

Cataract Surgery in Africa

1. Background

1.1. Definition of cataract

1.2. Applied anatomy and physiology

1.3. Diagnosis of Cataract

1.4. Causes of Cataract

1.5. The prevalence of Blindness and Cataract Blindness in Africa

1.6. The impact of cataract blindness

1.7. Management of cataract

1.8. Complications

1.9. Expected Results

1.10. The cost of cataract surgery

2. Equipment and human resources required to establish a cataract service

3. Vision 2020: The Right to Sight in Africa

3.1. The Cataract surgery rate

3.2. Barriers and innovations in the delivery of Vision 2020 Programmes in Africa

4. The Cost utility and Cost benefit of Cataract surgery

4.1. Other benefits of Cataract Programmes

5. Conclusion

6. References

1. Background

1.1. Definition of cataract

A cataract is a clouding or opacification of the crystalline lens of the eye, which causes a gradual progressive decrease in visual acuity, eventually leading to blindness. The word “cataract” is derived from the Latin word “cataracta” meaning “waterfall”. The grey white appearance of the mature cataract was thought to look like the streaky white appearance of falling water (<http://wordsmith.org/words/cataract.html>).

1.2. Applied anatomy and physiology

The lens is a transparent disc-shaped structure of about 10 mm in diameter, situated behind the iris. It consists of a central nucleus and peripheral cortex, enveloped by an elastic capsule.

The transparent capsule is attached to the ciliary body by fine fibrils called zonules, suspending the lens in the posterior chamber of the eye.

The lens substance consists of tightly packed lens fibres that originate from the inner surface of the capsule. New fibres are continuously laid down in the periphery, forming the soft lens cortex, and the older fibres, forming the nucleus, are compacted in the centre of the lens. This compression results in a progressive hardening of the lens nucleus with age.[1] The lens fibres are never shed because they originate from the inner surface of the lens capsule; consequently the lens continues to enlarge during life.

The normal transparency of the lens depends on both the microscopic structure and the biochemical processes within the lens; disruption of either will lead to opacification. The most important function of the lens is to collect and focus light onto the retina (**Figure 1**). The ability of the lens to refract light is made possible by the high



Figure 1 The lens focuses an image onto the retina

Courtesy: Alcon Laboratories

concentration of crystallin protein, which makes up 90% of the lens protein.[2] The second function of the lens is accommodation. By contraction of the ciliary body, the tension in the elastic capsule is relaxed and the central thickness of the lens increases. This results in the ability of the eye to change the focus to near objects.

1.3. Diagnosis of Cataract

When examining the normal eye through a direct ophthalmoscope, a bright red reflex from the choroid is observed through the transparent lens. When lens opacities develop, the non-transparent parts can be seen as black defects in the red reflex. Ultimately the lens becomes completely opaque and the red reflex is absent. At this stage the characteristic grey pupil is quite obvious when examining the eye with a torch (**Figure 2**).

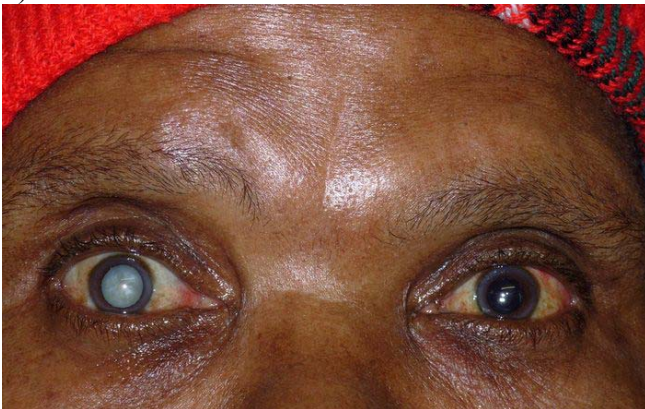


Figure 2 The grey pupil of a patient with a cataract in the right eye

1.4. Causes of Cataract

Age-related cataract is by far the commonest form of cataract; the condition occurs after the age of 50 and has no other evident cause.[3] Age-related cataract is a bilateral condition although its presentation is often asymmetrical. Normal ageing of the lens leads to yellowing and hardening of the lens nucleus.[1] Smoking, diabetes, and exposure to

ultraviolet light [4] are the most consistent factors known to cause oxidative stress and degenerative lens changes, such as protein degradation, membrane breakage, and cell disruption, [5] culminating in loss of transparency and the development of age-related cataract.[6]

