

Achieving oxygen saturation targets in preterm infants at birth: does using an SpO₂ target range help?

Neonatal resuscitation guidelines vary in their recommendations for oxygen saturation (SpO₂) targets – some use a single SpO₂ target, others use a target range. We conducted a prospective observational study collecting SpO₂ data on preterm infants born at <34 weeks' gestation. The objective of our study was to determine if using a range, rather than a single SpO₂ target, would be more achievable during preterm infant resuscitation.

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Keywords

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Key points

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1. We collected SpO₂ and heart rate data for the first 10 minutes of life in 50 preterm infants.
2. Irrespective of using an SpO₂ target range or a single SpO₂ target, only a proportion of preterm infants achieve target SpO₂ during the first 10 minutes of life.

Oxigen supplementation is often needed for preterm infants to maintain target oxygen saturation (SpO₂) levels at the time of birth. In the UK, Resuscitation Council UK Newborn Life Support (NLS), recommends targeting a single SpO₂ value (the 25th centile) for newborn resuscitation.¹ On the other hand, the European Resuscitation Council, American Heart Association Neonatal Resuscitation Programme (NRP) and the Australian and New Zealand Resuscitation Council guidelines recommend a range of SpO₂ values after birth.²⁻⁴ For example, NLS recommends targeting SpO₂ of 85% at five minutes and NRP recommends targeting SpO₂ between 80-85% at five minutes.

We suspect that following a SpO₂ range would be easier and more achievable than targeting a single value of SpO₂. There is also the possibility that targeting a single SpO₂ target could lead to the inadvertent administration of excessive oxygen. For example, a preterm infant with SpO₂ of 81% at five minutes is likely to receive more oxygen as they have not met the NLS SpO₂ target of 85%. This would be avoided if we followed a recommended target range of SpO₂ of 80-85%.

Recently, most resuscitation councils recommended the use of starting oxygen at levels from 21% to 30% for initial resuscitation of preterm infants at birth.^{1,2} The objective of our study was to find out whether using a target range (NRP) rather than a single SpO₂ target (NLS) would help in better achieving SpO₂ targets. We also report on the proportion of preterm

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infants (born at <34 weeks' gestation) with recorded SpO₂ below, above and within the target range during their first 10 minutes of life.

Methods

We conducted a prospective study over a period of 14 months (November 2019 to December 2020) in a single-centre neonatal intensive care unit. We did not recruit preterm infants with an antenatal diagnosis of major chromosomal or congenital abnormality. We followed the UK NLS manual for all newborn resuscitations and used starting oxygen from 21% to 30% titrated upwards to reach the oxygen saturation target.¹ At the time of this study, delayed cord clamping was not routinely practiced in our unit. We used a T-piece resuscitator (Draeger Resuscitaire) to provide positive pressure breaths. In our setup, each of our delivery rooms are equipped with standard pulse oximeters, however, whenever possible, the attending neonatal team used the study pulse oximeter if the birth gestational age was <34 weeks. For our study, we used the Masimo Rad-97 pulse oximeter, chosen because of its resistance to movement artefacts and good performance in states of

low perfusion.^{5,6} The pulse oximeter was set to normal sensitivity with two-second averaging times. All the pulse oximeter data were downloaded every two seconds directly into an Excel/CSV file. All demographic and resuscitation details were collected from the neonatal database. With limited documentation and dynamic changes, we could not collect information regarding oxygen supplementation.

With the prospective audit, we did not calculate a sample size and we continued recruitment until we reached a convenient sample of 50 preterm infants with at least 50% of the data from extreme preterm infants (ie birth gestational age of ≤ 27 weeks). We used descriptive statistics for population characteristics. Categorical variables were presented as proportions. Numerical variables were presented as a mean with standard deviation (SD) or as a median with interquartile range (IQR), as appropriate. Parametric and non-parametric statistical tests were applied based on the data distribution. Statistical analysis was performed using IBM SPSS Statistics (version 27; IBM Corp., Armonk, New York) and the figures were created using Python 3.6.9. This study was registered and approved by our local hospital audit department. As the study involved only data collection, we did not obtain ethics approval and informed consent. We used the Strengthening the Reporting of Observational Studies in Epidemiology statement (STROBE) guidelines for reporting of the study.⁷

