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A continuous improvement approach for cataract surgery outcomes based on internal benchmarking

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Abstract

Objective: We aim to assess the effectiveness of a cataract surgery outcome monitoring tool used for continuous quality improvement. The objectives are to study: 1) the quality parameters, 2) the monitoring process followed and 3) the impact on outcomes.

Design and procedure: In this retrospective observational study we evaluated a quality improvement method which has been practiced at the focal institution since 2012: internal benchmarking of cataract surgery outcomes (CATQA). We evaluated quality parameters, procedures followed, and clinical outcomes. We created tables and line charts to examine trends in key outcomes.

Setting: Aravind Eye Care System, India

Participants: Phacoemulsification surgeries performed on 718,120 eyes at 10 centres (five tertiary and five secondary eye centres) from 2012 to 2020 were included.

Interventions: An internal benchmarking of surgery outcome parameters, to assess variations among the hospitals and compare with the best hospital.

Primary and secondary outcome measures: Intraoperative complications, unaided visual acuity at post-operative follow-up visit and residual post-operative refractive error (within ± 0.5D).

Results: Over the study period the intraoperative complication rate decreased from 1.2% to 0.6%, surgeries with uncorrected visual acuity of 6/12 or better increased from 80.8% to 89.8%, and surgeries with postoperative refractive error within ± 0.5D increased from 76.3% to 87.3%. Variability in outcome measures across hospitals declined. Additionally, benchmarking was associated with improvements in facilities, protocols, and processes.

Conclusion: Internal benchmarking was found to be an effective quality improvement method that enabled the practice of evidence-based management and allowed for harnessing the available information. Continuous improvement in clinical outcomes requires systematic and regular review of results, identifying gaps between hospitals, comparisons with the best hospital, and implementing lessons learned from peers.

Strengths and Limitations of the study

- The study is based on comprehensive data of eye hospitals that have been benchmarking outcomes for continuous improvement for the past decade.
- Relatively complete data on all factors that influence quality of surgical outcomes were gathered and included in this study.
- Although the process is based on eye hospitals, it can be applied usefully to other clinical disciplines.

- Benchmarking results must be interpreted carefully, considering inclusion and exclusion criteria followed by hospitals and the definitions of outcome variables.
- The change management process that was followed for improvement is not discussed in detail in this study.

Keywords: Benchmarking, quality improvement method, internal benchmarking, continuous improvement

INTRODUCTION

Quality healthcare increases the likelihood of desirable health outcomes. High quality of health care services is essential to create trust(1) and increase demand.(2,3) Delivering quality healthcare services is also important for Universal Health Coverage.(1) Further, intensifying competition in healthcare markets(4) is increasing pressure on providers to deliver high quality, cost-effective and patient-centred care.(5)

In the context of eye health, cataract is the leading cause of blindness in the world, accounting for 45.5% of all blindness, and the second leading cause of moderate to severe visual impairment. (6) The success of cataract surgery is generally equated to achieving a threshold level of postoperative best corrected distance visual acuity (BCVA). However, significant concerns remain about quality of surgical outcomes, especially in developing countries.(7) For instance, a summary (8) of eight population-based studies in sub-Saharan Africa reports that the percentage of eyes with "good" vision, defined by the World Health Organization (WHO)(9) as postoperative visual acuity (VA) ≥ 6/18, ranged from 23 to 59 percent compared to the recommended level of 90%. The same summary also reports that the percentage of eyes that had "poor" vision (WHO definition is postoperative VA < 6/60) after surgery ranged from 23 to 64 percent compared to the recommend level of <5%.

The use of health information systems that enable evidence-based management is a critical foundational element to deliver quality healthcare services.(1) Measurement and reporting of outcomes is crucial for a hospital to learn and improve care over time.

