Pediatric ophthalmology in the developing world

Jennifer M. Maida, Keith Mathers and Cynthia L. Alley

Department of Ophthalmology, Temple University, Philadelphia, Pennsylvania, USA

Correspondence to Cynthia Alley, MD, Department of Ophthalmology, Temple University, 3509 N. Broad Street, 6th Floor Boyer Pavilion, Philadelphia, PA 19140, USA
Tel: +1 215 707 6617; e-mail: calley@temple.edu

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Purpose of review

It is estimated that of the 45 million people who are blind worldwide in 2000, 1.4 million are children from middle-income and low-income countries, the majority of whom live in the poorest regions of Africa and Asia. The focus of this paper is to discuss the status of pediatric ophthalmology in developing countries and the progress that has been made in the areas of avoidable childhood blindness and visual impairment, particularly corneal scarring as a result of vitamin A deficiency, congenital cataract and retinopathy of prematurity. In addition, we will review the prevalence of uncorrected refractive error and discuss the access to pediatric ophthalmologists in developing countries.

Recent findings

Some developing countries have begun incorporating vitamin A supplementation and measles immunizations and have seen a decrease in xerophthtalmia. With improvement in vitamin A status, cataract is becoming a more apparent cause of treatable childhood blindness. Amblyopia and uncorrected refractive errors are important and inexpensively treatable causes of visual impairment, with myopia being most common. As neonatal intensive care services in middle-income developing countries improve the survival of premature infants, retinopathy of prematurity is emerging as a significant cause of childhood blindness.

Summary

Childhood blindness and visual impairment in developing countries remains a significant public health issue, but recent initiatives have shown promise of future improvements.

Keywords

developing countries, pediatric cataract, refractive error, retinopathy of prematurity, vitamin A deficiency

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Introduction

In 1999, a joint initiative named VISION 2020: the Right to Sight was conceived by the World Health Organization (WHO) and International Agency for Prevention and Blindness [1]. Its purpose as a global initiative is to eliminate avoidable blindness, defined by WHO as blindness that can be effectively treated or prevented, by the year 2020. One of its priorities is childhood blindness. It is estimated worldwide that in 2000, 1.4 million children are blind [2,3], and that 50% of childhood blindness is avoidable [4]. Of the 1.4 million children, 93.5% live in middle-income and low-income countries. Blindness is especially devastating, as up to 60% of children die within a year of becoming blind and the others live on average an additional 40 years without vision [2]. As a result, childhood blindness is thought to be responsible for about one-third of the total economic cost of blindness [2]. This paper will review the current state of childhood blindness in middle-income and low-income countries, with emphasis on vitamin A deficiency (VAD), cataract, access to pediatric ophthalmologists, uncorrected refractive error and retinopathy of prematurity (ROP).

Vitamin A deficiency

Measles, parasitic infections, other diarrheal illness and malnutrition can produce xerophthalmia, corneal scarring and phthisis through a common pathway of VAD [5]. The WHO estimates that more than 3 million children under 5 years of age are affected by xerophthalmia; and a much larger group, 100–140 million, are deficient in vitamin A, making them susceptible to infections [2]. Vitamin A supplementation is proven to decrease the incidence of blindness and may also decrease the overall child mortality in those who are vitamin A deficient by up to 25% [2].

In sub-Saharan Africa (SSA) and parts of India and Asia, VAD has the greatest proportional impact on childhood blindness due to poor sanitation and nutrition, poverty and inadequately developed healthcare programs

[6,7,8•]. In Ethiopia, a survey of three schools for the blind found 44.0% of children were blind from VAD or measles. This accounted for 87% of all preventable causes of childhood blindness. The epidemiology of disease in Ethiopia is comparable to that of Malawi, Uganda and Sudan, but is higher than that of Kenya and South Africa [9–11].

In India, it is estimated that approximately 40 000 children less than 5 years of age lose their eyesight permanently from VAD [2]. There is a disparity between northern and southern India. Northern India has a high proportion of blindness from corneal scarring/phthisis [7], whereas refractive error and strabismus are the major causes in southern India [12,13]. In Bangladesh, VAD (either isolated or following illness) and measles accounted for 34.4% of all avoidable causes of blindness [8•].

