The medical and economic burden of childhood eye disease may call for a comprehensive approach to detection and treatment.

BY THE EDITORS OF RETINA TODAY, BASED ON INTERVIEWS WITH DARIUS M. MOSHFEGHI, MD; AND KEVIN D. FRICK, PHD

The World Health Organization defines childhood blindness as “A group of diseases and conditions occurring in childhood or early adolescence, which, if left untreated, result in blindness or severe visual impairment that are likely to be untreated later in life.” However, childhood blindness is not simply tragic and often avoidable, it is also potentially costly. Medical care, peripheral costs, and lost economic productivity due to blindness or low vision can be measured and estimated in real dollars, but the emotional, social, and psychological toll of pediatric eye disease is difficult to quantify.

Chiang and colleagues, in an official report for the American Academy of Ophthalmology (AAO), suggested that the total economic burden of eye disorders and vision loss among Americans is around $139 billion. In addition, uncorrectable vision loss is responsible for 283,000 disability-adjusted life years (DALYs). According to the AAO report, assuming a value of $50,000 per DALY this loss increases the economic burden by roughly $14 billion.

Retinopathy of prematurity (ROP), one of the most common causes of visual loss in childhood, can lead to lifelong vision impairment and blindness. ROP primarily occurs in premature infants weighing 2.75 pounds or less, and its incidence is on the rise due to improvements in neonatal care that result in increased survival rates for low and extremely low birth weight infants. Of the approximately 28,000 babies born in the United States each year weighing 2.75 pounds or less, a little more than half are affected by some degree of ROP; 1100 to 1500 infants with ROP require treatment annually, and 400 to 600 become legally blind from the disorder.

PILOT UNIVERSAL SCREENING PROGRAM
The increase in the number of infants requiring screening, coinciding with a decrease in the number of pediatric retinal specialists qualified to screen for disease, created an impetus for the creation of the Stanford University Network for Diagnosis of Retinopathy of Prematurity (SUNDROP) program, an initiative to install screening technology and protocols in neonatal intensive care units throughout the San Francisco Bay area, with interpretation centralized at Stanford University. Now in its 10th year of operation, the SUNDROP program has been instrumental in diagnosing treatment-warranting ROP in many infants, allowing treatment before any negative visual impact when necessary. According to published studies, the program has achieved 100% sensitivity, 99.8% specificity, 93.8% positive predictive value, and, perhaps most important, 100% negative predictive value for the detection of treatment-warranting ROP. This means

At a Glance
- The economic burden of eye disease in the United States may be as high as $139 billion; additionally, assuming $50,000 per disability-adjusted life year due to vision loss may add another $14 billion.
- Teleophthalmology screening programs have demonstrated the ability to detect treatment-warranting retinopathy of prematurity, saving vision for patients and lowering the economic burden.
- The plausibility of early detection to reduce treatment burden and associated costs of eye diseases may be a rationale for universal eye screening.
the program has captured 100% of cases and that no blinding disease has been missed.

The success of the SUNDROP program is an important proof of principle for the use of telemedicine programs in pediatric ophthalmology. Historically, binocular indirect ophthalmoscopy has been the gold standard for diagnosing ROP, and many specialists have been slow to adopt telemedicine practices. Technological advances are now making remote care a more plausible approach. For instance, the RetCam widefield digital imaging system (Clarity Medical Systems) is now included as an acceptable means of examination in official screening guidelines.5

The RetCam enables appropriate examination of patients, and the recorded images can be shared within the context of a telemedicine program or to facilitate collaboration with colleagues in difficult cases. A newly emerging benefit is the development of algorithms to automatically interpret the diagnosis of the examiner. For example, if the examiner indicates zone 1 stage 3 disease, the system responds with the appropriate treatment guidelines and/or follow-up recommendations.

**NEXT STEPS**
The success of telemedicine-based ROP screening programs has been validated in a number of studies, including the recently completed eROP study.6-10 A joint technical report from the AAO, the American Academy of Pediatrics, and the American Association of Certified Orthoptists lauded the ability of telemedicine programs to create an “ROP safety net,” including the integration of images into patients’ electronic health records, thereby adding to surveillance and detection paradigms while also serving as a vehicle for greater parent and staff education about ROP.11

The success of these programs also helps demonstrate the economic plausibility of universal eye screening. The next step logical step in the evolution of ROP screening would seem to be increased access to appropriate screening to further reduce the burden of ROP, which is treatable in about 99% of cases if detected early enough.

But limiting screening and surveillance to detection of ROP may not be enough. Currently, all children in the United States are tested for hearing in infancy, but screening for this disease is paramount, but only if detected early and within a specific time frame. Screening for this disease is paramount, but as of 2014 in India, where more than 3.5 million infants born premature annually require screening, there are fewer than 600 trained retinal surgeons, of whom fewer than 70 specialize in ROP.1

According to the World Health Organization, India records more premature births than any other country in the world.2 With the majority of the population in India living in rural communities, transporting these fragile patients to the few centers where screening can be performed can be expensive, emotionally traumatic for the parents, and medically risky for the babies. Telescreening is an efficient and, in some cases, necessary solution to this delicate problem.