Problem

The Aravind Eye Care System (Aravind) is a network of fourteen specialty eye-care hospitals in Southern India. In 2019-20, Aravind hospitals served over 4.6 million outpatient visits and performed 515,000 treatment procedures including 317,500 cataract surgeries. A third of the cataract surgeries are performed on patients brought in as part of outreach programs. These programs are conducted in remote areas, primarily on weekends. Being a post-graduate training and research institute, a significant number of cataract surgeries are performed by senior post-graduate students (15%) and post-graduate fellows (25%) who are undergoing specialization training. The volume of surgeries performed by each surgeon varies from 250 to 3,500 a year. Moreover, as a referral centre, a tertiary centre treats patients with advanced conditions and comorbidities referred by its satellite centres and other eye care providers. Considering all these factors, Continuous Quality Improvement is critical to ensure that outcomes are not compromised.

In 1999, Aravind began using its own software tool to track quality parameters and improve cataract surgery outcomes. While each hospital in the network was able to generate reports and improve outcomes, a casual comparison of outcomes across hospitals revealed a significant difference; this prompted the need for further actions for improvement.

While measuring outcomes that report the current status is necessary, comparing outcomes with peers both inside and outside the organization helps to identify variations and hence generate

opportunities to improve outcomes.(4) Continuous quality improvement (CQI) is practiced in hospitals by leveraging variability to optimize clinical care, reduce costs, and enhance customer service quality.(10) A systematic review of quality improvement (QI) methods(11) for health outcomes identified six commonly used methods: benchmarking, collaborative care model, chronic care model, Information Technology (IT) driven interventions, plan-do-check-act, and learning and leadership collaborative.

Rationale

QI is not a one-time event. What is a standard of excellence today may be the expected minimum norm of tomorrow. For instance, in 2021 the World Health Organization (WHO) revised the visual acuity threshold for a good visual outcome following cataract surgery to 6/12 or better from the previous norm of 6/18 or better.(12) Therefore, improvement should be an ongoing process, and benchmarking should be considered one part of that process.(13) A hospital can benchmark against itself by measuring variation in outcomes and tracking over time using control charts.(14) Understanding the variation and its cause and taking appropriate actions would help to raise the bar and improve the outcome.(14)

Benchmarking involves ascertaining the gap in our performance compared with the best performing organizations. It provides an opportunity to learn new working methods and practices from others, and subsequently adapting and adopting appropriate practices in our settings.(13) Existing literature primarily focuses on developing benchmarks(15–17) as a one-time exercise(11,18,19), and comparing with published reports.(20) Benchmarking is often described as comparing measurements in a limited time frame, but it also emphasizes gathering indicators over the long term, making this a real CQI approach.(21)

To exploit the opportunities of benchmarking in improving quality, Aravind upgraded the CATQA platform as a benchmarking tool in 2011, thus allowing hospitals and surgeons to compare themselves against each other and against the best performer within the Aravind network. This initiative aimed to narrow the variation between hospitals and between surgeons, so that quality of care could be improved across the system in a standard, consistent, and continuous manner.

Benchmarking has been discussed in a variety of disciplines; however, there has been little research on continuous quality improvement in the healthcare sector. A successful implementation of QI initiatives involves several factors that have been discussed.(22–25) The objective of this study was to present and evaluate an internal benchmarking system whose goal is to improve quality of outcomes of cataract surgery in the network of eye hospitals of the Aravind Eye Care System (AECS).

METHODS

Design

We conducted a longitudinal retrospective observational study to evaluate the quality improvement method practiced in a network of hospitals of AECS, India.

Patient and Public involvement

Patients and the public were not involved in the design, conduct, reporting or dissemination of plans of our research.

