Elimination of avoidable blindness due to cataract: Where do we prioritize and how should we monitor this decade?

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Background: In the final push toward the elimination of avoidable blindness, cataract occupies a position of eminence for the success of the Right to Sight initiative. **Aims:** Review existing situation and assess what monitoring indicators may be useful to chart progress towards attaining the goals of Vision 2020. **Settings and Design:** Review of published papers from low and middle income countries since 2000. **Materials and Methods:** Published population-based data on prevalence of cataract blindness/visual impairment were accessed and prevalence of cataract blindness/visual impairment computed, where not reported. Data on prevalence of cataract blindness, cataract surgical coverage at different visual acuity cut offs, surgical outcomes, and prevalence of cataract surgery were analyzed. Scatter plots were used to look at relationships of some variables, with Human Development Index (HDI) rank. Available data on Cataract Surgical Rate (CSR) was plotted against prevalence of cataract surgery reported from surveys. **Results:** Worse HDI Ranks were associated with higher prevalence of cataract blindness. Most studies showed that a significant proportion of the blind were covered by surgery, while a fifth showed that a significant proportion, were operated before they went blind. A good visual outcome after surgery was positively correlated with higher surgical coverage. CSR was positively correlated with cataract surgical coverage. **Conclusions:** Cataract surgical coverage is increasing in most countries at vision <3/60 and visual outcomes after cataract surgery are improving. Establishing population-based surveillance of cataract surgical need and performance is a strong monitoring tool and will help program planners immensely.

Key words: Blindness, cataract extraction, cataract, coverage, data aggregation, population, prevalence, visual impairment

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The goal of elimination of avoidable blindness by the end of this decade can only be realistically achieved if the existing magnitude of cataract blindness is tackled effectively. Cataract still remains the single largest cause of blindness, causing more than half of all blindness in many low and middle income countries (LMIC).[1-14] Data available at the start of the new millennium showed that population-based surveys reported between 30% and 60% of blindness in Africa as attributable to cataract, against 60–80% in most countries in South East Asia.[15] These studies also showed that visual impairment (VI) attributable to cataract is also of concern. This existing situation in parts of Asia compounds the challenge further as this region is home to the mega-populated countries including Bangladesh, China, India, and Pakistan.

An extensive review has recently been conducted of the global burden of blindness, cataract blindness, risk factors for cataract, and indicators for cataract surgery.[16] This exhaustive review highlighted that age, gender, and literacy status have universal importance as they show a significant association with blindness in general and cataract blindness in particular.[16]

The increasing 'graying' of populations in LMIC puts more people at risk for age-related eye disease than ever before. Therefore the technological revolution in cataract surgical techniques becomes redundant if a social breakthrough on translating this at the population level does not keep pace. For the social transformation to occur there is an urgent need for tools that will rapidly identify and help in prioritization as well as in adequate monitoring.

This review considers the existing situation in LMIC and suggests mechanisms that can be adopted for more effective monitoring so that a rapid response can be initiated in priority regions.

Materials and Methods

We considered available population-based studies from LMICs published after 2000. These included studies on the prevalence and causes of blindness as well as cataract surgical coverage (CSC) and surgical outcomes. Studies were only considered if they were population-based and provided adequate information on methodology, examination process and the results was provided. Both detailed population-based surveys as well as rapid assessment methods (Rapid Assessment of Cataract Surgical Services [RACSS]; Rapid Assessment of Avoidable Blindness [RAAB]) were included.

Blindness was defined as presenting vision in the better eye of <20/400 while visual impairment was defined as presenting vision in the better eye of <20/63–20/400. It therefore included the World Health Organization (WHO) categories of moderate and severe visual impairment.

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As noted earlier, in most studies, the population prevalence of cataract blindness or cataract-related visual impairment is not reported. What is generally reported is the proportion of blindness/VI due to cataract. Based on this information, the population prevalence of cataract blindness and cataract-related VI were computed using the denominator (number of persons examined), while the numerator was calculated using the proportion of blindness/VI due to cataract. Therefore prevalence of cataract blindness/VI was calculated as follows:

No. of cataract blind/VI = Proportion of blind/VI due to cataract × total number examined (Step 1).

No. of cataract blind/VI ÷ total number examined in survey × 100 (Step 2)

Cataract surgical coverage was defined as:

Number of operated individuals (aphakic or psuedophakic) ÷ all operated individuals + operable cataract individuals (waiting for surgery) × 100.

