

Status of Oxygen Monitoring in Four Selected Special Care Newborn Units in India

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Objective: To investigate the status of oxygen monitoring in Special Newborn Care Units. **Methods:** Observations were made and records reviewed of infants on oxygen in all four Special Newborn Care Units of a state delivering a model program for retinopathy of prematurity. Multiple choice questions were administered to nurses, semi-structured interviews conducted with pediatricians, ophthalmologists and senior nurses. **Results:** All units had more than 100% occupancy. The number of functioning pulse oximeters was 73% of that recommended. None of the units had air-oxygen blenders. The upper oxygen saturation alarm was set accurately only for 1 out of 18 babies receiving oxygen and none of the infants had continuous saturation monitoring. 84% of nurses did not know optimal oxygen saturation targets. Most interviewees attributed suboptimal care to overcrowding. **Conclusion:** Compressed air, air-oxygen blenders, sufficient functioning pulse oximeters, rational admission policies and training of nurses are needed to improve oxygen related practices.

Key words: Public health system, Knowledge, Retinopathy of prematurity.

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Many middle-income countries are facing an epidemic of blindness due to retinopathy of prematurity (ROP) as a result of a combination of uncontrolled oxygen delivery and greater survival of preterm babies [1]. In India, even though neonatal mortality rates have declined [2], awareness and interventions for preventing vision impairment from ROP have not increased proportionately [3]. Poorly regulated supplemental oxygen is an important risk factor for ROP [4]. Estimates suggest that 32,300 infants, approximately 10% of whom are in India, become blind or visually impaired from ROP every year [5]. A program to reduce blindness from ROP was launched by the Ministry of Health in 2013, supported by the Queen Elizabeth Diamond Jubilee Trust, and managed by the Indian Institute of Public Health (IIPH), Hyderabad [6]. Conducted in one of the four states delivering the program, which includes nurse training, this study investigated whether oxygen was being monitored satisfactorily in four district level Special Newborn Care Units (SNCU).

METHODS

A state reflecting the demographic profile of India, with an infant mortality rate within the range likely to make the state at risk of ROP blindness [7] was selected. In

this state, the program was implemented in four SNCUs – one in a medical college and three in district-level hospitals. During eight weeks in mid-2017, each SNCU was visited once for three days. Each SNCU was allocated a code (A-D) to maintain anonymity. In units A and B, only the nurses in-charge and ROP nurses (not directly involved in patient care) had been included in the training; whereas in units C and D, all nurses were included.

To assess nurses' understanding of ROP, multiple-choice questions (MCQs) were administered to nurses on duty (excluding nurses in-charge) on the first day of the visit. Questions included risk factors for ROP, saturation limits for alarm settings on monitors, criteria and timing of ROP screening according to RBSK guidelines [8] and drops used to dilate pupils before screening (MCQs available at https://figshare.com/articles/ROP_annexure/9757223/1). Most questions had been used by the National ROP Task Force in an earlier gap analysis [6]; new questions were validated by a neonatologist involved in ROP care.

On the second and third days, semi-structured interviews to assess ROP – related attitudes and practices were conducted with the ophthalmologist involved in ROP screening, pediatrician in-charge, nurse in-charge and ROP nurse. Questions covered their induction into

and perceptions of the program, challenges in the management of ROP and suggestions for improvement. Topic guides for interviews were developed (available at https://figshare.com/articles/ROP_annexure/9757223/1), and piloted before administration. Each participant provided informed consent, and was assigned a unique code to maintain confidentiality. On day three, equipment to deliver and monitor oxygen were assessed and compared with national guidelines [9]. Finally, medical records of infants receiving oxygen at the time of the visit were reviewed for documentation of oxygen saturation and frequency of monitoring.

Ethical approval for the study was obtained from the London School of Hygiene and Tropical Medicine and Indian Institute of Public Health; permission was obtained from the State National Health Mission. The study adhered to the recommendations of Declaration of Helsinki.

Statistical analyses: Qualitative data were manually coded and analyzed thematically. Similarities and differences in responses from different cadres and centers were analyzed. Triangulation was provided by observation of practices. Quantitative data were analyzed for proportions, confidence intervals and Z test for differences in proportions using STATA 2014. A *P*-value less than 0.05 was considered statistically significant.

RESULTS

All Newborn care corners located in labor rooms or

operating theatres had provision to start oxygen but none had air-oxygen blenders and none used pulse oximeters to monitor oxygen. Only SNCU A was able to provide continuous positive airway pressure (CPAP).

All SNCU nurses had a bachelor qualification but their number, according to SNCU guidelines [10], was adequate in only one SNCU (**Table I**). All SNCUs had more than 100% occupancy, which staff considered to be the main challenge in providing high-quality care (**Web Table I**). Only two SNCUs had enough pulse oximeters to comply with the national guidelines [9], and the number of functioning oximeters was 73% of that recommended. Of the 14 infants where pulse oximeters were being used, accurate alarms for lower limit of saturation were set in 13, and upper limit only in one. Among the four senior nurses interviewed, two stated that alarms were not routinely set; another said only lower limits were set, while the other said that alarms for both upper and lower limits were set. Ophthalmologists interviewed admitted that they did not focus on oxygen saturation while visiting SNCUs.

