

HEALTH IN TRANSITION

Translating developmental origins of health and disease science to improve future health in Africa



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AN APPROACH TO REDUCE THE BLINDNESS BURDEN IN SUB-SAHARAN AFRICA: SPECIAL FOCUS ON CHILDHOOD BLINDNESS

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Sub-Saharan Africa is afflicted with high levels of blindness burden, affecting the quality of life and productivity of its people. While cataracts account for over 40 per cent of blindness, uncorrected refractive error leading to vision loss is over 50 per cent. The number of ophthalmologists and optometrists in the region, who can restore vision by surgery, and provide corrective eyeglasses for uncorrected refractive error, respectively, is woefully inadequate. However, most of these countries have primary health care centres. Workers in these centres have played remarkably successful roles in working with professionals in helping to reduce the burden of blindness due to onchocerciasis and trachoma.

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In this chapter, encouraged by these success stories, we suggest that primary health care workers (and recruits from rural areas) be trained for set periods to become what is called Vision Technicians, who will acquire the three R's, namely:

- Recognise the blinding condition.
- Refract and estimate the level of uncorrected refractive error in people and offer corrective eyeglasses.
- Refer patients who need higher levels of care to the nearest hospital for management.

The recruitment and deployment of Vision Technicians can drastically reduce vision deprivation due to uncorrected refractive error; in particular, it can be expected to boost literacy, education and future development of children, and the productivity of adults. In sub-Saharan Africa, the growing popularity of mobile phones and internet access, now makes inter-tier connectivity possible, and organising Vision Technicians, optometrists and ophthalmologists in this way will help overcome the shortage of the latter two professionals to some extent. In addition, the availability of low-cost, high-resolution ophthalmic diagnostic devices will offer considerable economies in care.

A pyramidal model of rural eye care such as this has been tried with success at the LV Prasad Eye Institute, Hyderabad, India (see Figure 1). Hence we suggest an adaptation of this pyramidal model of eye care in order to improve the burden off blindness in Sub-Saharan Africa.

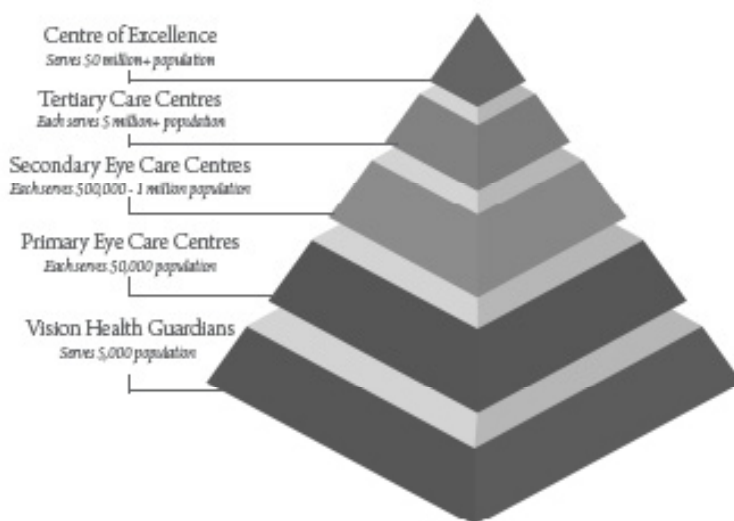


Figure 13.1 Pyramidal model of eye care delivery.

Introduction

Among the 17 United Nations (UN) 'Sustainable Development Goals', also called the '2030 Agenda', Goal 1 aims to end poverty in all its forms, Goal 3 aims to advance good health and well-being for people through universal health coverage, and Goal 17 wants partnership among nations to achieve all these goals. The UN's objective is to achieve these goals by the year 2030. In parallel, 'VISION 2020: The Right to Sight' wishes to eliminate avoidable blindness by the year 2020, two years hence; VISION 2020 is a joint initiative between the World Health Organization (WHO) and the International Agency for the Prevention of Blindness. The Sustainable Development Goals agenda and VISION 2020 are connected, since the burden of vision impairment, and blindness affects both individual and community health and happiness and also the economic growth of nations, due to the negative effect of the blindness burden on the economy.

