

BRIEF 002 · OXYGENATION · ~7 MIN READ

Can You Trust a Normal SpO2?

98%

REASSURING?
NOT ALWAYS.

A reassuring number does not always mean reassuring physiology.

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THE CLINICAL
QUESTION

Can we trust a normal SpO2 - or are we asking the number to tell us more than it actually measures?

A NUMBER IS ONLY USEFUL WHEN WE UNDERSTAND ITS BOUNDARIES.

Pulse oximetry has become inseparable from prehospital assessment. The probe goes on, a number appears and, within seconds, we have an apparently objective measure of how well the patient is oxygenating. It is quick, non-invasive and extraordinarily useful.

It can also be falsely reassuring. Sometimes, the number is technically inaccurate. At other times, the number itself is accurate, but the conclusion we draw from it is not.

IN THIS BRIEF

1. Understand what pulse oximetry measures and what it cannot.
2. Recognise when oxygen, carbon monoxide or poor perfusion can mislead.
3. Interpret the signal, patient, baseline and trajectory together.
4. Use the reading to support clinical judgement, never replace it.

WHAT IS THE PULSE OXIMETER ACTUALLY MEASURING?

A pulse oximeter passes red and infrared light through pulsatile tissue, usually a finger. It estimates the percentage of haemoglobin binding sites occupied by oxygen from the different light-absorption characteristics of oxygenated and deoxygenated haemoglobin (Jubran, 2015).

The displayed value is an estimate of peripheral oxygen saturation: SpO2. It is not a direct measurement of arterial oxygen partial pressure, carbon dioxide, adequacy of ventilation, haemoglobin concentration, cardiac output, tissue perfusion or cellular oxygen use.

That distinction matters.

THEORY

OXYGENATION IS NOT VENTILATION

Oxygenation describes movement of oxygen into the blood. Ventilation describes movement of air into and out of the lungs and elimination of carbon dioxide.

A patient can maintain an apparently normal SpO₂ while ventilation deteriorates, particularly when supplemental oxygen is administered. SpO₂ reflects oxygen saturation rather than alveolar ventilation (Jubran, 2015).

Fu et al. (2004) found that supplemental oxygen can delay recognition of hypoventilation by pulse oximetry. Although their postoperative setting limits direct generalisation to prehospital care, the physiological implication remains relevant: oxygen may preserve saturation while carbon dioxide rises and respiratory effort falls.

A normal SpO₂ should therefore not be treated as evidence of adequate ventilation. Respiratory rate, depth, consciousness and capnography may reveal deterioration that saturation alone cannot detect (Fu et al., 2004; Jubran, 2015).

THEORY IN ONE LINE

A normal SpO₂ does not tell us that ventilation or oxygen delivery is normal.

SATURATION IS NOT OXYGEN CONTENT

Most oxygen in blood is carried bound to haemoglobin. Oxygen delivery depends on more than the saturation displayed: it also depends on haemoglobin concentration and whether sufficient oxygenated blood reaches the tissues.

A profoundly anaemic patient may have an SpO₂ of 99%. The available haemoglobin may be almost completely saturated while total oxygen-carrying capacity remains substantially reduced. Likewise, an acceptable saturation does not confirm adequate cardiac output or tissue perfusion.

PRACTICE

WHEN A NORMAL NUMBER CAN MISLEAD

There are two different problems to recognise:

1. The displayed SpO₂ may not accurately represent arterial oxygen saturation.
2. The displayed SpO₂ may be accurate, but irrelevant to the physiological problem we need to detect.

1. SUPPLEMENTAL OXYGEN CAN CONCEAL HYPOVENTILATION

Supplemental oxygen may prevent a fall in SpO₂ while ventilation worsens. Fu et al. (2004) demonstrated this in postoperative patients; although the setting limits direct generalisation to prehospital care, the underlying physiology remains applicable.

The evidence supports caution, rather than rejection of pulse oximetry: saturation remains useful for oxygenation but is an inadequate surrogate for ventilation when inspired oxygen is increased. Clinical deterioration should outweigh a reassuring saturation when the two conflict.

PATIENT A

A patient has received opioid analgesia and is now drowsier than expected. They are receiving supplemental oxygen and have an SpO₂ of 98%. Their breathing is slow and shallow and consciousness is deteriorating.

The saturation is not necessarily false. It is answering the wrong question. The immediate problem is ventilation, not saturation.

2. CARBON MONOXIDE CAN PRODUCE FALSE REASSURANCE

Conventional two-wavelength pulse oximetry cannot reliably distinguish oxyhaemoglobin from carboxyhaemoglobin (Barker and Tremper, 1987; Jubran, 2015). A normal SpO₂ therefore cannot exclude carbon monoxide poisoning. Exposure history and appropriate carbon monoxide assessment remain the clinical priority.

PATIENT B

A patient is rescued from an enclosed-space fire. They report headache, nausea and dizziness. Their SpO2 is 99%.

That reading does not exclude carbon monoxide poisoning. The exposure history, symptoms, environment and appropriate assessment remain essential.

3. POOR PERFUSION CAN WEAKEN THE SIGNAL

Pulse oximetry depends on pulsatile blood flow. Cold extremities, vasoconstriction, shock, movement and probe position can degrade signal quality (Jubran, 2015). Evidence from emergency populations also suggests that accuracy is context-dependent: Wilson et al. (2010) found SpO2 overestimated SaO2 in severe sepsis and septic shock, with greater bias during hypoxaemia, while Lee et al. (2000) found clinically relevant overestimation was more frequent when carboxyhaemoglobin was elevated.