The cost of vitamin A supplementation has been demonstrated to be minimal in comparison to the potential benefit that it provides. Only two doses per year of 200 000 IU of vitamin A are demonstrated to be safe [14] and effective, costing approximately $1 [15]. It is also suggested that nutritional education can play a significant role. Foods high in vitamin A should be encouraged, for example, animal source food, sorghum, pulses and vegetables [16].

Globally, the epidemic of blindness from VAD is improving; however, progress is slow to absent in some areas. Unlike other causes of blindness, VAD and measles are unique in that they do not require the specialized care of a pediatric ophthalmologist for prevention. High dose supplementation of vitamin A has become part of several large immunization efforts, though not all vitamin supplementation programs have been successful. In Sri Lanka in 2001, an initiative to give one 105 000 IU dose every 3 years to children aged 1–7 years was found to have essentially no beneficial effect on VAD-associated ocular diseases [17]. It is important to realize this is significantly lower than the current recommended dose of 200 000 IU every 4–6 months and may be responsible for the suboptimal outcome. This study did, however, confirm that supplementation, as well as diarrheal illness, does dramatically affect serum vitamin A levels. Another study [6] looking at the causes of blindness and severe visual impairment (BL/SVI) in Ethiopia from 1986 to present determined that no significant progress has been made in controlling corneal blindness and VAD, and measles continue to be the leading cause. Despite an effort since 1996 to distribute vitamin A capsules to young children, two recent studies [18,19] determined that only approximately half of children under 5 years of age received the medicine.

In contrast, in some countries of SSA (Uganda, Tanzania and Nigeria), cataract is said to be overtaking corneal scarring as the major cause of childhood blindness, presumably due to the efforts of vitamin A supplementation [18,20–22]. One study [23] in Mali examined the effect of starting vitamin A supplementation during National Immunization Days. Between 1997 and 1999, the prevalence of xerophthalmia in preschool children was lowered from 6.9 to 3.3%. Improvements have also been noted in Bangladesh, largely due to the efforts of the Expanded Program of Immunization, which includes vitamin supplementation. There, the prevalence of VAD has decreased over the past few decades from 3.6% in 1982–1983 to 0.6% in 1996 [24]. Indonesia has also witnessed a declining trend in corneal disorders partially attributed to Posyandu (Indonesian Ministry of Health, http://www.gizi.net/pedoman-gizi/suplementasi-vit-a.shtml), a program providing vitamin A supplementation. This has decreased the morbidity and mortality related to VAD by 30–50% over the past 10–20 years [25]. Similar trends have also been reported in northern India [7].

A massive international effort to eliminate 90% of the world's measles morbidity by 2010 has proven quite successful. Named the Measles Initiative (http://www.measlesinitiative.org/mip2.asp), the program is a collaborative effort between the Red Cross, WHO, UNICEF, CDC and UN Foundation. In all, 44 countries, mostly in SSA and south-east Asia, have been targeted by national and sub-national programs to vaccinate as many children as possible. Initial reports demonstrate a profound decrease in measles deaths, from nearly 900 000 in 1999 to almost half of that number in 2005. This effort holds great promise for decreasing the morbidity and mortality of an easily preventable disease and will have a profound impact on the childhood blindness throughout the world.

Cataract

Cataract is one of the main causes of BL/SVI in children worldwide. It is the leading cause of surgically treatable blindness in many developing countries [6,8•,9,26–28]. It is estimated that 200 000 children are blind from cataract, and each year an additional 20 000–40 000 children are born with congenital cataract [29]. Recent studies [6,20,22,30] show that cataract may be overtaking corneal disease as the leading cause of avoidable BL/SVI in some countries of Africa. Even if surgery is available, the subsequent amblyopia resulting from poor follow-up remains a significant problem.

Studies done in the last 5 years at schools for the blind in various developing nations looked at the rate of different causes of BL/SVI, including cataract. Of the studies

reviewed, Bangladesh had the highest prevalence of BL/SVI due to lens disorders, primarily cataract. In Bangladesh, 32.5% of childhood blindness is attributed to lens abnormalities and 27.3% to unoperated cataract. This is in contrast to other developing countries, where lens disorders account for 10–20% [4]. Almost half of the children in Bangladesh who did receive surgery remained severely visually impaired due to amblyopia [8•]. Studies from Indonesia, Iran, Brazil and Ethiopia have reported rates of childhood blindness due to cataract of 15.5, 13.5, 12.8 and 9.2%, respectively [6,26–29,31]. In the Philippines, congenital cataract remains the primary cause of preventable childhood blindness, with 60% attributed to congenital rubella syndrome. Improved maternal immunization programs could dramatically decrease this figure [32].