Across the world, about 36 million people are blind (defined as visual acuity worse than 3/60), while 217 million suffer from moderate to severe visual impairment (MSV) which is visual acuity worse than 6/18 but better than 3/60 in the better eye (Bourne et al., 2017). Of the latter, 124 million have what is called uncorrected refractive error (needing corrective glasses to restore vision), and 65 million suffer from cataracts (opacification of the lens in the eye preventing light from focussing on the retina). The extent of children's blindness is estimated to be less than 0.1 per cent.

Of the two main causes of blindness, uncorrected refractive error is easily corrected. Rosamond Hutt points out that the world economy is robbed of 227 billion dollars every year due to lost productivity among adults who need glasses to correct their uncorrected refractive error.⁵ Providing affordable access to reading glasses alone would boost productivity by 34 per cent. Furthermore, since 80 per cent of all learning occurs through vision, providing corrective eyeglasses to children will boost literacy, education and future development. Hutt notes that "we are blind to the global cost of poor eyesight, but this can change".

Blindness burden in sub-Saharan Africa

It is against this background that we look at the blindness burden in sub-Saharan Africa, a rapidly growing and advancing subcontinent containing 12 per cent of the world population but two per cent of the world's gross domestic product. Economic advancement of sub-Saharan Africa has grown by five per cent per year

5 Hutt, R. 2016. We're blind to the global cost of poor eyesight. But this can change. *World Economic Forum: Global Agenda: Humanitarian Action*. [<https://bit.ly/34nGZjY>].

since 2000, compared to 2.4 per cent growth during the previous two decades. The population has grown by 2.7 per cent, life expectancy at birth rose to 56 years, and adult literacy has come up to 59.3 per cent. Economic growth increased from 1.4 per cent in 2016 to 2.4 per cent in 2017 and is estimated to be 3.1 per cent in 2018 and expected to grow to 3.7 per cent in two years.⁶

About 50 countries comprise sub-Saharan Africa. Among a population of about 1.06 billion, about 1.1 to 1.5 per cent are blind, and moderate and severe vision impairment affects about four per cent of the population. Across sub-Saharan Africa, 62 per cent of the 1.06 billion people are younger than 25 and 40 per cent younger than 15. Visual deprivation among children is of particular concern. The review by Bourne and colleagues (Flaxman, Braithwaite, Cicinelli, Das, Jonas, Keeffe, Kempen, Leasher, Limburg, Naidoo, Pesudovs, Resnikoff, Silvester, Stevens, Tahhan, Wong, Taylor and the Vision Loss Expert Group) points out that in 2015 in the central, eastern, southern and western parts of sub-Saharan Africa, uncorrected refractive error leading to blindness was about 13 per cent.⁷ Uncorrected refractive error leading to moderate and severe vision impairment accounted for 46-48 per cent, trachoma about 0.2 per cent in the central and southern parts, and around 3.4 per cent in the western part, but seven per cent in the eastern region of sub-Saharan Africa. Cataracts accounted for 35-45 per cent of the blindness burden, as earlier pointed out by Naidoo and colleagues (Gichuhi, Basáñez, Flaxman, Jonas, Keeffe, Leasher, Pesudovs, Price, Smith, Turner, White, Wong, Resnikoff, Taylor and Bourne), uncorrected refractive error leading to blindness in sub-Saharan Africa was 13-21 per cent and leading to moderate and severe vision impairment 45-53 per cent.⁸ Cataract related blindness was 31-35 per

