Original Article

Cost analysis of pediatric cataract surgery in a tertiary eye care hospital in Western India

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Purpose: To assess the cost of pediatric cataract surgery in a tertiary eye care hospital from a provider's perspective. Methods: Retrospective review of direct costs incurred for pediatric cataract surgery for the financial year April 1, 2018, to March 31, 2019. The cost analysis was done by standard costing methods. The fixed cost included the cost of land, buildings, construction, maintenance, personnel, operation theater (OT), and Out patient department (OPD) equipment. The variable cost included the cost of consumables used during surgery. The indirect costs were not considered. Results: The per-patient fixed facility cost was INR 1.52 ($0.02), maintenance cost was INR 39.06 ($0.55), OPD equipment and consultation were INR 19.64 ($0.28), OT equipment was INR 467.95 ($6.61), the cost for personnel was INR 5,300.33 ($74.92), and the cost of consumables varied between INR 16,418 ($314.44) and INR 22,313 ($397.76), with the choice of intraocular lenses (IOL) being the main determining factor. The net average cost for a pediatric cataract surgery varied between INR 22,246.50 ($314.44) and INR 28,141.50 ($397.76). Conclusion: Pediatric cataract surgeries are cost-intensive. High-volume surgeries and an increase in the number of patients in OPD reduce the fixed facility cost. But there is an overall increase in human resource (HR) and consumable cost owing to economic and technological reforms. However, the impact of operating a child, thereby, increasing his/her blindness-free years probably outweighs the cost and justifies it. High patient inflow, increased number of surgeries, and bulk purchase of consumables help in decreasing the cost.

Key words: Childhood blindness, cost analysis, cost of cataract, pediatric cataract

Childhood blindness (CHB) is a public health concern as global estimates show that there are around 1.42 million children suffering from blindness and 17.52 million children from moderate to severe visual impairment.[1] The current prevalence of blindness in children is known to be around 0.8/1,000.[2,3] The prevalence in the “low-middle-income countries is reported to be as high as 1.5 per 1,000 children” compared to 0.3 per 1,000 in the high-income countries.[4]

A 2016 report suggested that the overall prevalence of childhood and congenital cataract was 0.32 to 22.9/10,000 children and 0.63 to 9.74/10,000, respectively.[4] The incidence was 1.8 to 3.6/10,000 per year.[4] The prevalence of childhood cataract in low-income economies was 0.42–2.05 compared to 0.63–13.6/10,000 in high-income economies.[5,6,7]

An important cause of childhood blindness is cataract, which is defined as any opacity of the crystalline lens of the eye, which decreases the image clarity causing reduced visual acuity and impaired contrast sensitivity. It may be congenital or acquired, unilateral or bilateral, and is mostly treatable.[8]

It presents an enormous problem in terms of human morbidity, economic loss, and social burden. “Childhood blindness is important not just due to the number of children blind but also because the number of years that the surviving child has to live with blindness (blind years lived).”[9] Pediatric cataract surgery differs from adults in requiring experienced surgeons, anterior vitrectomy, anesthetic support, rehabilitation with spectacles, and amblyopia therapy.[10] Technically, cost analysis measures the cost-output relationship, determining the cost incurred as the investment made and how can these be utilized optimally to increase productivity.[11]

This study aims to analyze the cost of pediatric surgery, elaborate on the direct, indirect, variable cost, and cost of surgery per-patient in an eye care hospital. “It will help in making cost projections, consider cost recovery options, program cost efficiency, issues of equity, and priority setting in eye care.”[10]

A similar study was done in 2006–2007.[11] However, considering changes in technology, economic reforms, the social behavior of the population, availability of service centers, a cost analysis study was conducted again to get updated estimates of the cost of pediatric cataract surgery.

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Methods

A retrospective analysis of direct costs incurred for pediatric cataract surgery for the financial year April 1, 2018, to March 31, 2019, was done as per the Indian convention and adhered to the Helsinki protocol guideline. Approval from the hospital ethics committee was taken. Patient consent was not needed as there was no interaction with them for sensitive information.

