International Journal of Community Medicine and Public Health
Bharath B et al. Int J Community Med Public Health. 2017 Feb;4(2):320-327
http://www.ijcmph.com
pISSN 2394-6032 | eISSN 2394-6040

DOI: http://dx.doi.org/10.18203/2394-6040.ijcmph20170050

Original Research Article

Prevalence and determinants of cataract surgical coverage in India: findings from a population-based study

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Received: 26 December 2016
Accepted: 06 January 2017

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ABSTRACT

Background: Cataract is the leading cause of avoidable blindness in most parts of developing world, including India. The objectives were to assess cataract surgical coverage (CSC) and investigate the determinants for CSC among people aged 50 years or older in India.
Methods: A population-based, cross-sectional survey was conducted to include 2023 residents aged ≥50 years old from 72 clusters of 20 districts in six states from various parts of India. Presenting visual acuity (VA), history of cataract surgery and operable cataract were assessed by trained professionals. Prevalence of CSC and factors influencing cataract surgery (CS) were studied in the multivariable logistic regression model. A two-sided p-value of <0.05 was considered to be statistically significant.
Results: Cataract surgery was done in 478 (23.6%) people in both eyes. Using VA<6/18 cut-off, the CSC was estimated as 67.2% in persons. In LR model, increased age was significantly associated with increased CS (P<0.0001). The odds of prevalence of CS was significantly lower in Uttar Pradesh; adjusted Odds Ratio (OR), 0.59; (95% CI: 0.36-0.95; p=0.032) and in persons with diabetes; OR: 0.61; (95% CI: 0.38-0.94; p=0.028).
Conclusions: Cataract surgical need is currently not being met in India and the increasing prevalence of diabetes is an additional major challenge in addressing the gap in CS.

Keywords: Cataract surgical coverage, Diabetes, North India, Operable cataract, South India

INTRODUCTION

Cataract is still the main cause of blindness globally, causing more than half of all blindness. In India cataract has been reported to be responsible for 50-80% of bilateral blindness.[1,2] This phenomenon is not only limited to rural areas but also becoming more manifest in urban areas.[3] Global agencies including the World Health Organization (WHO) and its "Vision 2020" initiative are committed to the elimination of avoidable blindness especially due to cataract by increasing the number and quality of cataract surgeries to achieve satisfactory visual outcome and improved quality of life by the year 2020.[4]

While cataract surgical rate (CSR) is one of the major WHO indicators (WHO recommends an ideal CSR range of 3000-5000 per year per million population to meet the need), cataract surgical coverage (CSC) measures the proportion of individuals (or eyes) with operable cataract (defined at different presenting visual acuity cut-offs

<3/60, <6/60 and <6/18) who had cataract surgery.[5,6] It is a sensitive and efficient indicator which captures the extent to which services have met the need of the community and gives information on cataract workload in a region/country. Recent data from WHO show a 25% decrease in blindness prevalence which could have been due to the increased rates of CSR and CSC in India.[7] However, as up to date data are required for regional health service planning, we assessed the CSC and its determinants amongst people aged ≥50 years old and residing in several Northern and Southern Indian states.

METHODS

A population based cross-sectional epidemiologic study was conducted in six Indian states of Tamil Nadu (TN), Karnataka and Andhra Pradesh (AP) in southern, Punjab in the north western, Gujarat in the western and Uttar Pradesh (UP) in Northern part of India from October 2015 to March 2016 using a multistage cluster random sampling strategy.

Sample size estimation

The prevalence of blindness (VA<6/60 in the better eye) was estimated as 8.0% among 50 years or older in accordance to previously published reports in India.[8] Considering this as the baseline estimate and considering precision at 2.5%, 95% confidence level, 80% power, design effect of 2.0 for cluster sampling method and considering 20% non-response rate, the approximate sample size was estimated as 2200 for this study.