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- 6 Obulutsa, G. 2018. *Sub-Saharan Africa's economic growth to quicken to 3.1 pct in 2018 – World Bank*. Reuters, 18 April. [https://reut.rs/31onUwb].
- 7 Bourne, R.R.A., Flaxman, S.R., Braithwaite, T., Cicinelli, M.V., Das, A., Jonas, J.B., Keeffe, J., Kempen, J.H., Leasher, J., Limburg, H., Naidoo, K., Pesudovs, K., Resnikoff, S., Silvester, A., Stevens, G.A., Tahhan, N., Wong, T.Y., Taylor, H.R. & Vision Loss Expert Group. 2017. Magnitude, temporal trends, and projections of the global prevalence of blindness and distance and near vision impairment: a systematic review and meta-analysis. *Lancet Global Health*, 5(9), September:e888-e897. [https://doi.org/10.1016/S2214-109X(17)30293-0]; Bourne, R.R.A., Flaxman, S.R., Braithwaite, T., Cicinelli, M.V., Das, A., Jonas, J.B., Keeffe, J., Kempen, J.H., Leasher, J., Limburg, H., Naidoo, K., Pesudovs, K., Resnikoff, S., Silvester, A., Stevens, G.A., Tahhan, N., Wong, T.Y., Taylor, H.R. & Vision Loss Expert Group. 2017. Magnitude, temporal trends, and projections of the global prevalence of blindness and distance and near vision impairment: a systematic review and meta-analysis. *Lancet Global Health*, 5(9), September:e888-e897. [https://doi.org/10.1016/S2214-109X(17)30293-0].
- 8 Naidoo, K., Gichuhi, S., Basáñez, M.G., Flaxman, S.R., Jonas, J.B., Keeffe, J., Leasher, J.L., Pesudovs, K., Price, H., Smith, J.L., Turner, H.C., White, R.A., Wong, T.Y.,

cent and leading to moderate and severe vision impairment 16-20 per cent. Sub-Saharan Africa is also characterised by

... an inordinate amount of the global distribution of blindness, largely due to the high prevalence of neglected (infectious) tropical diseases such as trachoma (caused by the bacterium *Chlamydia trachomatis*) and onchocerciasis (river blindness caused by the parasitic worm *Onchocerca volvulus*, and transmitted by black flies breeding on riverfronts), with vision impairment ranking as one of the leading, and significantly preventable causes of disability.⁹

Children

Vision loss and deprivation among children is of particular concern. Besides being affected by infection-related causes, cataracts are of great concern. A cataract may be congenital (children are born with it) or developmental (appearing after the first year of life). It is estimated that in sub-Saharan Africa, about 90 000 children are cataract-blind, and about 19 000 children born every year with congenital cataract.¹⁰ Moreover, estimates from Malawi, Ethiopia, and South Africa suggest that refractive error, myopia, hypermetropia and astigmatism are prevalent to a notable extent (between 2.3-2.9 per cent) among school children in sub-Saharan Africa.¹¹ Several Asian countries have witnessed an increase in myopia as schooling and 'near work' increases.

Retinopathy of prematurity

It is also important to highlight an ophthalmic condition called Retinopathy of Prematurity, which is a pre-developmentally originating disorder. In many

Resnikoff, S., Taylor, H.R., Bourne, R.R. 7 Vision Loss Expert Group of the Global Burden of Disease Study. 2014. Prevalence and causes of vision loss in sub-Saharan Africa: 1990-2010. *British Journal of Ophthalmology*, 98(5):612-8. [https://doi.org/10.1136/bjophthalmol-2013-304081].

9 Bourne et al., 2017.

10 Courtright, P. 2012. Childhood cataract in sub-Saharan Africa. *Saudi Journal of Ophthalmology*, 26(1), January:3-6. [https://doi.org/10.1016%2Fj.sjopt.2011.10.006].

11 Msiska, V., Njuguna, M. & Kariuki, M. 2008. Magnitude and pattern of significant refractive errors in primary school children of Lilongwe, an urban district in Malawi. *East African Journal of Ophthalmology*, 14:9-41. [https://bit.ly/3hsFyoa]; Eth. J. Health Sci 2014, Alemu 2016; Naidoo, K.S., Raghunandan, A., Mashige, K.P., Govender, P., Holden, B.A., Pokharel, G.P. & Ellwein, L.B. 2003. Refractive error and visual impairment in African children in South Africa. *Investigative Ophthalmology & Visual Science*, 44(9), September:3764. [https://doi.org/10.1167/iovs.03-0283].

countries across sub-Saharan Africa, preterm births (babies born before 32 gestational weeks, or weighing less than 1 250-1 500g) account for over 15 per cent of births.¹² Among the several developmental origins of ill health that preterm babies face, Retinopathy of Prematurity is important in the context of a vision of interest here. The baby's eye takes about three-four weeks post-birth to develop fully. It thus becomes important to screen these preterm babies at the neo-natal stage, diagnose Retinopathy of Prematurity, treat it and attempt to save vision. Several South African ophthalmologists have published standard screening and treatment procedures.¹³ Adoption of these procedures across sub-Saharan Africa will be important.