**COMBATING RETINOPATHY OF PREMATURENESS IN INDIA**

By Anand Vinekar, MD, FRCS

India is one of a group of middle-income countries currently experiencing what is sometimes referred to as the third global epidemic of retinopathy of prematurity (ROP). This potentially blinding disease affecting premature infants can be treated with great success, but only if detected early and within a specific time frame. Screening for this disease is paramount, but as of 2014 in India, where more than 3.5 million infants born premature annually require screening, there are fewer than 600 trained retinal surgeons, of whom fewer than 70 specialize in ROP.1

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**HOW THE KIDROP PROGRAM WORKS**

In 2008, the Narayana Nethralaya Postgraduate Institute of Ophthalmology in Bangalore, India, established the KIDROP (Karnataka Internet-Assisted Diagnosis of ROP) program. Utilizing telemedicine technology, nonphysician technicians who have been trained by a pediatric ophthalmologist experienced in the diagnosis of ROP perform screenings using the RetCam (Clarity Medical Systems), a portable widefield digital imaging system. The teams have proven to be excellent at acquiring and analyzing the images with high accuracy, and their ability to deliver this service in rural areas is an invaluable advantage.3,4 Recently, a large, well-controlled study in the United States validated that remote review of RetCam images by trained technicians yields comparable diagnostic outcomes to live examinations performed by experienced pediatric ophthalmologists.3

The KIDROP teams travel throughout the districts of Karnataka, visiting one district each day. The field teams are typically composed of a project manager and one or two technicians. Each technician has been well trained in proper screening techniques, as well as how to triage the images and diagnose cases that requiring further follow-up.5 The images can be uploaded and sent for remote viewing by experts on smartphones or tablets for further review and diagnosis.5,6 The KIDROP team also handles treatment whenever possible, optimizing deployment of these valuable expert resources to the local centers and again eliminating the need to transport infants.

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they enter kindergarten, which may be too late for a positive intervention to address certain conditions.

Less well known is the potential socioeconomic impact universal eye screening may have. According to economic models, universal screening programs are generally beneficial when the incidence of a given pathology is greater than 2%. However, there are a number of other factors that must be considered, such as the accuracy of the screening tests, the ability to successfully provide early intervention, and the improved outcomes attributable to early detections. A large number of false-positives may have significant psychological effects on the population. The inability to effectively treat a detected pathology must also be considered.

In the case of ROP, the SUNDROP protocol yielded a low rate of false-negative results and a high rate of positive prediction. If similar programs are carried forward at a larger scale, similar results may be achievable in reducing ROP disease burden.

Yet there may be other eye conditions for which universal eye screening is likely to yield a positive benefit. A growing body of data from China, Brazil, Spain, and other countries indicates that the incidence of eye conditions at birth is significant. Universal screening of more than 8000 otherwise healthy neonates in China found an overall incidence of abnormal eye pathology of 23%, including 20.96% with retinal hemorrhage and 2.28% with other pathologies.12

The Newborn Eye Screen Testing (NEST) study, based at Stanford University, is now attempting to replicate and verify these findings in a US population. One sub-study of NEST, the Global Universal Eye Screen Testing (GUEST) study, is seeking to validate the technique of universal eye screening using images from around the world. Cohorts of individuals with different levels of training are being assessed to identify the least expensive cohort with the highest agreement in identifying presence or absence of ocular pathology. Similarly, the GUEST study is evaluating different image screening protocols to determine which protocol most reliably results in detection of disease.

One question the NEST program will attempt to answer is whether retinal hemorrhage may play a role in other treatable ocular pathologies. Most screenings coincide with immunization and booster appointments, making additional trips to health centers unnecessary and helping to enhance participation.

It is encouraging that the KIDROP program is being actively replicated across other states in India, and similar programs are being adopted in other countries. The epidemic of ROP will continue unless steps are taken to ensure screening of all infants without regard to their locale. Telescreening is a viable option that eliminates many barriers to ROP screening, and such programs hold exciting potential to be implemented in any region of the world.

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IN THE FUTURE

In addition to developing new image analyzing software tools and establishing reading centers that will facilitate screening and diagnosis, KIDROP is also expanding into a universal eye screening program. Although all infants in India are screened at birth for hearing and other abnormalities, eye health is not routinely tested. In an effort to change this, a comprehensive eye screening program has been developed. The FOREVER program (Focus on ROP, Eye cancer, Vision, Eye care and Rehabilitation) screens all newborns at birth, 6 weeks, and 14 weeks of age. The (Continued from page 63)

FUNDING THE PROGRAM

The KIDROP program is funded in two ways. In one subset, the capital expenditure is completely funded by the government. About thirteen districts of Karnataka are participating in the country’s first public-private partnership, utilizing government resources and private expertise to finance the rural ROP screening. In other areas, funding comes from donations, grants, and from surplus finances generated from other hospital programs. The program’s reach is further extended through cash-paying patients who are able to afford the expenses associated with screening. However, no baby or mother is ever denied screening due to a lack of finances. If the parents express an inability to pay, the charges are waived.

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retinal hemorrhages are considered benign and self-limiting; however, there are questions whether retinal hemorrhage plays a role in the development of strabismus and amblyopia. It is established that if a retinal hemorrhage obstructs the visual pathway for an extended period of time it will have an impact on ocular development. What remains to be determined is whether early detection and referral for treatment of such cases may be a mechanism to reduce the long-term incidence of amblyopia, or whether it simply leads to extra treatment with little benefit.

CONCLUSION

The medical benefit of screening pediatric patients for ocular conditions such as ROP has been demonstrated in multiple models. Economic models also suggest a benefit to society and individual patients from pediatric screening programs. The success of ROP screening provides a proof of principle for the wider use of screening for ocular pathologies among pediatric patients.

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