CLINICAL AND EXPERIMENTAL
OPTOMETRY

Blindness and poverty in India: the way forward

Clin Exp Optom 2007; 90: 6: 406–414 DOI:10.1111/j.1444-0938.2007.00199.x

Rohit Khanna MBBS DO MCEH
Usha Raman PhD
Gullapalli N Rao MD
LV Prasad Eye Institute, LVP Marg, Banjara Hills, Hyderabad India
E-mail: rohit@lvpei.org

Submitted: 7 May 2007
Revised: 24 July 2007
Accepted for publication: 2 August 2007

A few recent studies have shown that poverty is an exacerbating and often determining factor in the incidence of disabling conditions, including visual impairment. Recent estimates from the World Health Organization indicate that 90 per cent of all those affected by visual impairment live in the poorest countries of the world. India is home to one-fifth of the world's visually impaired people and therefore, any strategies to combat avoidable blindness must take into account the socio-economic conditions within which people live. This paper looks at the relationship between poverty and blindness in India and suggests strategies to address blindness prevention in a comprehensive manner.

Key words: blindness, India, poverty, prevention

Disability of any kind has an impact on well-being, be it social, emotional or economic. Visual impairment too has a socio-economic dimension. On the one hand, it can place the visually impaired person at risk of losing access to any means of livelihood and independent living. On the other, persons from socio-economically disadvantaged and marginalised groups are more likely to suffer from conditions that could lead to loss of vision.

The United Nations Millennium Development Goals (MDG), articulated in 2000 following a large gathering of world leaders,[1] relate various aspects of health directly to socio-economic development and the eradication of poverty. For instance, we know that of the 600 million people with disabilities worldwide, 82 per cent live below the poverty line, 20 per cent belong to the 'poorest of the poor' and only three to four per cent benefit from development activities.[2] This analysis by the International Agency for the Prevention of Blindness argues that seven of the eight MDG are related to the implementation of VISION 2020 and several factors that exacerbate conditions of poverty and disempowerment can be impacted by prevention of blindness measures.

Blindness is an important part of the disability spectrum, affecting 161 million worldwide.[3] While there is little direct work linking visual impairment and socio-economic disadvantage, based on the available literature, one may surmise that there exists a correlation similar to that between other forms of disability and poverty. This paper outlines the links between blindness and economic development, particularly in light of the MDG, and suggests some strategies to address the issue in a manner that alleviates the consequences of disability as well as poverty.

BLINDNESS AND POVERTY: TENUOUS BUT REAL LINKS

The first systematically obtained global data on blindness in 1995 indicated the inverse relationship between the prevalence of blindness and economic development.[4] Developing countries in Sub-Saharan Africa and Asia had a higher share of the burden of blindness than the established market economies, as did the former socialist economies of Europe and Latin America. The main causes of needless blindness were cataract, trachoma,

onchocerciasis, childhood blindness including Vitamin-A deficiency and refractive error.

It was also found that most of these conditions could be avoided, either prevented or treated, with cost-effective measures.[5] It was projected that without timely and appropriate measures to control blindness, the current level of blindness would double by 2020,[5] resulting in economic losses of close to US$150 billion to US$250 billion.[6] This realisation led to the conceptualisation and launch of VISION 2020: The Right to Sight in 1999, based on the assessment that a co-ordinated, collaborative initiative could significantly contain global blindness, reducing the number of blind persons to 24 million in 2020, thereby avoiding a potential 429 million blind person-years.[5,7] A conservative estimate of the economic gain from preventing blindness is $102 billion.[7] Comparing these data on blindness prevalence with the economic development in each region, Ho and Schwab[8] showed a surprisingly strong inverse association between the total number of blind and the economic status of each region. They also suggested that a critical stage of economic development might exist whereby the prevalence of preventable blindness becomes significantly less. According to this model, this threshold would appear to be near a per capita income of approximately US$2,000.[8]

Other studies that look at prevalence of blindness and impact of blindness prevention efforts have clearly shown that there is a relationship between poverty, socio-economic status and health, including blindness.[9–12] Experience indicates that with increasing socio-economic development, blindness from diseases like trachoma, malnutrition and conditions resulting from vitamin A deficiency have dramatically reduced.[13] The case of trachoma perhaps best illustrates how poverty, development and eye health are interconnected. In the United States, in the early part of the 19th Century, trachoma was extremely common and was classified as a 'dangerous contagious disease' accounting for a significant proportion of blindness. The virtual disappearance of the disease by the 1960s was attributed to the improvements in the standard of living, better education, reduced overcrowding, environmental sanitation and overall improvement in hygiene, all of which were a direct consequence of economic development.[13] In contrast, families with low socioeconomic status, poor water supply and suboptimal hygiene practices populate areas in which trachoma is still endemic.[14–16] These observations suggest that regression of trachoma in many regions of the world has followed a phase of economic development.