Courtright, Mathenge, Kello, Cook, Kalua and Lewallen have summarised the current methods of eye care in the continent and the kind of specialists available and used.¹⁴ Ophthalmologists provide most of the surgical services and management of several sub-speciality services. However, the number of ophthalmologists in sub-Saharan Africa is far fewer than the requisite number (at least one per at least 20 million people as opposed to one per 2.7 million).¹⁵ Mid-level eye-care personnel mostly consist of clinical officers and nurses who are specialised after

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- 12 March of Dimes, PMNCH, Save the Children & World Health Organization (WHO). 2012. *Born too soon: The Global Action Report on Pre-term Birth*. [<https://bit.ly/3hqrfjE>].
- 13 Visser, L., Singh, R., Young, M., Lewis, H. & McKerrow, N. 2013. Guidelines for the prevention, screening and treatment of retinopathy of prematurity (ROP). *South African Medical Journal*, 103(2), November: 116-25. [<https://doi.org/10.7196/samj.6305>]; Jacoby, M.R. & Du Toit, L. 2016. Screening for retinopathy of prematurity in a provincial hospital in Port Elizabeth, South Africa. *South African Medical Journal*, 106(6):598-601. [<https://doi.org/10.7196/SAMJ.2016.v106i6.106663>]; Kift, E.V., Freeman, N., Cook, C. & Myer, L. 2016. Retinopathy of prematurity screening criteria and workload implications at Tygerberg Children's Hospital, South Africa: A cross-sectional study. *South African Medical Journal*, 106(6):602-606. [<https://doi.org/10.7196/SAMJ.2016.v106i6.10358>]; Keraan, Q., Tinley, C., Horn, A., Pollock, T., Steffen, J. & Joolay, Y. 2017. Retinopathy of prematurity in a cohort of neonates at Groote Schuur Hospital, Cape Town, South Africa. *South African Medical Journal*, 107(1):64-69. [<https://doi.org/10.7196/SAMJ.2017.v107i1.11226>]; Mayet, I. & Cockinos, C. Retinopathy of prematurity in South Africans at a tertiary hospital: a prospective study. *Eye*, 20(1):29-31. [<https://doi.org/10.1038/sj.eye.6701779>].
- 14 Courtright, P., Mathenge, W., Kello, A.B., Cook, C., Kalua, K. & Lewallen, S. 2016. Setting targets for human resources for eye health in sub-Saharan Africa: what evidence should be used? *Human Resources for Health*, 14:11. [<https://doi.org/10.1186/s12960-016-0107-x>].
- 15 African Vision Research Institute, International Agency for the Prevention of Blindness (IAPB), International Centre for Eye Health & Sightsavers. 2014. *Addressing the eye health workforce crisis in Sub-Saharan Africa: Business as usual is not an option*. IAPB Policy Paper, October. [<https://bit.ly/2EbTjzB>].

working in primary health for a few years. These are also personnel trained for varying durations from one to three years and are dedicated eye-care personnel. Some of the personnel are trained to perform cataract surgeries and are termed as ‘non-physician cataract surgeons’ in countries such as Tanzania, Malawi and Kenya.¹⁶ However, such non-physician cataract surgeons are not accepted in a few countries such as Nigeria, South Africa and Rwanda.¹⁷ Optometrists are a cadre of personnel mainly involved in the provision of refraction services. An optometrist is generally a high school graduate who has been trained for three or four years both in theory and practical areas at eye hospitals, and upon completion of the programme, awarded a bachelor’s degree. They can work in hospitals or private practice and set up shops as ‘opticians.’ Although 17 established institutions in nine countries across sub-Saharan Africa offer optometry programmes and degrees, the number is suboptimal (3.7 optometrists per million population, as opposed to the desired 10 per million).¹⁸ Some ophthalmic clinical officers and nurses also provide refraction services. Essentially, refraction services form the second level of care in African countries. Primary eye care in Africa is provided as a large part of primary level health care centres by primary health care workers. The personnel usually form the ‘first contact’ for any eye-related conditions.