Sample

All persons aged ≥50 years old residing in the selected study clusters for more than 6 months and consenting for interview and examination were considered eligible for the study. Each village or urban slum was considered as a cluster. As part of the sampling procedures, a list of districts were obtained from the states in which the base hospital operates its services. From this list, the first stage units of 20 districts were selected randomly; the first 10 districts were selected within a radius of 150-200 Kilometers that are being covered by a base hospital and the remaining 10 districts were randomly selected from the region where base hospital coverage (i.e. within 150-200 kilometers) is absent. This balance was maintained to ensure that the study participants were equally representatively recruited from serviced and not serviced districts by the base hospital. These districts ranged from a minimum of one in AP to a maximum of six in Karnataka. From selected districts, all villages/urban slums (clusters) were enumerated and listed out. On an average 3 to 4 clusters (range: 1 to 4 clusters/per district) from each of these selected districts were randomly selected as a second stage units by using a simple random sampling method. In summary, 72 clusters (59 rural and 13 urban slums) from the 20 districts of these states were chosen. A house to house visit was made by trained Field Investigators (FIs) in these selected clusters. A minimum of 30 eligible persons were studied from each selected cluster. A total of 2023 (92%) persons out of enumerated persons of 2200 were consented (signature or thumb imprint) and participated in the study.

A team of three FIs and a team leader were trained for data collection and management respectively. Field investigators were especially trained thoroughly for identification of persons with operable cataract using a torch and vision assessment and assessment of type of surgery based on status of lens (i.e., aphakia or pseudophakia) using a torch and based on a personal interview. These FIs were standardized with that of an optometrist (gold standard) and the inter-observer agreement in terms of Kappa statistics between both (for presenting VA and lens examination) was >90%. At least 2-3 visits were made to the households. If an eligible person refused to give written informed consent (signature or thumb imprint) and/or refused or non-cooperative to be part of either interview or examination was considered to be a non-respondent.

Prior approval was obtained from the Institute's Institutional Review Board of Sankara Eye Foundation India, Bangalore, Karnataka and the study has followed the tenets of the Helsinki Declaration involving humans. Data collection was done in the selected clusters by house to house visits. Eligible persons in the household were interviewed about their age, gender, educational status (any formal education considered as literate), smoking status, history of cataract surgery (pseudophakia/aphakia), and details on systemic illness. Participants were deemed to be diabetic or hypertensive, if they were currently on medication and/or had a recent prescription from a certified physician.

Participant assessment

Presenting distance visual acuity (VA) was measured using the Snellen's or illiterate E chart, in each eye separately in front of the house in the day light. After measuring VA, eye examination was performed in a shaded dark area of the house. All eyes with a VA <6/18 were examined with a torch to assess lens status. Lens status was noted as normal lens, obvious lens opacity present, lens absent (aphakia) or intraocular lens implantation (IOL). If the lens was not in a position to be examined in cases like corneal scarring, then it was recorded as "no view of lens" and therefore such patients were excluded from the study.

Outcome definitions

Never operated cataract blind (operable cataract):

A person who was unilateral or bilaterally blind (VA<6/60) because of cataract but had never undergone cataract surgery.

CSC was determined for people for visual acuity cut-offs of <6/60, <3/60 or <6/18 as follows:

For people:

$$\frac{(x+y)}{(x+y+z)} \times 100$$

Where,

x = People with unilateral pseudophakia/aphakia in one eye and operable cataract in the other eye;

y = People with bilateral pseudophakia/aphakia; and

z = People with bilateral operable cataract.

Statistical analysis

Data were analyzed descriptively first. Categorical data analysis was carried out by using either $\chi 2$-test or Fisher's test as appropriate. The unadjusted and adjusted odds ratios (OR) (with 95% confidence interval (CI)) of the cataract surgery were calculated for a comparison between different age group, gender, place of residence, education status, systemic illness and geographic location. A final multivariable logistic regression model included all of the variables with a p-value ≤0.20 obtained in the univariable logistic regression model. A two-sided p-value of <0.05 was considered to be statistically significant. SPSS version 19.0 (SPSS Inc., Chicago, IL, USA) was used for data analysis.

RESULTS

A total of 2023 (92.0%) people out of 2200 enumerated were interviewed and examined with mean age of 63.8±8.9 (range 50-108 years). A total of 1,017 (50.3%) were female. Table 1 shows the percent examined from each state. A minimum of 40 and a maximum 247 samples were recruited from each district.

Table 2 describes the cataract surgery details either in one or both eyes and lens status in terms of bilateral operable cataract with presenting visual acuity <6/18 in the better eye and status of no cataract in either eye. A total of 478 (23.6%; 95% Confidence Interval (CI): 21.8%, 25.5%) participants (223 men and 255 women) had received cataract surgery (either pseudophakia/aphakia) in both eyes (Table 2); Tamil Nadu (TN) being the highest and UP being the least performer among the states (Table 2).