Setting

AECS was established in 1976 in Madurai, India and currently has a network of 7 tertiary, 7 secondary, 6 community and 101 primary eye care centres across Tamil Nadu, Andhra Pradesh and Pondicherry states in India. Since its inception, AECS has been serving over half of its patients at deeply subsidized prices or for free. Online hospital management system (HMS) was implemented in 1991 to automate the patient care functions, capture necessary data, and make the information available for real-time monitoring, planning and decision-making. eyeNotes, a comprehensive electronic medical record (EMR) system was introduced in 2016. It was developed by AECS's in-house information technology team, using Microsoft (MS) technology (asp.net) and Google Angular for frontend with MS SQL server 2016 database at the backend. HTML, MS SQL server reporting services and Google chart for reports and dashboards

Intervention

Introduction of benchmarking

In 2011, Aravind's internal IT team developed the Cataract Outcome Monitoring System (CATQA) and deployed it into the cloud. Benchmarking parameters for this study were selected from existing outcome monitoring variables and some additional variables were included to make the system more comprehensive. The data can be uploaded using Microsoft Excel files, which are populated with information extracted from hospital management systems and electronic medical records.

Quality parameters selected for benchmarking

Benchmarking is done for a number of outcome variables, with the option of filtering the outputs either individually or combined across factors that affect outcomes. Details of the parameters and filters included for benchmarking are shown in Table-1.

Table-1: List of outcome variables and variables to filter the outputs.

Sl.no	Quality parameters (Facts)	Description of the parameter
1	Pre-operative uncorrected visual acuity in operated eye (<6/60)	To measure the proportion of patients with poor pre-operative visual acuity
2	Cataract diagnosis in operated eye	To measure the proportion of patients with advanced conditions of cataract (Mature cataract, hyper mature etc.) who underwent surgery
3	Surgical procedure	Phacoemulsification (Phaco), manual small incision (SICS), extra-capsular extraction (ECCE), femto Laser assisted (FLACS), and others
4	Anaesthesia	General, local or topical anaesthesia

5	Anaesthesia complications	These include the multitude of ocular or systemic complications that could occur during or after administration of local injectable or topical anaesthesia.
6	Intra-operative complications	Complications occurring during the surgery
7	Post-operative complications	Post-operative complication noted a few hours after surgery or on first post-operative day
8	Re-surgeries	Procedures performed to manage complications occurring intra-operatively or post-operatively (immediately or later, but within six months) to enhance the outcome of surgery.
9	Immediate post-operative (Day-1 or discharge) pinhole visual acuity	Visual acuity measured at the time of discharge (or day after surgery for day-care patients)
10	Post-operative follow-up visit (2 to 8 weeks)	Whether patient was examined 2 to 8 weeks after cataract surgery
11	Complications at follow-up	Complications developed after discharge and found during the follow-up examination
12	Uncorrected distance visual acuity at follow-up visit	Uncorrected distance visual acuity in the operated eye
13	Best corrected distance visual acuity at follow-up visit	Best corrected distance visual acuity in the operated eye
14	Spherical equivalent	Spherical + 0.5 (Cylinder value) of refraction
15	Infection	Patient is identified with endophthalmitis
16	Culture test	Result of the culture test
17	Visual recovery post infection treated	Vision acuity after managing the infection

Sl.no	**Filter options (Dimensions)**	**Description of filters**
1	Period	Duration of report
2	Patient source	Paying, free (walk-in), outreach
3	Surgical procedure	Phaco, SICS, ECCE, others
4	Lens type	PMMA (polymethyl methacrylate), acrylic, aspheric, toric, multifocal etc.
5	Surgeon type	Medical officer/consultants, fellows, residents, trainees
6	Surgeon	Name of the surgeon
7	Surgery volume	Number of cataract surgeries performed by a surgeon in a year

Several factors that have not been measured, measured inadequately, or are mis-specified, such as surgeons' skill, clinical protocol, patient selection, data definition, and data source, can confound the outcome of cataract surgery.(26) Therefore, all relevant variables as well as details of all patients who have undergone cataract surgery are included in Aravind's benchmarking platform. Across the system the surgeon mix has been maintained consistently. All hospitals used standardized protocols and forms for recording findings. With these measures, the risks associated with uneven collection and definition of data, and the chance of including patients selectively are reduced.