Any model of eye care that is aimed to address significant public health challenges, such as the ones seen in sub-Saharan Africa, should have three key components:

- Financial and geographic accessibility to eye care;
- A mechanism to route patients from a primary to a tertiary level of care; and
- Appropriately trained human resources available to deliver this form of eye care.

A policy paper by the International Agency for the Prevention of Blindness and the Situation Analysis of Optometry in Africa, and other similar reports, indicate the current availability of such resources and the distribution of human resources

16 Eliah, E., Lewallen, S., Kalua, K., Courtright, P., Gichangi, M. & Bassett, K. 2014. Task shifting for cataract surgery in eastern Africa: productivity and attrition of non-physician cataract surgeons in Kenya, Malawi and Tanzania. *Human Resources for Health*, 12(Supplement 1):4. [<https://doi.org/10.1186/1478-4491-12-S1-S4>]; Lewallen, S., Etya’ale, D., Kello, A.B. & Courtright, P. 2012. Non-physician cataract surgeons in Sub-Saharan Africa: situation analysis. *Tropical Medicine & International Health*, 17:1405-1408. [<https://doi.org/10.1111/j.1365-3156.2012.03084.x>].

17 Eliah et al., 2014.

18 Lewallen et al., 2012; Oduntan, O.A., Mashige, K.P., Kio, F.E. & Baoadi-Kusi, S.B. 2014. Optometric education in Africa: Historical perspectives and challenges. *Optometry and Vision Science*, 91(3):359-365. [<https://doi.org/10.1097/OPX.000000000000153>].

for accessing eye care in sub-Saharan Africa.¹⁹ It is evident that both these parameters are far from ideal, and there is a need for novel thoughts to address the present problem.

It is against this background that we need to look at ways and means to reduce the devastating blindness burden on this subcontinent, using both locally available methods and adapting successful models from regions elsewhere in the world with comparable economic and sociological backgrounds. With this aim, the comprehensive and analytical scoping review by Du Toit and colleagues (Faal, Etya'ale, Wiafe, Mason, Graham, Bush, Mathenge and Courtright, 2013) and the suggestions made therein are relevant.²⁰ They quote the International Agency for the Prevention of Blindness Primary Eye Care Working Group's definition, that:

Primary care for eye health is an integrated, participatory, and inclusive component of primary health care consisting of promotive, preventive, curative and rehabilitative services. It is delivered by the health workforce (formal and informal) in conjunction with community members, up to and including services at the front-line health facilities.²¹

Involving people at existing primary health care centres is possible in several ways. A notable and successful example of successful involvement of primary health care centres is the drastic reduction in the prevalence of *onchocerciasis* in the region, through the efforts of the African Programme for *Onchocerciasis* Control.²² With river blindness, while there is still some way to go before total elimination, there is

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- 19 Courtright et al., 2016; Oduntan et al., 2014; African Council of Optometry, Brien Holden Vision Institute, IAPB & Vision Aid Overseas. 2016. Situation Analysis of Optometry in Africa. *Optometry and Vision Science*, 91(3), March:359-65. [https://doi.org/10.1097/OPX.000000000000153];
- 20 Loughman, J., Moodley, V.R., Holden, B. & Naidoo K., University of Kwa-Zulu Natal & Dublin Institute of Technology, Brien Holden Vision Institute. 2014. Access to optometric education: Challenges in Sub-Saharan Africa. *Literacy Information and Computer Education Journal*, 5(3):1543-1549. [https://doi.org/10.20533/licej.2040.2589.2014.0218].
- 21 African Vision Research Institute et al., 2014.
- 22 Du Toit, R., Faal, H.B., Etya'ale, D., Wiafe, B., Mason, I., Graham, R., Bush, S., Mathenge, W. & Courtright P. 2013. Evidence for integrating eye health into primary health care in Africa: a health systems strengthening approach. *BMC Health Services Research*, 13:102. [https://doi.org/10.1186/1472-6963-13-102]. Tekle, A.H., Zouré, H.G.M., Noma, M., Boussinesq, M., Coffeng, L.E., Wilma, A., Stolk, W.A. & Remme, J.H.F. 2016. Progress towards onchocerciasis elimination in the participating countries of the African Programme for Onchocerciasis Control: epidemiological evaluation results. *Infectious Diseases of Poverty*, 5:66. [https://doi.org/10.1186/s40249-016-0160-7].