Cataract surgical coverage

The CSC (person) at VA<6/60 was 75.0% (80% for male and 75% for female). The CSC (person) at VA<6/60 was highest in the district of Kheda in Gujarat (93.2%) and it was lowest in the district of Kannauj in UP (47.1%) (Table 3). The CSC (person) at VA<6/60 was better in the state of TN with an average of 80%, however, it was less in the district of Virudhunagar (64.7%) (Table 3). Overall, south Indian states of TN, Karnataka and AP had reasonably high CSC when compared to other states (Tables 3).

Table 4 reports the crude prevalence of pseudophakia/aphakia either unilateral or bilateral. The prevalence of pseudophakia/aphakia either unilateral or bilateral was 40.4% (95% CI: 38.2%, 42.5%) (Table 4). The prevalence of bilateral pseudophakia was 21.9% (95% CI: 20.1%, 23.7%) (n = 443) and the prevalence of bilateral aphakia was 0.9% (95% CI: 0.6, 1.4) (n = 19). Of the 441 bilateral IOL operated persons, 189 (42.9%) had obtained better visual acuity outcome (≥6/18) in both eyes and very few patients (7.9%; n = 35) had worst visual acuity (<6/60).

The prevalence of cataract surgery (CS) was significantly increased with increased age (p<0.0001) and higher in females but not significant (p=0.115, Table 5). The prevalence of CS was significantly less in persons with diabetes; adjusted odds ratio (OR): 0.60 (95% confidence interval (CI): 0.38, 0.93) (p=0.028) and in the state of UP, OR: 0.59 (95% CI: 0.36, 0.94) (p=0.032) (Table 5). The prevalence of CS was significantly higher in the state of TN, OR: 2.19 (95% CI: 1.44, 3.32) (p<0.0001). The CS was similar between urban slums and rural population (p=0.525) (Table 5).

Table 1: Coverage of study population (≥ 50 years old) in selected states in India.

State	Persons aged ≥ 50		
	Enumerated	Examined	%
Tamil Nadu	450	417	92.7
Karnataka	550	545	99.1
Andhra Pradesh	250	247	98.8
Gujarat	250	230	92.0
Punjab	300	259	86.3
Uttar Pradesh	400	325	81.3
Total	2200	2023	92.0

Table 2: District wise distribution of study population according to history of cataract surgery and lens status.

State	District	Surgery required in one eye & surgery done in other eye; n (%)	Surgery done in both eyes; n (%)	Bilateral operable cataract (VA <6/18); n (%)	No cataract in either eye; n (%)	Total
Gujarat	Ahmedabad	25 (25.0)	16 (16.0)	17 (17.0)	42 (42.0)	100
	Kheda	27 (20.8)	28 (21.5)	12 (9.2)	63 (48.5)	130
Karnataka	Bangalore urban	22 (14.0)	35 (22.3)	21 (13.4)	79 (50.3)	157
	Chikkamagaluru	6 (10.3)	14 (24.1)	6 (10.3)	32 (55.2)	58
	Davanagere	5 (6.2)	23 (28.4)	16 (19.8)	37 (45.7))	81
	Mandya	5 (5.4)	25 (27.2)	10 (10.9)	52 (56.5)	92
	Shimoga	17 (17.3)	23 (23.5)	18 (18.4)	40 (40.8)	98
	Tumkur	8 (13.6)	13 (22.0)	12 (20.3)	26 (44.1)	59
Tamil Nadu	Thiruvannamali	12 (20.7)	18 (31.0)	9 (15.5)	19 (32.8)	58
	Thoothukudi	4 (10.0)	18 (45.0)	6 (15.0)	12 (30.0)	40
	Tiruppur	19 (15.6)	56 (45.9)	24 (19.7)	23 (18.9)	122
	Virudhunagar	31 (15.7)	58 (29.4)	51 (25.9)	57 (28.9)	197
Andhra Pradesh	Guntur	57 (23.1)	55 (22.3)	52 (21.1)	83 (33.6)	247
Punjab	Bhatinda	9 (16.7)	5 (9.3)	10 (18.5)	30 (55.6)	54
	Jalandhar	13 (21.3)	16 (26.2)	11 (18.0)	21 (34.4)	61
	Ludhiana	26 (18.1)	25 (17.4)	30 (20.8)	63 (43.8)	144
Uttar Pradesh	Kannauj	6 (9.2)	10 (15.4)	20 (30.7)	29 (44.6)	65
	Kanpur Dehat	30 (26.1)	18 (15.7)	36 (31.3)	31 (26.9)	115
	Kanpur Nagar	8 (12.3)	9 (13.8)	16 (34.6)	32 (49.2)	65
	Unnao	21 (26.2)	13 (16.2)	28 (35.0)	18 (22.5)	80
Total		351 (17.4)	478 (23.6)	405 (20.0)	789 (39.0)	2023