The continuous outcomes monitoring and improvement process

The following processes are used in all AECS hospitals. The process flow is given in Figure-1.

Data extraction and uploading: Data from electronic medical records is extracted and uploaded twice per surgery into the benchmarking platform. Data up to the point of discharge is extracted during the first week following surgery. A second extraction is performed at the beginning of the eighth week following surgery to ensure that all data has been included for patients who have returned to the clinic for routine follow-up within 49 days after surgery.

Data verification: After uploading the data, a summary report that gives counts of all the variables is generated in the benchmarking platform which is cross verified by the respective hospital with their own reports. In the event of discrepancies in the counts of any variable, a detailed checklist of patients is generated and verified against the electronic medical record database. Each data set is verified and approved by the personnel who generate it; for instance, data on intraoperative complications is generated by staff at the operating theatres and data on postoperative complications by staff at the ward or outpatient clinic.

Data processing for benchmarking of quality parameters: Once the data is uploaded and verified, an internal software routine processes the data to generate summary reports for various parameters (facts) and filters (dimensions); this is referred to as building a data mart (warehousing). In the event of data being uploaded again for the same period for any reason, the process is repeated. This process enables users to access reports in less than a minute.

Communication email: After completing the data processing, an email (Supplementary Figure-1) with the surgery results is sent to each surgeon who performed surgery during a given month. This report includes surgery volume, complication rate, and uncorrected and best-corrected visual outcomes on the follow-up visit. A hyperlink is included in this communication to access complete benchmark performance details, which allows a surgeon to compare their own outcome with either all the other surgeons or with the respective peer group, i.e., a post-graduate can compare the scores with all the surgeons or only with post-graduates. The trend chart (Supplementary Figure-2) compares the surgeon's or hospital's performance with the best and average scores over the past six months.

Internal review meetings: The head of the cataract clinic meets weekly with surgeons, especially those who have had complications during surgery, as well as operating room, ward and outpatient clinic nurses. In these meetings, medical records of patients with complications are reviewed. A monthly meeting is also held with surgeons, operating room nurses, ward nurses, biometry staff, and key staff from outpatient clinics. A monthly meeting agenda typically includes the confirmation of minutes of the last meeting, the status of action taken on the minutes, a review of quality parameters for the hospital, and benchmark reports of complications, visual outcome, spherical equivalent, and infection rates for the entire hospital.

Sharing of better practices: The gaps identified from the benchmarking reports are discussed at the monthly meeting as well as at the weekly meeting of cataract clinic heads from all the centres. Factors contributing to the best-performing hospitals are discussed. In order to implement necessary changes

the Director of Quality conducts a detailed review of the protocol, facilities, etc. if the variation persists or is present at multiple sites.

Follow-up on the intended improvements: The implementation plans are developed in accordance with inputs received and needs at each hospital. During the internal meeting, the status of the plans is discussed, and the results of the actions are tracked in benchmarking reports.

Measures

The hospital report compares performance of the focal hospital with the overall average of all the hospitals and the best performing hospital on the key outcomes shown below. (Supplementary Figure-3). The surgeon level outcome report follows the same format.

Preoperative conditions:	% of eyes with advanced cataracts, % of eyes with poor vision
Adverse events:	% of eyes with intraoperative and postoperative complications
Visual outcome:	Following WHO classification, visual acuity groups were created. The following measure of visual acuity are used. - Pinhole visual acuity at discharge or immediate next post-operative day, - Uncorrected and best-corrected visual outcome at follow-up visit between 7 and 49 days after surgery
Accuracy of Biometry:	% of surgeries within± 0.5 spherical equivalent (Spherical+ (0.5*Cylinder))
Infection:	% of endophthalmitis per 10,000 surgeries

Report writing

We used the SQUIRE guidelines to present this quality improvement report.

Data Analysis

Excel was used to create a comparative report across hospitals and calculate average, standard deviation (SD) and coefficient of variation, for the selected outcome variables.