no denying the fact that this condition is no longer a significant threat to vision.²³ Likewise, the efforts to win over trachoma through the implementation of SAFE – Surgery, Antibiotics, Facial cleanliness and Environmental improvement – involved community participation through primary health care centres, and Ghana is now declared by the WHO to have eliminated trachoma.²⁴

We now need to ask whether frontline workers at the primary health care centres can be trained to look at eye health in at a more cohesive professional level, and offer advice and even possible first level treatment. It is with this in mind that we advocate training primary health care workers, who are present at every primary health care centre, to become Vision Technicians. As Willcox and colleagues (Peersman, Daou, Diakite, Bajunirwe, MUBangizi, Mahmoud, Moosa, Phaladze, Nkomazana, Khogali, Diallo, Maeseneer and Mant, 2015) point out, while additional resources are needed, it should be possible to use existing resources more cost-effectively.²⁵

Training a cadre of eye-care workers

When people come to primary health care centres for any eye-health needs, the priority is for staff to examine their eyes, test vision and record the data. The second is for some of these primary health care workers to be trained to:

- Recognise the vision-impairing, and common blinding conditions of the people referred to them.
- Refract with good accuracy and recommend/ dispense corrective spectacles.
- Refer the patient to a higher-level expert eye physician or ophthalmologist for management if needed.

23 Kim, Y.E., Sicuri, E. & Tediosi, F. 2015. Financial and Economic Costs of the Elimination and Eradication of Onchocerciasis (River Blindness) in Africa. *PLoS Neglected Tropical Diseases*, 9(9):e000405. [<https://doi.org/10.1371/journal.pntd.0004056>].

24 Colebunders, R., Basáñez, M.G., Siling, K., Post, R.J., Rotsaert, A., Mmbando, B., Suykerbuyk, P. & Hopkins, A. 2018. From river blindness control to elimination: bridge over troubled water. *Infectious Diseases of Poverty*, 7(1):21. [<https://doi.org/10.1186/s40249-018-0406-7>]; Aryee, J. 2020. *Ghana poised to eradicate NTDs by 2030*. [<https://bit.ly/2Qhqtuu>]; Kokutse, F. 2018. Ghana makes history on trachoma in Africa. *SciDevNet*, 25 June. [<https://bit.ly/32lopGr>].

25 Willcox, M.L., Peersman, W., Daou, P., Diakite, C., Bajunirwe, F., Mubangizi, V., Mahmoud, E.M., Moosa, S., Phaladze, N., Nkomazana, O., Khogali, M., Diallo, D., Maeseneer, J.D. & Mant, D. 2015. Human resources for primary health care in Sub-Saharan Africa: progress or stagnation? *Human Resources for Health*, 13:76:1-11. [<https://doi.org/10.1186/s12960-015-0073-8>].

To provide primary health care workers with these skills requires hands-on training for about 12 months, after which he/she can be certified as a Vision Technician. Such integration of eye health into primary health services has been tried in Tanzania, albeit with limited success, and in India with better results.²⁶ A training programme for a Vision Technician would typically involve high school graduates who work at primary health care centres, or others from the community (and the 'first contact' volunteers). It would include six months of classroom training, followed by clinical and practical training under the supervision of experts in chosen eye hospitals for the next six months. The exit competencies of such Vision Technicians would be:

- demographic information/history recording;
- visual acuity assessment;
- refraction;
- slit-lamp examination;
- measurement of intraocular pressure; and
- direct ophthalmoscopy.

Such training programmes would enable a Vision Technician to do the three Rs:

- Recognise** the blinding conditions.
- Refract** and suggest/offer corrective glasses.
- Refer** the patient who needs greater care to the nearest eye hospital for treatment.