Table 3: Cataract surgical coverage (persons by men and women with visual acuity <6/60).

State	District	Cataract operated in one eye/both eyes		Cataract not operated with vision <6/60		Total un-operated + operated (<6/60)		Cataract surgical coverage <6/60		
		Male	Female	Male	Female	Male	Female	Male	Female	Total
Gujarat	Ahmedabad	15	26	5	9	20	35	75.0	74.3	74.5
	Kheda	21	34	2	3	23	37	91.3	91.9	93.2
Karnataka	Bangalore urban	27	30	8	10	35	40	77.1	75.0	76.0
	Chikkamagaluru	10	10	1	3	11	13	90.9	76.9	83.3
	Davanagere	14	14	2	2	16	16	87.5	87.5	87.5
	Mandya	15	15	5	3	20	18	75.0	83.3	78.9
	Shimoga	19	21	6	5	25	26	76.0	80.8	78.4
	Tumkur	13	8	4	6	17	14	76.5	57.1	67.7
Tamil Nadu	Thiruvannamalai	16	14	5	2	21	16	76.2	87.5	81.1
	Thoothukudi	10	11	2	2	12	13	83.3	84.6	84.0
	Tiruppur	31	44	7	4	38	48	81.6	91.7	87.2
	Virudhunagar	39	49	18	30	57	79	68.4	62.0	64.7
Andhra Pradesh	Guntur	52	59	13	14	65	73	80.0	80.8	80.4
Punjab	Bhatinda	8	6	2	2	10	8	80.0	75.0	77.8
	Jalandhar	14	15	2	2	16	17	87.5	88.2	87.9
	Ludhiana	31	20	15	8	46	28	67.4	71.4	68.9
Uttar Pradesh	Kannauj	10	6	8	10	18	16	55.6	37.5	47.1
	Kanpur Dehat	27	21	19	11	46	32	58.7	65.6	61.5
	Kanpur Nagar	10	7	5	4	15	11	66.7	63.6	65.4
	Unnao	12	22	6	11	18	33	66.7	66.7	66.7
Total		394	432	135	141	529	573	74.5	75.4	75.0

Table 4: Crude prevalence (%) of pseudophakia / aphakia (unilateral or bilateral).

	Total sample N	Prevalence (%)		
		Men	Women	Total
Age (Years)				
50 – 60	866	70 (8.1)	118 (13.6)	188 (21.7)
60 – 70	794	181 (22.8)	208 (26.2)	389 (48.9)
≥ 70	363	134 (36.9)	106 (29.2)	240 (66.1)
Place of residence				
Urban slum	509	89 (17.5)	100 (19.6)	189 (37.1)
Rural	1514	296 (19.6)	332 (21.9)	628 (41.5)
Education				
Illiterate	1284	204 (15.9)	356 (27.7)	560 (43.6)
≤ Grade 5	491	122 (24.8)	65 (13.2)	187 (38.1)
Grade 6-10	180	38 (21.1)	5 (2.8)	43 (23.9)
≥ Grade 11	67	21 (31.3)	6 (8.9)	27 (40.3)
Systemic illness				
Diabetes	178	29 (16.3)	29 (16.3)	58 (32.6)
Hypertension	298	48 (16.1)	78 (26.2)	126 (42.3)
Diabetes+HTN	118	23 (19.5)	31 (26.3)	54 (45.8)
Others	193	41 (21.2)	42 (21.8)	83 (43.1)
None/Don't know	1227	242 (19.7)	250 (20.4)	492 (40.1)
Geographic location				
Gujarat	230	31 (13.5)	60 (26.1)	91 (39.6)
Karnataka	545	96 (17.6)	100 (18.3)	196 (35.9)
Tamil Nadu	417	97 (23.3)	118 (28.3)	215 (51.6)
Andhra Pradesh	247	51 (20.6)	57 (23.1)	108 (43.7)
Punjab	259	56 (21.6)	43 (16.6)	99 (38.2)
Uttar Pradesh	325	54 (16.6)	54 (16.6)	108 (33.2)
Total	2023	385 (19.0)	432 (21.4)	817 (40.4)

Data on education status was not available for one participant and data on systemic illness was not available for 9 participants. HTN: Hypertension.

