Saudi Arabian retinopathy of prematurity national telemedicine program: Achievements and challenges

Saleh A. Al Amro1,2, Sami M. Al Ghamdi1, Marwan A. Abouammoh3, Fahad Al Aql4, Khabir Ahmad5, Sulaiman M. Alsulaiman6

Abstract:
The Saudi Arabian Retinopathy of Prematurity National Telemedicine programme (SAROP) is a product of the National Committee for Retinopathy of Prematurity (ROP). The program includes ROP telescreening, diagnosis, and management of cases requiring treatment. Digital retinal images and filled ROP software requests were uploaded from 20 level-3 neonatal intensive care units (NICU) in the Kingdom of Saudi Arabia (KSA) to the King Khaled Eye Specialist Hospital server and the ROP teledermatology website. The data were accessed and reported by qualified retinal and pediatric ophthalmologists. Currently, retinal wide-angle digital cameras are available in 20 of the 31 level-3 NICUs of the Ministry of Health, Kingdom of KSA. This teledermatology approach is practical and effective in detecting and managing ROP cases. In the first 2.5 years, encouraging results were noticed with no unfavorable outcomes in the participating NICUs. Technical challenges were resolved promptly to ensure that the program ran smoothly. Therefore, this ideal state-of-the-art ROP teledermatology program could be also applied to similar and neighboring countries.

Keywords:
Retinopathy of prematurity, Saudi Arabia, teledermatology, telescreening

INTRODUCTION
Retinopathy of prematurity (ROP) is a vasoproliferative disease affecting the growing retinal vasculature of premature infants, which can lead to extraretinal fibrovascular proliferation and tractional retinal detachment (TRD), resulting in blindness. It affects 25%-56% of infants with a birth weight (BW) of ≤1500 g.1-2 The incidence increases with a decrease in BW. Most cases resolve spontaneously; however, a few, if left untreated, typically result in TRD and blindness in both eyes. ROP is the leading cause of noninherited bilateral childhood blindness.3 Fortunately, ROP blindness can be prevented when the condition is detected and treated promptly before TRD develops. Therefore, screening at-risk infants in the neonatal intensive care unit (NICU) is crucial to achieving this goal.

Conventionally, ROP screening is performed at the bedside with dilated fundus examination using a binocular indirect ophthalmoscope (BIO). However, this can only be accomplished by an ophthalmologist trained in the retinal examination of premature infants, and qualified ophthalmologists are not readily available, particularly in peripheral hospitals.

A newer retinal imaging modality introduced more than two decades ago, which has improved over time, is the wide-field digital pediatric retinal camera. These portable handheld cameras are easy to use with premature infants in the supine position. Therefore, NICU nurses and ophthalmic photographers should be trained to capture the images of the retinal periphery of these infants using this method.

In a large country such as the Kingdom of Saudi Arabia (KSA), with an area of 2.15 million km² and a population of 34.8 million distributed in widely scattered cities, there is a lack of well-trained ophthalmologists for ROP screening in peripheral cities, though good information technology (IT) and internet infrastructure, as well as excellent electronic government
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Therefore, the committee established the National Saudi Arabian ROP telemedicine program (SAROP) and chose to adopt the use of wide-field digital retinal cameras and a telescreening approach, as this method proved to be as good as the bedside BIO examination in detecting treatment-warranted ROP, with the added benefit of being less stressful to the neonate.\[9,10\] The guidelines have been solicited and endorsed by both the Saudi Ophthalmological Society and the Saudi Neonatology Society. The program is aimed to cover all 31 level-3 NICUs in the KSA.

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Screeners
NICU nurses (optometrists in some centers) were trained using a digital fundus camera to image the infants’ eyes. They can become qualified ROP photographers after completing a 2-day didactic and hands-on course on how to take state-of-the-art, high-quality retinal and anterior segment images in premature infants according to the Saudi Arabian ROP imaging protocol. They were taught how to upload the retinal images to the RCRS and server, and the completed requests of the Saudi Arabian ROP software to the KKESH telemedicine website. The training course was conducted by experienced photography instructors and retraining was performed if deemed necessary. The SAROP protocol uses six images: one for the anterior segment, one for the posterior pole centered on the optic disc, and one for each peripheral quadrant (superior, inferior, nasal, and temporal). Each NICU had a nurse coordinator who acted as a liaison with the program director.

Readers and treaters
These are consultant ophthalmologists specializing in retina or pediatric ophthalmology, whose role is to read the images sent from the screening centers to the KKESH server/RCRS and file a diagnostic report and plan of treatment on the Saudi Arabian ROP software on the KKESH telemedicine website within 48 hours, and to provide treatment when needed, such as intravitreal anti-VEGF injections or laser ablative surgery. A team, called the flying squad for the treatment of ROP (FST-ROP), was formed. The main goal of FST is to deliver prompt treatment within 72 h of diagnosing treatment-warranted ROP in areas devoid of qualified treaters. Treatment is generally performed on weekends, and airplanes are used to reach these peripheral cities.