The Human Development Index (HDI) is defined by the United Nations (UN) as a composite indicator, which combines life expectancy at birth, educational attainment and income.[17] HDI values for 2011 are scored between 0 and 1 for each country and based on the relative scores, an HDI Rank is allocated to each country. The HDI Rank has been correlated with the prevalence of cataract blindness and cataract indicators at the country level.

Results

Prevalence of blindness and VI data was obtained from population-based surveys in LMIC [Table 1].[1-14,18-33] There were limitations in assessing available data due to variations in age structure of the population covered, examination protocols (rapid/detailed), definitions of blindness, and VI. The prevalence of blindness, based on presenting vision, ranged from a low of 0.4% in Iran,[30] to a high of 8.1% among 40 + individuals in Myanmar .[13] Two studies reported prevalence based on best corrected vision after examination of 40 + individuals. These estimates were low, both in China (0.3%)[28] and Sri Lanka (1.1%), [14] compared with other studies reporting presenting vision. In relation to VI, most studies reported a ratio of visual impairment to blindness of 3:1 to 4:1, while one study (Lumbini, Nepal) reported visual impairment to be eight times higher.[31] The proportion of blindness due to cataract ranged from 36% to 89% in most studies except in Cameroon where it was 21%.[23] Prevalence of cataract blindness/VI rate at the population level was reported in a few studies only. Therefore, based on the available data, these estimates for both cataract blindness and VI were computed as part of this review.

To illustrate the relationship between cataract blindness and development, a set of data from comparative population groups (50+) was extracted and plotted against the HDI Rank. Data from five studies in South America (Brazil,[25] Chile,[24] Guatemala,[11] Mexico,[24] and Venezuela[24]), six studies in Africa (Botswana,[18] Eritrea,[10] Kenya,[21] Malawi,[6] Rwanda,[7] and Tanzania[9]), and four in Asia (China,[2] India,[3] Iran,[29] and Nepal[1]) were used [Fig. 1]. To make the data comparable, only studies covering the 50 + population were used.

Where more than one study was reported from a country, only one study was used for comparison with the HDI Rank so that duplication was avoided. The decision on which study to include was based on the following criteria:

- Studies which reported data on all variables analyzed were given preference.
- If this was equally reported by all studies in the country, then the one with larger sample size was chosen.
- If the sample size was similar, the most recently published study was used.

An age cut-off of 50 + years was chosen only because the largest number of studies reported on this age group. As the HDI Rank worsened, there was a higher prevalence of cataract blindness which could mean that development is associated with a reduction of cataract blindness. The trend line showed a linear relationship, except for one study from Nepal which was a significant outlier.

Data on cataract surgical coverage and visual outcomes after cataract surgery was also extracted from population-based surveys from LMIC [Table 2].[1,2,6-7,9-11,18,21,23,24,31,33-40] A total of 20 surveys reported data on CSC. Though most studies were conducted on 50 + populations, there were a few studies, which covered either the 40 + population (Nigeria),[34] or the 30 + population (Pakistan).[33] In relation to the comparison of CSC rates, the age structure of the population will be of lesser concern, because the indicator looks at the proportion of operated among those who potentially need surgery (already operated or waiting for surgery). CSC can be computed at different visual acuity (VA) cut-off levels (<20/400; <20/200; <20/63). A comparison of the three VA cut-offs helps us understand whether most of the blind are receiving surgery or whether a significant proportion of surgery is being done on those who are not yet blind. Seven of the twenty studies reviewed (35%) showed that less than half of those who potentially need surgery were operated, thereby meaning that the surgical needs of more than half were still to be realized. At the same time, 5 (33.3%) of the 15 studies which presented data on CSC at <20/63 VA cut-off level revealed that more than half the people operated were at relatively better VA cut-off levels.

