

# A multicentric cross-sectional study measuring the equity of cataract surgical services in three high-volume eyecare organizations in North India: Equitable cataract surgical rate as a new indicator

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**Purpose:** Cataract remains the leading cause of blindness and visual impairment in most low-and middle-income countries, with the greatest burden borne by women. To achieve Global Action Plan targets, cataract programs must target people, especially women, with maximum need. This study examines whether cataract surgical programs in three major north Indian eyecare institutions are equitable and describes a refined indicator for reporting equity. **Methods:** Retrospective one-year cross-sectional study of cataract surgery utilization using routine administrative data from three north Indian eyecare institutions. Patient data were categorized by paying category, sex, and preoperative visual acuity. Comparisons were made between payment categories and sexes. **Results:** Out of the total number of patients operated, 86,230 were in the non-paying category and 56,738 in the paying category. Overall, 8.2% were blind, 21.1% were severely visual impaired (SVI) or worse, and 86.1% were moderate visual impaired (MVI) or worse. Non-paying patients had a significantly higher proportion of poorer visual categories compared to paying patients [(blind, 9.7% vs. 5.8%; SVI or worse, 24.6% vs. 15.8%; and MVI or worse, 89.1% vs. 81.6%, respectively, ( $P < 0.001$ )]. Women had significantly higher proportion of poorer visual categories than men [(blind, 8.9% vs. 7.4%, SVI or worse, 21.9% vs. 20.3% and MVI or worse 87.6 vs. 84.7%) ( $P < 0.001$ )]. **Conclusion:** The institutions primarily provided surgery to patients with maximum need: too poor to pay, low visual acuity, and women. Similar data from all service providers of a region can help estimate the proposed "equitable cataract surgical rate": the proportion of patients operated with maximum need among those operated in a year. This can be used for targeting people in need.

**Key words:** Blind, cataract surgical rate, moderate visual impairment, preoperative visual acuity, public health, severe visual impairment

Cataract remains the leading cause of avoidable blindness, and the second leading cause of visual impairment in the world, affecting over 65.2 million people.<sup>[1]</sup> In India, while the prevalence of blindness and visual impairment due to cataract is decreasing, the absolute number of people impaired by cataract is increasing due to population growth.<sup>[2]</sup> This trend is even more pronounced among women and those belonging to lower socioeconomic levels.<sup>[1]</sup> In fact, the cataract surgical coverage (CSC: defined as the proportion of people in a population who have received cataract surgery among those

in need of surgery) among blind people, in some regions, is as low as 70%.<sup>[3]</sup>

In India, the cataract surgical rate (CSR: defined as the number of cataract surgeries per million per year) has increased from 700 in 1981 to around 6000.<sup>[4]</sup> A substantial contribution to the CSR comes from community-oriented eye care institutions utilizing a pyramidal model of service delivery,<sup>[5]</sup> and a cross-subsidy payment scheme.<sup>[6]</sup> The bottom of the pyramid involves extensive outreach activities to find and transport poor patients either to primary level eye care centers (vision centers) or to eye hospitals directly. These institutions provide services for free to patients who cannot afford to pay and subsidizes these patients by charging fees from those who can pay and typically come directly to the hospital.<sup>[5,6]</sup> To date, the cataract programs in these institutions have focused on patients with

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more severe visual impairment. To be able to achieve the target set by Global Action Plan (GAP) to reduce avoidable blindness and visual impairment across the globe by 25%, these programs need to continue to target people with blindness, severe and moderate visual impairment, and women.<sup>[7]</sup>

The Bodhya Eye Consortium (BEC) was formed in 2018 as a collaboration between six high-volume eye institutions delivering high-quality and high-volume care to their service populations. The BEC provides a platform through which these institutions conduct research and share knowledge on how to expand service capacity and improve clinical services. Pooling data from these high-volume centers provides stronger evidence for strategies needed to improve service delivery.