Equipped with these skills a well-trained Vision Technician can play a significant role; with such Vision Technicians appointed to primary health care centres, a

26 Willcox, M.L., Peersman, W., Daou, P., Diakite, C., Bajunirwe, F., MUBangizi, V., Mahmoud, E.M., Moosa, S., Phaladze, N., Nkomazana, O., Khogali, M., Diallo, D., Maeseneer, J.D. & Mant. D. 2015. Human resources for primary health care in Sub-Saharan Africa: progress or stagnation? *Human Resources for Health*, 13:76:1-11. [<https://doi.org/10.1186/s12960-015-0073-8>]; Jolley, E., Mafwiri, M., Hunter, J. & Schmidt, E. 2017. Integration of eye health into primary care services in Tanzania: a qualitative investigation of experiences in two districts. *BMC Health Services Research*, 17:823:1-12. [<https://doi.org/10.1186/s12913-017-2787-x>]; Rao, GN. 2004. An infrastructure model for the implementation of VISION 2020: the right to sight. *Canadian Journal of Ophthalmology*, 39(6), October:589-590. [[https://doi.org/10.1016/s0008-4182\(04\)80023-1](https://doi.org/10.1016/s0008-4182(04)80023-1)].

significant portion of uncorrected refractive error will be able to be handled at the primary level. Providing such care to children will boost literacy, achievement in education and future development.²⁷ Impaired vision due to uncorrected refractive error does not need an ophthalmologist or an optometrist to be corrected and restored.

Given the key roles that Vision Technicians and graduate optometrists are known to be able to play in eye-care delivery, we need to learn from existing models that have been successfully implemented elsewhere in countries and communities with resource settings comparable to those in sub-Saharan Africa. A second prerogative is to embrace the present and future technologies and innovations in such a way that they can be adapted for effective use under the conditions found in the countries across sub-Saharan Africa. One area with such innovation is the use of low-cost, high-resolution devices for diagnosis.

Using low-cost, high-resolution devices for diagnosis of eye conditions

Jolley, Mafwiri, Hunter and Schmidt (2017) have pointed out that integration of the kind of eye health care we suggest into primary health services has been tried in Tanzania, and that while the trained Vision Technicians could perform well, they were constrained by the lack of equipment for diagnosis and treatment.²⁸ This finding underscores that while the human resources need to be made available, resources for obtaining and installing the necessary equipment are also a critical factor. It is here that innovative low-cost, high-resolution diagnostic devices become useful. Many of these products were tested, and performance parameters compared to those used by ophthalmologists in their clinics. Bhattacharyya, Khor, Mc Gahan, Dunne, Daar and Singer cite some products such as intraocular lenses for cataract surgery and glasses.²⁹ A group called Smart Vision Labs in the USA lists several devices that can be attached to a person's Smartphone to help self-diagnosis of refractive power and to help in choosing the frame of choice for eyeglasses.³⁰ Satgunam, Datta, Chillakala, Bobbili and Joshi (2017) have devised low-cost equipment to record the perimeter of vision accurately in infants, and the group 'Srujana', based at the LV Prasad Eye Institute, Hyderabad, India, has produced

27 Hutt, 2016.

28 Jolley, E., Mafwiri, M., Hunter, J., Schmidt, E. 2017. Integration of eye health into primary care services in Tanzania: a qualitative investigation of experiences in two district. *BMC Health Serv Res.*, 17(1):823.

29 Rao, G.N. 2015. The Barrie Jones Lecture: Eye care for the neglected population: challenges and solutions. *Eye*, 29:30-54. [<https://doi.org/10.1038/eye.2014.239>].

30 Smart Vision Labs. 2017. *Vision Industry Disruptors!* March 14. [<https://bit.ly/35lqGEs>].

low-cost, high-resolution diagnostic devices in ophthalmology.³¹ Many of these have been tested at primary level eye-care centres and are seen to work very well. Examples include:

- the Phoropter, a portable device that allows the user to screen and measure the refractive status (spectacle power) of his/her eyes to within \pm one diopter, (cost less than one US dollar);
- the Bulls-Eye, a device that, when attached to a smartphone, allows the capture of the surface features of the human cornea allowing the examination of the topography of the cornea (cost less than 10 US dollars); and
- Open Indirect Ophthalmoscope, a handheld instrument that offers the fundus imaging of the patient, with an accuracy and resolution comparable to high-end fundus cameras, yet costing less than 800 US dollars.

