First Rapid Assessment of Avoidable Blindness Survey in the Maldives: Prevalence and Causes of Blindness and Cataract Surgery

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Purpose: A nationwide rapid assessment of avoidable blindness survey was undertaken in the Maldives among people aged 50 years or more to assess the prevalence and causes of blindness and visual impairment, cataract surgical coverage, cataract surgery outcome, and barriers to uptake of cataract surgical services.

Design: Prospective population-based study.

Methods: In the cluster sampling probability proportionate to size method, 3100 participants in 62 clusters across all 20 atolls were enrolled through house-to-house visits. They were examined in clusters by an ophthalmologist-led team. Data was recorded in mRAAB version 1.25 software on a smartphone.

Results: The age-sex standardized prevalence of blindness was 2.0% [95% confidence interval (CI), 1.5–2.6]. Cataract was the leading cause of blindness (51.4%) and uncorrected refractive error was the leading cause of visual impairment (50.9%). Blindness was more prevalent in higher age groups and women (16.3%). Cataract surgical coverage was 86% in cataract blind eyes and 93.5% in cataract blind persons. Good visual outcome in cataract operated eyes was 67.9% (presenting) and 76.6% (best corrected visual acuity). In this study, 48.1% of people had received cataract surgery in neighboring countries. Important barriers for not using the services were "did not feel the need" (29.7%) and "treatment deferred" (33.3%).

Conclusions: Cataract surgical coverage is good, though nearly half the people received surgery outside the Maldives. Cataract surgery outcomes are below World Health Organization standards. Some barriers could be overcome with additional human resources and training to improve cataract surgical outcomes, which could encourage greater uptake of services within the country.

Key Words: Maldives, rapid assessment of avoidable blindness, blindness, visual impairment, cataract surgical coverage

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Blindness and severe visual impairment remain leading causes of disability in the world. In 2010, the World Health Organisation (WHO) estimated that 285 million people had visual impairment, of which 39 million were blind. Further, 90% of blind people live in developing countries.[1] Similarly, the Global Burden of Disease (GBD) 2010 data showed that globally, 32.4 million people [95% confidence interval (CI), 29.4–36.5 million people; 60% women] were blind, and 191 million people (95% CI, 174–230 million people; 57% women) had moderate to severe visual impairment (MSVI). The age standardized prevalence of blindness in older adults (50+ years) in South Asia was 4.4% (95% CI, 3.5–5.1%), and the MSVI prevalence in older adults was highest in South Asia (23.6%; 95% CI, 19.4–29.4%).[2] The WHO Global Action Plan (GAP) 2014–2019 called on member states to work toward reducing the prevalence of avoidable visual impairment by 25% by the year 2019.[3]

The GAP identifies the rapid assessment of avoidable blindness (RAAB) as a preferred method to assess the prevalence and causes of visual impairment in a specific population.

Findings of RAAB surveys are useful for managers to develop intervention programs for control of blindness based on a community's needs.[4] Recently RAAB studies have been conducted in Southeast Asia (Thailand,[5] Sri Lanka,[6] Nepal[7]) and are in progress in India, Myanmar, and Indonesia. There has never been a prevalence study on eye health in the Maldives. The primary objective of this study was to assess the principal causes of blindness and visual impairment in the elderly Maldivian population. In the absence of baseline data, it would be difficult to assess the impact of eye care services vis-à-vis the WHO global action plan. Hence the Ministry of Health, Government of Maldives agreed to this nationwide blindness prevalence study.

MATERIALS AND METHODS

Selection of Study Clusters

The islands of the Maldives form 26 natural clusters of islands and are administratively divided into 20 atolls (administrative areas). The atolls are divided into 198 administrative subdistricts and further divided into 997 census blocks. Of these, 468 blocks have less than 300 people, 519 blocks have between 300 and 700 people, and 10 blocks have more than 700 people. As per the 2014 census data, approximately 14.3% of the Maldivian population was aged 50 years and above. A populaton unit of 350 people of all ages was thus necessary to find 50 people aged 50 years and older. To create the population unit of appropriate sizes, we combined the 2 nearest possible census blocks on the same island when the population was less than 300 people in a given census block. The 10 census blocks which could not be joined with another block on same island were joined with randomly chosen census blocks from the nearest possible island. Five census blocks with a population of 700 or more were segmented into 2 population units.