The purpose of this study was to assess whether the cataract programs of three of these north Indian eye care institutions, from which cataract surgical data could be pooled, were adequately targeting people with blindness and visual impairment in the region and to demonstrate that a refined indicator, cataract surgical volume, and rate, by visual acuity and sex, will help programs to target cataract services to people with the greatest need.

## Methods

This is a retrospective cross-sectional evaluation of the routine administrative cataract surgical data of three north Indian community-based eye hospitals from April 2017 to March 2018. While two of the hospitals provided single-center data, the third hospital contributed data from its four satellite centers spread across two north Indian states.

The three eye care institutions conduct outreach screening and diagnostic camps. People requiring cataract surgery received free transportation to and from the base hospital facility and free surgery if indicated. All three organizations also function through vision centers that refer patients needing cataract surgery to the hospitals. In all three organizations, patients are assessed for paying capacities by specialized counselors based on standardized questions regarding their possessions and family composition. Further, 95% of non-paying patients come through outreach camps or vision centers whereas 95% of paying patients came as walk-in.

Data were extracted from the same Integrated Hospital Management System operational at all three institutions. Patients were categorized according to the World Health Organization definitions: presenting visual acuity (of better eye) of less than 6/18 but better than or equal to 6/60 as moderate visual impairment (MVI), better than or equal to 3/60 but less than 6/60 as severe visual impairment (SVI), and less than 3/60 as blindness category.<sup>[8]</sup>

Data from the three institutions were aggregated and comparisons were made between the proportion of patients (total and by sex) at each visual acuity level in the paying and non-paying patient populations.

Data were analyzed using R software, version 3.6.0. The Z-test for proportions was used to compare camp and hospital walk-in patients. A *P* value of less than 0.05 was considered significant.

The study was approved by the individual ethics committees and/or institutional review boards of all three participating organizations and followed the tenets set in the Declaration of Helsinki. All identifiable data were anonymized, and no individual data were shared between the centers or disclosed during the analysis process.

## Results

The study included 1,42,968 patients, 86,230 (60.3%) non-paying and 56,738 (39.7%) paying cataract surgical patients from the three institutions, between April 2017 and March 2018. A total of 1,43,250 records were reviewed and 282 (0.2%) cataract surgical patients were excluded due to missing visual acuity data. Of the total surgical patients, 71,070 (49.7%) were male and 71,898 (50.3%) were female. The data of surgical patients by sex are shown in Fig. 1.

The overall proportion of blinds was 8.2%. The proportion was significantly higher among non-paying [Table 1]. [9.7% and 5.8% for non-paying and paying patients, respectively ( $P < 0.001$ )]. The overall proportion of patients with SVI or worse (better eye vision less than 6/60) was 21.1%. This proportion was significantly higher in non-paying versus paying patients [Table 1]. [24.6% versus 15.8% for non-paying and paying patients, respectively ( $P < 0.001$ )]. The overall proportion of patients with MVI or worse was 86.1%. This proportion was significantly higher in the non-paying versus paying patients [Table 1]. [89.1% versus 81.6% for non-paying and paying patients, respectively ( $P < 0.001$ )].

Of all surgical patients, 71,070 (49.7%) were male and 71,898 (50.3%) were female [Table 2]. Proportions of blind, SVI, and MVI among females and males are presented in Table 2. Proportions of blind, SVI or worse, and MVI or worse categories among women were consistently higher, and the differences were statistically significant ( $P < 0.001$ ).

Table 3 shows the gender break-up within non-paying and paying patients. Among female patients in the non-paying category, 10.7% were blind, 25.7% were SVI or worse, and 90.7% were SVI or worse. Proportions of blind, SVI or worse, and MVI or worse among both male and female patients was significantly higher in the non-paying category as compared to that in the respective paying category ( $P < 0.001$ ).