Similarly, it is known that as a disability, blindness often leads to unemployment, which in turn leads to loss of income, higher levels of poverty and hunger and low standards of living. This then results in limited accessibility and affordability of health-care services and deprives those affected of educational and other opportunities. All of these together lead to early mortality and loss of economic productivity of a nation as a whole. This is best illustrated with the example of onchocerciasis.[17,18] The efforts of the World Bank and Merck in the Mectizan Donation Program and the Vector control measures to free land for cultivation as well as in reducing labour absenteeism represent a major success in the blindness control program.[19,20] Economic benefits were derived as a result of reductions in blindness, in terms of increased labour productivity, additional land-availability, increased household level welfare, reduced health expenditure because of a reduced transmission of the parasite. Economic evaluations of the Onchocerciasis Control Program (OCP) in West Africa have calculated a net present value—equivalent discounted benefits minus discounted costs—of $485 million for the program over a 39-year period, using a conservative 10 per cent rate to discount future health and productivity gains.[21,22] The net present value for the African Program for Onchocerciasis Control (APOC) is calculated at US$88 million over a 21-year period, also using a 10 per cent discount rate.[21,22] Cost-effectiveness analyses of Ivermectin distribution have found a cost of US$14 to US$30 per disability-adjusted life-year prevented—estimates comparable with other priority disease control programs.[21,22]

Poverty also marginalises already marginalised groups from access to health care and gender combined with poverty is a complicating factor in health promotion efforts, including blindness prevention.[23] Women and children, particularly girls, bear approximately two-thirds of the burden of blindness.[24] It is also established that countries with lower levels of socio-economic development suffer in terms of other human development indices as well, such as child mortality.[25] Up to 50 per cent of children in developing countries are likely to die within a year of becoming blind—and again, child mortality is higher among those from socio-economically disadvantaged populations.[25] This impacts on a family's well being in multiple ways. The blindness of mothers and other caregivers reduces their contribution to child care, leading to dependence on the extended family and community.

INDIA: POPULATION AND HUMAN AND SOCIAL DEVELOPMENT FACTS

India, with 28 states and seven union territories, has a combined population of a little more than one billion and represents about one-sixth of the world's population.[26] In 2007, India had a gross domestic product (GDP) per capita of US$3,700.[27] Roughly 27.5 per cent of the population lives below the poverty line, defined as monthly per capita consumption expenditure below Rs 356.35 for rural areas and Rs 538.60 for urban areas.[28] These figures vary considerably from state to state and also within the states.

In terms of socio-economic development and health status, there is wide variation, with states like Kerala at one end of the development spectrum and Bihar, Rajasthan, Uttar Pradesh and Madhya Pradesh closer to the other end, representing the extremes of the Indian paradox. State-wise analyses of human development (Figure 1) indicate that Kerala, Punjab and Haryana are the three highest-ranking states. Similarly, Bihar,

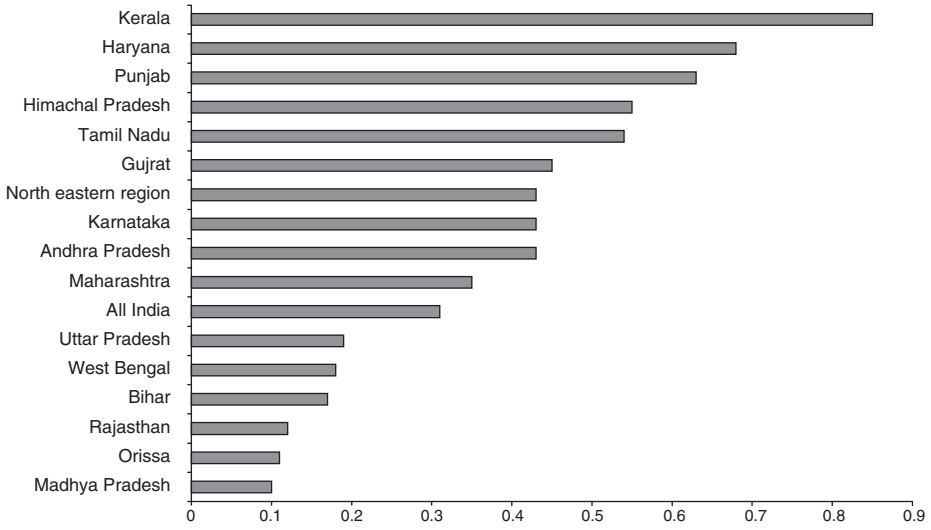

Figure 1. Human Development Index: interstate disparities. State-wise analyses of human development indicate that Kerala, Punjab and Haryana are the three highest-ranking states. Similarly, Bihar, Orissa, Madhya Pradesh and Rajasthan occupy low ranks.[29] Reproduced with permission.

Condition	Ratio of poor to rich
Tuberculosis	4.5
Malaria	3.2
Leprosy	2.8
Mortality (under two)	2.2
Limb impairment	1.8
Blindness	11.7

Source: India Rural Development Report, 1999

Table 1. Prevalence of disease among the poor. Reproduced with permission.[29]