Other causes for the development of cataracts are the long term use of corticosteroids[7], and physical damage in trauma or fluid collection occurring in ketoacidosis, which can result in dramatic loss of vision over a few days. In children, cataracts may be caused by infections, trauma or may develop due to a genetic predisposition. As yet, no treatment has been identified to prevent the cataract formation.

1.5. The prevalence of Blindness and Cataract Blindness in Africa

Blindness or low vision in a person is determined by his or her Snellen’s acuity and the size of the visual field. The definitions are summarised in **Table 1**.

Table 1 Definitions of Low Vision and Blindness based on Snellen’s Acuity:[8]

Normal vision	A presenting visual acuity of 6/6 to 6/18 in the better eye. A visual acuity of 6/12 is the minimum acuity required to qualify for a driver’s license.
Low vision	A presenting visual acuity of less than 6/18, but equal or better than 3/60 in the better eye.
Blindness	A presenting visual acuity of less than 3/60 in the better eye or a visual field defect extending to 10 degrees from fixation in the better eye

More than 6 million people in Sub-Saharan Africa are blind. In areas without eye care services, the prevalence of blindness in people over the age of 50 is as high as 9%, and cataract is responsible for more than 50% of this blindness.[9] In a district of 1 million people, about 5,000 people are blind due to cataract and about 3 times as many have low vision.[7] The incidence of new cataract blindness is estimated to be about 1,000 people per million population per year.[10]

1.6. The impact of cataract blindness

The gradual deterioration in sight initially prevents patients from recognizing faces or finding their way in unfamiliar territory. Eventually, the patient requires constant care. The failure to contribute towards their keep in the family often leads to social exclusion. Unable to move about freely, the blind cannot access social services and health care, resulting in increasing poverty and ill health. In Australia, 2.7% of the national total of life years was lost due to blindness, which was similar to the life years lost due to diabetes and to coronary heart disease.[11]

Blindness leads not only to a loss of income and ill health for the individual, but also places an economic burden on the family and the community. There are costs involved in caring for the blind, both in time and in lost wages. Younger children are often taken out of school to look after the elderly blind, thus depriving the child of education and perpetuating the cycle of poverty within the community.

In terms of the national impact, the burden of blindness on the African economy will be 0.5% of the continent’s GDP by 2020, if effective prevention of blindness programmes are not implemented.[12]

1.7. Management of cataract

The management of cataract is surgical. A cataract extraction is indicated when a person's vision is such that he or she cannot cope with their daily activities. Historically, the first successful procedure to treat cataract was couching, which is still practiced in some parts of Africa. The zonules are disrupted by a sharp instrument inserted just behind the limbus, causing dislocation of the whole lens into the vitreous. This procedure is often complicated by conditions such as uveitis and glaucoma, resulting in permanent and untreatable blindness.[13, 14]

Modern cataract surgery consists of creation of a limbal entry wound and the removal of the nucleus and cortex of the lens through an anterior central opening of the capsule, with the retention of the remainder of the capsule to act as scaffolding for the placement of a synthetic lens. In younger patients, the nucleus is so soft that it can be aspirated via a 2-way infusion cannula through a 3-mm incision. However, in patients over the age of 40, the nucleus has hardened to the extent that it has to be removed in one piece through an incision of 7 mm or larger, or it needs to be fragmented into small pieces before being aspirated.