A total of 18 surveys reported on visual outcomes after cataract surgery at the population level [Table 2]. Such data is very useful to ascertain how operated individuals perform in the long-term as such studies cover people operated at different times and who have survived till the conduct of the survey. We extracted data on best corrected or pin-hole visual acuity (BCVA) as we feel that this will indicate the best possible visual outcome of surgery rather than the person-level factors, if presenting VA was considered. Only two studies (both from Nepal) reported a poor outcome using WHO recommended cut-offs (BCVA<20/200) of 5%.[1,31] An additional seven studies reported poor outcomes to be <20%. Therefore, only 50% of the studies reported a poor outcome in less than 1 in 5 operated individuals after best correction/pin hole. One study (Cameroon) reported poor outcomes in more than half the operated persons.[23]

Since poor outcomes are generally reported to affect the uptake of cataract surgery, a scatter plot of CSC with BCVA was plotted [Fig. 2]. The graphic illustrated that the trend line was linear with good outcomes being related to higher CSC using a 20/400 VA cut-off, though the slope of the trend line showed only a narrow incline. However, there was a wide outlier in Cameroon,[23] where even though poor outcomes were observed in half the operated individuals, CSC was as

Table 1: Prevalence of blindness, visual impairment and cataract-blindness and visual impairment from population based studies

Area covered; year	Age group; data type	Examined sample	Prevalence blind (< 3/60 BE) %	Prevalence visual impairment (< 6/18 BE) %	Cataract as proportion of blind %	Cataract as proportion of visual impairment %	Prevalence cataract blindness (< 3/60 BE) %	Prevalence cataract visual impairment (< 6/18 BE) %	References
Africa									
South-Malawi; 2010	50+; RAAB	3430	3.3	12.2	48.2	48.8	1.59	5.95	6
National - Eritrea; 2008	50+; RAAB	3163	7.5	13.5	55.1	55.4	4.13	7.5	10
Kilimanjaro, Tanzania; 2007	50+; RAAB	3436	2.4	8.8	52.4	54.8	1.25	3.67	9
Botswana - National; 2007	50+; Survey	2127	3.7		46.9	40.2	1.73		18
National; Nigeria; 2007	40+; Survey	15.027	4.2[a]	11.53[a]	43.0[b]	28.3[b]	1.8[b]	3.25[b]	19[a], 20[b]
Western Rwanda ; 2006	50+; RAAB	2206	1.8	6.6	65.0	55.9	1.17	3.69	7
Nakuru-Kenya; 2005	50+; RAAB	3503	2.0	7.3	42.0	38.9	0.84	2.84	21
National, Ethiopia; 2005	All ages; Survey	25,650	1.6	3.7	49.9	42.3	0.8	1.6	22
Limbe-Cameroon; 2004	40+; RACSS	2215	1.1	3.3	21.0	47.3	0.23	1.6	23
South America									
Bio Bio, Chile; 2006	50+; RAAB	3000	1.4[a]	7.6[a]	57.0[a]		0.6[†b]	2.4[† b]	12[a]; [b]24
Sao Paulo, Brazil; 2005	50+; Survey	3678	1.51[μ]	4.74	40.0[μ]	33.2	0.6[μ]	5.27	25
Nueve Leon- Mexico; 2005	50+; Rapid	3780	1.5[a]	8.8[a]	67.0[a]		0.7[†]	2.6[†]	12[a]; [b]24
Guatemala – 4 regions 2004	50+; Rapid	4806	4.1	18.1	66.0	6.3	2.8%	5.9	11
Venezuela- National; 2004	50+; Rapid	3317	2.3[a]	10.3[a]	68.0[a]		1.3[† b]	1.9[† b]	12[a]; 24[b]
Asia									
National, Bangladesh; 2001	30+; Survey	11,624	1.39	7.7	79.6		1.11		4
Satkhira- Bangladesh; 2005	50+; RAAB	4868	2.9	10	79	47.7	2.3	4.77	26
Handan, China; 2007	30+; Survey	6799	0.6	4.7	36.6	12.1	0.22	0.57	27
Kunming- China; 2006	50+; RAAB	2588	3.7	12.1	63.2	56.5	2.32	6.84	2
Beijing-China; 2001	40+; Survey	4439	0.3[†]	1.1[†]	38.5[†]	36.7[†]	0.11	0.4	28
Navsari, Gujarat, India; 2009	50+; Survey	4738	4.3	12.1	82.6	43.8	3.55	5.3	8
15 districts, India; 2007	50+; RAAB	40,447	3.6	21.2	72.2	67.9	2.6	15.3	3
Varamin, Tehran-Iran; 2009	50+; RAAB	2819	1.51	8.3	31.7	28.9	0.47	2.40	29
Tehran, Iran; 2002	40+; Survey	4560	0.4	4.65		25.4		1.18	30
Meiktila, Myanmar; 2005	40+; Survey	2076	8.1	32.9	53.0	70.0	4.29	23.0	13
Rautahat, Nepal; 2006	50+; Survey	4717	6.9	36.1	85.9		5.92		1
Lumbini zone – Nepal; 2006	50+; Survey	5138	2.3	18.3	48.1		1.11		31
Pakistan – National; 2005	30+; Survey	16,507	2.7[a]	14.3[a]	51.5[b]	44.3[b]	1.75[c]	8.1[c]	32[a]; 5[b]; 33[c]
Kandy, Sri Lanka; 2007	40+; Survey	1375	1.1[†]	4.8[†]	79.0[†]		0.87[†]		14