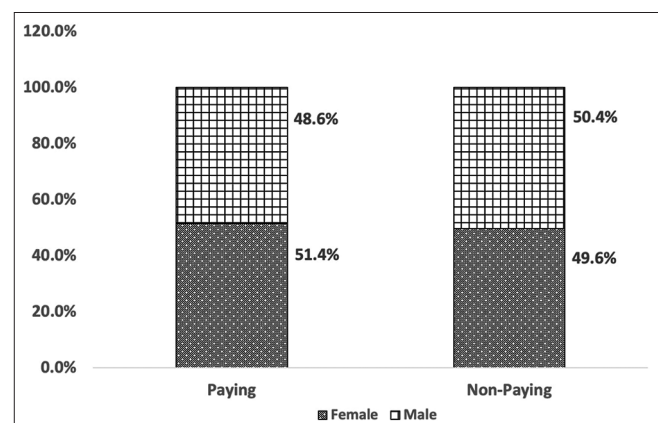


Figure 1: Sex segregation of paying and non-paying patients. [Original]

**Table 1: Comparison of visual impairment levels across non-paying and paying patients**

Visual Impairment Level	Non-paying	Paying	Total	Total %	P
1. Blind	8397 (9.7%)	3306 (5.8%)	11703	8.2%	<0.001
2. SVI	12825 (14.9%)	5651 (10%)	18476	12.9%	<0.001
3. MVI	55634 (64.5%)	37340 (65.8%)	92974	65%	<0.001
4. Mild or no impairment	9374 (10.9%)	10441 (18.4%)	19815	13.9%	<0.001
Total	86230 (100%)	56738 (100%)	142968	100%	
SVI or Worse (1+2)	21222 (24.6%)	8957 (15.8%)	30179	21.1%	<0.001
MVI or Worse (1+2+3)	76856 (89.1%)	46297 (81.6%)	123153	86.1%	<0.001

**Table 2: Proportions of patients at different levels of visual impairment among women and men**

Visual Impairment Level	Women	Men	P
1. Blind	6426 (8.9%)	5277 (7.4%)	<0.001
2. SVI	9353 (13%)	9123 (12.8%)	0.332
3. MVI	47188 (65.6%)	45786 (64.4%)	<0.001
4. Mild	8931 (12.4%)	10884 (15.3%)	<0.001
Total	71898 (100%)	71070 (100%)	<0.001
SVI or Worse (1+2)	15779 (21.9%)	14400 (20.3%)	<0.001
MVI or Worse (1+2+3)	62967 (87.6%)	60186 (84.7%)	<0.001

Table 4 shows the number of cataract surgeries in three different classes linked to three equity dimensions viz. level of visual impairment (MVI or worse), gender (women), and socioeconomic condition (non-paying) segregated by the organizations participating in this study. These depicted the surgeries among patients with maximum need. Pooled averages of the equity variables were as follows: 86.1% of all surgeries were done to patients with MVI or worse; 50.3% of all patients were female, and 60.3% were non-paying. The proportion of operated patients meeting all three equity criteria, (females belonging to non-paying category with MVI or worse), thus representing those with maximum need was 27.1% (total number 38,775; Table 4) and varied between 25.5% and 30.1% among the three organizations.

## Discussion

In a densely populated low-income region of northern India, three of the largest service providers combined their cataract surgical utilization data and analyzed the characteristics of their cataract surgical patients by sex, preoperative visual acuity, and capacity to pay. These cataract surgical patient characteristics were used to assess the "equity" of their programs in serving women and poorer patients in greatest visual need.

In the three institutions, the proportion of cataract surgical patients with preoperative vision in the blind, SVI or worse, and MVI or worse categories were significantly higher among non-paying than paying patients. This is expected as most patients in the free category come from outreach services that are conducted in remote locations, while patients in the paying category typically presented as walk-in patients. Interestingly, even among patients who came directly to the hospital and could pay for their surgery, approximately 16% were in the SVI or worse category and 81% were in the MVI or worse category. In organization C for example, 89%

of the total cataract surgical patients were in the MVI or worse category.