Access to pediatric ophthalmologists

Early diagnosis, access to surgical treatment and postoperative management to limit amblyopia are critical for the prevention of childhood blindness from cataract [21,33,34]. Studies suggest that delay in presentation is the most important factor limiting visual outcome from cataract [20]. To address these problems, centers for high-quality pediatric cataract surgery have been developed in a number of SSA countries and India, yet the need is still great [21]. The goal of VISION 2020 is that there will be one ophthalmologist trained in pediatric eye conditions for every 10 million people by 2020 [4]. One country working toward this goal is Bangladesh where the rate of unoperated cataracts is exceptionally high. A national analysis of services in 2001–2002 [8•] identified only one fully trained pediatric ophthalmologist. Since then, Bangladesh launched the Childhood Cataract Campaign to educate pediatric ophthalmologists and clinical teams, develop health education strategies and actively find children in need [2]. As of 2007, there are eight new centers in Bangladesh providing pediatric services and eight more are needed to reach the VISION 2020 goal [8•]. In Indonesia, there are approximately 17 pediatric ophthalmologists practicing mostly in cities [26]. With a population of roughly 235 million, Indonesia is still in need of at least six pediatric ophthalmologists to meet VISION 2020 goals. In the Philippines, there are fewer than 20 pediatric ophthalmologists for a population of 81 million people, with tentative plans to institute three fellowships at institutions in Manila [32].

Much attention is needed in SSA, where the population approaches 950 million. Currently, there is only one pediatric ophthalmologist each in Nigeria and South Africa [35]. In Ethiopia, there are only two pediatric ophthalmologists and there are no tertiary centers for the treatment of childhood eye disorders [6]. Based on the goal of VISION 2020, more than 90 additional pediatric ophthalmologists would be needed in SSA. There are ophthalmologists from Ghana, Kenya and West Africa undergoing pediatric training in India with the hope that they will return to their respective countries to practice. Additionally, the Department of Health in South Africa has started training pediatric ophthalmologists at five separate training centers in the region [35].

Refractive error

Refractive error is one of the five priority areas for VISION 2020. A recent WHO bulletin estimated 12.8 million children aged 5–15 years worldwide are visually impaired from uncorrected or inadequately corrected refractive error [36•]. This is a significant finding, as diagnosis is easy and treatment with corrective eyewear is inexpensive and associated with large improvements in function [36•,37]. Prior to 2000, there were limited population data studies on the prevalence of uncorrected refractive error in children from developing countries that could be easily compared. Previous studies used various methods, definitions and demographics. To address the need for comparable population-based studies in children, a protocol called the Refractive Error Study in Children (RESC) was developed [38]. The RESC surveys assess the prevalence of visual impairment due to refractive error in children from different countries using consistent methods and definitions. RESC surveys, for children aged 5–15 years, have recently been published for Chile, a rural area of Beijing, an urban area of southern China, Nepal, South Africa, New Delhi, and a rural population in India. For the purpose of this review, we will compare the following studies on prevalence of uncorrected visual acuity (UCVA) of 20/40 or less in the better eye and myopia.

In seven RESC studies [39–42] to date, urban China had the highest prevalence of UCVA 20/40 or less at 22.3%, followed by Chile (15.8%), rural Beijing (12.8%) and New Delhi (6.4%). Nepal, rural India and South Africa had the lowest prevalence rates of UCVA 20/40 or less at 2.9, 2.7 and 1.4%, respectively [43–45]. Refractive error was the major cause of the high rates of UCVA 20/40 or less in both urban and rural Beijing, China (94.4 and 89.5%), as well as in urban India (81.7%) [39,40,42].

The most common refractive error by the age of 15 across all seven RESC studies was myopia. This was particularly apparent in urban China with a prevalence of 73.1% and rural China where a gender discrepancy was noted, 55% in girls and 37% in boys [39,40]. New Delhi also had a relatively high rate of 7.4%, which was double that of rural India (4.1%) [42,44].