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TABLE 1. Distribution of Study Participants

Category	Enrolled	Examined	Response Rate %
Male	1286	1233	95.9
Female	1814	1787	98.5
All	3100	3020	97.4

Sample Size

Using RAAB 5 computerized software, the sample size was calculated and the study clusters were chosen. In the absence of any previous prevalence data, we assumed a 4.2% prevalence of blindness in people aged 50 years and over. With 20% tolerable error, 95% precision, and adjusting the cluster design effect of 1.5 for the cluster size of 50, the sample size was 3061 (Maldives population per 2014 census: 341,848). The participants were recruited from 62 study clusters spread over 738 population units of 20 atolls. The country was divided into 3 zones for data collection purposes: north, central, and south. The north zone consisted of 17 clusters in 7 atolls, the central zone consisted of 27 clusters in 3 atolls, and the south zone consisted of 18 clusters in 10 atolls. The capital city Malé was located in the central zone.

Training and Pilot Study

There were 2 study teams. Each study team consisted of 1 ophthalmologist, 1 assistant, 1 cluster community worker, and 1 village guide. The principal investigator (U.T.) and the study coordinator (F.S.) supervised both teams.

The actual fieldwork was preceded by 4 days of training and a pilot study. The certified RAAB trainer (Y.S.) conducted the training that began with an introduction to the RAAB survey and methodology, followed by practice of certain examination procedures such as the measurement of visual acuity using the tumbling E,[8] anterior segment eye examination using a flashlight, fundus examination using direct ophthalmoscope with mydriasis when required, and assigning the principal cause of visual impairment for each eye and in the person. Everyone practiced using the mRAAB loaded on a smartphone and entered mock data. The principal investigator practiced downloading information sent by the data collection team from the study site as an email attachment. An interobserver variation (IOV) test was done in 1 of the nonstudy clusters, and the task included the measurement of visual acuity and ocular examination in the same group of people by both groups. The training concluded with a pilot study in 1 nonstudy cluster to standardize all examination and data entry procedures.

Examination and Data Entry

Each clinical team consisted of 1 ophthalmologist, 1 ophthalmic assistant, and 1 cluster/village guide. The sequence of individual examination consisted of the following: 1) the basic data including the study participant's name, age, sex, and history regarding the use of distance and near spectacles were entered in the software; 2) distance vision was recorded using the tumbling E chart at 6 m, which was brought to 3 m and 1 m for those who could not read the chart; 3) flashlight examination of the eye and adnexa was done; 4) direct ophthalmoscope was used to see the media clarity; and 5) the pupils were dilated if pinhole visual acuity was less than 6/18 unless there were obvious causes such as corneal opacity or cataract. The definitions of diseases were in line with the RAAB instruction manual version 5.0.[8] Those who had been operated on for cataract were asked about the duration of surgery, insertion of intraocular lens (IOL) (yes/no), mode of payment (totally free, partially paid, or fully paid), place of surgery (government, private, abroad), and the surgical settings (eye camp/improvised setting/hospital setting). Those who had not had surgery despite having visual impairment due to cataract were asked about the barriers (did not feel the need, fear of surgery, poor result, cannot afford, asked to defer treatment by provider, unaware of treatment, no access to treatment, no one to accompany them) and the 2 important causes in order of priority. In cases where the person was not available, was not able to communicate, or refused the examination, he/she was enrolled in the study and the possible details of vision and cause of blindness (cataract, causes other than cataract, or operated for cataract) were obtained from a relative or neighbor. The participant was considered "absent for clinical examination" if not available on 2 repeat visits.

Ethical Considerations

The protocol was reviewed and approved by the Health Research Committee, Ministry of Health, Maldives. A written consent form in the local language (Dhivehi) was read out with explanation and each study participant's signature was obtained for consent. Participants were also informed that they could withdraw from the study at any time.