These institutions have extensive outreach activities to find and transport poor patients to hospitals for surgery.<sup>[5]</sup> The outreach camp linked to the base hospital approach for cataract surgery delivery is effective at reducing avoidable blindness at affordable costs and in hard-to-reach areas.<sup>[4,8]</sup> The institutions also provide services in a cross-subsidy model, originally demonstrated by the Aravind Eye Care System, whereby people who can afford to pay for services cover the costs of people too poor to pay.<sup>[6]</sup>

In the three institutions, the proportion of women falling into each of the blinds, SVI or worse, and MVI or worse preoperative visual acuity categories were significantly higher than men, both in the paying and non-paying patient groups. This demonstrates the need to favor women in eye care programs. The higher proportion of poor preoperative visual acuity in women is reflected in the low CSC at all visual acuity levels found in women versus men in this part of India.<sup>[9,10]</sup>

The population-based indicator, CSC establishes the proportion of a population whose needs are met by cataract surgical services. It is estimated by a population-based epidemiological study, such as the widely used rapid assessment of avoidable blindness studies.<sup>[11]</sup> CSR, on the other hand, simply measures the volume of cataract operations per million population in a region. Therefore, it does not report on the proportion of cataract operations conducted according to sex, preoperative visual acuity, or capacity to pay. The impact that the number of cataract surgeries performed in a year may have on reduction of blindness and visual impairment cannot be monitored using CSR alone as an indicator.

In regions where most of the cataract surgical volume is conducted by a single surgical center (Organization Band C, for example, contribute more than 75% of the cataract surgical volume in their regions), their routine administrative data on cataract surgical services provides a reasonable estimate of the appropriateness of cataract surgical services in a region. That is, their cataract surgical activities, in terms of sex and preoperative VA, largely determine the CSC, in their regions. For example, the CSC estimates are quite high (84.5%) for vision less than 6/18 in the catchment areas of organizations B and C, reflecting the focus of these programs on providing services to the population in greatest visual need.<sup>[12,13]</sup>

The value of analyzing cataract surgical service utilization data in an institution can be seen with Saharanpur, one of

**Table 3: Proportions of women and men at different levels of visual impairment in the non-paying and paying categories**

Visual Impairment Level	Female			Male		
	Non-paying	Paying	P	Non-paying	Paying	P
Blind	4563 (10.7%)	1863 (6.4%)	<0.001	3834 (8.8%)	1443 (5.2%)	<0.001
SVI	6412 (15%)	2941 (10.1%)	<0.001	6413 (14.7%)	2710 (9.8%)	<0.001
MVI	27800 (65%)	19388 (66.5%)	<0.001	27834 (64%)	17952 (65.1%)	0.011
Mild	3972 (9.3%)	4959 (17%)	<0.001	5402 (12.4%)	5482 (19.9%)	<0.001
Total	42747 (100%)	29151 (100%)		43483 (100%)	27587 (100%)	<0.001
SVI or Worse (1+2)	10975 (25.7%)	4804 (16.5%)	<0.001	10247 (23.6%)	4153 (15.1%)	<0.001
MVI or Worse (1+2+3)	38775 (90.7%)	24192 (83%)	<0.001	38081 (87.6%)	22105 (80.1%)	<0.001

**Table 4: Number of cataract surgeries in different classes linked to equity dimensions [Original]**

Institution	Total number of surgeries	MVI or Worse	Female	Non-paying	Number of non-paying females with MVI or worse (patients with maximum need)
A	14437	10764 (74.6%)	6739 (46.7%)	11703 (81.1%)	4346 (30.1%)
B	22509	17560 (78%)	11154 (49.6%)	18014 (80%)	7399 (32.9%)
C	106022	94829 (89.4%)	54005 (50.9%)	56513 (53.3%)	27030 (25.5%)
Total	142968	123153 (86.1%)	71898 (50.3%)	86230 (60.3%)	38775 (27.1%)

the districts where a secondary hospital of organization A is located. Although 72% of patients in the non-paying category belonged to the blind, SVI, and MVI preoperative visual acuity categories, the CSC among these categories is less than 75% (lower than the national averages).<sup>[12]</sup> Organization A is targeting services to more non-paying patients with MVI or worse in order to improve CSC to state and national standards. Individual data has been provided in additional documents.