In all SNCUs, none of the neonates receiving oxygen had continuous saturation monitoring. Saturations had been recorded in medical records for all babies receiving oxygen. During interviews, three of the four neonatologists stated that oxygen saturations were monitored every 1-2 hours, whereas one acknowledged that continuous monitoring was only provided for critical neonates. Among senior nurses, two said that monitoring took place every two hours or according to doctors'

Table I Equipment for Oxygen Delivery and Oxygen Monitoring Practices in Four Special Newborn Care Units (SNCU)

Characteristics	Only ROP nurses sensitized		All staff sensitized		All SNCUs
	A	B	C	D	
SNCU centre					
Occupancy (bed strength)	42 (30)	27 (20)	32 (27)	28 (20)	129 (97)
Nurses, no. (recommended)*	18 (25)	15 (17)	17 (22)	20 (17)	70 (81)
Babies receiving oxygen at the time of visit	12	2	3	1	18
Preterm infants receiving oxygen	7	1	2	1	11
Blenders	0	0	0	0	0
Equipment for CPAP	Yes	Yes	Yes	Yes	
No. of pulse oximeters that should have been there [#]	21	14	21	14	70
Adequate functioning pulse oximeters [#] , Yes/No (actual no.)	No (8)	No (3)	Yes (24)	Yes (16)	51
<i>Oxygen monitoring of all babies receiving oxygen</i>					
Pulse oximeters being used	8	2	3	1	14
Upper alarms on	0	0	1 (in CPAP)	0	1
Upper limit set (target SpO ₂)	0	0	1 (100)	0	1
Number of lower alarms on (%)	8 (67)	1 (50)	3 (100)	1 (100)	13
Correctly set lower limit alarms [‡] (%)	8 (100)	1 (50)	3 (100)	1 (100)	13

*As per ref. 10; [#]At least 14 per 20 beds recommended as per ref. 9; [‡]88-89% SpO₂; CPAP: Continuous positive airway pressure.

WHAT THIS STUDY ADDS?

- This mixed-method study identified the limitations in the equipment and deficiencies in practices of delivering and monitoring oxygen in four Special newborn care units in one state in India.

instructions. One stated that all neonates receiving oxygen received continuous monitoring whereas another stated that this was only done for critically ill neonates. The frequency of documentation varied from two-hourly for critical to six-hourly for less critical babies. Most cadres identified shortage of equipment and poor maintenance as reasons for irregular monitoring (**Web Table I**).

MCQs were administered to 19 nurses (four each in SNCUs A and D, five in B and six in C). In units C and D, nurses' combined score was 80.0% (95% CI, 68.7-88.6), which was significantly higher than in units A and B (39.5%, 95% CI, 27.6-52.8%; $P < 0.001$). Overall, only 16% of answers to questions on upper and lower oxygen saturation targets were correct; the three nurses with correct answers worked in unit C. All the pediatricians interviewed were aware of the appropriate settings. Regarding gestational age and birthweight criteria for ROP screening, none of the nurses in SNCUs A and B and 5 of 10 nurses in C and D answered correctly. All nurses knew that preterm babies should be screened for ROP by 30 days after birth.

DISCUSSION

Our study found overcrowding, lack of adequate knowledge among nurses, inadequate equipment, and inefficient use of available equipment to be challenges in providing good oxygen practices. Overcrowding, which was the main challenge, leads to a relative shortage of nurses which can compromise the quality of care [11]. Although all the pediatricians knew the optimal target oxygen saturations, these were known by only a few (16%) nurses, which may explain why most alarms were not set or were incorrectly set. A shortage of functioning pulse oximeters was a reason given for lack of continuous oxygen saturation monitoring, but two SNCUs were not continuously monitoring despite having adequate oximeters. Despite existing International recommendations [12], air-oxygen blenders were not available in any newborn care corner or SNCU, making delivery of 100% oxygen the only alternative. The higher MCQ scores obtained by nurses in SNCUs C and D could be because unlike in centers A and B, all the nurses involved in patient-care had been included in ROP orientation sessions.

Since this study was planned as an early assessment

of the ROP program in India, many of the planned interventions had not been implemented before the visits. The findings are not, therefore, likely to reflect the full impact of the interventions planned. The small number of SNCUs covered by the program in the state, and low number of infants receiving supplemental oxygen at the time of observation may limit generalizability of findings. Further, since MCQs were administered only once in each unit to avoid contamination, the number of nurses assessed was limited.

In India, SNCU nurses undergo only short-term formal training in neonatology and most training is in-service. Previous studies have recommended training and sensitization of nurses to improve practices [13,14] as nurses play an important role in the prevention of ROP [4]. Similar findings on inadequate personnel, equipment and inconsistencies in knowledge of ROP have been observed in Peru [15].

A ROP program supported by the Trust is presently being implemented within the government health system as a pilot, with a potential for national scalability. Although the program has increased awareness about ROP among healthcare professionals and provided ROP services, our study highlights that better oxygen delivery and saturation monitoring are required. Based on our findings, we recommend making available positive pressure air supply, oxygen blenders and one pulse oximeter per infant [16] with spare probes in SNCUs. Repeated training and sensitization of SNCU nurses to improve their knowledge and use of equipment is also needed to reduce the incidence of ROP, as has been reported in Peru [15]. Rational admission policies to reduce overcrowding and an increase in beds and staff could also improve practices. An assessment of quality of care regarding oxygen administration is being planned after all the quality improvement interventions have been delivered, and data from this study will allow comparisons to be made.

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Web Table I Quotes from the Interviews With Medical Personnel

<i>Theme</i>	<i>Quotes</i>
Over-crowding	<ul style="list-style-type: none"> • “The most difficult to control is admission...” (ROP Nurse, SNCU B) • “Whom can we refuse? We cannot refuse” (Pediatrician, SNCU C) • “Because of overcrowding they do everything with a shortcut and that becomes a habit” (Pediatrician, SNCU D)
Equipment availability	<ul style="list-style-type: none"> • “Equipment is also a problem, like oximeters, [which] have to be removed from one baby and put on the other” (Nurse in-charge, SNCU B).
Equipment maintenance	<ul style="list-style-type: none"> • “Monitors are there but repairing [them] is a big problem.....process takes a long time” (Pediatrician, SNCU A)