“Cost is defined as the value of resources used to produce a quantifiable service.”[12] In simpler terms, “it is the amount of money spent on the resources to provide a service.” The detailed cost analysis was done by the standard costing method.[13,14] Cost is broadly categorized as direct and indirect costs. Direct cost is the price directly tied to the production of service. It can be of fixed and variable types. Indirect costs are expenses unrelated to the production of a service.[15]

Fixed cost is the expense incurred by an organization, irrespective of business activity.[15] It can be capital and recurrent costs. Capital costs are for resources that last for more than a year. They are one-time expenses incurred on the purchase of land, buildings, construction, and equipment used in the production of goods or services.[18] Recurrent costs are for resources that require purchase at regular intervals.[19]

Capital costs in our study were construction and equipment. The construction was presumed to have a shelf life of 20 years.[18] Their annual cost is calculated by dividing the capital cost by the approximate shelf life.

We have included the cost of the equipment with a unit price of more than $100.[10] The equipment in the pediatric outpatient department (OPD) were two -slit-lamps, two chair units, one auto refractometer, one trial set lenses with frames, one retinoscope, two direct ophthalmoscopes, one 90 D, one indirect ophthalmoscope with 20 D, one Teller Acuity Chart, one set of Cardiff’s cards, one set of Cambridge charts, one set of Lea Grating Paddles, two Snellen’s chart, one TNO Stereopsis test, one prism bar, one loose prism set, and one A-B scan ultrasonography machine. The operation theater (OT) had two motorized operating tables, two operating microscopes, ten cataract sets, one phacoemulsification machine, two Boyle’s apparatus, ten oxygen cylinders, one pulse oximeter, one suction machine and one anesthesia resuscitation equipment, one stethoscope, and one sphygmomanometer. These were used for all cases done under general anesthesia, including other paid procedures. There are two sets of instruments, specifically used for pediatric cataracts and squints. The cost of purchase of equipment was considered with a shelf life of 7 years for OPD and 5 years for OT. The annual cost of equipment in OPD and OT was divided by the total number of patients examined in the OPD and the number of surgeries conducted in the OT, to arrive at the cost per-patient in OPD and OT, respectively.

The recurrent cost in our study includes the cost of doctors, assistants, technicians, health care workers, maintenance including telephone, electricity, water, vehicle, and repair. Two pediatric ophthalmologists along with two fellows provide specialized care to children in the OPD. Of the 25 working days in the hospital, they spend 8 days in the cataract and squint surgeries and 17 days in the OPD, every month. Thus, they spend 32% of their time on pediatric surgeries and 68% time in the OPD facility. Their remuneration was calculated as per their time devoted toward cataract surgery and OPD patients.

In the OPD, one orthoptist, one optometrist, one counselor, one attendant, and one pediatrician provide full-time pediatric eye care. Their annual salary along with the proportion of the salary of the ophthalmologist toward OPD care was divided by the total number of patients seen in the OPD to get the per-patient OPD consultation fee.

All pediatric cases are done under general anesthesia (GA) and there is a team that works part-time for the same in the OT. It includes one anesthetist and his assistant, two OT assistants spending 25% time toward pediatric care, and two nurses spending 50% time and two OT assistants spending 25% time. This total salary combined with the proportion of salary of the ophthalmologist toward pediatric surgical care was divided by the total number of surgeries done in the year to get per-patient OT human resource (HR) cost.

As for the maintenance cost of the hospital, the total expenditure in the financial year 18–19 was divided by the total number of patients attending the facility to get the per-patient maintenance cost.

The variable cost varies depending on the number of products or services used.[15] The variable cost for surgeries includes the cost of irrigating solutions, keratomes, viscoelastic, suture materials, anesthetic gases or drugs, intraocular lenses (IOL), anterior vitrectomy 23-gauge cutter, eyepatch, dark glasses, intra-cath (intravenous cannula), lab investigations, medicines, and some miscellaneous items. Hence, we have considered a minimum and maximum cost for these to assess the variability. All patients under 14 years were done under GA, and those between 14 and 16 years were done under local anesthesia with sedation. The cost of anesthetic gases was considered per case. We used the Microsoft Excel software to tabulate the cost of all factors, including the time spent on each.

The hospital follows a strict protocol for pediatric cataract surgeries, with phacoemulsification, peripheral button hole iridectomy, posterior capsulotomy with anterior vitrectomy (children up to 6 years of age, older uncooperative children), and suture application for wound closure in all cases. Acrylic hydrophobic foldable IOL are used in all pediatric cases more than 18 months and in unilateral cases after the age of 9 months. All require hospital admission for a day after surgery.

Cost for travel, food, lodging, spectacles, and further visits are indirect costs, borne by the patient, and have not been included.