The commonest form of cataract extraction performed in Africa is **extra-capsular cataract extraction**, or ECCE. The procedure is performed under local anaesthetic; a general anaesthetic is indicated if a patient cannot lie still due to communication or physical factors. The duration of surgery is about 20 minutes. The anterior chamber is entered through a scleral incision of 10-12 mm that is made parallel to the limbus. A circular opening is made in the anterior capsule, through which the lens nucleus is removed, and the remaining cortex is aspirated (**Figures 3, 4, 5**). The refractive function of the lens is restored by replacing it with a synthetic intra-ocular lens (IOL) using the capsule to anchor the IOL (**Figure 6**). The synthetic lens is made from hard plastic (polymethylmethacrylate) and consists of a central 6 mm lenticule (optic) and 2 anchoring loops (haptics) (**Figure 7**). Intra-ocular lenses are made in a variety of powers, and the power for each patient is calculated preoperatively by process of biometry. The wound is closed with multiple 10.0 nylon sutures.

A modification of this procedure is called **scleral tunnel extra-capsular surgery**. The entrance wound is modified to form a scleral tunnel of 6-8 mm in width, which does not require suturing (**Figure 8**). The self-sealing wound results in safer surgery and faster postoperative visual recovery.[15]

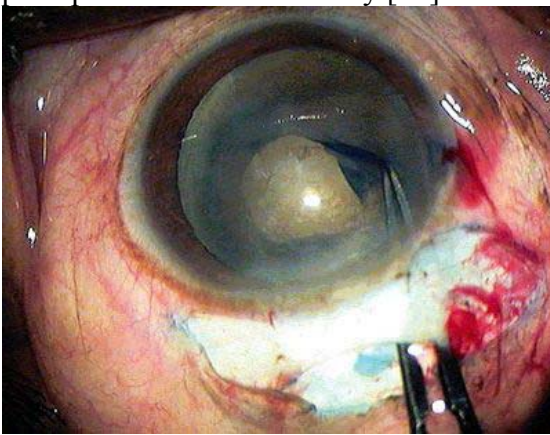


Figure 3
Opening the anterior capsule (the capsule has been stained dark blue for better visualisation)
Photograph: K Hennig Courtesy JCEH
Community Eye Health J 2008;21(65): 5