Results

During the study period, there were a total of 5,426 deliveries with 270 babies born at <34 weeks' gestation. Based on the availability of the attending neonatal team using the study pulse oximeter and excluding poor quality data ($n=4$), we obtained data for a total of 50 infants for our final analysis (18.5%). The cohort demographics were:

- mean birth gestational age = 28 ± 3.2 weeks
- 25 infants (50%) were of gestational age <27 weeks
- 27 (54%) infants were male
- 36 (72%) infants were born by caesarean section
- the median Apgar scores were 9 (IQR=5-7) and 9 (IQR=7-9) at one and five minutes, respectively
- 46 infants (92%) received some form of resuscitation and 20 infants (40%) were intubated at delivery.

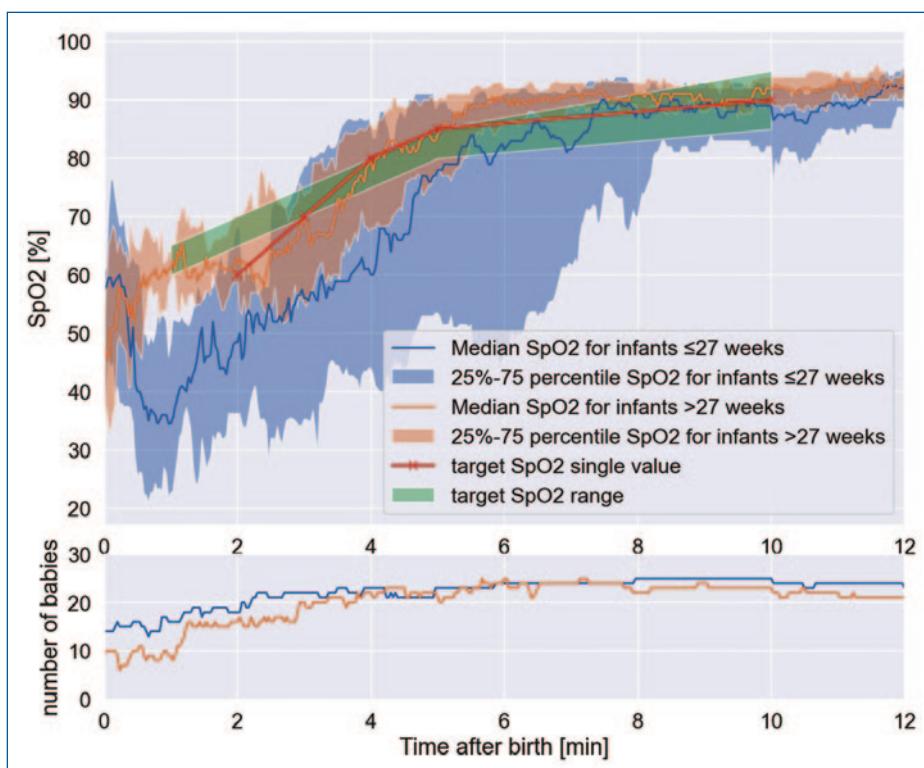


FIGURE 1 The achieved median SpO₂ with 25-75th percentiles in the first 10 minutes of life.