Results

The cost of construction of the pediatric department was INR 36,30,000. The total area of the eye hospital was 2,000 square feet (sq. ft), with INR 1,500 being the unit cost per square foot, amounting to INR 30,00,000. The area for pediatric outpatient and in-patient department was 20% — the cost came to INR 6,00,000. Assuming the shelf life of this property to be 20 years, the per annum (pa) cost comes to INR 30,000 per annum and with 19,723 children attending this setup, the cost of land per-patient was INR 1.52.

The total fixed cost of equipment in the pediatric OPD was INR 27,11,547 [as in Table 1]. Considering, shelf life of 7 years, the per annum cost was INR 5,87,363.86 and the per-patient cost
of equipment in the OPD was INR 19.64. The equipment in the OT was used for all the cases done under GA and a few adult paid surgeries. The total cost of the OT equipment was INR 95,00,277. Assuming the shelf life of this equipment to be 5 years, the per annum cost was INR 19,00,055.40. The total surgeries performed were 4,797 and the per surgery equipment cost was INR 396.09 [as in Table 2]. Two sets of instruments (cataract sets) are used exclusively for pediatric eye surgeries which cost INR 1,20,000. With a shelf life of 5 years, the per year cost was INR 24,000. This was divided by 334 pediatric surgeries conducted to get per surgery equipment cost of INR 71.85 [as in Table 3]. Thus, the total per surgery OT equipment cost was INR 467.95.

The total annual cost of HR was INR 63,25,569. The annual salary of the OPD staff along with the proportion of the salary of the pediatric ophthalmologist toward OPD care was considered and the annual HR cost in OPD was INR 46,33,738. This was divided by 19,723, (total pediatric patients seen) and the per-patient OPD HR cost was INR 234.94. The remuneration of the OT staff was also considered by the time devoted toward pediatric care and the annual OT HR cost was INR 16,91,841 which was divided by 334 pediatric surgeries to get an HR cost of INR 5,065.39 per surgery. Thus, the total per surgery HR cost was INR 5,300.33.

A minimum and maximum cost of consumables were calculated. Contributors to the variability were viscoelastic and IOL. The choice of IOLs available at the hospital range from INR 1,120 to INR 6,600. The variable cost of surgery was a minimum of INR 16,418 and a maximum of INR 22,313 [as in Table 4].

The total cost of pediatric cataract surgery varied between INR 22,246.50 and INR 28,141.50.

**Discussion**

A cataract is a leading cause of preventable blindness\[6\] and pediatric cataract is a leading cause of avoidable visual disability.\[16\] It accounts for 7.4–15.3% of pediatric blindness and significant preventable disability-adjusted life year (DALY).\[17–19\]

### Table 1: Cost of equipment in the outpatient department (in INR)

| Equipment                        | Number | Price (INR) |
|----------------------------------|--------|-------------|
| Chair units                      | 2      | 2,59,600    |
| Slit-lamps                       | 2      | 6,00,000    |
| Trial frames with lenses         | 1      | 21,697      |
| Teller’s acuity chart            | 1      | 4,20,000    |
| Cardiff’s cards                  | 1      | 50,400      |
| Lea’s chart                      | 1      | 36,960      |
| Cambridge chart                  | 1      | 42,560      |
| Snellen’s visual acuity chart    | 2      | 60,000      |
| TNO Titmus                       | 1      | 60,000      |
| Prism bars                       | 1      | 5,500       |
| Loose prisms                     | 1      | 32,480      |
| Autorefractometer               | 1      | 3,90,000    |
| Retinoscope                      | 1      | 28,000      |
| Ophthalmoscope-direct           | 2      | 42,000      |
| Ophthalmoscope-Indirect (90 D; 20 D) | 1       | 1,17,550   |
| A-B scan                         | 1      | 5,00,000    |
| Keratometer                      | 1      | 44,800      |
| Total                            |        | 27,11,547   |
| Per year cost (considering life for 7 years) | 3,87,363.86 |
| Per-patient cost                 | 19723  | 19.64       |