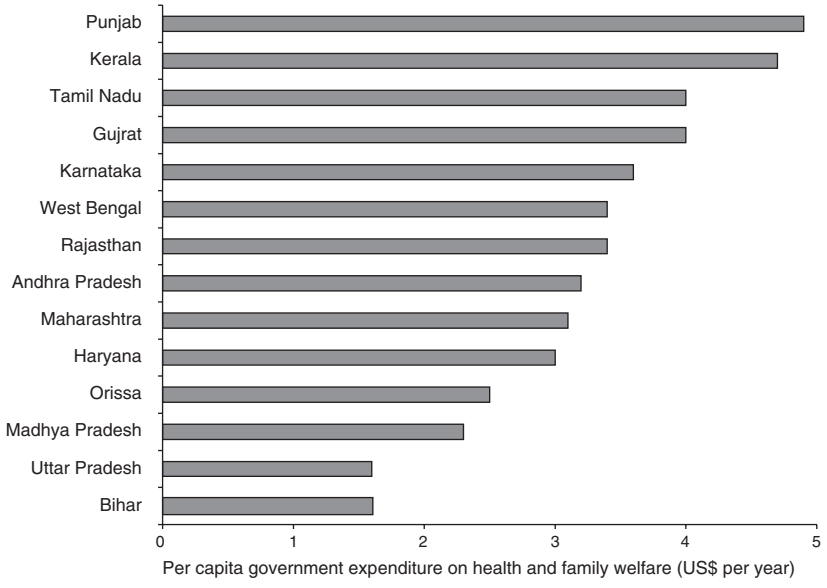

Figure 2. Interstate disparity on government health expenditure. The levels of spending on health-care in Bihar and Uttar Pradesh are only one-half as much as in Maharashtra and Andhra Pradesh and a mere one-third of that in Kerala and Punjab.[29] Reproduced with permission.

Orissa, Madhya Pradesh and Rajasthan occupy low ranks.[29]

Similarly, there are wide variations across states (Figure 2) with the levels of spending on health-care in Bihar and Uttar Pradesh only one-half as much as in Maharashtra and Andhra Pradesh and a mere one-third of that in Kerala and Punjab.[29]

The difference in incidence of disease between the poor and the rich is still very high,[29] as shown in the Table 1.

It is difficult to speak of India with any sense of uniformity; strategies to tackle any social or economic development issue must differ widely according to the context and the peculiarities of the state where they are to be implemented.

BLINDNESS AND POVERTY IN INDIA

India carries a significant proportion of the world's blindness and visual impairment, with nearly 6.7 million blind people.[3] While to some degree blindness is a problem throughout the country, the relative magnitude of different diseases and eye conditions varies. More than three-fourths of those below the poverty line

Parameters	Rajasthan (Bharatpur)	Tamil Nadu (Sivaganga)
Prevalence of blindness (uncorrected)	11.9%	6%
Prevalence of blindness (corrected)	6.1%	2.5%
Visual acuity worse than 6/60 after cataract surgery	33.7%	13.8%

Table 2. Regional variation in prevalence of cataract blindness and surgical outcome

reside in rural areas and only a small percentage of the population can afford any expenditure on health care.[30] Therefore, any meaningful intervention, both ophthalmic and otherwise, must be targeted to the rural poor.

There have been several studies on the prevalence of blindness in India from 1971 to 2002.[31–34] The prevalence varies considerably across different states of the country but comparison among these studies becomes difficult in view of their different definitions of blindness. In all of these studies, it was clear that blindness increased with age, was higher among illiterates, lower in urban areas and higher among females.[31–34] Similarly, the Andhra Pradesh Eye Disease Study (APEDS) revealed that those in the lowest socio-economic group have a nine-times greater prevalence of blindness than persons in the highest socio-economic bracket.[32,33]

Regional variation in prevalence of cataract-related blindness and outcomes is also evident in the rapid assessment studies done in a district in Rajasthan (Bharatpur)[35,36] and Tamil Nadu (Sivaganga) (Table 2).[37,38]

The economic burden of blindness in India, as calculated by Shamanna, Dandona and Rao[39] in 1997, using the cost-of-illness methodology was US$4.4 billion. The cumulative loss over the lifetime of the blind was estimated at US$77.4 billion.[39]

STRATEGIES TO COMBAT BLINDNESS AND POVERTY

The data presented above indicate that there is an association between the increased prevalence of blindness and poor economic development in developing countries, including India. They also indicate that emphasis and resources should be directed towards the development of areas most in need, to successfully eliminate the preventable and curable causes of blindness. Blindness prevention will also have a significant impact on the achievement of the UN Millennium Developmental Goals, many of which have to do with increasing access to education and livelihood opportunities, decreasing infant mortality levels and enhancing quality of life for marginalised populations. Poverty, lack of education and lack of access to public services are all part of a larger context. Efforts to prevent blindness can tackle the confounding influence of these factors only if they are part of a co-ordinated strategy that seeks to address not only the medical problem but also the underlying socio-economic issues. Therefore, blindness must be seen as a public health issue of considerable magnitude, which must be tackled with a public health approach—an approach that puts in place systems that alleviate not only preventable blindness but the conditions within which such blindness keeps occurring.

Developing strategies is a big challenge, however, there is a strong commitment from the government at the state as well as the central level, a commitment that pre-dates VISION 2020 by more than three decades. The first organised national efforts in prevention of blindness in India started in 1963 with the trachoma control program.[40] In 1976, India became the first country to start a National Program for Control of Blindness (NPCB).[41] In addition, efforts by non-governmental organisations (NGOs) have increased since the initiation of VISION 2020: The Right to Sight. The National Program has focused mainly on disease control. It was only after the initiation of VISION 2020 that attention was paid to other areas such as public education, medical training for a larger cadre of eye-care workers and advocacy at both the community and government levels. Efforts by the national coalition of VISION 2020: The Right to Sight India Forum has resulted in a significant increase in the budgetary allocation for blindness prevention and eye health in the Government of India's 11th five-year plan. This is reflective of a changing attitude toward eye health, which is the result of several years of advocacy at various levels and among different stakeholders. In recent years, eye health has been seen within the larger context of health; blindness and visual impairment are receiving more attention within the disability rights spectrum. The range of stakeholders engaged directly and indirectly in blindness prevention work and in advocacy for those with visual impairment has broadened, too, however, disease-specific strategies remain the underpinnings of many national and NGO programs.