[†]Best corrected / Pin hole visual acuity; [μ]: VA < 6/60

Table 2: Prevalence of cataract surgery, cataract surgical coverage, and, outcomes after cataract surgery

Area covered; year	Age Group; data type	Sample examined	CSC < 20/200 person level	CSC < 20/400 person level	CSC < 20/63 person level	Post op BCVA >= 6/18	Post op BCVA < 6/60	Prevalence cataract surgery (%)	References
Africa									
South-Malawi; 2010	50+; RAAB	3430	34.5	44.6	15.8	52.6	32.1	1.63	6
Eritrea; 2008	50+; RAAB	3163	63.7	67.9	48.0	51.9	28.0		10
Tanzania; 2007	50+; RAAB	3436	65.0	69.8	42.1	69.6	19.4	5.6	9
Botswana; 2007	50+; Survey	2127	73.0	65.4	62.3				18
Nigeria; 2007	40+; Survey	13,591	31.6[b]	38.3[b]	20.7[b]	55.9[a]	23.2[a]	1.6[b]	34[a], 35[b]
Rwanda; 2006	50+; RAAB	2206	42,6	47.2	21.4	55.0	41.0		7
Kenya; 2005	50+; RAAB	3503	70.8	78.0	50.9	63.5	22.1		21
Cameroon; 2004	40+; RACSS	2215	71.0	80.0		23.1	57.7		23
South America									
Chile; 2006	50+; RAAB	3000	71	76	45.0	69.0	14.0		24
Brazil; 2005	50+; Survey	3678		89.7	61.4	79.5	12.2	6.3	36
Mexico; 2005	50+; Rapid	3780	64	79	50.0	71.0	20.0		24
Guatemala; 2004	40+; Rapid	4806	29	38	15.0	41.0	36.0	2.9	11
Venezuala; 2004	50+; Rapid	3317	59	70	52.0	77.0	13.0		24
Asia									
Satkhira- Bangladesh; 2005	50+; RAAB	4868	56.3	60.9	35.6	67.6	20.2	3.7	26
9 provinces China; 2006	50+; Survey	45,747	35.7	43.1		57.6	17.7	2.09	37
Kunming. China; 2006	50+; RAAB	2588	46.4	58.9		45.0	25.6	3.51	2
Navsari, Gujarat, India; 2009	50+; Survey	4738	72.2	81.4	44.5	74.8	11.0	17.6	38
RAAB, India; 2007	50+; RAAB	40,447	66.0	82.3		69.4	15.8		39
Myanmar; 2004	40+; Survey	2076	20.11	22.3	9.74				40
Lumbini, Nepal; 2006	50+; Survey	5138		66.6		89.0	5.6	7.0	31
Rautahat, Nepal; 2006	50+; Survey	4717		37.3		84.6	5.1	9.8	1
Pakistan; 2004	30+; Survey	16,507	69.3	77.1	43.7			8.0	33

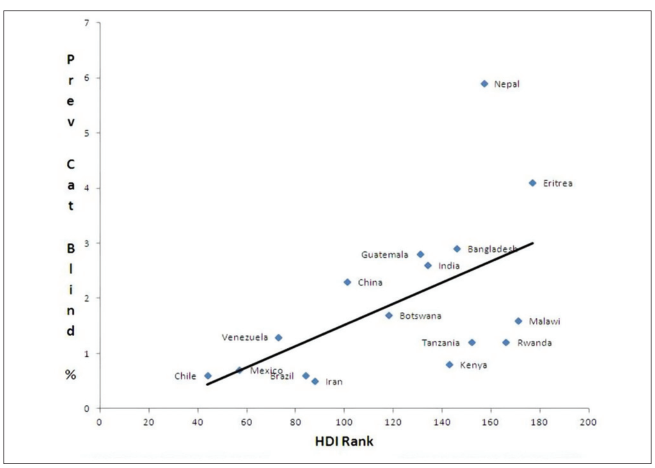

Figure 1: Relationship between prevalence of cataract blindness among 50+ population and Human Development Index Rank