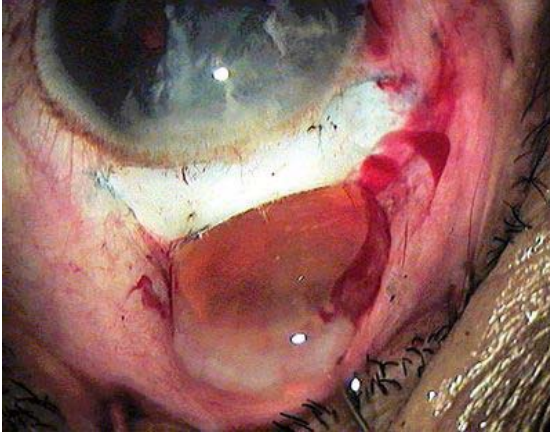


Figure 4

Delivering the brown nucleus and grey cortex

Photograph: K Hennig

Courtesy JCEH Community Eye Health J 2008;21(65): 5

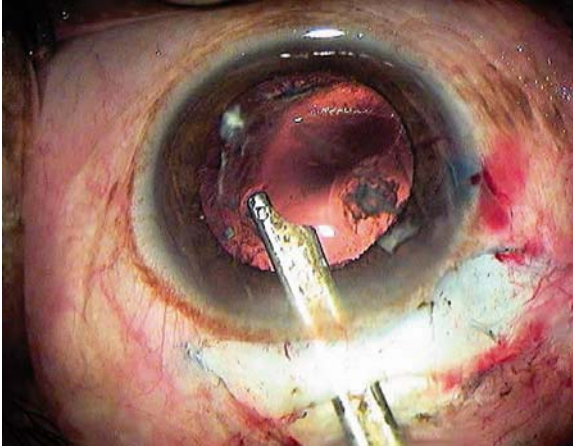


Figure 5

Removing the soft lens cortex with a cannula

– note re-appearance of the red reflex

Photograph: K Hennig

Courtesy JCEH Community Eye Health J 2008;21(65): 5

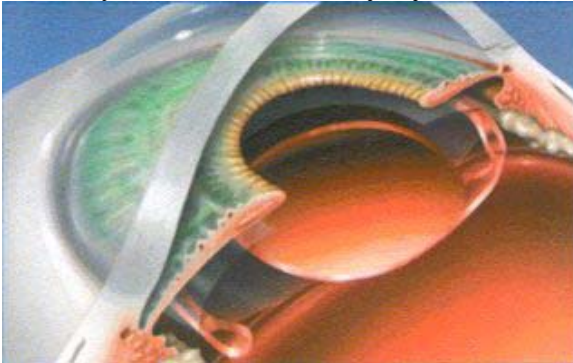


Figure 6

The intraocular lens in the capsular bag

Courtesy: Alcon Laboratories



Figure 7

An Intraocular lens

Courtesy: Alcon Laboratories

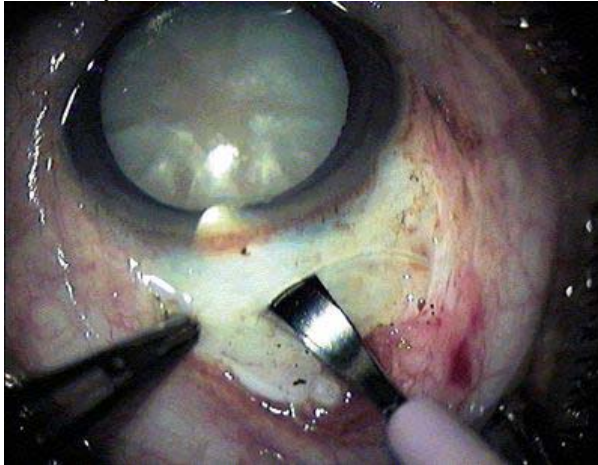


Figure 8

Making a scleral tunnel

Photograph: K Hennig

Courtesy JCEH Community Eye Health J 2008;21(65): 4

Phacoemulsification is a more sophisticated technique for cataract extraction in which an ultrasound probe is inserted into the eye through a limbal incision. The ultrasound power is used to fragment the hard nucleus, and the lens fragments are then aspirated through the same probe (**Figure 9**). The procedure can be performed through a 3-mm incision, and the IOL, made of a soft plastic (acrylic or silicone), is folded for insertion through the same incision. The IOL unfolds once it is inside the capsular bag. The advantage of this procedure is that visual recovery is faster than in extra-capsular cataract extraction; however, the cost of the additional equipment and consumables precludes the wide scale use of phacoemulsification in developing countries.[16] There is no significant difference in the outcome between scleral tunnel extra capsular surgery and phacoemulsification surgery. [17]

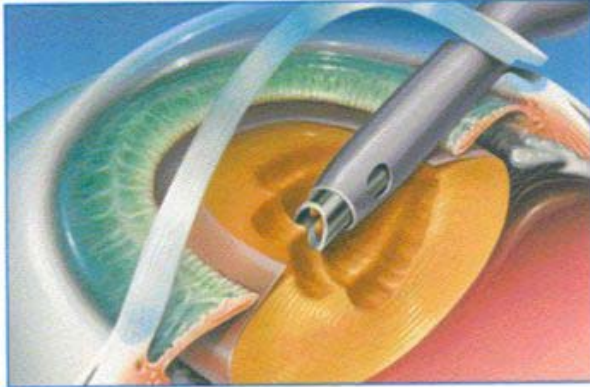


Figure 9

Aspiration of the lens fragments through a phaco probe

Courtesy: Alcon laboratories

Additional spectacle correction is usually required after the surgery. Prior to the routine use of IOLs, patients still required thick spectacle lenses after surgery to obtain good vision. When these spectacles were damaged or lost, the patient was rendered almost as blind as before the surgery. With the routine use of affordable IOLs, most patients have unimpaired sight for distance, and only require reading glasses for near vision.