Supplies
Requirements that are needed for performing screening or treatments:
- Pupil dilating drops (phenylephrine 2.5% and tropicamide 1%)
- Infant size eyelid speculum
- Coupling lubricant gel
- Topical anesthetic drop (tetracaine or proparacaine)
- Pediatric scleral rotator/depressor.

Workflow
The workflow is illustrated in Figure 1.

Program Statistics
The total number of patients observed from the start of the program in April 2019 until the end of 2021 was 2188, and ROP was observed in 566 infants (26%). Table 1 shows the number of patients and the enrollment date of each hospital. Some NICUs only refer critical patients, giving a falsely high prevalence of ROP in these NICUs. The different stages of ROP for each eye are illustrated in Figure 2. Stages 1 and 2 constituted most the cases. Treatment was administered to 169 infants (29.7% of ROP patients and 7.7% of all patients). Anti-VEGF injections were administered to 144 infants and laser ablative surgery was performed in 25 infants.

Details of these results will be presented in a future publication, as this article describes the logistics of the program itself.

Achievements
1. Implementation of the Kingdom-wide telemedicine program for the ROP is one of the largest worldwide. This program was designed to screen, diagnose, and treat ROP. Currently, it covers 20 referral maternity and children’s hospitals under the MOH (level-3 NICUs), which will gradually increase to include all level-3 NICUs in the KSA to achieve the main goal of the program eradicate ROP blindness
2. The program succeeded in proving the effectiveness of the examination using wide-angle digital retinal cameras and telemedicine technology, making it an efficient alternative to clinical bedside examinations
3. No cases of advanced ROP or blindness were observed in the participating NICUs. However, before the initiation of the SAROP program and based on previous data, 29 infants with advanced ROP were recorded in some hospitals of the MOH in Saudi Arabia between January 2012 and January 2019. In another report, over a period of 1-year duration (2016), 58 patients with ROP were referred to King Abdulaziz University Hospital ER in Riyadh, which is the main hospital managing patients with ROP in the

Table 1: The number of patients and date of enrollment of each hospital (note that some neonatal intensive care units only refer critical patients)

| Screening center (Hospital name) | All patients | ROP patients | Enrolment date |
|---------------------------------|--------------|--------------|---------------|
| Hafer Al Batin MCH              | 342          | 92           | April 2, 2019 |
| Hail MCH                        | 82           | 9            | September 17, 2019 |
| Al Madinah MCH                 | 182          | 25           | November 17, 2019 |
| Makkah MCH                      | 207          | 107          | November 19, 2019 |
| Abha MCH                        | 167          | 49           | December 19, 2019 |
| Al Ahsa MCH                     | 80           | 14           | January 13, 2020 |
| Arar MCH                        | 97           | 19           | February 18, 2020 |
| King Fahad Hospital, Al Baha    | 41           | 2            | February 24, 2020 |
| KSMEC, Riyadh                   | 342          | 107          | March 11, 2020 |
| Hera Hospital, Makkah           | 124          | 45           | March 19, 2020 |
| King Fahad Central Hospital, Jazan | 23      | 5            | June 17, 2020 |
| Al Jouf MCH                     | 116          | 11           | June 18, 2020 |
| King Faisal Medical Complex, Taif | 11           | 9            | October 27, 2020 |
| Najran MCH                      | 51           | 15           | December 01, 2020 |
| King Khaled Hospital, Tabuk      | 30           | 11           | December 10, 2020 |
| East Jeddah Hospital            | 21           | 4            | December 29, 2020 |
| Buraydah MCH                    | 48           | 28           | January 27, 2021 |
| Al Yamnah Hospital, Riyadh      | 19           | 9            | April 08, 2021 |
| Dammam MCH                      | 74           | 8            | September 21, 2021 |
| King Salman Hospital            | 3            | 0            | June 29, 2021 |

ROP: Retinopathy of prematurity

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KSA. However, of these, nine patients (15.5%) had TRD and were practically blind owing to inadequate screening and late referral (presented at the Saudi Ophthalmology Conference, 2017). In 2021, 1.5 years after the start of the SAROP program, the same hospital received 36 patients with ROP and only one patient with stage 5 ROP in both eyes, who were referred from a private hospital.

4. Based on these encouraging results, we believe that the program can be expanded to include all at-risk neonates in all governmental and private sector hospitals to become a national program.

**CHALLENGES**

One of the biggest challenges is ensuring that treatment is promptly provided because ROP is a time-sensitive disease. Many hospitals under this program provide treatment to patients with qualified ophthalmologists. However, in some hospitals, particularly in the periphery, the situation is more challenging owing to the lack of ophthalmologists specializing in ROP. Therefore, other treating doctors from the FST-ROP team need to travel to deliver treatment.

Another option is to refer these patients to the nearest tertiary care hospital for treatment, which the program attempts to avoid.

The program was mainly based on photographing patients, which is the job of trained nurses. However, many trained nurses left the program, their jobs, or the KSA after they had mastered photographing patients. The comments were that this was cumbersome extra work, without any incentives. This aspect must be considered because of its importance in program continuity. In addition, training and retraining are required. Each NICU has two to three trained nurses to ensure good coverage in case of vacations or sickness.