Routine administrative data therefore can be used to monitor and evaluate whether a cataract surgical program is equitable. Equity of cataract services at the organizational level can be defined as the proportion of cataract patients belonging to key categories, including sex, preoperative visual acuity, or capacity to pay among the operated patients. This has been done for the three institutes in our study and was found to vary between 25.5% and 32.9%. Similar institutional analysis can be done for large public health eye hospitals to showcase their impact. If all eye care providers in a region report their cataract cases by these categories, then an equitable CSR (eCSR) can be estimated for a region. This eCSR (as per visual needs alone) would be calculated as a percentage with the number of patients operated with maximum visual needs (MVI or worse) in a year as the numerator and total cataract surgeries in the year as the denominator. This would help in monitoring the proportion of patients among those included in the CSR of the year who are targeted to have an impact on blindness and visual impairment. This could be further refined by including only women with MVI or worse belonging to low socioeconomic status in the numerator, if that data is available from all providers. The national portal, being already used by the service providers to provide numbers, gender, and operated eye visual acuity, could be updated to capture both eye preoperative visual acuity and socioeconomic status. This data could be monitored by respective district blindness control societies. The providers could be directed to provide uniform standardized data or use a standardized validated tool (as decided by experts for the national program for

prevention of blindness and visual impairment, NPCBVI), to report socioeconomic status. A uniform excel template could be developed by NPCBVI for data collection and management by the providers.

A study estimating the percentage of blind people among those operated by an institution over a year has been conducted earlier in Nepal,<sup>[14]</sup> but the equity indicators described in our study have never been reported on a program, state, or national level.

Based on CSC targets, NPCBVI could set state or district targets for eCSRs for preoperative VA levels, by sex and socioeconomic status. Yearly trends could be observed for resetting targets. A low eCSR in a region of low CSC would mean that less proportion of people with visual impairment or blindness are being operated in the general public despite the prevalent need. Reimbursements for surgeries could be linked to providing the necessary data and complying with the targets. As it gets monitored along with CSR, it could motivate outreach services to target patients with higher visual needs and making CSR more impactful. This would also help the programs to achieve the objectives of the GAP to reduce blindness and visual impairment in low-income populations.<sup>[7]</sup>

Our proposed indicator captures the three important variables -paying capacity, gender, and visual needs of the population undergoing cataract surgery. However, the limitation of this indicator is that some of the other factors such as age, education, ethnicity, or area of residence may still need to be incorporated in the future. One limitation of the data used for paying status is that the category of the patients was decided by counselors as per organizational protocols and not based on any validated tool. We recommend standardized tools to be used uniformly at the national level for this purpose.

In some of the patients, additional eye conditions could be contributing to the visual impairment status. However, if these patients have an operable cataract, they should be targeted as patients with maximum visual need. However, if a large

number of such patients (with MVI or worse status) are being operated in a program without cataract contributing to poor vision, that would automatically result in a higher proportion of poor visual outcomes due to poor case selection. These outcomes for all providers could be monitored by NPCBVI.

A key strength of our study is combining data from multiple centers in north India in order to identify common trends and indicators. Although we used retrospective data, the uniform software used by all the centers to collect and store patient data-enabled standardized data extraction. The quality of data available for this study is highlighted by the fact that only 0.2% of the patient records were incomplete and had to be excluded.

## Conclusion

Our study focuses on large community-based eye care institutions in north India. It highlights the importance of utilizing administrative data to analyze the equity of cataract service delivery. Our proposed indicator, eCSR, could be used to target services toward people in greatest need in a region and can supplement the presently used indicators, CSR and CSC, for monitoring cataract programs.

## Ethical review

SCEH Ethics Committee (IRB/2020/sep/57), the SNC Institutional Review Board (SNC/PO/2020-111), as well as the SEH Ethics Committee (SEH/2019-20/639) approved the study.

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## Conflicts of interest

There are no conflicts of interest.

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