These studies are observational and setting-specific, so they cannot define the error of a particular device in a particular patient. They do, however, challenge the assumption that a displayed number is automatically reliable. Waveform quality, pulse correlation, perfusion, movement and consistency with the clinical picture should be assessed before accepting a reading.

Nail products, henna, tattoos, ambient light and device-specific limitations may also affect performance.

4. ACCURACY IS NOT EQUAL ACROSS ALL SKIN TONES

Pulse oximetry may overestimate arterial oxygen saturation in people with darker skin pigmentation, particularly during hypoxaemia (Bickler, Feiner and Severinghaus, 2005; Sjoding et al., 2020). This can contribute to occult hypoxaemia.

However, the evidence does not show that every reading is inaccurate. Martin et al. (2024) found an overall tendency towards overestimation, but 64% of included studies were at high risk of bias and only a minority directly assessed skin tone. Fawzy et al. (2022) linked measurement discrepancy with delayed treatment recognition, yet its COVID-19 hospital cohort limits direct transferability to undifferentiated prehospital populations. The evidence therefore supports caution near decision thresholds, rather than rejection of pulse oximetry.

Where SpO2 conflicts with trajectory or examination, wider assessment should carry greater weight (MHRA, 2021; Martin et al., 2024).

5. A SINGLE READING HIDES THE TRAJECTORY

An SpO2 of 95% can represent very different situations.

PATIENT 1	99% → 97% → 95%	DETERIORATING
PATIENT 2	89% → 92% → 95%	IMPROVING

The isolated number is identical. The clinical meaning is not.

BTS guidance notes that a sudden fall of more than 3% should prompt fuller assessment even within a target range (O'Driscoll et al., 2017). Trend adds information but does not replace whole-patient assessment.

BEYOND

WHEN 'NORMAL' BECOMES A DIAGNOSIS

The word normal carries psychological weight. Once a clinician sees an SpO2 of 98%, it can become an anchor around which the rest of the assessment is interpreted.

Respiratory distress becomes 'anxiety'. Reduced consciousness becomes 'sleepiness'. Smoke exposure feels less concerning. Shallow breathing appears less urgent. The possibility of serious respiratory pathology moves further down the differential.

Numbers feel objective, immediate and definitive. But a pulse oximeter does not assess work of breathing, recognise exhaustion, listen to air entry, measure carbon dioxide, identify anaemia or understand the mechanism of exposure.

It cannot tell whether the patient is maintaining physiology through increasing effort, or how long that compensation will last.

CLINICAL MEANING

A normal saturation is one piece of reassuring evidence. It is not a respiratory diagnosis.

NORMAL FOR WHOM?

There is no single oxygen-saturation target that applies to every patient.

BTS guidance recommends 94-98% for many acutely unwell adults not at risk of hypercapnic respiratory failure, and generally 88-92% for those with recognised risk while awaiting blood-gas information (O'Driscoll et al., 2017).

These ranges show why 'normal' is not universal. An SpO2 of 91% may represent hypoxaemia in one patient, an intended target in another, improvement from baseline in a third, or deterioration in someone normally saturating at 97%.

Population targets support decision-making but cannot replace baseline, trajectory, treatment context or clinical judgement. The same number can therefore carry different clinical meanings in different patients.

The number requires a patient, a baseline, a clinical situation and a trajectory before it gains meaning.

WHAT SHOULD WE TRUST?

The answer is not to distrust every reading. It is to understand the conditions under which the reading deserves our confidence.

A credible SpO₂ should come from a correctly positioned probe with an adequate pulsatile signal and should fit the patient's pulse and presentation. It should be interpreted as a trend and in relation to supplemental oxygen and baseline (MHRA, 2021).

Technical credibility does not guarantee clinical sufficiency. An accurate reading may still fail to identify hypoventilation, dys-haemoglobinaemia, anaemia or inadequate oxygen delivery (Fu et al., 2004; Jubran, 2015). Conversely, artefact or poor perfusion may make the value itself unreliable.

When number and patient disagree, both measurement error and interpretation error should be considered. Reassessment is safer than automatically privileging either the monitor or the initial clinical impression.

THE TAKEAWAY

TRUST THE READING - BUT KNOW WHAT YOU ARE TRUSTING IT TO TELL YOU

Before allowing a normal SpO₂ to reassure you, ask:

1. **Is the signal technically credible?** Check the waveform, pulse correlation, probe position, movement and peripheral perfusion.
2. **Is the patient receiving supplemental oxygen?** A normal saturation may persist despite worsening ventilation.
3. **Could abnormal haemoglobin affect the reading?** Conventional pulse oximetry cannot exclude carbon monoxide poisoning.
4. **Does the reading fit the patient?** Consider respiratory effort, rate, depth, air entry, mental state, perfusion and overall appearance.
5. **What is the trend?** A falling saturation may matter before it crosses an escalation threshold.
6. **What has SpO₂ not measured?** It has not measured carbon dioxide, haemoglobin concentration, cardiac output or tissue oxygen delivery.

**SpO₂ can tell you something important.
It cannot tell you everything important.**

BEYOND THE BRIEF

THE SAFEST INTERPRETATION BEGINS WITH THE BOUNDARIES

The next time a normal saturation appears inconsistent with the patient in front of you, pause before accepting the reassurance.

Confirm that the signal is credible. Look at the trend. Consider whether oxygen is masking hypoventilation. Ask whether the clinical problem is one that pulse oximetry can detect at all.

Because sometimes the monitor is wrong. Sometimes the number is right. And sometimes we have simply asked it the wrong question.

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