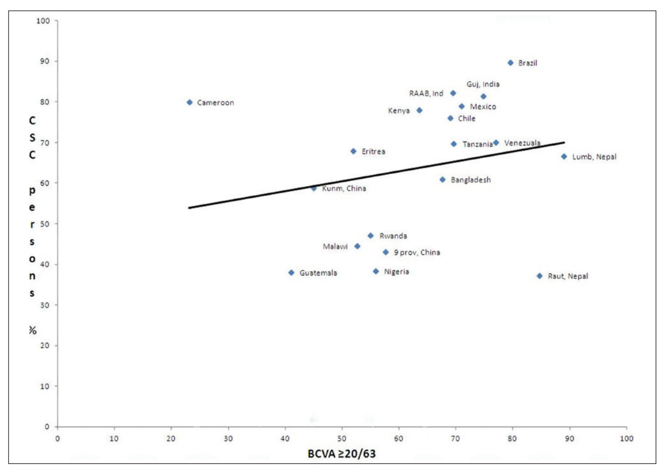

Figure 2: Relationship between Cataract Surgical Coverage (<20/400 person level) and Best Corrected Visual Acuity (≥20/63 in better eye)

high as 80%. Similarly in Rautahat, Nepal a good outcome was not associated with increased CSC.[31]

A scatter plot was also drawn to ascertain whether HDI Rank of a country was related to CSC at VA cut-off of 20/63 to provide evidence for the hypothesis that a better HDI Rank (indicating superior developmental indices) may prompt people to be operated at VA levels much before they go blind [Fig. 3]. Countries with higher CSC at 20/63 cut-off level had better developmental profiles. There were a few outliers like

Eritrea.[10] However, it has to be remembered that HDI Rank pertains to the entire country while most of the surveys were only undertaken at regional rather than at national level. To reduce bias in this comparison, only one survey from each country was used, if there were more than one survey undertaken in a country.

An indicator like the prevalence of cataract surgery which is possible to generate from population-based surveys has been sparingly reported. Only 11 studies have reported the population prevalence of cataract surgery since 2000. The prevalence of cataract surgery ranged from a low of 1.6% in Nigeria[35] and Malawi[6] to a high of 17.6% in India.[38] A scatter plot was drawn to review whether higher prevalence of cataract surgery, obtained from surveys led to enhanced CSC considering VA <20/400 [Fig. 4]. It was observed that there was a linear relationship between prevalence of cataract surgery and increased CSC. It therefore appears that when prevalence rates for cataract surgery increase, the cataract blind individuals also get a better opportunity to be covered by cataract surgery, except in the Rautahat survey in Nepal.[31]

Available data on cataract surgical per million population or the cataract surgical rate (CSR) was extracted for countries where population-based surveys were undertaken after 2000.[41] It was observed that there was a strong linear relationship between CSR and observed prevalence of cataract surgery in surveys in most countries [Fig. 5].

Discussion

Data used in this review are primarily from secondary sources, and therefore comparisons are difficult due to variation in methodology, age groups, definitions adopted, etc. However, the available data provides an opportunity to glean trends, despite the stated weakness. An additional weakness is that, for some interpretations, data are from a national level while the studies were not always nationally representative. This was done because no local level data are available in most countries in LMIC. It should also be emphasized that using an ecological study design, which has been adopted in looking at some correlations at the country level, has its own inherent weaknesses. Such designs suffer from an ecological fallacy as inference is based solely on aggregate statistics at the population level, being completely aware that every individual in the population does not completely share the group's characteristics. However, sometimes this is the only sort of data available for interpretation.

