and distribute this limited resource more equitably.[12 13] While the present study was conducted in a well-resourced setting, the clinically insignificant increase in frequency of hypoxaemia when the 94–98% target SpO_2 range was lowered suggests that the new target of 92 –96% is likely to enhance resource utilisation in addition to the provision of safe care. This issue is also relevant to resource-limited settings where the cost of oxygen therapy would be reduced when a more conservative target range was applied.

The key study limitations relate to the comparison of annual cohorts of data, restricting the inference of causation between lowering the standard target range and the change in SpO_2 values and NEWS2. Potential confounding events that may have independently influenced oxygen delivery practices between 2019 and 2022 include the COVID-19 pandemic, as well as the publication of practice changing critical care trial data analysing different oxygen delivery strategies.[27–29] These large, randomised, clinical trials are yet to offer conclusive evidence for the optimal target SpO_2 range for the subgroups of intensive care unit (ICU) patients with different disorders; and so, while approximately 5% of observation sets in the present study were from ICU patients, our study findings are most applicable to non-ICU patients, for which large, multicentre, randomised trials assessing the effect of different target ranges on morbidity and mortality have yet to be conducted.

Skin tone is known to influence the accuracy of pulse oximetry measurements such that SpO_2 has a higher likelihood of overestimating a paired measure of arterial oxygen saturation (SaO_2) (the reference standard) in people with darker skin pigmentation.[30–32] This can result in increased exposure to occult hypoxaemia, that is variably defined, but is commonly considered as an SpO_2 ≥88% when the simultaneously measured SaO_2 is <88%.[31] Ethnicity, skin tone and paired SaO_2 measurements were not available for this analysis, so the effect of skin tone on the frequency of occult hypoxaemia in this study population is uncertain.

Accuracy of pulse oximetry also differs by the type of oximeter in use, introducing further bias into the measurement of SpO_2.[33–35] The study findings were observed in a hospital where all oximeters in use are calibrated by the medical physics team on a regular basis, so are less generalisable to clinical settings without quality control measures in place, where pulse oximetry is likely to be less accurate.

This study reports a large number of analyses, inflating the risk of type I error. The study dataset contains over half a million observation sets, yet, all were from a single metropolitan hospital, which is well resourced, limiting the generalisability of the findings. With this administrative dataset, we were unable to make the unit of analysis of individual patients, in order to properly preserve anonymity, and, for that reason, we could not adjust for other potential confounding variables. Some patients contributing to individual observations had measurements made on both room air and oxygen at different stages of their admission.

Complementing current evidence,[9–11] this study supports a standard target range for oxygen prescription of 92–96% in non-ICU settings. With the 92–96% range, the proportion of observations with SpO_2 <90% or NEWS2 score ≥5 was greater; however, the absolute differences were very small and unlikely to be clinically relevant, in contrast to hyperoxaemia for which the proportion of observations was markedly less when this range was in use. As such, a target range of between 92% and 96% likely represents the standard oxygen prescription where risks are best balanced, and the findings of this study support proposals that the BTS recommendations should be updated to reflect this.

Contributors Design of the work—BRO'D, LK, MW, NDB, RB and PT. Analysis of the work—BRO'D and MW. Interpretation of the data—BRO'D, LK, MW, NDB, PT, JC and RB. Drafting and reviewing the content of the work—BRO'D, LK, MW, NDB, PT, JC and RB. Final approval of the published version—BRO'D, LK, MW, NDB, PT, JC and RB. Agreement to be accountable for the accuracy and integrity of the work—BRO'D, LK, MW, NDB, PT, JC and RB. Guarantor—BRO'D.

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Competing interests BRO'D was the chair of the BTS Guideline Development Committee in 2008 and 2017. RB has received research funding from Fisher and Paykel Healthcare and is a member of the TSANZ adult oxygen guidelines group.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants and permission to publish the anonymised aggregated datasets which were captured as part of routine clinical care was granted by the Trust Medical Director and by the Trust Caldicott Guardian.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request. Anonymised datasets are available upon reasonable request, until a minimum of 10 years after publication to researchers who provide a methodologically sound proposal that has been approved by the study investigators. This is possible through a signed data access agreement and subject to approval by the principal investigator (ronan.o'driscoll@nca.nhs.uk).

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