The participants were informed of the findings of eye examination and advised of any appropriate actions. Treatment for minor ocular conditions was given during the examination at no cost to the subjects. Those who required cataract surgery or advanced investigation/examination were referred to the Indira Gandhi

TABLE 2. Prevalence of Blindness, SVI, and MVI by Bilateral Presenting Visual Acuity

VA Category	Prevalence	Male % (95% CI)	Female % (95% CI)	All % (95% CI)
Blindness (PVA < 3/60)	Crude	2.4 (1.5–3.2)	2.4 (1.7–3.1)	2.4 (1.9–2.9)
	Age-sex adjusted	1.8 (1.0–2.7)	2.3 (1.6–3.0)	2.0 (1.5–2.6)
SVI (PVA < 6/60–3/60)	Crude	3.0 (2.0–4.0)	1.6 (1.0–2.1)	2.2 (1.6–2.7)
	Age-sex adjusted	2.2 (1.3–3.2)	1.9 (1.4–2.4)	1.9 (1.4–2.4)
MVI (PVA < 6/18–6/60)	Crude	15.4 (13.2–17.6)	10.5 (8.9–12.1)	12.5 (11.1–13.9)
	Age-sex adjusted	12.7 (10.5–14.9)	10.0 (8.4–11.6)	11.4 (10.0–12.8)

PVA indicates presenting visual acuity.

TABLE 3. Prevalence of Blindness According to Age Group

Age Group	Male % (95% CI)	Female % (95% CI)	All % (95% CI)
50–59 y	0.6 (0.0–1.3)	0.6 (0.1–1.0)	0.6 (0.2–1.0)
60–69 y	1.0 (0.0–2.1)	1.1 (0.2–1.9)	1.0 (0.4–1.7)
			OR, 1.8 (0.67–4.8; $P = 0.2$)
70–79 y	3.0 (1.2–4.8)	5.4 (2.6–8.2)	4.2 (2.5–5.9)
			OR, 7.6 (3.4–17.0; $P < 0.05$)
80+ y	10.7 (5.0–16.3)	16.3 (8.7–24.0)	13.1 (8.4–17.8)
			OR, 23.2 (10.4–51.8; $P < 0.05$)
All 50+ y	2.4 (1.5–3.2)	2.4 (1.7–3.1)	2.4 (1.9–2.9)

Memorial Hospital (government facility) in Malé. All services were provided free of cost to study participants covered by the national health insurance scheme.

Statistical Analysis

We used the following statistical methods for analysis of the collected data: 1) the crude and estimated age- and sex-adjusted prevalence of visual impairment and blindness; 2) 95% confidence interval (CI); 3) odds ratio (OR) to assess the ratio of blindness according to age and sex; and 4) cataract surgery visual outcome analysis comparison between public and private hospitals and those treated in the country and abroad. A P value of less than or equal to 0.05 was considered statistically significant.

RESULTS

Interobserver Variation

The findings of interobserver agreement Kappa analysis were 0.78 (right eye) and 0.79 (left eye) for presenting vision; 0.76 (right eye) and 0.74 (left eye) for best-corrected vision; 0.94 (right eye) and 0.82 (left eye) for lens status; and 0.67 for assigning the principal cause of visual impairment.

A total of 3020 (97.4%) people of the 3100 enrolled survey participants were examined. Reasons for the 80 people not examined included "refused" (n = 43), "not available" (n = 26), and "could not communicate" (n = 11). The age- and sex-specific distribution of the study participants showed that females were more likely to be examined in this study [n = 1787, 98.5%; OR, 2.8 (95% CI 1.8–4.5); $P < 0.005$] (Table 1).

The distribution of blindness is shown in Table 2. The crude prevalence and age- and sex-adjusted prevalence of blindness was 2.4% and 2.0%, respectively; severe visual impairment (SVI) was 2.2% and 1.9%, respectively; and moderate visual impairment (MVI) was 12.5% and 11.4%, respectively. The prevalence of blindness (vision less than 3/60) was 1.8% for males and 2.3% for females. Total visual impairment and blindness (vision less than 6/18) was 16.7% in males and 14.7% in females. There was no sex difference in blindness and visual impairment in the study population. Age-specific prevalence of blindness is shown in Table 3. There was an increase in blindness in the older age cohort.

The distribution of blindness and visual impairment is shown in Table 4. Cataract was the principal cause of avoidable blindness and severe visual impairment, whereas refractive error and cataract were the main causes of moderate visual impairment. Complications of cataract surgery accounted for 1.4% and 4.6% of blindness and severe visual impairment, respectively. Nontrachomatous corneal opacity accounted for 5.6% of all blindness; age-related macular degeneration (AMD) accounted for 6.3% of severe visual impairment (vision less than 6/60 to 3/60) and 3.2% of moderate visual impairment (vision less than 6/18 to 6/60) (Table 4).