The WHO estimates refractive error to be 2–10% worldwide. Each of the RESC studies presented here had

prevalence rates at or above that range, with the exception of South Africa (1.4%). The low prevalence of uncorrected refractive error in South Africa compared with that in the other sites surveyed, however, should not suggest that this is not a public health issue. In the South African study, 81% of children with significant refractive error were not wearing glasses [45]. In the populations surveyed, the lack of correction seems to be due to several factors, most importantly the lack of screening and availability of affordable spectacles. Furthermore, cultural disincentives may play a role in some countries where routine screenings and free spectacles are provided, but compliance with the spectacles remains low [46]. The RESC surveys suggest that screening programs should be implemented beginning at age 11 or 12 years, as myopia, the most prevalent refractive error in the RESC studies, begins to markedly increase at this age. A notable exception was China, where the shift toward myopia started much earlier around the age of 8 years. This trend of earlier onset for myopia has been reported in other studies from Asia where myopia has reached epidemic proportions, including Japan, Hong Kong, Taiwan and Singapore [47]. Therefore, it may be beneficial to begin screening for refractive error as well as other ocular abnormalities in the preschool age, especially in Asian countries, where there is a shift toward myopia earlier. Programs also are needed in rural areas where many children do not attend school, so these children are screened and free or subsidized correction can be attained.

Retinopathy of prematurity

ROP is not considered a significant cause of childhood blindness in very poor countries of SSA and Asia due to the low survival rate of premature infants [48]. ROP is emerging as a major cause of childhood blindness in middle-income countries [49]. In the 1940s and 1950s, ROP became apparent in industrialized countries after the establishment of neonatal intensive care units (NICUs) and the widespread use of supplemental oxygen. This is often termed the 'first epidemic' [50,51]. At that time, ROP was seen in babies with birth weights averaging 1354 g in the United States and 1370 g in the United Kingdom [51]. As NICU services and oxygen monitoring improved, a 'second epidemic' emerged in the 1970s and 1980s, characterized by smaller, more premature babies developing the disease [52].

The current increase in ROP in developing countries is referred to as the 'third epidemic' [48,49]. This epidemic is similar to the first one, with larger, older infants developing the disease. This is being attributed to a lack of resources, inadequate oxygen monitoring, lack of awareness and skilled personnel, financial constraints, and poorly organized or nonexistent screening and treatment programs [53].

An observational study [53] comparing characteristics of infants who develop severe ROP from countries with low, moderate and high levels of development showed that larger, more mature infants are at risk in the less developed countries. In the developing countries, the mean birth weight of infants with severe ROP ranged from 903 to 1527 g, compared with 737 to 763 g in the highly developed countries. The mean gestational age of infants with severe ROP from the developing countries was 26.3–33.5 weeks, compared with 25.3–25.6 weeks in highly developed countries. In nearly all of the middle-income countries, infants who developed severe ROP had gestational age of more than 32 weeks and weighed more than 1500 g. This fact demonstrates the inadequacy of the current screening guidelines used in developed countries when evaluating infants from middle-income countries [54–56].

Recognizing these limitations, ophthalmologists in middle-income countries are establishing more appropriate screening guidelines for their population of premature infants. In north India, investigators reviewed charts of 592 infants with ROP and found that 17.7% of babies with severe ROP would not have been screened using the American screening guidelines and 22.6% would not have been screened using the British screening guidelines. Based on this information, the authors began screening all infants less than 1700 g or gestational age of 34 weeks [57•]. Other studies [58,59] from India have yielded consistent results.

Similar studies from China [60], Vietnam [61], Thailand [62] and Saudi Arabia [63] have also found the American and British screening criteria to be inadequate for their patients.

Almost half of the world's 50 000 children who are blind from ROP live in Latin America [2]. The WHO estimates that 24 000 of the 100 000 visually impaired infants in Latin America are attributed to ROP [64,65]. In 2001, the Latin American branch of the VISION 2020 project formed a subcommittee dedicated to reducing blindness from ROP through these three goals: improve prenatal and postneonatal care, develop early screening programs and restore useful vision in children with retinal complications through vitreoretinal surgery and/or offer rehabilitation. By 2007, all but three of the countries in the program had established or substantially improved their ROP programs [2].

The data from developing countries suggest screening larger, older infants in order to diagnose all of the babies who may develop severe ROP, resulting in more babies requiring screening and regular follow-up. This poses a problem in many of these countries, particularly in rural areas, where resources and appropriately trained ophthalmologists are extremely limited [2,53].

