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# A mobile team for screening of retinopathy of prematurity in India: Cost - effectiveness, outcomes, and impact assessment

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**Abstract:**

**PURPOSE:** To study the cost effectiveness, outcomes and impact of retinopathy of prematurity (ROP) screening and management model for urban neonatal intensive care units (NICUs).

**STUDY DESIGN:** Public health intervention study.

**METHODS:** This study was conducted in 2013. Staff of a mobile unit assessed all infants aged less than 34 weeks of Gestation age at birth and/or birth weight 1700 GM or less admitted in five NICUs between 2013 and 2015. A trained ophthalmologist performed bedside ROP screening through dilated pupils using indirect ophthalmoscope. ROP was graded and managed as per the International Classification of Retinopathy of Prematurity treatment guidelines. Counseling and laser treatment were the interventions. The incidence, grade and determinants of ROP were estimated. Direct and indirect costs were calculated to estimate the unit cost of screening and managing a child with ROP using the model.

**RESULTS:** The study sample included 102 preterm/underweight infants. The prevalence of ROP of different grades in either eye was 32% (95% Confidence Intervals (CI): 23.2–41.5). ROP stage I was present in 75% of these eyes. The model could help in preventing/reducing visual disability in 4 infants with advanced stages of ROP. The unit cost of ROP screening, identifying one child with ROP and addressing visual disability due to ROP was US $ 198.9, 596.7 and 4,137.4 respectively.

**CONCLUSION:** A mobile screening is likely feasible and cost-effective method to detect ROP and offer timely intervention for NICU in urban areas with limited resources.

**Keywords:**

Childhood blindness, health economics, retinopathy of prematurity, screening

## Introduction

Retinopathy of prematurity (ROP) is an important cause of preventable blindness in children.[1] In regions such as Latin America, Eastern Europe, and Asia, the number of ROP cases has grown dramatically because of higher overall birth rates and improved neonatal survival due to neonatal care facilities.[2,3] Persistent variability in quality of neonatal care and shortage of adequately trained ophthalmologists are concerning in view of the emerging international ROP "epidemic."[3-6] Poor accessibility and lack of awareness among parents as well as health-care providers result in late presentation and irreversible damage.[7,8]

In the era of wide angle pediatric retinal imaging system called as "RetCam" and telemedicine, screening, and prompt management of eye diseases such as diabetic retinopathy and ROP have been performed using digital transfer of images from screening site to the experts at tertiary eye centers.[9,10] Unfortunately, the high cost of infrastructure at the screening site prohibits

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the broad application of telemedicine.[11] Moreover, the RetCam may not be affordable for all ophthalmologists and its transportation to different neonatal Intensive Care Unit (NICU) with smaller setups may not be feasible.

The cost-effectiveness of ROP screening had been evaluated in industrialized countries.[12,13]

To the best of our knowledge, the outcomes of ROP screening and management model to cover NICUs in western India have not been previously published.

The community Ophthalmology Department of the National Institute of Ophthalmology established this model for ROP screening in 2013. The team members of this model periodically visited five small-sized NICUs, but with at least 15 beds capacity in Pune, India. They screened premature infants for ROP, proposed management, and counseled the parents accordingly. We present the outcomes and impact of ROP screening using this model in Pune, India.

## Methods

The Institutional Ethical Committee approved this project. This study was conducted in 2013. Pune city with a population of 5.1 million has approximately 15 registered NICUs which have associated ophthalmic services and around 25 NICUs which are standalone NICUs who do not have in-house services of ophthalmologists for ROP screening and they usually send the babies for ROP screening upon discharge, that is, by 36–37 weeks postgestation.

With the aim to reach out to stand alone NICU predominantly catering to lower socioeconomic strata of the society and who were not equipped with in-house services of an ophthalmologist, Five NICUs with 15-30 beds in Pune city to participate in this project. One trained ophthalmologist, two trainee ophthalmologists, an epidemiologist, and a paramedical staff were the field investigators, equipped with a portable indirect ophthalmoscope (IDO) (Keeler, UK) and portable laser unit (Iridex Laser, USA). These NICUs were well equipped to manage critical preterm babies. The NICU staff was trained to inform the ROP screening unit when babies fulfilling the inclusion criteria were registered. NICU nurses and resident doctors catering to premature babies were briefed about the purpose and benefit of ROP screening. Parents of the premature babies too were briefed about the necessity of this screening and further management if needed. Ophthalmologist visited each NICU twice a week. Specific days were designated each week, wherein the NICU staff would intimate the ophthalmologist about number of babies to be screened in that visit and they ensured that pupils of all babies due for eye checkup were dilated. This assuredly saved time of the ophthalmology team. We also inducted trainee doctors into this program, so they could acquire the necessary skills and understand the management of ROP and referral to base hospital whenever necessary.