Recent evidence from three countries in different parts of the world (Kenya, Bangladesh, and Philippines) demonstrated, unequivocally, that cataract surgery improved quality of life, irrespective of the cultural background.[42] Coupled with the fact that cataract is the single largest cause of blindness and a significant cause of visual impairment, and given that life expectancies in LMIC are rising rapidly, there is every reason to emphasize on cataract surgical programs in LMIC if elimination of avoidable blindness is to be a reality in the near future. We have calculated that if the CSC remains similar, using the potential incidence and prevalence of cataract blindness and the predicted age structure of the population, then by 2020, there would be nearly 8 million people in need of cataract surgery in India, alone.[43] Therefore the challenge is to translate the available technology to benefit the blind and visually impaired poor populations in LMIC, at a pace that can reach the stated goals within the shortest span of time. At the time when professionals are documenting that technology

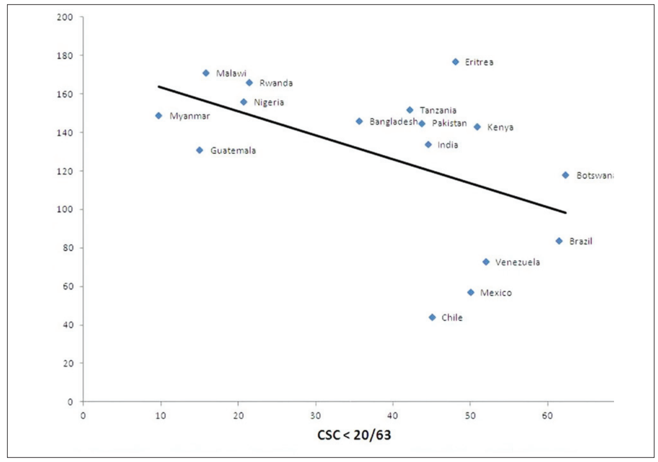

Figure 3: Relationship between Human Development Index Rank and Cataract Surgical Coverage (<20/63 better eye - person level)

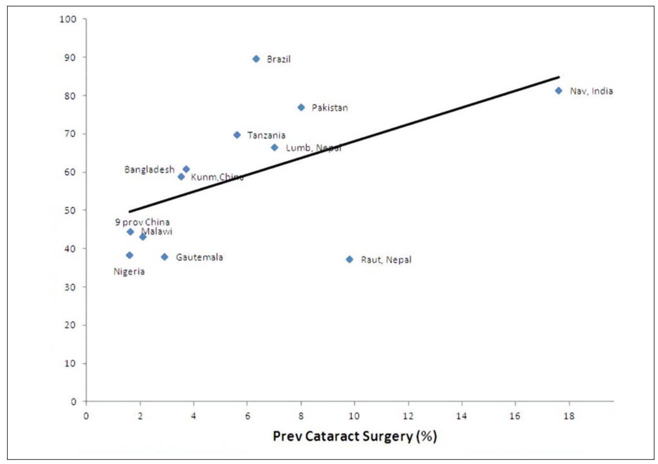

Figure 4: Relationship between prevalence of cataract surgery (%) and Cataract surgical coverage (<20/400 - person level)

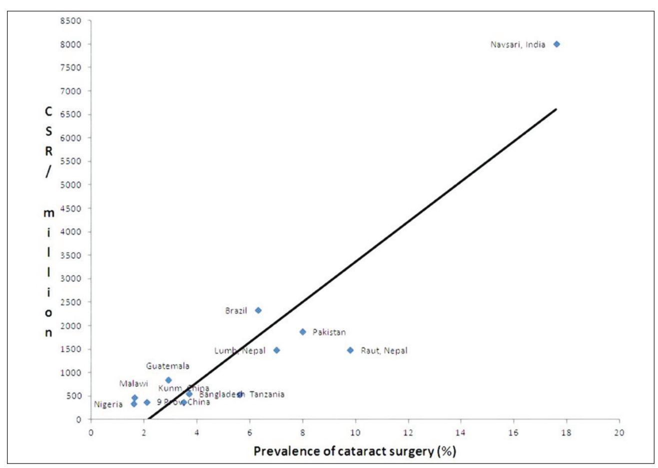

Figure 5: Relationship between prevalence of cataract surgery (%) and reported Cataract Surgical Rate/million population

like biometry and manual small incision cataract surgery/ phacoemulsification can revolutionize visual outcomes after cataract surgery,[44,45] there comes evidence from West Africa on high rates of couching and appalling visual outcomes as a consequence, even to this day.[46]