RESULTS

For the complete study period of 2012 to 2020, data were available for ten eye hospitals, which performed 718,120 phacoemulsification cataract surgeries. To evaluate the effectiveness of internal benchmarking, we selected the following outcome variables to present in this study: intraoperative complications, unaided visual acuity, and residual post-operative refractive error at the postoperative follow-up visit. We analysed the trends in these three key outcomes variables.

Intraoperative complications

Intraoperative complication is one of the most important factors affecting the visual outcome of cataract surgery. Additionally, it is often a predictor of postoperative complications. Managing high-risk cases by assigning a surgeon with the right level of experience could reduce the likelihood of complications, although they can never be completely eliminated.(27) Results of a comparative analysis of intraoperative complications are presented in Figure-2. The average complication rate across hospitals reduced by half from 1.2% in 2012 to 0.6% in 2020. The standard deviation (SD) across hospitals also showed a declining trend indicating reduced variability. Nevertheless, the coefficient of variation (CV) increased over the study period because the average declined faster than the SD.

Unaided visual acuity at post-operative follow-up visit

Good unaided visual outcomes are more likely to be achieved in surgeries without complications and with accurate biometric measurements. Figure-3 shows percentage of patients who gained 6/12 vision or better without correction. On average all study hospitals improved in terms of this outcome measure over the study period. Further, both the SD and CV showed declining trends indicating reduced variability.

Residual post-operative refractive error (within ± 0.5D)

Postoperative refractive error is caused by inaccurate biometric measurements or using the wrong intraocular lens (IOL) power during surgery. Figure-4 shows the percentage of surgeries within ± 0.5D refractive error (without adjusting target refraction). The positive trend in the average is consistent with the improvement in accuracy of biometry in recent years. Moreover, both the SD and CV showed declining trends indicating reduced variability across hospitals.

Note that COVID19 lockdowns in 2020 resulted in a larger fraction of patients with advanced conditions being operated on, which led to more variability in all three outcome measures.

Besides clinical outcomes, internal benchmarking has also resulted in improvement in processes, inputs and resources. The following are examples of the significant changes that were introduced in processes and resources due to benchmarking.

- *Standardization of refraction:* This was achieved by fixing the correct distance for refraction, upgrading refraction charts with self-illuminated charts, and refining protocols on measuring post-operative patients by introducing a time gap after removing the eye pad and encouraging patients to read as many letters as possible. These changes were implemented both at the base hospitals and at outreach sites.

- *Design improvements for intraocular lenses*: The system detected variations in post-operative visual outcome and related them to a specific IOL model. As a result of the evidence obtained, the IOL manufacturing firm diagnosed the problem as using the wrong A-constant which they subsequently corrected.

- *Biometry equipment upgrade:* This upgrade made it easier for technicians to interact with patients and ensure the measurements were accurate.

- *Strengthen post-operative counselling:* Patients with poor visual outcomes upon discharge were counselled again about the importance of a follow-up visit.

Discussion:

Continuous improvement requires a commitment to learning from a structured and evidence-based approach to managing, taking into account one's own experience as well as others' best practices.(28)

In our analysis of outcomes from cataract surgeries over the nine-year study period, we found significant improvements in all quality parameters. The study hospitals' performance and outcomes improved across the board. The percentage of patients with good visual outcomes was better than WHO guidelines.(9) In addition, the percentage of complications was lower than the percentage reported by hospitals in developed countries.(29–31) Moreover, residual post-operative refractive error was reduced and remained well within acceptable limits. A noteworthy finding was the reduced variation and greater consistency in outcomes across hospitals over time, as expected with CQI and aided by internal benchmarking.