Conclusion

As we approach the halfway point of the VISION 2020 initiative, progress has been made in identifying and treating the most prevalent causes of childhood blindness in developing countries. VAD and measles are leading causes of BL/SVI in the poorest countries of the world. Cataract remains an important cause of BL/SVI in developing countries of all income levels, whereas ROP is an emerging cause in middle-income countries [4]. An increasing number of programs are beginning in many developing countries to address the need for improved access to diagnostic, therapeutic and surgical ophthalmic services as well as better nutrition, immunization and ROP screening programs.

References and recommended reading

Papers of particular interest, published within the annual period of review, have been highlighted as:

- • of special interest
- •• of outstanding interest

Additional references related to this topic can also be found in the Current World Literature section in this issue (pp. 435–436).

1 World Health Organization International Agency for the Prevention of Blindness. State of the world's sight: VISION 2020: the Right to Sight: 1999–2005. World Health Organization International Agency for the Prevention of Blindness. WHO; 2005.

2 Vision for Children. A global overview of blindness, childhood and VISION 2020: the right to sight. World Health Organization (WHO) and the International Agency for the Prevention of Blindness (IAPB). www.v2020.org.

3 Resnikoff S, Pascolini D, Etya'ale D, *et al.* Global data on visual impairment in the year 2020. Bull World Health Organ 2004; 82:844–851.

4 Gilbert C, Foster A. Childhood blindness in the context of VISION 2020: the right to sight. Bull World Health Organ 2001; 79:227–232.

5 Semba RD, Bloem MW. Measles blindness. Surv Ophthalmol 2004; 49:243–255.

6 Kello AB, Gilbert C. Causes of severe visual impairment and blindness in children in schools for the blind in Ethiopia. Br J Ophthalmol 2003; 87:526–530.

7 Titiyal JS, Pal N, Murthy GVS. Causes and temporal trends of blindness and severe visual impairment in children in schools for the blind in North India. Br J Ophthalmol 2003; 87:941–945.

8 • Muhit MA, Shah SP, Gilbert CE, Foster A. Causes of severe visual impairment and blindness in Bangladesh: a study of 1935 children. Br J Ophthalmol 2007; 91:1000–1004.
This was the first large-scale study looking at the causes of blindness in children in Bangladesh. Over two-thirds of causes were avoidable and this study's results led to the initiation of the Bangladesh Childhood Cataract Campaign.

9 Gilbert CE, Wood M, Waddel K, *et al.* Causes of childhood blindness in east Africa: results in 491 pupils attending 17 schools for the blind in Malawi, Kenya and Uganda. Ophthalmic Epidemiol 1995; 2:77–84.

10 Zeidan Z, Hashim K, Muhit MA, Gilbert C. Prevalence and causes of childhood blindness in camps for displaced persons in Khartoum: results of a household survey. East Mediterr Health J 2007; 13:580–585.

11 O'Sullivan J, Gilbert C, Foster A. The causes of childhood blindness in South Africa. S Afr Med J 1997; 87:1691–1695.

12 Dandona R, Dandona L. Childhood blindness in India: a population based. Br J Ophthalmol 2003; 87:263–265.

13 Nirmalan PK, Vijayalakshmi P, Sheeladevi S, *et al.* The Kariapatti Pediatric Eye Evaluation Project: baseline ophthalmic data of children aged 15 years or younger in southern India. Am J Ophthalmol 2003; 136:703–709.

14 Daulaire NMP, Starbuck ES, Houston RM, *et al.* Childhood mortality after a high dose of Vitamin A in a high risk population. Br Med J 1992; 304:207–210.

15 World Bank. World Development Report 1993: Investing in Health. New York: Oxford University Press; 1993.

16 Schmid MA, Egeland GM, Salomeyesudas B, *et al.* Traditional food consumption and nutritional status of Dalit mothers in rural Andhra Pradesh, South India. Eur J Clin Nutr 2006; 60:1277–1283.

17 Madatuwa TMJC, Mahawithanage STC, Chandrika UG, *et al.* Evaluation of the effectiveness of the national vitamin A supplementation programme among school children in Sri Lanka. Br J Nutr 2007; 97:153–159.