DISEASE SPECIFIC STRATEGIES

Cataract

There is clear evidence of the positive impact of cataract surgery on the quality of life.[42] In a study conducted by the Aravind Eye Care System in and around Madurai, Tamil Nadu, 85 per cent of males and 58 per cent of females who had lost their jobs as a result of blindness regained their jobs following cataract removal. After surgery, 88 per cent of males and 93 per cent of females regained their social standing. On average, an individual who regained functional vision through cataract surgery generated 1,500 per cent of the cost of surgery in increased economic productivity during the first year following surgery. Similarly, in a study conducted in the LV Prasad Eye Institute, Hyderabad, which looked at the impact of cataract surgery on visual function, there was a trend showing that cataract definitely worsens the level of dif-

Causes	Rahi et al,[52] 1995	Dandona et al,[53] 1998	Hornby et al,[54] 2000	Titiyal et al,[55] 2003
Congenital globe anomalies	20.7%	25%	20.2%	27.4%
Retinal diseases	19.3%	22.2%	31.1%	15.1%
Optic nerve diseases	5.9%	16.7%	4.9%	NA
Cataract and lens related	12.3%	15.3%	7.9%	10.9%
Corneal	26.4%	11.1%	24.3%	21.7%

Table 3. Major causes of childhood blindness

ficulty perceived in the activities of daily living (ADL) and in the overall quality of life (QOL) of an individual. Cataract surgery improves the ability to perform better in ADL, increases social interaction and self confidence, reduces worries related to cataract, and enhances direct and indirect income of the family (Unpublished data).

The most common indicator used to measure cataract surgical performance and to compare different countries and states is the cataract surgical rate (CSR). The CSR is the number of cataract surgeries per million of population per year and is lowest for the less developed states like Bihar (1,450) compared with developed states like Gujarat (10,200) and those in South India (6,000 to 7,000). Even intraocular lens implantation during cataract surgery varies from 63 per cent (Bihar) and 73 per cent (Uttar Pradesh) to more than 95 per cent in Southern India (VISION 2020 India: Personal communications). The low output and outcome are also related to the GDP of these states, suggesting the level of socio-economic development in these states.

Apart from addressing the barriers to uptake of services such as lack of awareness, transportation, accessibility, issues of gender and cost,[43–45] the most important issue that needs to be addressed is surgical outcome. Different outcome-based studies have shown that approximately one-fourth of eyes operated for cataract are blind after surgery[46–48] and nearly 50 per cent of the post-cataract blindness is due to non-availability of aphakic spectacles, often because they are unaffordable, again a link with poverty.

Refractive error

Refractive error as a cause of blindness has received attention recently after the APEDS study.[32,33] This study established that refractive error is a leading cause of moderate visual impairment, with blindness due to refractive error having a prevalence of 0.03 per cent. In subjects 15 years or younger, the prevalence of myopia (spherical equivalent worse than -0.50 D in the worse eye) was 3.19 per cent (95% CI 2.24 to 4.13%) and hyperopia (spherical equivalent worse than +0.50 D in the worse eye) was 62.6 per cent (95% CI 57 to 68.1%). In this age group, myopia increased with increasing age and children in urban areas had 83 per cent higher odds of having myopia compared to those in rural areas. In subjects older than 15 years, the prevalence of myopia was 19.4 per cent (95% CI 17.89 to 21%) and hyperopia was 8.4 per cent (95% CI 6.9 to 9.8%). Use of spectacles was higher for those with any level of education and those residing in urban areas.

Data on economic loss due to refractive error and uncorrected hyperopia are not available for India nor are data on impact of refractive error correction. It is logical that the strategy should be directed towards children aged between five and 15 years (school-going children) and adults over 45 years for near visual correction. The focus should be on providing affordable spectacles. Primary health care centres, vision centres and schools should be sites for screening refractive error.

Childhood blindness

Prevention of childhood blindness is one of the priorities of VISION 2020: The Right to Sight.[25,49] Although blindness in childhood is estimated to be less common than in other age groups, the cumulative blind-person-years suffered due to childhood blindness may be comparable to those suffered due to other leading cause of blindness in adults.[25,49] It is estimated that there are 1.5 million blind children in the world, two-thirds of whom are in developing countries.[50] The causes of blindness in children vary according to region and socio-economic development with poor countries (Africa and South-East Asia) having more corneal blindness (measles, VAD, ophthalmia neonatorum et cetera) and rich countries (Europe) more unavoidable causes.[51] Hence, region-wise information on major causes of blindness in children is required to design effective prevention programs.[51] Table 3 summarises the major cause of childhood blindness in studies conducted in India.