1.8. Complications

The most important surgical complications that affect the visual outcome are capsular rupture and vitreous loss, and post operative infection called endophthalmitis. These complications may occur in about 6% of cataract surgeries cases in the developing world[18] compared to about 4% in developed countries. Poor results due to surgical complications can be limited through continuous training and visual outcome monitoring.[19] Endophthalmitis, although rare, can be devastating and results in blindness in 15% of affected cases.[20] The use of prophylactic intra-operative intracameral antibiotics has reduced this risk of developing endophthalmitis significantly.[21]

1.9. Expected Results

In a unit with well-trained surgeons, it is expected that 90% of patients should see equal to or better than 6/18 after surgery, allowing about 6 weeks for recovery. [22, 23] The use of the scleral tunnel technique, the insertion of IOLs and the use of biometry to refine the correct power selection of IOLs have optimised the good results following cataract surgery.[24]

1.10. The cost of cataract surgery

The cost of cataract surgery to the service provider includes the variable costs (consumables) and fixed costs (staff salaries, capital costs of equipment and the running cost of the surgical unit). Bulk purchase of the consumables can reduce the variable cost to less than £7 per case (calculated in 2005). [25] In a high volume unit, about 20% of the cost is related to consumables.[10] The fixed costs per surgery are reduced with increased numbers of surgery through economy of scale.[26]

2. Equipment and human resources required to establish a cataract service

Assuming that the necessary equipment required for an outpatient eye clinic is in place, the most important additional equipment needed to establish a cataract surgery

programme is biometry equipment, an operating microscope, and a minimum of 2 sets of microsurgical instruments per surgeon.

In Africa, various skilled personnel, ranging from ophthalmologists to ophthalmic surgical assistants, perform cataract surgery. Ophthalmologists usually undergo a 4-year post-graduate training course at a medical school and qualify after successfully passing the final examination. Medical officers should be able to perform cataract surgery after a 6-month intensive training course during which clinical acumen and microsurgery skills are acquired. Ophthalmic medical assistants are midlevel personnel who have undergone a 2-year training course in an ophthalmic unit, and are well trained to perform cataract surgery.[27]

It takes more than a cataract surgeon to restore the sight of a patient with a cataract. Midlevel personnel such as ophthalmic nurses, optometrists and programme managers are essential to perform support services and free the surgeons to perform surgery. Ophthalmic nurses and optometrists screen and assess patients, perioperatively, and provide postoperative refraction. Programme managers ensure that programmes are run efficiently and effectively. [28]

3. Vision 2020: The Right to Sight in Africa

Vision 2020 is an international collaboration between the World Health Organization (WHO) and the International Agency for the Prevention of Blindness (IAPB), in response to the increasing burden of blindness in the world. One element of this initiative is the development of a public health programme called Vision 2020 Eye Care Plan. [29] The programme was launched in 1999. The Vision 2020 programme includes guidelines regarding the human resources and infrastructure needed to develop services in a district, and also outlines the disease control strategies to combat the most common blinding diseases such as cataract.[29]

3.1. The Cataract surgery rate

The cataract surgical rate (CSR) is the number of cataract operations done per million population each year. This useful output indicator is used to measure the progress of cataract services in a country or district.[10] The Vision 2020 recommendation is that a CSR of at least 2000 should be achieved each year to eliminate unnecessary blindness due to cataract in Africa.[30]