As mentioned, 20 hospitals were included in the first phase of the program. However, some hospitals do not follow the SAROP meticulously. Some hospitals are also struggling to properly implement the program. To ensure the effective activation of the program, the MOH should address hospital administrations and stress the need to adhere to the program and be more committed.

The program requires the availability of consumables and tools for imaging and treatment. Most of the hospitals enrolled in the program are mainly maternity and children’s hospitals, where they do not have ophthalmology departments. Providing these consumables and tools, such as dilating drops, speculums,
and treatment injections, is time-consuming and requires extraarrangements.

In addition, the program has been temporarily discontinued in some hospitals because of a broken lens caused by the mishandling of the camera handpiece. The lens is expensive and the process of purchasing a replacement lens takes a lot of time, which may extend up to several months. Backup lenses are important to ensure program continuity.

As the program is essentially a telemedicine program, there are greater technical challenges. The quality of cloud storage, data transmission, and maintenance of the telemedicine website should be considered, and any technical problems should be managed without delay to avoid interrupting the program or making it as short as possible. In addition, there should be a contingency plan to continue ROP screening by BIO bedside examinations during these off-time periods.

**Program Monitoring**

The program performance was monitored through KPIs on a monthly, quarterly, and annual basis. These indicators serve to monitor hospital performance in terms of commitment to timely imaging, image quality, number of turned-down images, and requests for repeat imaging. In addition, the performance of readers and their commitment to reporting the cases during a period of 48 h from the receipt of SMS and email alerts were monitored. New performance indicators are being considered and will be added soon to improve program monitoring.

**Conclusion**

The SAROP is an ambitious telemedicine program that covers all 31 MOH level-3 NICUs that are widely scattered in the KSA. This program proved to be practical and effective in identifying and managing all patients with ROP that required treatment. No cases of unfavorable outcomes were observed in the patients of the participating NICUs. Technical challenges were resolved promptly to ensure that the program ran smoothly. During the first 2.5 years of the program, highly encouraging results were observed. Therefore, this ideal state-of-the-art program could be also applied in similar and nearby countries.

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**Conflicts of interest**

There are no conflicts of interest.

**References**

1. Reisner SH, Amir J, Shohat M, Krickler R, Nissenkorn I, Ben Sira I. Retinopathy of prematurity: Incidence and treatment. Arch Dis Child 1985;60:698-701.
2. Palmer EA, Flynn JT, Hardy RJ, Phelps DL, Phillips CL, Schaffer DB, et al. Incidence and early course of retinopathy of prematurity. The Cryotherapy for Retinopathy of Prematurity Cooperative Group. Ophthalmology 1991;98:1628-40.
3. McNamara JA, Moreno R, Tasman WS. Retinopathy of prematurity. In: Tasman W, Jaeger EA, editors. Duane’s Clinical Ophthalmology. Philadelphia (PA): Lippincott-Raven; 1996.
4. Al-Amro SA, Al-Kharfi TM, Thabit AA, Al-Mofada SM. Retinopathy of prematurity at a University Hospital in Riyadh, Saudi Arabia. Saudi Med J 2003;24:720-4.
5. Binkhathlan AA, Almahmoud LA, Saleh MJ, Srungeri S. Retinopathy of prematurity in Saudi Arabia: Incidence, risk factors, and the applicability of current screening criteria. Br J Ophthalmol 2008;92:167-9.
6. Amer M, Jafri WH, Nizami AM, Shomrani AI, Al-Dabaan AA, Rashid K. Retinopathy of prematurity: Are we missing any infant with retinopathy of prematurity? Br J Ophthalmol 2012;96:1052-5.
7. Waheeb S, Alshehri K. Incidence of retinopathy of prematurity at two tertiary centers in Jeddah, Saudi Arabia. Saudi J Ophthalmol 2016;30:109-12.
8. Al Amro SA, Al Aql F, Al Hajar S, Al Dhibi H, Al Nemri A, Mousa A, et al. Practical guidelines for screening and treatment of retinopathy of prematurity in Saudi Arabia. Saudi J Ophthalmol 2018;32:222-6.
9. Chiang MF, Melia M, Baffenn AN, Lambert SR, Recchia FM, Simpson JL, et al. Detection of clinically significant retinopathy of prematurity using wide-angle digital retinal photography: A report by the American Academy of Ophthalmology. Ophthalmology 2012;119:1272-80.
10. Dai S, Austin N, Darlow B, New Zealand Paediatric Ophthalmology Interest Group, Newborn Network, Fetus and Newborn Special Interest Group, et al. Retinopathy of prematurity: New Zealand recommendations for case detection and treatment. J Paediatr Child Health 2015;51:955-9.
11. AlBathl L, Abouammoh N, AlSwaina N, AlBalawi HB, Al Qahtani AA, Talea M, et al. Pitfalls of advanced retinopathy of prematurity presentation: A content analysis of medical records. Risk Manag Healthc Policy 2021;14:3873-82.