Internal benchmarking establishes performance standards within an organization.(32) It demonstrates successes within a hospital's own culture and environment, establishes a communication channel and network for highlighting and sharing improvements and innovations, and stimulates internal competition. It is faster and less complex than external benchmarking. It does not present the challenge of obtaining confidential data; further, internal partners often use a common or similar database and employ uniform definitions of variables. Internal benchmarking is significantly less expensive compared to external benchmarking. Furthermore, it is often the starting point for all benchmarking processes since it is essential to know about internal business processes, services, or products before embarking on an external benchmarking exercise.(33) Using external benchmarks makes sense only when we have access to the details of the process involved in achieving a better outcome, so that a hospital can adopt them and improve the outcomes.

AECS implemented a number of strategies to achieve these improvements besides implementing a benchmarking platform: standardized clinical protocols, simplified forms for data collection, creation of a data quality team, implementation of an EMR to record data in real-time, development of a data warehouse and benchmarking platform, making information easily accessible to the right people, monthly email to individual surgeons with outcome summary, performing systematic reviews to identify gaps and opportunities for improvement, and implementing improvements. These strategies were developed at different times primarily based on monitoring results.

Quality improvement is a journey that requires continuous feedback to ensure alignment. Monitoring surgical performance is an important tool to assess trainee progress, explain poor surgical outcomes, refine protocols and strengthen training.(34–37) Internal learnings can be accepted and implemented more easily since the results are backed by evidence. Following standard protocols and processes is the key to delivering care consistently across the organization and improving efficiency.

Hospital networks, whether government, missionary, or private, have unique opportunities for learning and improving their outcomes through internal benchmarking and also reducing variability within the network. Funding organizations that support hospitals also have the opportunity to encourage such a benchmarking process amongst the hospitals they fund to induce cross-learning for overall improvement.

If learning is what makes a hospital outstanding in its field, benchmarking is a way of sharing the experience of improvements among staff members and creating healthy competition among them. To have the desired effect on performance, Gundmundsson et al. (2005) emphasize that findings of benchmarking must be communicated to stakeholders within the organization. Benchmarking encourages users to identify the root cause of variation. Benchmarking as a tool for continuous improvement at AECS has shown both improvement in outcomes and reduced variation among hospitals.

This study's main strength was the use of comprehensive data of eye hospitals that have been benchmarking outcomes for continuous improvement for the past decade. Even though the process is based on eye hospitals, it can be applied usefully to other clinical disciplines. However, benchmarking results must be interpreted carefully, taking into account inclusion and exclusion criteria followed by hospitals and the definitions of outcome variables. A limitation of this study is that it did not discuss in depth the change management process that was followed for improvement. This will be a subject of further research.

Conclusion:

Benchmarking is a quality improvement method that has proven to be very valuable in operationalizing evidence-based management. Internal benchmarking allows hospitals to learn from their peers inside the organization. Analysing the root cause for variation, implementing learnings, and regular monitoring ensure continuous improvement in outcomes. The practice of internal benchmarking builds the organization's capacity to confidently engage in external benchmarking.

Statements

Author Contributions:

GBS, TR, CW and FVM conceived and designed the study. GBS data acquisition and performed the study. GBS, SG, RR, TR and FVM analysed and interpreted the data. GBS wrote the manuscript. GBS, SG, RR, TR, HM, CW, SVR and FVM reviewed the manuscript. All authors read and approved the manuscript.

Conflict of Interest:

The Author(s) declare(s) that there is no conflict of interest

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Data availability statement:

The data for this study are the reports generated from a database system, which are shared in the results. Surgery level data are available upon request.

Ethical Considerations:

The study was performed with adherence to the tenets of the Declaration of Helsinki. Ethical clearance was obtained from the institutional ethics committee at Aravind Eye Hospital, Madurai.