By 2005, only 9 of 46 countries in Sub-Saharan Africa had a CSR greater than 500. In contrast, the CSR in India in the same year was 3650, and in Australia it was more than 6000.[31]

3.2. Barriers and innovations in the delivery of Vision 2020 Programmes in Africa

The main constraints to successful cataract programmes in Africa are a lack of commitment from government, a shortage of skilled human resources, poor results, and inefficiency in hospitals.[10]

The lack of commitment by governments to eye care services is evident from the fact that less than 20% of the African need for eye care services was addressed in 2004, and only 33% of countries in Sub-Saharan Africa had drafted a national eye care plan by 2005.[31]

The main reason for the lack of commitment to eye care is the competition with other services such as child health, HIV AIDS, and malaria programmes. [32] Non governmental organizations (NGOs) have supported eye care programmes to such an extent that they provided more eye care services in Africa than state-run institutions [32]; moreover, private and mission hospitals were found to be better equipped and managed

compared to Ministry of Health hospitals.[27]. Not only have NGOs funded programmes, but in their capacity as the IAPB, they also co-founded the VISION 2020 initiative and provided support in advocacy and training to implement services.

Skilled human resources for cataract programmes are scarce in Africa. Sub-Saharan Africa (SSA) has the lowest ratio of ophthalmic surgeons per million population in the world. In many areas there is only one ophthalmologist per million as opposed to the recommended minimum of 4.[10, 28, 29] The shortage of surgeons is particularly acute in rural communities where it is difficult to retain qualified staff. One solution to the problem is to train midlevel workers to perform cataract surgery. More than 130 ophthalmic technical assistants have been trained in Eastern Africa over the past 20 years. They are working in Zambia, Kenya, Tanzania, and Uganda. A survey of 88 of these surgeons revealed that they performed on average 243 cataract surgeries per surgeon per year.[27] There was no significant difference in the surgical outcomes between ophthalmologists and ophthalmic technical assistants in Kenya. [19] Well-trained ophthalmic technical assistants have proven to be a useful resource in treating cataract blindness in rural areas in which otherwise no services would be available.

Performing enough surgeries alone is not enough to reduce the prevalence of blindness due to cataract. The quality of the surgery should also be of such a standard that the majority of patients have no visual impairment after surgery. It is estimated that 25% of the cataract surgery performed in the developing world results in poor acuities.[18] Poor outcomes can be attributed to the poor selection of patients, perioperative complications and residual postoperative refractive error.

Patient selection is improved by continuous training of midlevel workers. Improving surgical results requires well-trained surgeons with access to quality equipment. Ideally, cataract surgery should be performed in an eye care centre, of which there should be at least one per district. High surgical volumes are essential as the outcomes improve continuously as more surgeries per surgeon are performed.[33] The postoperative management of patients in such a centre ensures prompt treatment of complications and prevents visual loss. For those who cannot access these services, surgery can be performed in eye camps; if experienced surgeons perform the surgery, the surgical outcomes are acceptable. [34] However, postoperative care in eye camps is lacking, leading to poorer long-term results.

Post-operative refractive error was reported to be responsible for up to 50% of poor outcomes in Africa.[24, 35, 36] Postoperative blindness due to refractive error is particularly relevant in eye camp surgery in which there is no follow up. In contrast, high-volume units that routinely use biometry have reported 90% of patients with a post operative visual acuity of 6/18 or better. [19, 33]

Efficiency in an ophthalmic surgical unit is essential to justify the expenses incurred to establish them. Theatres need to be equipped with an adequate number of instrument sets [27], there should be adequate numbers of staff in the operating room and outpatient clinic and operating room facilities should be used 5 or 6 days per week. This requires motivated and well-trained surgeons and commitment from the facility managers.[28] NGOs are committed to contribute toward eradicating needless blindness in developing countries, but they do require the maximum return on their money and are therefore more likely to contribute toward a programme that has proven its efficiency.