Infants aged <34 weeks of gestation age at birth and/or birth weight ≤1500 g (India considered <1700 g) and were admitted in the NICUs between 2013 and 2015 were included in our study. Eye examination was performed at 3–4 weeks after birth or 31 weeks postconception age whichever was earlier.[14] Informed consent of each parent was obtained before ROP screening. The pupils were dilated with 10% phenylephrine eye drops that were diluted with artificial tears in the ratio of 1:4. One drop was instilled in each eye and if the dilation was inadequate, an additional drop was instilled after 30 min. A detailed retinal examination was performed with indirect ophthalmoscope, infant speculum, and scleral indentation. ROP was graded into stages and zones based on the International Classification of Retinopathy of Prematurity.[15] All babies with a normal retina on the first examination were asked to follow-up at the referring hospital every 6 months for 1 year and then once yearly. Once vascularization of the temporal retina is completed or infant reaches gestational age of 40 weeks and weight of 2000 g, we did not follow them further. Infants who required laser therapy or surgery were followed every 3 months.

All eyes with threshold ROP were treated with laser at the gestational age of 32–34 weeks. The laser spot size was 200 μ, power of 150–200 mW, duration of 100Ms, and then was followed every week till regression of vascularization was noted. Lasers were done at the NICU and one baby who needed surgical intervention was referred to the base hospital.

To calculate the cost of screening and management, we included the cost of capital investment of equipment and the recurrent cost that included an annual salary of eye team involved for the duration of screening, counseling, and management. Frequencies, percentage proportion, and 95% confidence intervals (CIs) of incidence of ROP were calculated.

## Results

A total of 102 pre-term infants were screened in this study. ROP in either eye was noted in 32 infants. The incidence of ROP was 32% (95% CI: 23.2–41.5). The grades of ROP are presented in Table 1. Twenty-eight infants were closely monitored without any intervention as their ROP was mild and regressed. Three infants (12%) were treated with laser and one infant (3%) was treated with pars planavitrectomy (PPV). The mobile unit could

help in preventing blindness in five eyes with advance stage of ROP.

The cost of mobile ROP screening unit was estimated in Indian Rupees and then was converted to US $ at a rate of 69 Indian Rupees = 1 $. The costing was grouped into capital investment (fixed cost) and recurrent cost for a 3-year project [Table 2]. We reduced capital cost by 20% less in subsequent years to account for depreciation of the items. We also increased the cost of recurrent expenses by 5% every year to account for inflation. The total cost of ROP screening over 3 years of screening was Indian Rupees 1,427,413 (US $ 20,687).

The unit cost of ROP screening in five NICUs in our study was 20,687/104 = US $ 198.9. The unit cost of identifying one child with ROP was US $ 596.7. The unit cost of addressing visual disability due to ROP in our project was 20,687/5 = US $ 4137.4

## Discussion

The aim of the study was to put forth the idea that this model can be employed by ophthalmologists very easily for small NICU in their vicinity. There are NICU in every city which do not have access to ROP screening facility in their premises and babies cannot be shifted out of the NICU during their NICU stay and many babies perhaps harboring ROP may be missed or deferred treatment till discharge from the NICU leading to possible progression of ROP. This can be prevented if the ophthalmologist visits such NICUs while the baby is admitted and ROP, if present, can be picked up early. This model also does not burden the ophthalmologist financially.

The cost of our initiative to address visual disabilities due to ROP is not very high. In UK, the cost of ROP telescreening by a trained nurse was 176 pounds.[13] However, at the time of reviewing the cost-effectiveness, one should note the societal burden of blindness that far exceeds the costs of treatment of ROP per child[15] [Table 3]. Use of telemedicine and simple alternatives of using low cost methods has further reduced the cost of ROP screening.[16,17] Kemper *et al*. suggested that the evidence is not sufficient to recommend retinal imaging as a routine at NICUs to identify infants who have serious ROP.[18]

This model has been developed considering its feasibility in developing nation where this model was implemented targeting the low socioeconomic sections of the society. The doctors work here as a part of their social responsibility and charge less than their meritorious fees.

The cost of screening one child was US $ 198.9. To identify a child with ROP, average three examinations were needed at NICU. The unit cost for identifying one true case of ROP was US $ 596.7. While the unit cost of management of positive ROP case was US $ 4137.4.

Two studies, one from the US and another from the UK, have directly compared the cost-effectiveness of telemedicine versus ophthalmoscopy for ROP management. Both studies assumed the diagnostic accuracy of telemedicine and ophthalmoscopy to be

**Table 1: Stages of retinopathy of prematurity in infants aged ≤34 weeks and/or weight ≤1700 g**

| Stage of ROP | RE (*n*=32), *n* (%) | LE (*n*=30), *n* (%) | Either eye (*n*=32), *n* (%) |
|---|---|---|---|
| Stage I | 24 (75.0) | 24 (80.0) | 24 (75.0) |
| Stage II | 4 (12.5) | 3 (10.0) | 4 (12.5) |
| Stage III | 3 (9.4) | 2 (6.7) | 3 (9.4) |
| Stage IV | 1 (3.1) | 1 (3.3) | 1 (3.1) |