Patient consent for publication: Not applicable

References

1. World Health Organization, World Bank Group O. Delivering quality health services [Internet]. World Health Organization, World Bank Group, OECD. 2018. 1–100 p. Available from: http://apps.who.int/bookorders.
2. Sahn DE, Younger SD, Genicot G. The demand for health care services in rural Tanzania. Oxf Bull Econ Stat. 2003;65(2):241–60.
3. Tsegay Wellay, Measho Gebrelassie, Molla mesele, Hailay Gebretinsae, Brhane Ayele AT and YZ. Demand for health care service and associated factors among patients in the community of Tsegedie District, Northern Ethiopia. 2018. p. 18:697.
4. The Strategy That Will Fix Health Care [Internet]. [cited 2021 May 30]. Available from: https://hbr.org/2013/10/the-strategy-that-will-fix-health-care
5. Using Health Outcomes Research to Improve Quality of Care | Executive and Continuing Professional Education | Harvard T.H. Chan School of Public Health [Internet]. [cited 2021 Jun 9]. Available from: https://www.hsph.harvard.edu/ecpe/using-health-outcomes-research-to-improve-quality-of-care/
6. Bourne RRA, Steinmetz JD, Saylan M, Mersha AM, Weldemariam AH, Wondmeneh TG, et al. Causes of blindness and vision impairment in 2020 and trends over 30 years, and prevalence of avoidable blindness in relation to VISION 2020: The Right to Sight: An analysis for the Global Burden of Disease Study. Lancet Glob Heal. 2021;9(2):e144–60.
7. Lewallen S, Thulasiraj RD. Global Public Health : An International Journal for Research , Policy and Practice Eliminating cataract blindness – How do we apply lessons from Asia to sub-Saharan Africa ? (October 2014):37–41.
8. Congdon N, Yan X, Lansingh V, Sisay A, Müller A, Chan V, et al. Assessment of cataract surgical outcomes in settings where follow-up is poor: PRECOG, a multicentre observational study. Lancet Glob Heal. 2013;1(1):37–45.
9. WHO Informal Consultation on Analysis of Blindness Prevention Outcomes (1998: Geneva, Switzerland) & WHO Programme for the Prevention of Blindness and Deafness. (1998). Informal Consultation on Analysis of Blindness Prevention Outcomes, Geneva, 16-18 16-18 February 1998. World Health Organization. WHO PBL Geneva, 16-18 February 1998 [Internet]. 1998. p. 23. Available from: https://apps.who.int/iris/handle/10665/67843
10. Health AC. Healthcare Systems: Supporting and Advancing Child Health. Continuous Quality Improvement. J Hosp Med. 2010;91–2.
11. Kampstra NA, Zipfel N, Van Der Nat PB, Westert GP, Van Der Wees PJ, Groenewoud AS. Health outcomes measurement and organizational readiness support quality improvement: a systematic review. [cited 2021 Jun 7]; Available from: https://doi.org/10.1186/s12913-018-3828-9
12. Keel S, Müller A, Block S, Bourne R, Burton MJ, Chatterji S, et al. Keeping an eye on eye care: monitoring progress towards effective coverage. Lancet Glob Heal. 2021;9(10):e1460–4.
13. Kay JFL, Qid M, Uk M, Medicine F. Health Care Benchmarking. 2007;12(2):22–7.
14. Neuhauser D, Provost L, Bergman B. The meaning of variation to healthcare managers , clinical and health-services researchers , and individual patients. BMJ Qual Saf. 2011;(June 2014).
15. Hahn U, Krummenauer F, Kölbl B, Neuhann T, Schayan-Araghi K, Schmickler S, et al.

Determination of valid benchmarks for outcome indicators in cataract surgery: A multicenter, prospective cohort trial. Ophthalmology [Internet]. 2011 Nov [cited 2021 Jun 4];118(11):2105–12. Available from: https://pubmed.ncbi.nlm.nih.gov/21856011/

16. Jaycock P, Johnston RL, Taylor H, Adams M, Tole DM, Galloway P, et al. The Cataract National Dataset electronic multi-centre audit of 55 567 operations: Updating benchmark standards of care in the United Kingdom and internationally. Eye. 2009;23(1):38–49.