Many hospitals in Africa do not experience a great demand for surgery. The lack of demand may lead to a false impression by facility staff that the problem of blindness is not as large as is described in population-based prevalence surveys. The barriers to uptake of surgery are, however, considerable and widespread. Studies in Malawi, South

Africa, and Rwanda found that less than 40% of the cataract blind in the community had undergone surgery.[28, 36, 37]

The lack of demand can mostly be attributed to lack of awareness, cost, and distance. Ignorance results in the accepted notion that the blindness brought on by ageing is inevitable and untreatable; any anecdotes of unsuccessful surgery in the community also create fear and resistance to offers of help. There is often no transport to bring patients across large distances to facilities, and the cost incurred to travel and the loss of wages of the escorts often make the journey too expensive to undertake.[35, 38] Case finders, transport services [27], a patient-friendly referral chain [38], and good reputation of the surgical institutions are essential to bring the needy to the hospitals for surgery [23]. In spite of the financial and human resource restraints in Africa, many successful cataract programmes have been established, mostly with the assistance of NGOs, offering good quality service through attention to training and efficiency, the monitoring of results, and the development of patient friendly services.

An example of such a successful eye care programme is the Gambian Eye Care Programme, on which many of the Vision 2020 principles are based. In this country of about a million people, 2 ophthalmologists and 4 ophthalmic assistants, supported by ophthalmic nurses, increased the cataract surgery rate from 300 to more than 1600 within 7 years. In so doing, the prevalence of blindness in the country decreased by 40%, between 1989 and 1996.[39, 40] Similarly, Nakuru district in Kenya has an established eye care centre with a CSR of about 1000 per year. In a population-based study, the prevalence of blindness in the district was found to be only 0.3 % compared to the overall prevalence in Africa of 1%. Similar pockets of excellence are found in districts in a number of countries with CSRs over 1000 per year.[38] (Cook, C. Personal communication: colin.cook@uct.ac.za)

4. The Cost utility and Cost benefit of Cataract surgery

The implementation of successful cataract programmes in Africa is beneficial in economic terms to the individual, as well as to the country. Cost utility analysis is the measure by which the cost and the benefit of a procedure, as well as the value that the recipient perceives of the procedure, are calculated in terms of monetary value. There are numerous variables in determining the cost utility of cataract surgery, including the productivity of the unit (the more surgeries done, the lower the cost), the preoperative visual acuity (the worse the preoperative acuity, the more the benefit) and postoperative results. For the individual, cost utility analysis of cataract extraction has found it to be a very cost-effective procedure.[41]

At a national level, the economic burden of blindness and the cost of implementing Vision 2020 programmes have been estimated for 8 countries in Southern Africa. The overall cost benefit ratio of implementing eye care programmes was calculated to be 14.6. The economic benefit of reducing blindness in Africa is therefore about 14 times larger than the implementation cost of eye care services. This study demonstrates that the economic burden of blindness is of such a magnitude that developing countries in Africa can ill afford not to invest in establishing Vision 2020 programmes.[42]

4.1. Other benefits of Cataract Programmes

The implementation of a cataract programme in a district brings not only social and financial benefit to the community, but also a comprehensive eye care service to the area. A district cataract programme inherently includes refractive error services. These services benefit both schoolchildren and those over the age of 40 who develop presbyopia and who are in need of spectacles. By virtue of the equipment and qualified staff, a cataract

unit is also equipped to deal with ocular trauma, trachoma, glaucoma, and the identification of diabetic retinopathy.

5. Conclusion

Blindness due to cataract is a significant disease resulting in social and economic burdens in poor communities, and exacerbates the cycle of poverty and handicap.

Cost-effective disease control strategies are available and supported by NGOs in the African continent. Barriers to the implementation of cataract services can be overcome by the establishment of well-run, effective, and cost-efficient high-volume cataract units that are of great benefit to the districts in which they operate.

The establishment of at least one cataract unit per district of a million must be encouraged.

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