18 United Nations Children's Fund. The state of world's children 2001: early childhood. New York: UNICEF.

19 Semba RD, Pee SD, Sun K, *et al.* Coverage of the national vitamin A supplementation program in Ethiopia. J Trop Pediatr 2008; 54:141–144.

20 Bowman RJC. How should blindness in children be managed? Eye 2005; 19:1037–1043.

21 Eriksen JR, Bronsard A, Mosha M, *et al.* Predictors of poor follow-up in children that had cataract surgery. Ophthalmic Epidemiol 2006; 13:237–243.

22 Ezegwui IR, Umeh RE, Ezepue UF. Causes of childhood blindness: results from schools for the blind in south eastern Nigeria. Br J Ophthalmol 2003; 87:20–23.

23 Schémann JF, Banou A, Malvy D, *et al.* National immunization days and vitamin A distribution in Mali: has the vitamin A status of preschool children improved? Public Health Nutr 2003; 6:233–244.

24 Ahmed F. Vitamin A deficiency in Bangladesh: a review and recommendations for improvement. Public Health Nutr 1999; 2:1–14.

25 Helen Keller International. Nutritional and health surveillance in rural and urban slums areas in Indonesia. Indonesia Crisis Bull 2004; 1:1–13.

26 Sitorus RS, Abidin MS, Prihartono J. Causes and temporal trends of childhood blindness in Indonesia: study at schools for the blind in Java. Br J Ophthalmol 2007; 91:1109–1113.

27 Mirdehghan SA, Dehghan MH, Mohammadpour M, *et al.* Causes of severe visual impairment and blindness in schools for visually handicapped children in Iran. Br J Ophthalmol 2005; 89:612–614.

28 Haddad MAO, Lobato FJC, Sampaio MW, Kara-José N. Pediatric and adolescent population with visual impairment: study of 2385 cases. Clinics 2006; 61:239–246.

29 Foster A, Gilbert C, Rahi J. Epidemiology of cataract in childhood: a global perspective. J Cat Refract Surg 1997; 23:601–604.

30 Waddell KM. Childhood blindness and low vision in Uganda. Eye 1998; 12 (Part 2):184–192.

31 Gogate P, Deshpande M, Sudrick S, *et al.* Changing pattern of childhood blindness in Maharashtra, India. Br J Ophthalmol 2007; 91:8–12.

32 Santiago APD. Pediatric ophthalmology in the Philippines. J AAPOS 2005; 9:103–105.

33 Mwende J, Bronsard A, Mosha M, *et al.* Delay in presentation to hospital for surgery for congenital and developmental cataract in Tanzania. Br J Ophthalmol 2005; 89:1478–1482.

34 Wilson ME, Pandey SK, Thakur J. Paediatric cataract blindness in the developing world: surgical techniques and intraocular lenses in the new millennium. Br J Ophthalmol 2003; 87:14–19.

35 Murray AND. Pediatric ophthalmology in South Africa. J AAPOS 2005; 9:404–406.

36 • Resnikoff S, Pascolini D, Mariotti SP, Pokharel GP. Global magnitude of visual impairment caused by uncorrected refractive errors in 2004. Bull World Health Organ 2008; 86:63–70.
Uncorrected refractive errors are a large public health problem globally.

37 McCarty CA, Taylor HR. Myopia and Vision 2020. Am J Ophthalmol 2000; 129:525–527.

38 Négrel AD, Maul E, Pokharel GP, *et al.* Refractive error study in children: sampling and measurement methods for a multicountry survey. Am J Ophthalmol 2000; 129:421–426.

39 He M, Zeng J, Liu Y, *et al.* Refractive error and visual impairment in urban children in Southern China. Invest Ophthalmol Vis Sci 2004; 45:793–799.

40 Zhao J, Pan X, Sui R, *et al.* Refractive study in children: results from Shunyi District China. Am J Ophthalmol 2000; 129:427–435.

41 Maul E, Barroso S, Munoz SR, *et al.* Refractive error study in children: results from La Florida, Chile. Am J Ophthalmol 2000; 129:445–454.

42 Murthy GVS, Gupta SK, Ellwein LB, *et al.* Refractive error in children in an urban population in New Delhi. Invest Ophthalmol Vis Sci 2002; 43:623–631.

43 Pokharel GP, Negrel AD, Munoz SR, Ellwein LB. Refractive error study in children: results from Mechi Zone, Nepal. Am J Ophthalmol 2000; 129:436–444.