The studies[52–55] cited in Table 3 suggested that about 30 to 40 per cent of the patients suffered from easily preventable and treatable causes of blindness, primarily corneal disease (mainly due to Vitamin A deficiency/measles) and lens-related disorders. The rest were due to relatively unavoidable causes (mainly congenital anomalies and genetic diseases). Vitamin A deficiency (VAD) was probably low in Andhra Pradesh[53] because the area surveyed had a sound agricultural economy and presumably was more prosperous. Other studies representing major blind schools all over India found VAD to be a major cause of preventable blindness, particularly in rural areas.[52,56] VAD is also a cause of mortality from diarrhoea and respiratory tract infections. The prevalence of blindness due to keratomalacia is underestimated due to high mortality associated with blinding malnutrition. Regional variation was seen in VAD as a cause of blindness where it was lowest in the state of Kerala (7.5 per cent) and Karnataka (11.5 per cent) and was highest in the most underdeveloped states of Madhya Pradesh (26.7 per cent) and Uttar Pradesh (21.6 per cent).[52] In a recent study from a more affluent state, a changing pattern of childhood blindness was clearly observed.[52,57] The study showed a decline in diseases due to malnutrition

and infection, that is, corneal blindness and an increase in the proportion of congenital and hereditary disorders. In a recent blind school study in Delhi, India,[55] corneal blindness was reported to be less important in younger children than in older children. The lower incidence of corneal blindness, particularly in some of the better developed states in India where mortality of children aged five years and below is declining, is almost certainly due to better primary health-care, higher measles immunisation coverage and child survival initiatives that include control of VAD. Similarly, corneal blindness (nutritional and infective) is not a major cause in neighbouring countries like China, which also reflects the improved health and socio-economic status of the country.[58] Supplementation of vitamin A is the most cost-effective of all interventions and it takes only two doses a year to prevent blindness.[5,59]

The other important treatable causes include childhood cataract and retinopathy of prematurity. One of the major aetiologic factors for childhood cataract is rubella infection and immunisation against rubella will have a salutary effect on visual impairment due to childhood cataract.

Strategies to combat childhood blindness should include health education programs to promote awareness of increased risk associated with consanguineous marriages, the effect of maternal smoking or use of alcohol or other illegal drugs during pregnancy, and of sexually transmitted diseases during pregnancies. Training of traditional birth attendants, midwives, doctors and other personnel involved with childbirth in the benefit of prophylaxis for ophthalmia neonatorum, and increasing awareness among neonatologists and paediatricians about retinopathy of prematurity and white reflex in pupillary area is also warranted. There is a need for streamlining vitamin A intervention programs by having them focus on areas with significant VAD and increasing public awareness about risk of visual loss due to trauma, especially sharp objects and fire crackers. In addition, there is need to train the required number of specialised personnel, including paediatric ophthalmologists and to develop models of specialised paediatric eye care-centres, incorporating preventive, curative and rehabilitative components.[60]

Using the concept of blind-person-years proposed by Foster[25,49] and assuming the blind child has a mean life expectancy of 15 years lower than the average of the Indian population, on average, a child will live for 43 years after becoming blind (assuming the mean onset of blindness to be five years), resulting in a total of 11.2 million blind-person-years. In India, the cumulative loss from 250,000 children blind and for 33 working years of life is 801 billion rupees, which is 28.7 per cent of cumulative GNP loss due to blindness.[39] Planning should take into account these data, so that programs are targeted toward children and communities most at risk. A greater focus on rehabilitative measures would also help enhance opportunities and quality of life for children with incurable visual impairment.

Corneal blindness

There is considerable regional variation in the amount of blindness attributed to corneal disease. In the World Bank-National Programme for Control of Blindness (WB-NPCB) survey in Rajasthan,[35] corneal disease (including trachoma) caused 16.8 per cent of blindness, whereas the same study showed a four per cent contribution of corneal disease to blindness in the state of Tamil Nadu.[37] Trachoma as a cause for corneal blindness has decreased over time,[31,34] however, some of the underdeveloped states in the northern part of India (Rajasthan) do report cases of trachoma, which again is linked with the level of socio-economic development in the state.

INFRASTRUCTURE AND HUMAN RESOURCE DEVELOPMENT

The distribution of infrastructure and human resources in India is in stark contrast to the disease pattern seen. Most of the infrastructure is located in urban areas and the little present in the rural areas has limited accessibility. Similarly, there is gross disparity in the availability of human resources. Nearly 70 per cent of ophthalmologists reside in urban areas where 30 per cent of the population lives.

A recent survey conducted by the All India Institute of Medical Sciences[61] found that more than one-half the eye-care facilities were located in the private sector and 69 per cent of ophthalmologists were employed in the private and non-governmental sectors. There was a wide disparity in access to ophthalmologists and dedicated eye beds across the country. Of all dedicated eye beds 71.5 per cent were managed by these two sectors. Hence, the role of the private and NGO sector becomes important, if any widespread intervention has to be planned. It was also found that five states (Maharashtra, Uttar Pradesh, Karnataka, Andhra Pradesh and Tamil Nadu) had one-half the practising ophthalmologists in India. Hence, it was suggested that some states would need special attention and instead of an across-the-board increase in ophthalmologists and eye beds, regions that are deficient would need to be prioritised and concerted action initiated to achieve an equitable distribution of the available resources.

Strategies for the development of infrastructure should focus on developing reasonable quality sustainable infrastructure in the underserved rural areas that will serve the eye-care need of the population in the long term. This is best done by involving communities, and developing comprehensive eye-care services of good quality that are available and accessible to all at an affordable price. Similarly, issues related to human resources include training and availability. Training should not be limited to ophthalmologists but to other cadres like optometrists, ophthalmic technicians, ophthalmic nurses, managers and other non-clinical staff. At the same time, strategies for making theses resources available in rural and underserved areas need to be adopted.