Table 5: Univariable and multivariable logistic regression analysis between age, gender, place of residence, education, systemic illness and geographic location and cataract surgery.

Determinant	Total sample	Cataract surgery; n (%)	Unadjusted Odds Ratio (95% CI)	P	Adjusted Odds Ratio (95% CI)	P
Age (Years)						
50 – 60	866	88 (10.2)	1.00		1.00	
60 – 70	794	234 (29.5)	3.69 (2.83, 4.83)	<0.0001	4.01 (3.04, 5.29)	<0.0001
≥ 70	363	156 (43.0)	6.66 (4.92, 9.02)	<0.0001	7.28 (5.30, 9.99)	<0.0001
Gender						
Male	1006	223 (22.2)	1.00		1.00	
Female	1017	255 (25.1)	1.18 (0.96, 1.44)	0.124	1.21 (0.96, 1.54)	0.115
Place of residence						
Urban slum	509	115 (22.6)	1.00 (0.80, 1.20)	0.525	--	--
Rural	1514	363 (24.0)	1.00			
Education						
Illiterate	1284	332 (25.9)	1.00		1.00	
≤ Grade 5	491	102 (20.8)	0.75 (0.59, 0.97)	0.026	0.80 (0.60, 1.06)	0.119
Grade 6-10	180	28 (15.6)	0.53 (0.35, 0.81)	0.003	0.65 (0.40, 1.01)	0.060
≥ Grade 11	67	16 (23.9)	0.95 (0.51, 1.60)	0.719	1.22 (0.64, 2.31)	0.550
Systemic illness						
Diabetes	178	29 (16.3)	0.63 (0.41, 0.95)	0.039	0.60 (0.38, 0.93)	0.028
Hypertension	298	78 (26.2)	1.17 (0.88, 1.56)	0.284	1.08 (0.79, 1.49)	0.602
Diabetes+HTN	118	33 (28.0)	1.28 (0.84, 1.96)	0.248	1.05 (0.67, 1.65)	0.842
Others	193	49 (25.4)	1.13 (0.79, 1.59)	0.511	1.12 (0.76, 1.65)	0.578
None/Don't know	1227	285 (23.2)	1.00		1.00	
Geographic location						
Gujarat	230	44 (19.1)	1.00		1.00	
Karnataka	545	133 (24.4)	1.36 (0.93, 2.00)	0.111	1.27 (0.83, 1.94)	0.272

Tamil Nadu	417	150 (36.0)	2.38 (1.62, 3.48)	<0.0001	2.19 (1.44, 3.32)	<0.0001
Andhra Pradesh	247	55 (22.3)	1.21 (0.78, 1.89)	0.399	0.96 (0.59, 1.55)	0.877
Punjab	259	46 (17.8)	0.91 (0.58, 1.44)	0.696	0.72 (0.43, 1.18)	0.191
Uttar Pradesh	325	50 (15.4)	0.76 (0.49, 1.20)	0.247	0.59 (0.36, 0.94)	0.032

Data on systemic illness was not available for 9 participants and data on education status was not available for 1 participant. 95% CI: 95% Confidence Intervals. HTN: Hypertension.

DISCUSSION

Based on this study, the CSC has improved slightly as compared to a study done previously in India.[8] Since, cataract surgery is considered as one of the most cost-effective interventions with a cost of disability-adjusted life years saved of US$ 20–40, and CSC being one of the vital indicator for an evaluation of eye care programs, therefore, these findings are very useful for planning an effective and appropriate eye care intervention programs in the regions, in particular, in north Indian states.[4,9] Our findings suggest that UP and Punjab states are lacking behind in providing cataract surgical services, which needs a concerted effort to improve the present situation.