### Table 2: Cost of operation theater equipment (shared by all surgeries in the OT) per surgery (in INR)

| Equipment                        | Number | Price (INR) |
|----------------------------------|--------|-------------|
| Operating microscope             | 2      | 44,00,000   |
| Phaco machines                   | 1      | 43,22,502   |
| Anesthesia work station          | 1      | 1,25,000    |
| Motorized operation table        | 2      | 90,000      |
| Boyle’s apparatus                | 2      | 10,000      |
| Suction machine                  | 1      | 20,000      |
| Pulse oximeter                   | 1      | 4,00,000    |
| Oxygen cylinder                  | 10     | 1,30,000    |
| BP machine                       | 1      | 2,200       |
| Stethoscope                      | 1      | 575         |
| Total                            |        | 95,00,277   |
| Per year cost (considering 5 years shelf-life) | 19,00,055.40 |
| Per surgery cost                 | 4797 surgeries done | 396.09 |

### Table 3: Cost of cataract sets and equipment used exclusively for pediatric surgery (in INR)

| Equipment                        | Number | Price (INR) |
|----------------------------------|--------|-------------|
| Cataract set and equipment       | 2      | 1,20,000    |
| Per year cost                    |        | 24,000      |
| Per surgery cost                 | 334 surgeries done | 71.85 |

### Table 4: Cost of consumables per surgery (in INR)

| Item                             | Minimum | Maximum |
|----------------------------------|---------|---------|
| Drapes                           | 25      | 25      |
| Irrigating solutions             | 40      | 40      |
| Keratomes                        | 80      | 80      |
| Viscoelastics                    | 33      | 448     |
| Vitrectomy                       | 6,350   | 6,350   |
| IOL                              | 1,120   | 6,600   |
| Suture 10-0 MFN                  | 557     | 557     |
| Suture 10-0 vicryl               | 769     | 769     |
| Anesthetic gases                 | 6,160   | 6,160   |
| Eyepatch                         | 21      | 21      |
| Laboratory/Investigations        | 100     | 100     |
| Dark glasses                     | 11      | 11      |
However, Pediatric eye care is a demanding job, in terms of time, expertise, and finance.\textsuperscript{[20]}

Pediatric cataract surgery differs from adults in requiring experienced surgeons, vitrectomy, rehabilitation with spectacles, amblyopia therapy,\textsuperscript{[9]} additional anesthetic gases, equipment, expertise, and has an increased risk of surgery.

In adults, 80% causes of blindness are either preventable or treatable, whereas in children, “less than 50% of the causes are avoidable” and cataract is one of the avoidable causes of blindness among children.\textsuperscript{[21]} Cataract surgery in adults can decrease blindness in a person by at least 5 years and that in children by up to 50 years.\textsuperscript{[17]}

Studies have concluded adult cataract surgery to be a very cost-effective intervention by decreasing the DALY\textsuperscript{[14,24]} and decreasing the number of blind years lived.\textsuperscript{[8]} But similar studies for pediatric cataract surgeries are few.\textsuperscript{[23]}

Such studies are needed to analyze the investments made to provide this service and ensure optimal usage for maximizing the benefits. They will help in budgeting, making cost projections, fund generation, channelization, generate recovery options, and cost-effective programs to ensure financial sustainability. Revenue generation is paramount importance for the long-term survival of the hospital or institution.\textsuperscript{[4,9,22]}

The per-patient fixed facility cost was INR 1,52, maintenance cost INR 39.06, OPD equipment and consultation was INR 19.64, OT equipment was INR 467.95, the cost for personnel INR 5,300.33, and cost of consumables varied between INR 16,418 and INR 22,313, with the choice of IOL being the main determining factor. The net average cost for a pediatric cataract surgery varied between INR 22,246.50 ($314.44) and INR 28,141.50 ($397.76). Gogate et al.,\textsuperscript{[10]} in 2006–2007, calculated that the average direct costs for consultation, equipment, and building were INR 675, and in our study, it was INR 489.11. The fixed facility maintenance cost was INR 145 in 2006–2007, whereas INR 39.06 in 2018–2019. This decrease was due to an increase in the in-patient inflow of 19,723, compared to 6,441 previously.

The personnel cost for adult cataract surgeries was found to be $10 less than that for pediatric surgeries.\textsuperscript{[24,25]} However, pediatric care demands more time for workup, follow-up, amblyopia therapy, refractive correction, anesthetic requirement, postoperative care in the recovery room, and management of complications. All these, with the increased patient inflow, led to an increase in the workforce in the OPD and OT.

In the study by Gogate et al.,\textsuperscript{[10]} in 2006–2007, the per surgery cost of personnel was INR 2,427, and in our study was INR 5,300.33. This is because of the increase in HR and the cost of human resources.