Available evidence shows that cataract programs are reaching more and more people in need as evidenced by increasing CSC across many of the LMIC. This augurs well for the immediate future as does the evidence that there is a steady improvement in visual outcomes after cataract surgery. Analyzing trends in barriers to the uptake of cataract surgery would also be useful in identifying the reasons that prompt better uptakes so that programs can incorporate changes based on these barriers. It therefore, needs to be seen how countries like Nigeria can quickly bring about a change in the population perceptions on the ill effects of practices like couching. Whether the high couching prevalence is a consequence of poor access to modern cataract surgical services or whether there are other important predisposing factors that compound the situation need to be addressed. This single report from Nigeria brings issues like awareness and popular perceptions along with access and affordability to the forefront.[46]

The evidence from the present review, that good visual outcomes fuel increased CSC, is heartening because this ensures that continued emphasis on quality in programs is the key to increased acceptability of services. Hospital-based studies have shown that regular monitoring of cataract surgeries and providing timely feedback to the surgeons, helps in improving the quality of surgical outcomes.[47,48] Similarly improving case selection and providing adequate refractive correction after surgery also improves outcome.[49]

The fact that more and more surgeries are being done before people go blind is positive as it shows increased awareness and would prevent people from going blind. However, this should not be at the cost of people who are already blind and awaiting surgery.

This review shows that prevalence of cataract blindness and CSC at better visual acuity cut-offs (VA> 20/63) are related to developmental indices. At the same time, evidence from Kilmanjaro (Tanzania),[9] Nakuru (Kenya),[21] Lumbini (Nepal),[31] or Navsari (India)[38] adds credence to the fact that local efforts can go a long way in mitigating adverse circumstances, even in the face of poor socio-developmental parameters. What these examples also highlight is that district/regional planning of cataract surgical services is crucial for success. This is a critical determinant for planning cataract programs as is documented by the recent papers from Africa,[50] wherein the importance of the local situation is strongly emphasized also exhibiting that there cannot be a policy of 'one-shoe-fits-all' with regard to required CSR or cataract dynamics in different populations.

CSR has been used extensively to monitor the programs at the country level. However, the problem with CSR for planning cataract services at present is that available information on CSR does not provide any evidence on the age of those operated or on the case-mix for surgery (first eye versus second eye; visual acuity of those operated, etc.).[8] It has also been stated that CSR computation is determined by the accuracy of data that are available at the country level.[8,51] In countries where the private sector is the major player, it will be very difficult to obtain timely and accurate data on cataract surgery from individual practitioners. It may still be possible in less populated countries or where the number of ophthalmic surgeons is small but would be impossible in the mega-populated countries with a variable mix of surgical practitioners. We have earlier observed that in the state of Gujarat, which reports the highest CSR in India, a population-based survey found that the actual CSR was much lower than what was officially reported.[38] If accurate CSR data can be obtained, then CSR is an excellent indicator as it is easy to collect. However, when accuracy cannot be ensured, then it is more prudent to use evidence available from rigorously conducted population surveys. Our review shows that there is a linear relationship between another indicator (population prevalence of cataract surgery) and CSR. This indicator should be routinely reported from population-based surveys and can be used to advantage to supplement existing CSR data. Fig. 5 revealed that for many countries the two indicators correlated well but the data from Navsari district in India was a clear outlier, and thus needs to be carefully scrutinized.

With less than a decade for achieving the target of elimination of avoidable blindness, it is important that we strengthen monitoring mechanisms so that remedial action can be taken at the earliest possible time. This cannot be achieved by isolated surveys or RAABs in one or a few districts in a country. Eye care professionals now need to seriously consider what is being adopted by other health programs. Many countries have established health and demographic surveillance systems. It is essential that cataract surgery be incorporated in these surveillance systems. Such a surveillance system can collect data on prevalence of cataract surgery and CSC as a minimum requirement to prevent inundation and therefore be adapted to the requirements of eye care professionals. India established a sentinel surveillance system under the National Blindness Control Program using 25 medical schools as the primary data collection units wherein population-based data in addition to hospital-based data was contemplated.[52] Unfortunately, the program could not be monitored adequately and the amount of information to be collected is increasing to such an extent that the system is collapsing under its own weight. Such systems need to be carefully developed and implemented on a pilot basis in a few countries in each of the continents. As monitoring outcomes has been seen to be positively correlated with improved outcomes and increased uptake of cataract surgery, can the WHO, International Agency for Prevention of Blindness or other international funding organizations take the lead to conceptualize and fund such initiatives?

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