Comparison of CSC estimates with data from other studies needs caution, as different formulae are in use. For example, in our study we have used a formula that only includes participants if they were bilaterally blind due to cataract (presenting visual acuity (VA) of <6/60 and <3/60), and unilateral pseudophakia/aphakia with "operable cataract" in the other eye, which has been extensively used earlier.[6,10-12] In a most recent Rapid Assessment of Avoidable Blindness (RAAB) survey conducted during 2006-2007 by Murthy et al from 16 districts in India reported the CSC for persons as 66.0% and 82.3% at a VA cut-offs of <6/60 and <3/60 respectively.[8] Our study reports the CSC estimates (persons) at the same VA cut-offs as 75.0% and 91.6%. This increase may be attributed to the better intervention strategies for improved CSC by governmental and non-governmental agencies in India recently. In our study, a huge variation in CSC was noted in relation to the geographic location, which suggests that access to the cataract surgical services is poorly distributed across the country. We found that CSC at VA<3/60 ranged from a low of 75.1% in UP to a high of 98.0% in Gujarat. In the multivariable model, after adjusting for other factors the CS was noticed to be significantly lower in UP suggesting that the state significantly lacks in eye care services. UP being the most populous and least covered state in India in terms of cataract surgical services, an appropriate planning to improve the existing low rate of CSC is required. One of the possible reasons for low CSC observed in UP was due to the lack of awareness levels about cataract in the population and a lack of adequate infrastructure and manpower which requires a concerted effort for improvement.[13] Though it was not significant, the odds of prevalence of CS were also low in Punjab. Though in India, an average CSR of 5000 is observed, we have to still recognize the fact that about half of the states and districts are performing less than the national average, as seen in UP and Punjab. Therefore, improving cataract surgical services is very important towards elimination of avoidable blindness in these states. In our study, CSC at the VA<6/60 (75.0%) was comparable to the findings reported previously (Pakistan-69.3%), but higher than other findings; (Rajasthan, India-66% & Bangladesh–61%).[14-16] As noted in other studies, we noticed that increased age had a significant association with increased CS (Table 5), a finding which is expected as per demographic shift in terms of increasing older population in India.[17-19]

We found no gender difference in terms of CSC (persons at VA<6/60); 74.5% and 75.4% for males and females respectively. From the results of bivariable as well as multivariable logistic regression model, we have noticed that, though not significant, women had higher odds of prevalence of CS; OR: 1.21 (95% CI: 0.96, 1.54) (p=0.115) (Table 5), which means that a noticeable improvement has occurred in terms of access to the cataract surgical services by women recently thereby suggesting that the scenario has changed significantly from past situation where lower female access to cataract services was reported.[18,20-22] Even though our finding is in accordance with a previous report from Nepal; OR: 1.30, (95% CI: 0.90, 1.80), however, further studies are warranted to confirm this finding.[23]

There exists an association between presence of diabetes and CS both in bivariable and multivariable analysis. Persons with presence of diabetes had significantly lower odds of prevalence of CS. This could be due to the fact that the persons with diabetes are often not fit enough to undergo surgery and hence are left un-operated. However, there should be a mechanism where these patients can be identified, treated for diabetes and then should be operated upon. This has public health implications in India, especially due to the fact that India is emerging to be one of the countries with the highest burden of diabetes mellitus, if the current trends continues.[24] The study has few limitations. A slit lamp examination with dilation of the pupil was not performed because of which the operable cataracts have been either overestimated or under estimated.

CONCLUSION

In conclusion, this study has found that there are regional differences in CSC in India. It suggests to creation of more awareness about the cataract problem in the

population along with development of adequate eye care infrastructure with more man power to achieve better CSC. For the first time, this study reports the significant association of diabetes with lower CS. The findings in this study will help NGOs and governmental organizations to plan appropriate cataract surgical intervention programs in the studied states to achieve the goal of Vision 2020 in India.

ACKNOWLEDGEMENTS

The authors thank the Sankara Eye Foundation – India for funding this study and authors thank field investigators who involved in the data collection and all volunteers who participated in this study.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Review Board of Sankara Eye Foundation – India, Bangalore, India

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Cite this article as: Bharath B, Krishnaiah S, Imtiaz A, Ramani RV. Prevalence and determinants of cataract surgical coverage in India: findings from a population-based study. Int J Community Med Public Health 2017;4:320-7.