The International Partnership for Innovative Healthcare Delivery quotes the adaptation of the LV Prasad Eye Institute model in Mexico.³² Thus, using them at primary health care centres and by Vision Technicians in sub-Saharan Africa, in place of the far more expensive equipment used in eye hospitals, would save a considerable amount of money and yet yield high-quality diagnostic data [<http://www.lvpei.org/services/innovation>].

Using mobile phones, internet, and related technology for vision care in sub-Saharan Africa

Even as efforts are being made to increase the number of optometrists, it should be possible to initiate the Vision Technician programmes, connect them with the optometrists in their country through electronic means, and also to the ophthalmologists. African populations have taken to internet usage enthusiastically. In 2018, the total number of internet users in the continent was estimated to be over 453 million, roughly every alternate person.³³ Mobile phone penetration rates

31 Bhattacharyya, O., Khor, S., Mc Gahan, A., Dunne, D., Daar, A.S. & Singer, P.A. 2010. Innovative health service delivery models in low and middle-income countries – what can we learn from the private sector? *Health Research Policy and Systems*, 15;8(24):1-11. [<https://bit.ly/2UizR24>]; [<http://srujana.lvpei.org/>].

32 Satgunam, P., Datta, S., Chillakala, K., Bobbili, K.R. & Joshi, D. 2017. Pediatric Perimeter: a novel device to measure visual fields in infants and patients with special needs. *Translational Vision Science and Technology*, 6(3). [<https://doi.org/10.1167/tvst.6.4.3>].

33 Singhal, M., Moe, J. & Bartlett, R. 2013. Replicating Indian Eye Care Innovation in Mexico: The founding and expansion of salaUno. *International Partnership for Innovative Healthcare Delivery*. Case Study 102. [<https://bit.ly/3aQNPzD>].

have reached 80 per cent across the continent, and as the World Bank report in 2014 noted, more Africans now have a mobile phone than a toilet. Fast internet access has also been rapidly improving. Some ophthalmic clinicians are already using mobile phones to capture the image and examine the retina of Retinopathy of Prematurity patients.³⁴

Given this emerging advantage and the fact that more and more youngsters across Africa are now using electronic communications towards healthcare, we suggest the promotion of this connectivity and information exchange across the tiers of eye care (primary health care centres, Vision Technicians, optometrists, non-physician cataract surgeons and ophthalmologists located in regional, private, mission hospitals and ophthalmic clinics across the country).³⁵

Electronic media could also be used to promote periodic cataract surgery 'camps'. Such camps involve transporting cataract-needy patients to the nearest centre where cataract surgery can be done, and coordinating what may be called periodic 'cataract camps'. Given that surgical management of childhood cataracts has improved over time, such cataract camps are worth considering.³⁶ Electronic communication can also offer, and avenue to improve post-operative care such that any potential complications, such as infection are reduced or even avoided.

Conclusion

Given that a major portion of childhood blindness in sub-Saharan Africa is due to uncorrected refractive error, cataract and corneal infection, and specialist resources on the continent are limited, an inter-tier programme for eye care based on successful models elsewhere would be well worth attempting. A successful, working example of this kind of pyramidal model of inter-tier training and information transfer, real-time monitoring of collaborative, interdisciplinary activities, treatment and clinical practice is at the LV Prasad Eye Institute in Southern India, a non-government, not for profit eye care institution. It caters to a population of over 90 million people, 70 per cent of them are semi- or illiterate and they live in rural areas with not-so-efficient primary health care centres; the model this institute offers has successfully delivered quality eye care to over 24 million people over the last 30 years.³⁷

34 Internet World Stats. 2020. *Internet Penetration in Africa 2020 - Q1 - March*. [<https://www.internetworldstats.com/stats1.htm>].

35 Oluleye, T.S., Rotimi-Samuel, A. & Adenekan, A. 2016. Mobile phones for retinopathy screening in Lagos, Nigeria, sub-Saharan Africa. *European Journal of Ophthalmology*, 26(1):92-94. [<https://doi.org/10.5301/ejo.50000666>].

36 Courtright, 2012.

37 Rao, 2015.

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