The cost of consumables in our study varied from INR 16,418 to INR 22,313; whereas, in the 2006–2007 study, it was INR 1,452 to INR 15,267. This is due to the current use of disposable consumables. A standard set of consumables is used, irrespective of the package chosen to keep in mind the sensitivity and longevity of this age group. It has been observed in a few studies that single-use disposable cutters are used as they have increased efficiency and decreased risk of cross-contamination, as compared to reusable cutters, where wear and tear seem to be problematic even after careful handling.\textsuperscript{[26]}

With the advances in anesthetic care, the cost of anesthetic gases today is INR 2,500, which previously was INR 218 to INR 1,900.\textsuperscript{[28]} Sevoflurane, an expensive inhalational anesthetic agent for induction, is of choice over halothane,\textsuperscript{[27]} due to its potential to maintain the heart rate, lack of airway irritation, and faster recovery.\textsuperscript{[28]}

Our center uses LMA (laryngeal mask airways) and not endotracheal tubes (ET) as they are easier to insert, have fewer changes in hemodynamic factors, and have decreased incidence of postoperative complications—bronchospasm, laryngospasm, and soft tissue trauma.\textsuperscript{[29]} They are preferred for positive pressure ventilation in children,\textsuperscript{[29]} and those with upper respiratory tract infections.\textsuperscript{[29]}

The price of viscoelastic varied from INR 33 to INR 448 compared to the previous INR 48 and INR 1,750\textsuperscript{[10]} depending upon whether Indian-made hydroxy-propyl-methyl-cellulose (HPMC) or the USA-made sodium hyaluronate (Healon GV). The latter has a surgical advantage in children, but incomplete removal is associated with a higher incidence of postoperative glaucoma requiring close follow-up.\textsuperscript{[31]}

With recent advances, the choice of IOLs available to patients has significantly increased. As a standard practice, only foldable hydrophobic acrylic IOL are used in the tertiary eye care hospital considered in this study. The cost of IOL ranges from INR 1,120 to 6,600.

Results show that the cost of cataract surgery in children is higher than in adults. The average cost in adults varies from (depending on the choice of the lens) $41.82 to $125.02.\textsuperscript{[29]} A study by Gogate et al.\textsuperscript{[25]} in 2007, showed the average cost of phacoemulsification surgery in India to be INR 1,978.89 ($42.10) and for SICS (small-incision cataract surgery) INR 720.99 ($15.34). A 2014 study by Evans et al.\textsuperscript{[27]} showed that the service provided cost $340 but the average charge was $117.

The average cost of pediatric cataract surgery in the 2006–2007 study by Gogate et al. was INR 4,722 ($122) to INR 18,537 ($475), and in our study, it is minimum INR 22,246.50 ($314.44) and maximum INR 28,141.50 ($397.76). This significant difference is due to the increased HR and consumable cost (choice of IOL being the largest variable) owing to economic reforms and changes in technology and the current use of strictly disposable consumables.

Cost analysis gives the cost of a surgical procedure. However, it is important to understand the cost-effectiveness. The impact of cataract surgeries can be measured in terms of DALY.

DALYs for a disease or health condition are calculated as the sum of the Years of Life Lost (YLL) due to premature mortality in the population and the Years Lost due to Disability (YLD) for people living with the health condition or its consequences. One DALY can be thought of as one lost year of a “healthy” life.\textsuperscript{[30]} Cataract surgeries account for better living in terms of decreased disability-adjusted life years.\textsuperscript{[19]} It restores vision, improves social standards, boosts confidence, provides better job opportunities, and uplifts the socioeconomic condition of
the person. The DALY loss in a blind child is greater than in blind adults owing to more number of years to live.[3]

High-volume surgeries, bulk purchase of consumables, increase in the number of patients in the OPD, and surgeries reduce the fixed facility cost incurred.[14,20] The results of this study are in a setting with a high inflow of pediatric patients, hence, comparisons with those where patient turnout is low, should be done with caution.

**Conclusion**

Pediatric cataract surgeries are cost-intensive. However, the impact of operating a child, thereby, increasing his/her blindness-free years, probably outweighs the cost and justifies it. High patient inflow, increased number of surgeries, and bulk purchase of consumables help in decreasing the cost.

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**Conflicts of interest**

There are no conflicts of interest.

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