EYE CARE MODELS AND ROLE OF STAKEHOLDERS

Equitable models of eye-care delivery do exist in the Southern states. Those that

have been tried and tested include an infrastructure model developed by the LV Prasad Eye Institute (LVPEI) in Hyderabad, and a technology-based model put in place by Aravind Eye Hospitals in Madurai.[62,63] The first is based on a pyramidal system[64] with a base of community eye-care workers at the village level, connected through primary eye-care centres and then secondary service centres at the district level to a tertiary care referral centre in an urban hub. Each level has its own permanent infrastructure with trained medical and paramedical staff and in the rural areas is managed by persons drawn from the local community. The tertiary centre may develop into a centre of excellence that performs the functions of patient care, research, training, rehabilitation and advocacy. The second model makes use of low-cost communication technology combined with high-end teleconferencing facilities to make available expertise across distance, supplemented by trained primary eye-care workers.

More work is needed to determine the cost-effectiveness of these models. The important thing is that such approaches should be explored in a widespread manner and not be limited to experiments by a few institutions in the country if large-scale benefit is to be achieved. It is clear that much more data from the ground are needed before eye-care infrastructure and services can be planned in a manner that addresses not only disease control but also the socio-economic betterment of those affected by visual impairment. The dialogue on health-care needs must expand to include aspects of life that impact the health and health-care access of communities most in need. This implies that the circle of organisations and professionals involved in blindness prevention work must expand to include educationists, rehabilitation professionals, a wider range of medical professionals and social workers, as well as health policy makers. Already non-government organisations engaged in project funding and implementation, and service delivery organisations are focusing on involving various community stakeholders such as school teachers and women's self-help groups, micro-credit institutions and local government representatives.

Our understanding of the impact of visual impairment and its relationship with economic and social well-being suggests also that policymaking must take into account the limitations imposed on access by location, caste, class, gender and disability. Situational and contextual data on visual disability combined with poverty data must inform such policy makers. The available and tested models such as those put in place by LVPEI and Aravind can be expanded and adapted to serve wider groups of needy people across the country, while the development of new and more innovative models must be encouraged.

CONCLUSION

The apparent association between the increased prevalence of blindness and poor economic development in developing countries (including India) suggests that emphasis and resources should be directed towards improving those economies to successfully eliminate the preventable and curable causes of blindness. Though the development of blindness prevention programs conceived in isolation is well intended and most appropriate on a humanitarian basis, these efforts unaccompanied by other support measures will serve only to temporarily reduce the current backlog of world blindness. Several NGOs have localised service delivery programs that provide much-needed care in underserved areas and if they are to have a longer-lasting impact, these need to be linked to other development programs, such as education and child and maternal health. Successful disease control measures, such as trachoma and onchocerciasis control programs have had sustained impact because they have also addressed contextual issues of education, general hygiene and access to natural resources. As outlined in the Millennium Development Goals, specific and strategic measures are needed, if poverty and its consequences on health and well-being are to be addressed. Each of the disease control measures discussed here would have an impact on access to education, equitable distribution of opportunity and wealth, and employability. Ultimately, it is only through these that poverty and therefore ill health can be alleviated.

We believe that prevention schemes alone will not reduce the global burden of blindness. Rather, implementing preventive and rehabilitative measures that work in conjunction with economic development is the most prudent approach to further the goal of eliminating avoidable blindness throughout the world. Recently, India has entered the elite trillion dollar GDP group of countries. The visible signs of economic progress augur well for a brighter future for the visually impaired in the country.

REFERENCES

1. http://www.unmillenniumproject.org
2. IAPB booklet on Blindness and Poverty, available at the VISION2020 web site http://www.v2020.org/page.asp/section=000100010015
3. Resnikoff S, Pascolini D, Etya'ale D, Kocur I, Pararajasegaram R, Pokharel GP, Mariotti SP. Global data on visual impairment in the year 2002. *Bull World Health Organ* 2004; 82: 844–851.
4. Thylefors B, Negrel AD, Pararajasegaram R, Dadzie KY. Global data on blindness. *Bull World Health Organ* 1995; 73: 115–121.
5. WHO. Global Initiative for the Elimination of Avoidable Blindness. Programme for prevention of blindness and deafness. Geneva: WHO, 1997 (WHO/PBL/97.61).
6. Smith AF, Smith JG. The economic burden of global blindness: a price too high! *Br J Ophthalmol* 1996; 80: 276–277.
7. Frick KD, Foster A. The magnitude and cost of global blindness: an increasing problem that can be alleviated. *Am J Ophthalmol* 2003; 135: 471–476.
8. Ho VH, Schwab IR. Social economic development in the prevention of global blindness. *Br J Ophthalmol* 2001; 85: 653–657.
9. Salive ME, Guralnik J, Christen W, Glynn RJ, Colsher P, Ostfeld AM. Functional blindness and visual impairment in older adults from three communities. *Ophthalmology* 1992; 99: 1840–1847.
10. Tielsch JM, Sommer A, Katz J, Quigley H, Ezrine S. Baltimore Eye Survey Research Group. Socioeconomic status and visual impairment among urban Americans. *Arch Ophthalmol* 1991; 109: 637–641.
11. Klein R, Klein BEK, Jensen SC, Moss SE, Cruickshanks KJ. The relation of socioeconomic factors to age-related cataract,