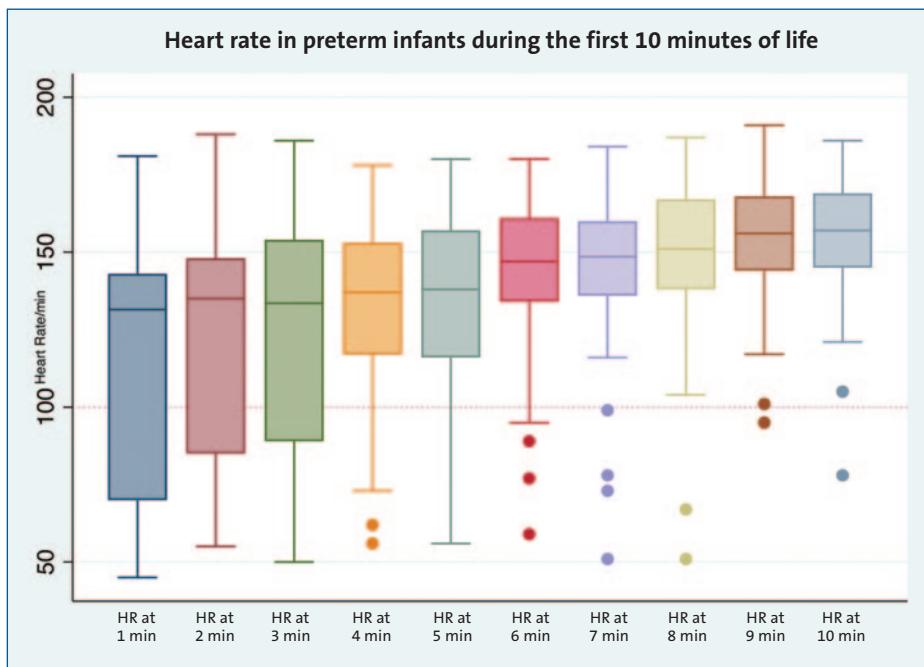


FIGURE 2 A boxplot of heart rate (HR) for the first 10 minutes of life.

Oxygen saturations

Only 19 (38%) infants achieved SpO₂ of 85% at five minutes and 30 (60%) infants achieved SpO₂ of 90% at 10 minutes. The median time to reach SpO₂ of 85% was 5.24 minutes (IQR=3.42-5.72); SpO₂ of 90% was 6.06 minutes (IQR=4.28-8.03), and heart rate >100 beats/min was 1.46 minutes (IQR=0.14-3.56).

The median SpO₂ at five minutes was 81% (IQR=68-90) and at 10 minutes 91%

(IQR=84-94) (FIGURE 1). There is no dependence of the SpO₂ on the sex of the infant or mode of delivery for those who achieved 85% SpO₂ at five minutes and 90% SpO₂ at 10 minutes, compared with infants who did not achieve these target saturations.

Median heart rates during the first 10 minutes of life are provided in FIGURE 2. The number of preterm infants within, below and above the target SpO₂ (as per

Time after birth	2 min (n = 35)		3 min (n = 42)		4 min (n = 45)		5 min (n = 48)		10 min (n = 50)	
	NLS target: 65%	NRP target: 65-70%	NLS target: 70%	NRP target: 70-75%	NLS target: 80%	NRP target: 75-80%	NLS target: 85%	NRP target: 80-85%	NLS target: 90%	NRP target: 85-95%
SpO₂ below the target	17 (49%)	23 (66%)	26 (62%)	24 (57%)	27 (60%)	22 (49%)	29 (60%)	21 (44%)	20 (40%)	14 (28%)
SpO₂ within the target	3 (9%)	4 (11%)	1 (2%)	6 (14%)	1 (2%)	6 (13%)	0	8 (17%)	6 (12%)	33 (66%)
SpO₂ above the target	15 (43%)	8 (23%)	15 (36%)	12 (29%)	17 (38%)	17 (38%)	19 (40%)	19 (40%)	24 (48%)	3 (6%)

TABLE 1 The number of preterm infants with SpO₂ above, below and within target.

NLS) and target SpO₂ range (as per NRP) during the first 10 minutes of life can be seen in **TABLE 1**. As there were large amounts of missing data (>50%), we did not report the numbers during the first minute of life. There is no statistical difference in infants achieving the target using the NLS SpO₂ single target compared with the NRP SpO₂ range, except at 10 minutes where a higher proportion of infants achieved the SpO₂ target using the NRP range (odds ratio=11.67; 95% confidence interval: 3.19 to 42.69; p≤0.001).

Discussion

In our study, we have reported the achieved SpO₂ and heart rate data for preterm infants during the first 10 minutes of life using both the single SpO₂ target value (NLS) and the SpO₂ target range (NRP). In our set-up, each of our delivery rooms is equipped with standard pulse oximeters (data not used for the study) and the neonatal team would normally use these devices as a default over the study pulse oximeter. The team was able to use the study pulse oximeter only if there was enough time to set up the device and this explains the reason for the large amount of excluded data.