ROP=Retinopathy of prematurity, LE=Left eye, RE=Right eye

**Table 2: Costing of retinopathy of prematurity screening and management project using a mobile unit**

| | 1st year | 2nd year | 3rd year | Average annual cost |
|---|---|---|---|---|
| Capital investment | | | | |
| Indirect ophthalmoscope | 45,000 | 36,000 | 29,800 | 36,933 |
| +20D Volk lens | 15,000 | 12,000 | 9600 | 12,200 |
| Portable laser machine | 1,450,000 | 1,160,000 | 928,000 | 1,179,333 |
| Eyelid speculum and scleral depressor | 350 | 300 | 240 | 296 |
| Subtotal | 1,510,350 | 1,208,300 | 967,640 | 1,228,763 |
| Recurrent expense | | | | |
| Human resource (salary per year) | | | | |
| Ophthalmologist* | 1,20,000 | 1,26,000 | 1,32,300 | 126,100 |
| Nurse assisting the study* | 60,000 | 63,000 | 66,150 | 63,050 |
| Equipment maintenance | | | | |
| Transportation charges (fuel) | 3000 | 3500 | 4000 | 3500 |
| Laser machine | 4000 | 5000 | 6000 | 5000 |
| Medications and other | 1000 | 1000 | 1000 | 1000 |
| Subtotal | 188,000 | 198,500 | 209,450 | 198,650 |
| Total | INR 1,427,413=US $ 20,687 | | | |

*Ophthalmologists and nurses were paid their professional fees and they were not full-time staff for this project. INR=Indian Rupees, US=United States

**Table 3: Income loss due to blindness**

| Income | Male | Female |
|---|---|---|
| Per capita income (2013) ($) | 1497 | 1497 |
| Average life expectancy (years) | 66.9 | 69.9 |
| Average yearly income lost ($) (during economically active years) | 52,395 | 52,395 |
| Average lifetime income lost ($) (during economically in-active years) | 7,185.6 | 4491 |
| Total income lost ($) per person on an average | 59,580.6 | 56,886 |

identical found that several telemedicine strategies were more cost-effective than current ophthalmoscopic management strategies.[13,19]

We used indirect ophthalmoscopy for ROP screening in our study. Adhikari *et al*. in Nepal used similar equipment for ROP screening.[20]

Documentation of findings in our study was done by manual diagrams. Prakalapakorn *et al*. have published that documenting of the retinal image using RetCam (Clarity Medical Systems Inc., Pleasanton, CA, USA) as well as indirect ophthalmoscopy system are costly but perhaps better tools for ROP screening.[21,22] Capturing retinal images using smartphone and telemedicine facilities are perhaps the best solution to overcome high cost of ROP screening.[23]

The 32% incidence of ROP in our study was within the range for developing countries.[24-27] More than one-sixth required active intervention. The parents of the rest were counseled and infants were monitored without intervention. In Latin America, the prevalence of ROP ranged from 7% to 82%. Among these cases, 1%–24% of eyes with severe ROP required treatment.[23] In Turkey, the prevalence of ROP among preterm infants was 56%.[25] A study in Karnataka, India, the incidence of ROP in urban population was 16.5%.[26] The incidence of ROP in a pediatric unit of hospital in Pune was 23%.[27] Although the criteria for screening were similar, there was wide variation in the incidence of ROP. Even within India, the rate varied from 33% in present study to 45% in a study from Chandigarh, India.[6]

The main drawback of this model would seem to be the need of a trained ophthalmologist to screen the babies as against telemedicine and RetCam which can be accomplished by technicians. However, some families may not be satisfied as there is an obvious lack of face-to-face interaction with the ophthalmologist.[9] The average time spent by the ophthalmologist was 2½ h in every week which included the commuting time too. To ensure that this model would be self–sustaining, we introduced trainee ophthalmologists into this program and they learned the indirect ophthalmology skills and standard ROP management. With this, we hope that model will continue even when the trainee ophthalmologists finish their curriculum and begin with their own clinical practice.

In urban cities such as Pune, there is no dearth of ophthalmologists, and therefore, we believe that this model can be implemented voluntarily as a part of social responsibility without the need for investing in a RetCam or resorting to telemedicine.

For developing nations, this model can be a boon as impact of having a blind child due to ROP can be addressed to some extent by timely diagnosis. The main drawback of this model is lack of documentation in the form of photographs which is readily provided by the RetCam and telemedicine. Use of smartphone with 360° photography app may solve this issue and also provide some protection against medicolegal liability.

ROP has recently been included as a priority blinding eye disease in VISION 2020 – India.[1] Efforts of strengthening teamwork by neonatologists and ophthalmologists through clinical workshops will further enhance the need to adopt cost-effective and practical approach for ROP screening and timely interventions. In the meanwhile, this initiative by trained ophthalmologists well versed in indirect ophthalmoscopy can work wonders and provide reach to babies who otherwise could have been missed.


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## Conflicts of interest

There are no conflicts of interest.

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