maculopathy, and impaired vision: the Beaver Dam Eye Disease Study. *Ophthalmology* 1994; 101: 1969–1979.
12. Dandona R, Dandona L. Socioeconomic status and blindness. *Br J Ophthalmol* 2001; 85: 1484–1488.
13. Allen SK, Semba RD. The trachoma menace in the United States, 1897–1960. *Surv Ophthalmol* 2002; 47: 500–509.
14. West SK, Congdon N, Katala S, Mele L. Facial cleanliness and risk of trachoma in families. *Arch Ophthalmol* 1991; 109: 855–857.
15. Lynch M, West SK, Munoz B, Kayongoya A, Taylor HR, Mmbaga BB. Testing a participatory strategy to change hygiene behavior: face washing in central Tanzania. *Trans R Soc Trop Med Hyg* 1994; 88: 513–517.
16. West SK, Munoz B, Lynch M, Kayongoya A, Mmbaga BB, Taylor HR. Risk factors for constant, severe trachoma among preschool children in Kongwa, Tanzania. *Am J Epidemiol* 1996; 143: 73–78.
17. Kim A. Health and Labor Productivity: The Economic Impact of Onchocercal Skin Disease. (1997) The World Bank, S1 (#WP 1836).
18. World Bank Economic Impact of Onchocercal Skin Disease—Report of a Multi-Country Study. 1997 Onchocerciasis Coordination Unit, The World Bank.
19. Alleman MM, Twum-Danso NA, Thylefors BI. The Mectizan Donation Program—highlights from 2005. *Filaria J* 2006; 5: 11.
20. Thylefors B, Alleman M. Towards the elimination of onchocerciasis. *Ann Trop Med Parasitol* 2006; 100: 733–746.
21. Waters HR, Rehwinkel JA, Burnham G. Economic evaluation of Mectizan distribution. *Trop Med Int Health* 2004; 9: A16–A25.
22. Benton B. Economic impact of onchocerciasis control through the African Programme for Onchocerciasis Control: an overview. *Ann Trop Med Parasitol* 1998; 92 Suppl 1: S33–S39.
23. Shah A, Cook C, Woodcock M, King M, Murray A, Cassels-Brown A. Barriers to Cataract Surgery for Women In Urban Cape Town. World Blindness and its Prevention. Proceedings of the 7th General Assembly, International Agency for the Prevention of Blindness, Sep 20–24 2004, Dubai, UAE. IAPB: 2005.
24. Abou-Gareeb I, Lewallen S, Bassett K, Courtright P. Gender and blindness: a meta-analysis of population-based prevalence surveys. *Ophthalmic Epidemiol* 2000; 8: 39–56.
25. Gilbert C, Foster A. Childhood blindness in the context of VISION 2020: The Right to Sight. *Bull World Health Organ* 2001; 79: 227–232
26. www.censusindia.net.
27. GDP data available from http://www.indexmundi.com/india/gdp_per_capita_(ppp).html.
28. Poverty statistics available from http://en.wikipedia.org/wiki/Poverty_in_India.
29. Shariff A. 'Poverty & Equity in India with a Special Emphasis on Health', Background Paper a Session on 'Equity and Health', Forum 8—Health Research to Achieve the Millennium Development Goals, Mexico City, 16–20 November 2004.
30. Dandona L. Blindness control in India: beyond anachronism. *Lancet* 2000; 356 (Suppl): S25.
31. Angra SK, Murthy GV, Gupta SK, Angra V. Cataract related blindness in India and its social implications. *Indian J Med Res* 1997; 106: 312–324.
32. Dandona L, Dandona R, Srinivas M, Giridhar P, Vilas K, Prasad MN, John RK, McCarty CA, Rao GN. Blindness in the Indian state of Andhra Pradesh. *Invest Ophthalmol Visc Sci* 2001; 42: 908–916.
33. Dandona R, Dandona L. Review of findings of the Andhra Pradesh Eye Disease Study: policy implications for eye-care services. *Indian J Ophthalmol* 2001; 49: 215–234.
34. Murthy GVS, Gupta SK, Bachani D, Jose R, John N. Current estimates of blindness in India. *Br J Ophthalmol* 2005; 89: 257–260.
35. Murthy GV, Gupta S, Ellwein LB, Munoz SR, Bachani D, Dada VK. A population-based eye survey of older adults in a rural district of Rajasthan: I. Central vision impairment, blindness, and cataract surgery. *Ophthalmology* 2001; 108: 679–685.
36. Murthy GV, Ellwein LB, Gupta S, Munoz SR, Bachani D, Dada VK. A population-based eye survey of older adults in a rural district of Rajasthan: II. Outcomes of cataract surgery. *Ophthalmology* 2001; 108: 686–692.
37. Thulasiraj RD, Rahamathulla R, Saraswati A, Selvaraj S, Ellwein LB. The Sivaganga eye survey: I. Blindness and cataract surgery. *Ophthalmic Epidemiol* 2002; 9: 299–312.
38. Thulasiraj RD, Reddy A, Selvaraj S, Munoz SR, Ellwein LB. The Sivaganga eye survey: II. Outcomes of cataract surgery. *Ophthalmic Epidemiol* 2002; 9: 313–324.
39. Shamanna BR, Dandona L, Rao GN. Economic burden of blindness in India. *Indian J Ophthalmol* 46: 169–172: 1998.
40. Preobragenski VV, Gupta UC. The national trachoma control programme in India. *J All India Ophthalmol Soc* 1964; 12: 68–73.
41. Agarwal LP. National programme for prevention of visual impairment and control of blindness. *Indian J Ophthalmol* 1978; 25: 1–5.
42. Javitt JC. Cataract. In: Jamison DT, Mosley WH, Measham AR, Bobadilla JL, eds. Disease Control Priorities in Developing Countries. New York: Oxford University Press for the World Bank, 1993.
43. Gupta SK, Murthy GV. Where do persons with blindness caused by cataracts in rural areas of India seek treatment and why? *Arch Ophthalmol* 1995; 113: 1337–1340.
44. Dandona R, Dandona L, Naduvilath TJ, McCarty CA, Rao GN. Utilisation of eye care services in an urban population in southern India: the Andhra Pradesh eye disease study. *Br J Ophthalmol* 2000; 84: 22–27.
45. Vaidyanathan K, Limburg H, Foster A, Pandey RM. Changing trends in barriers to cataract surgery in India. *Bull World Health Organ* 1999; 77: 104–109.
46. Anand R, Gupta A, Ram J, Singh U, Kumar R. Visual outcome following cataract surgery in rural Punjab. *Indian J Ophthalmol* 2000; 48: 153–158.
47. Dandona L, Dandona R, Naduvilath TJ, McCarty CA, Mandal P, Srinivas M, Nanda A, Rao GN. Population-based assessment of the outcome of cataract surgery in an urban population in Southern India. *Am J Ophthalmol* 1999; 127: 650–658.
48. Limburg H, Foster A, Vaidyanathan K, Murthy GV. Monitoring visual outcome of cataract surgery in India. *Bull World Health Organ* 1999; 77: 455–460.
49. Johnson GJ, Minassian DC, Weale RA, West SK. The Epidemiology of Eye Disease, 2nd ed. Hodder Arnold, 2003.
50. WHO. Preventing blindness in children: report of WHO/IAPB scientific meeting. Programme for prevention of blindness and deafness and International Agency for prevention of blindness. Geneva: WHO, 2000 (WHO/PBL/00.77).
51. Gilbert CE, Anderton L, Dandona L, Foster A. Prevalence of visual impairment in children: a review of the available data. *Ophthalmic Epidemiol* 1999; 6: 73–82.
52. Rahi JS, Sripathi S, Gilbert CE, Foster A. Childhood blindness in India: causes in 1318 blind school students in nine states. *Eye* 1995; 9: 545–550.
53. Dandona L, Williams JD, Willliams BC, Rao GN. Population based assessment of childhood blindness in southern India. *Arch Ophthalmol* 1998; 116: 545–546.
54. Hornby SJ, Adolph S, Gothwal VK, Gilbert CE, Dandona L, Foster A. Evaluation of children in six blind schools of Andhra Pradesh. *Indian J Ophthalmol* 2000; 48: 195–200.
55. Titiyal JS, Pal N, Murthy GV, Gupta SK, Tandon R, Vajpayee RB, Gilbert CE. Causes and temporal trends of blindness and severe visual impairment in children in schools for blind in North India. *Br J Ophthalmol* 2003; 87: 941–945.
56. Rahi JS, Sripathi S, Gilbert CE, Foster A. Childhood blindness due to vitamin A deficiency in India: regional variations. *Arch Dis Child* 1995; 72: 330–333.