Cataract surgical coverage among the bilateral cataract blind was 93.5% (male, 94.4% and female, 92.7%). Among the cataract blind eyes (includes unilateral cataract blind) the coverage was 86.0% (male, 85.5% and female, 86.5%). The cataract surgical coverage at other presenting visual acuities is shown in Table 5.

Eight hundred fifty people (850 eyes) had undergone surgery for cataract; 817 (96.1%) eyes had IOL implantation and 33 eyes did not. Overall good visual outcome (at least 6/18) according to

TABLE 4. Principal Causes of Blindness, SVI, and MVI (PVA)

Causes	Blindness % (n)	SVI % (n)	MVI % (n)
Refractive error	0.0 (0)	1.5 (1)	50.9 (192)
Cataract	51.4 (37)	64.6 (42)	36.3 (137)
Cataract surgical complications	1.4 (1)	4.6 (3)	1.9 (7)
Nontrachomatous corneal opacity	5.6 (4)	0.0 (0)	1.3 (5)
Glaucoma	2.8 (2)	3.1 (2)	0.3 (1)
Diabetic retinopathy	0.0 (0)	3.1 (2)	0.8 (3)
AMD	2.8 (2)	6.2 (4)	3.2 (12)
Other posterior segment disease	27.8 (20)	12.3 (8)	4.0 (15)
All other globe/central nervous system abnormalities	8.3 (6)	4.6 (3)	1.3 (5)
Total	100.0 (72)	100.0 (65)	100.0 (377)

TABLE 5. Adjusted Results for Cataract Surgical Coverage

Cataract Surgical Coverage	Male %	Female %	Total %
VA < 3/60			
Persons	94.4	92.7	93.5
Eyes	85.5	86.5	86.0
VA < 6/60			
Persons	89.7	90.0	89.9
Eyes	78.7	81.4	80.0
VA < 6/18			
Persons	67.1	71.3	69.1
Eyes	58.4	65.0	61.5

the WHO definition was seen in 67.9% and 76.6% presenting and best-corrected visual acuity (BCVA), respectively. Overall, a poor outcome was seen in 14.8% and 13.4% presenting and best-corrected visual acuity, respectively. In general, aphakic eyes had a poorer outcome (Table 6). Cataract surgery in 409 (48.1%) of 850 eyes was performed outside the country and in 92 (10.8%) eyes surgery was performed in the government hospital in Malé. The visual outcomes of surgery are shown in Table 7. A higher percentage of people who were treated outside the country had good visual outcome compared with those patients operated on in the Maldives [OR, 2.0 (95% CI 1.5–2.7); $P < 0.05$] (Table 7).

The 2 major barriers to the uptake of cataract surgery in the study cohort were "did not feel the need" (29.7%) and "treatment deferred by the provider" (33.3%). Other causes included "fear," "cost," "access," and "lack of accompanying person" (Table 8).

DISCUSSION

The Maldives health care delivery system consists of 20 atoll-based hospitals, 7 regional hospitals (including 2 operated at the tertiary level), and 165 health centers located on populated islands. Several private clinics also operate and are mainly located in the capital Malé. The capital city of Malé houses over a third of the total population. The city has 2 tertiary level hospitals: 1 government and 1 private. The eye health personnel distribution is as follows: 1 ophthalmologist per 34,000 people, 1 optometrist per 34,100 people, and 1 eye care nurse per 23,184 people. All Maldivians are insured by the Aasandha universal health insurance scheme fully financed by the government and eye health services are integrated within the health care system.

There has never been a blindness and visual impairment survey in the Maldives to date. The response rate of 97.4% to the first nationwide survey was very good. This success owes much to the nationwide media coverage ahead of the study, good house-specific local area maps, and excellent local support for survey work.

The RAAB survey method, by design, focuses on cataract, the most common cause of avoidable blindness. Examination techniques do not measure the posterior segment in detail and do not measure the visual field. Hence, it is likely to overlook the retina, glaucoma, or optic nerve disorders if visual acuity is not reduced concurrently.