44 Dandona R, Dandona L, Srinivas M, *et al.* Refractive error in children in a rural population in India. Invest Ophthalmol Vis Sci 2002; 43:615–622.

45 Naidoo KS, Raghunandan A, Mashige KP, *et al.* Refractive error and visual impairment in African children in South Africa. Invest Ophthalmol Vis Sci 2003; 44:3764–3770.

46 Khandekar R, Mohammed AJ, Al Raisi A. The compliance of spectacle wear and its determinants among school children of Dhakhiliya region of the Sultanate of Oman: a descriptive study. Univ J Sci Res Med Sci 2002; 4:39–42.

47 Saw SM, Tong L, Chau WE, *et al.* Incidence and progression of myopia in Singaporean school children. Invest Ophthalmol Vis Sci 2005; 46:51–57.

48 Wheatley CM, Dickinson JL, Mackey DA, *et al.* Retinopathy of prematurity: recent advances in our understanding. Br J Ophthalmol 2002; 86:696–700.

49 Gilbert C, Rahi J, Eckstein M, *et al.* Retinopathy of prematurity in middle-income countries. Lancet 1997; 350:12–14.

50 Terry TL. Extreme prematurity and fibroplastic overgrowth of persistent vascular sheath behind each crystalline lens. Am J Ophthalmol 1942; 25:203–204.

51 King M. Retrolental fibroplasias. Arch Ophthalmol 1950; 43:695–709.

52 Gibson DL, Sheps SB, Schechter MT, *et al.* Retinopathy of prematurity: a new epidemic? Pediatrics 1989; 83:486–492.

53 Gilbert C, Fielder A, Gordillo L, *et al.* Characteristics of infants with severe retinopathy of prematurity in countries with low, moderate, and high levels of development: implications for screening programs. Pediatrics 2005; 115:e518–e525.

54 Wilkinson AR, Haines L, Head K, Fielder AR. UK retinopathy of prematurity guideline. Early Hum Dev 2008; 84:71–74.

55 American Academy of Pediatrics: Section on Ophthalmology. Screening examination of premature infants for retinopathy of prematurity. Pediatrics 2001; 108:809–811.

56 American Academy of Pediatrics, American Academy of Ophthalmology, and American Association for Pediatric Ophthalmology and Strabismus: Section on Ophthalmology. Screening examination of premature infants for retinopathy of prematurity. Pediatrics 2006; 117:572–576.

57 Vinekar A, Dogra MR, Sangtam T, *et al.* Retinopathy of prematurity in Asian
• Indian babies weighing greater than 1250 grams at birth: ten year data from a tertiary care center in a developing country. Indian J Ophthalmol 2007; 55:331–336.

Screening guidelines for ROP used in developed countries may not be adequate for developing countries where larger babies often develop severe ROP.

58 Jalali S, Matalia J, Hussain A, Anand R. Modification of screening criteria for retinopathy of prematurity in India and other middle-income countries. Am J Ophthalmol 2006; 141:966–968.

59 Sharma R, Gupta VP, Dhaliwal U, Gupta P. Screening for retinopathy of prematurity in developing countries. J Trop Pediatr 2007; 53:52–54.

60 Chen Y, Li X. Characteristics of severe retinopathy of prematurity patients in China: a repeat of the first epidemic? Br J Ophthalmol 2006; 90:268–271.

61 Phan MH, Nguyen PN, Reynolds JD. Incidence and severity of retinopathy of prematurity in Vietnam, a developing middle-income country. J Pediatr Ophthalmol Strabismus 2003; 40:208–212.

62 Trinavarat A, Atchaneeyasakul LO, Udompunturak S. Applicability of American and British criteria for screening of the retinopathy of prematurity in Thailand. Jpn J Ophthalmol 2004; 48:50–53.

63 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; 92:167–169.

64 Gilbert C. Worldwide causes of childhood blindness. In: Hartnett ME, Trese M, Capone Jr A, Deats BJB, Steidl SM, editors. Pediatric retina. Philadelphia, USA: Lippincott Williams & Wilkins; 2005. pp. 315–329.

65 Haddad MAO, Sei M, Sampaio MW, Kara-Jose N. Causes of visual impairment in children: a study of 3,210 cases. J Pediatric Ophthalmol Strabismus 2007; 44:232–240.