57. Gogate P, Deshpande M, Sudrik S, Taras S, Kishore H, Gilbert C. Changing pattern of childhood blindness in Maharashtra, India. *Br J Ophthalmol* 2007; 91: 8–12.
58. Hornby SJ, Xiao Y, Gilbert CE, Foster A, Wang X, Liang X, Jing H, Wang L, Min W, Shi Y, Li Y. Causes of childhood blindness in the People's Republic of China: results from 1,131 blind school students in 18 provinces. *Br J Ophthalmol* 1999; 83: 929–932.
59. World Bank. World Development Report 1993: Investing in Health. New York: Oxford University Press, 1993.
60. Dandona L, Gilbert CE, Rahi JS, Rao GN. Planning to reduce childhood blindness in India. *Indian J Ophthalmol* 1998; 46: 117–122.
61. Murthy GV, Gupta SK, Bachani D, Tewari HK, John N. Human resources and infrastructure for eye care in India: current status. *Natl Med J India* 2004; 17: 128–134.
62 Natchiar G, Robin AL, Thulasiraj RD, Krishnaswamy S. Attacking the backlog of India's curable blind. The Aravind Eye Hospital model. *Arch Ophthalmol* 1994; 112: 987–993.
63. Dandona L, Dandona R, Shamanna BR, Naduvilath TJ, Rao GN. Developing a model to reduce blindness in India: The International Centre for Advancement of Rural Eye Care. *Indian J Ophthalmol* 1998; 46: 263–268.
64. Rao GN. An infrastructure model for the implementation of VISION 2020: The Right to Sight. *Can J Ophthalmol* 2004; 39: 589–594.

Corresponding author:
Dr Rohit Khanna
LV Prasad Eye Institute
LVP Marg, Banjara Hills
Hyderabad
Andhra Pradesh 500034
INDIA
E-mail: rohit@lvpei.org