Most infants achieve target SpO₂ levels after five minutes, probably due to the many interventions and the technical limitations of pulse oximetry. Pulse oximetry takes a median time of 90 seconds to display valid data.¹ Until then, there is no guide for oxygen titration. Initial resuscitation interventions need to clear the lung fluids and aerate the lungs, which happens during the first few minutes of life. Resuscitation Council UK recommends starting with minimal oxygen to avoid hyperoxia; hypoxia could be the countereffect of reducing hyperoxia.¹ Moreover, most resuscitation interventions

such as mask adjustment, suctioning and endotracheal tube placement, are likely to happen during the first five minutes after birth; this could increase the time taken to achieve target SpO₂ levels. Similar results have been reported in other studies.^{8,9}

The current recommended oxygen saturation percentile charts were created using data that included relatively healthy infants who did not require any resuscitation (56.5%), term infants (37%) and a small proportion of preterm infants born at <32 weeks' gestation (4.7%).¹⁰ Use of automated oxygen control during preterm resuscitation¹¹ and use of graphical display of the target real time SpO₂ data, could potentially help in achieving the SpO₂ targets.¹² An unanswered question in this area is whether targeting a higher oxygen saturation percentile (>25th percentile) would achieve a better outcome.

Our study has some noteworthy strengths in that we collected data prospectively with direct downloading of data from the pulse oximeter and 50% of the data are from extreme preterm infants. However, we did not collect information on the amount of oxygen given and the titration strategy and although we collected details on resuscitative measures, we do not have timelines of interventions and their relationships with SpO₂. Nevertheless, all members of the clinical team attending resuscitations are NLS trained and are expected to follow the algorithm without major variation in interventions.

We collected heart rate data for the first 10 minutes of life in 50 preterm infants. A study by Dawson et al provided data on the normal range of heart rate during the first minutes of life.¹³ In the Dawson study there were 160 preterm infants of <37 weeks' gestation and none received any medical interventions at resuscitation. In our study, all of the infants were

<34 weeks' gestation and received some form of medical intervention.

From our study, we conclude that a significant proportion of preterm infants did not reach SpO₂ targets during the first 10 minutes of life irrespective of using the currently recommended SpO₂ targets (NLS) or a target range (NRP).

Conclusion

In our study, only a proportion of preterm infants achieved recommended SpO₂ targets, with more infants achieving target SpO₂ at 10 minutes than at five minutes after birth. In conclusion, the use of an SpO₂ target range does not help to achieve an oxygen saturation target at birth, compared to use of a single value SpO₂.

Acknowledgement

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Statement of ethics, author contributions and data availability

This study was registered as an audit and the protocol was approved by James Cook University Hospital, South Tees NHS Foundation Trust. As an audit, no written informed consent was obtained from the participants.

PL was responsible for concept, design, data collection, interpretation of data, drafting the initial manuscript and approving the final manuscript. AB was responsible for data collection, interpretation of data and approval of the final manuscript. VN was responsible for design, interpretation of data and approval of the final manuscript. DS was responsible for design, interpretation of data, data

analysis and approval of the final manuscript. CB was responsible for design, interpretation of data, data analysis and approval of the final manuscript.

The data are available to researchers who provide a methodologically sound proposal and research ethics board approval. Proposals should be submitted to pkannanloganathan@nhs.net

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30 NOVEMBER-1 DECEMBER 23

NeoNATE Newcastle

Neonatal Neurology Assessment and Treatment Education (NeoNATE) has been developed by the British Paediatric Neurology Association to improve neonatal neurological education and the diagnosis and management of neonates with neurological disorders. NeoNATE is a practical two-day course consisting of lectures and interactive workshops delivered by a faculty of paediatric neurologists and neonatologists. It offers an introduction to neurological assessment in neonates and covers a wide range of conditions.