The blindness and visual impairment prevalence and causes in the Maldives were not much different than the global profile, with cataract accounting for 51.4% of blindness and 64.6% of severe visual impairment and uncorrected refractive error accounting for 60% of visual impairment.[1,2] Trachoma, still prevalent in other South Asian countries, was not detected in this study cohort. There was a high prevalence of posterior segment disorders. Cataract surgical coverage at 93.5% is very good, although close to half (409 of 850) of the patients had opted to have surgery outside the country, and these eyes had better visual outcome. Although the cost of surgery was not an important barrier and fear of surgery was within a reasonable limit, the 2 important barriers were "did not feel the need" and "deferred by the service provider." The former barrier could be addressed by better advocacy and patient education. "Deferred by the service provider," which translates to increased waiting time and additional expense, is related to the current ophthalmic surgical infrastructure and unavailability of cataract surgical services in atoll hospitals. Maldivian eye health personnel, at 1 ophthalmologist per 34,000 people and 1 optometrist per 34,100 people, are within the WHO recommendations[9,10]; however, more than half of the ophthalmologists and all of the optometrists are expatriates and are based in the capital city of Malé. To improve the service standards, the Maldives should increase and expand the skill base by establishing regional cataract surgical centers among the atolls beyond the capital city of Malé. Delivering universal eye health care that is based on the pyramid model of eye care[3,11] from primary care at the village level, secondary level eye care at the town level, and tertiary eye care at the city level could be a good model of equitable eye care in the Maldives. Human resources are key to success in this model. Midlevel ophthalmic personnel play an important role.[12] Availability of comprehensive eye care, including correction of refractive error and quality cataract surgery in the regional hospitals and elevating the central hospital at Malé to deliver tertiary eye care, will accelerate the necessary eye care reforms.

The limitation of this study is the RAAB itself in the sense that it assesses blindness and visual impairment of people 50

TABLE 6. Visual Outcomes of Cataract Surgery

Outcomes	Visual Acuity	Aphakia % (n)	Pseudophakia % (n)	All % (n)
Good (≥6/18)	PVA	42.4 (14)	68.9 (563)	67.9 (577)
	BCVA	42.4 (14)	78 (637)	76.6 (651)
Borderline (<6/18–6/60)	PVA	12.1 (4)	17.5 (143)	17.3 (147)
	BCVA	12.1 (4)	9.9 (81)	10.0 (85)
Poor (<6/60)	PVA	45.5 (15)	13.6 (111)	14.8 (116)
	BCVA	45.5 (15)	12.1 (99)	13.4 (114)
All cataract operated eyes		100.0 (33)	100.0 (817)	100.0 (850)

TABLE 7. Visual Outcomes of Cataract Surgery According to Location of Surgery

	Government		Abroad		Private		Eye Camp		Total	
Outcomes	**Eyes**	**%**	**Eyes**	**%**	**Eyes**	**%**	**Eyes**	**%**	**Eyes**	**%**
Good	51	55.4	310	75.8	197	61.4	19	67.9	577	67.9
Borderline	21	22.8	45	11.0	79	24.6	2	7.1	147	17.3
Poor	20	21.7	54	13.2	45	14.0	7	25.0	126	14.8
Total	92	100.0	409	100.0	321	100.0	28	100.0	850	100.0

TABLE 8. Barriers to Uptake of Cataract Surgery (BCVA < 6/18 Due to Cataract)

	Males		Females		Total	
	n	**%**	**n**	**%**	**n**	**%**
Did not feel the need	22	30.6	19	28.8	41	29.7
Fear	4	5.6	13	19.7	17	12.3
Cost	5	6.9	5	7.6	10	7.2
Treatment deferred by provider	24	33.3	22	33.3	46	33.3
Cannot access treatment	10	13.9	2	3.0	12	8.7
Lack of accompanying person	7	9.7	5	7.6	12	8.7
Total	72	100.0	66	100.0	138	100.0

years and older. An all-age eye disease study could have more ideal results. However, RAAB has been proven to cost-effectively detect the most common cause of blindness and visual impairment. The strength of this study is that it is the first study to measure the prevalence of blindness and visual impairment in the country, though this particular study was confined to the elderly population. Additionally, the population cohort was pooled from the entire country despite difficult travel logistics. It is believed that the results could help the Maldives design a sound eye health policy planning and eye care delivery system.

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