Venue: Leonardo Hotel, Newcastle

Cost: £375-420

Contact: https://courses.bpna.org.uk/ecomm_product_view.php?courseid=884

5 DECEMBER 23

Saving Babies Lives: Reducing Stillbirth and Implementing SBLv3

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Contact: www.healthcareconferencesuk.co.uk/virtual-online-courses/saving-babies-lives-reducing-still-birth

13 DECEMBER 23

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Cost: From £300

Contact: www.healthcareconferencesuk.co.uk/conferences-masterclasses/maternal-deterioration?utm_medium=email&utm_source=hcukad&utm_campaign=MaternalDet1232

14 DECEMBER 23

MBRRACE-UK Perinatal Confidential Enquiry Report 2023

This one-day virtual conference will present the findings of the MBRRACE-UK confidential enquiry into baby deaths, exploring the impact of ethnicity on care and outcomes and the National Perinatal Mortality Review Tool Annual Report 2023. For any health professional involved in the delivery of maternity and neonatal care.

Venue: Virtual online conference

Contact: <https://web.cvent.com/event/cc7eeb0a-f33b-4fa7-9df1-89b0da4b2d60/summary>

18-19 JANUARY 24

UK Preterm Birth Network Conference

Hosted by the Harris Centre, University of Liverpool and The Cheshire and Merseyside Women's Health and Maternity Programme, this conference is for clinicians and scientists working in preterm birth prediction, prevention and optimisation. A place to share research, audit and service evaluation work and hear about the latest developments in the field.

Venue: Liverpool

Cost: From £100

Contact: ptbconference2024@gmail.com
<https://pretermconference.com>

24-26 JANUARY 24

BPNA 2024

The 50th annual conference of the British Paediatric Neurology Association hopes to share innovation, promote and create collaboration, and showcase achievements. New and returning features include research workshops, the annual general meeting, specialist interest groups, etc.

Venue: Marriott Hotel, Bristol

Contact: <https://bpna.org.uk/conference/2024/index.php?contentid=1331>

1 FEBRUARY 24

North West Neonatal Study Day

Organised by the North West Neonatal Operational Delivery Network, this annual study day offers an opportunity to learn and network with neonatal colleagues. The day includes talks from specialists within the neonatal multidisciplinary team and interactive workshops. The target audience includes: neonatal doctors, nurses, ANNPs, AHPs, pharmacists, physician assistants and maternity colleagues.

Venue: Haydock Park Race Course, Warrington

Cost: From: £30

Contact: www.eventbrite.com/e/north-west-neonatal-study-day-tickets-735464954477

27-28 FEBRUARY 24

BAPM Spring Conference: Learning Together

The BAPM Spring Conference 2024 is aimed at an audience of paediatric and neonatal trainees at all levels of training, advanced neonatal nurse practitioners and allied health professionals. The conference will deliver the latest updates on essential clinical topics as well as the chance for delegates to network and learn together.

Venue: The Grand Hotel, Leicester and online

Cost: From £70, early bird rates before 3 December

Contact: bapm@rcpch.ac.uk
www.bapm.org/events/bapm-spring-conference-2024

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7 MARCH 24

Post Qualified in Specialty Neonatal Nurse Study Day

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Venue: Halliwell Jones Stadium, Warrington

Cost: £20

Contact: www.eventbrite.com/e/nwnodn-cm-educators-post-qualified-in-specialty-neonatal-nurse-study-day-tickets-751609553407

7-8 MARCH 24

NeoNATE Leeds

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Venue: Novotel Leeds Centre

Cost: £375-420

Contact: https://courses.bpna.org.uk/ecomm_product_view.php?courseid=925

7-9 MARCH 24

Perinatal Science International

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Venue: Venice, Italy

Cost: From €793

Contact: www.mcascientificevents.eu/psi

12-14 APRIL 24

EAP 2024

The European Academy of Paediatrics (EAP) conference promotes the health of children and young people, aiming to improve standards in training, service and research. The conference includes the MasterCourse workshop, which this time focusses on vaccines and paediatric infectious diseases.

Venue: Porto, Portugal

Cost: From €200, early bird rates before 20th December

Contact: <https://eap-congress.org>

17-21 APRIL 24

11th Europaediatrics Congress

Europaediatrics is the major scientific event of the European Paediatric Association and the Union of National European Paediatric Societies and Association (EPA-UNEPSA). The scientific programme will commence with a series of workshops along with keynote lectures, symposia, debates, poster presentations and meet the expert sessions.

Venue: Turkey

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Contact: <https://europaediatrics2024.org>

11-14 JUNE 24

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Contact: terrie@cfsevents.co.uk
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