17. Nihalani BR, Vander Veen DK. Benchmarks for outcome indicators in pediatric cataract surgery [Internet]. Vol. 31, Eye (Basingstoke). Nature Publishing Group; 2017 [cited 2021 Jun 4]. p. 417–21. Available from: https://pubmed.ncbi.nlm.nih.gov/27813517/

18. Staiger RD, Schwandt H, Puhan MA, Clavien PA. Improving surgical outcomes through benchmarking. Br J Surg. 2019;106(1):59–64.

19. De Korne DF, Sol K, Van Wijngaarden JDH, Van Vliet EJ, Custers T, Cubbon M, et al. Evaluation of an international benchmarking initiative in nine eye hospitals. Health Care Manage Rev. 2010;35(1):23–35.

20. Oyewole K, Tsogkas F, Westcott M, Patra S. Benchmarking cataract surgery outcomes in an ethnically diverse and diabetic population: Final post-operative visual acuity and rates of post-operative cystoid macular oedema. Eye [Internet]. 2017 Dec 1 [cited 2021 Jun 4];31(12):1672–7. Available from: https://pubmed.ncbi.nlm.nih.gov/28643796/

21. Na A, Torchi-Tardy ET, Levif M, Michel P. Benchmarking: A Method for Continuous Quality Improvement in Health Le benchmarking : une méthode d' amélioration continue de la qualité en santé. Vol. 7, HEALTHCARE POLICY. 2012.

22. Kaplan HC, Froehle CM, Cassedy A, Provost LP, Margolis PA. An exploratory analysis of the Model for Understanding Success in Quality. Health Care Manage Rev. 2013;38(4):325–38.

23. Dewan M, Parsons A, Tegtmeyer K, Wenger J, Niles D, Raymond T, et al. Contextual Factors Affecting Implementation of In-hospital Pediatric CPR Quality Improvement Interventions in a Resuscitation Collaborative. Pediatr Qual Saf. 2021;6(5):e455.

24. Griffin A, McKeown A, Viney R, Rich A, Welland T, Gafson I, et al. Revalidation and quality assurance: The application of the MUSIQ framework in independent verification visits to healthcare organisations. BMJ Open. 2017;7(2):1–10.

25. Kaplan HC, Provost LP, Froehle CM, Margolis PA. The model for understanding success in quality (MUSIQ): Building a theory of context in healthcare quality improvement. BMJ Qual Saf. 2012;21(1):13–20.

26. Lovaglio PG. The scientific WorldJOURNAL Benchmarking Strategies for Measuring the Quality of Healthcare : Problems and Prospects. 2012;2012(iii).

27. Yorston D. Cataract complications [Internet]. Vol. 21, Community Eye Health Journal. International Centre for Eye Health; 2008 [cited 2021 Jul 3]. p. 1–3. Available from: www.cehjournal.org

28. David A Gravin. Building a Learning Organization. Harvard Business Review. 1993. p. 6.

29. Day AC, Donachie PHJ, Sparrow JM, Johnston RL. The Royal College of Ophthalmologists ' National Ophthalmology Database study of cataract surgery : report 1 , visual outcomes and complications. 2015;44(December 2014):1–9. Available from: http://dx.doi.org/10.1038/eye.2015.3

30. Jaycock P, Taylor H, Adams M, Galloway P, Canning C, Day AC, et al. The Cataract National

Dataset electronic multi- centre audit of updating benchmark standards of care in the United Kingdom and internationally. 2009;3(December 2014):38–49. Available from: http://dx.doi.org/10.1038/eye.2015.3

31. Barry P, Henry Y. Evidence-based guidelines for cataract surgery : Guidelines based on data in the European Registry of Quality Outcomes for Cataract and Refractive Surgery database. 2012;1086–93.

32. Freytag P V., Hollensen S. The process of benchmarking, benchlearning and benchaction. TQM Mag. 2001;13(1):25–33.

33. Yasin MM, Harris R, Zimmerer TW. The role of benchmarking in achieving continuous service quality. Int J Contemp Hosp Manag. 1995;7(4):27–32.

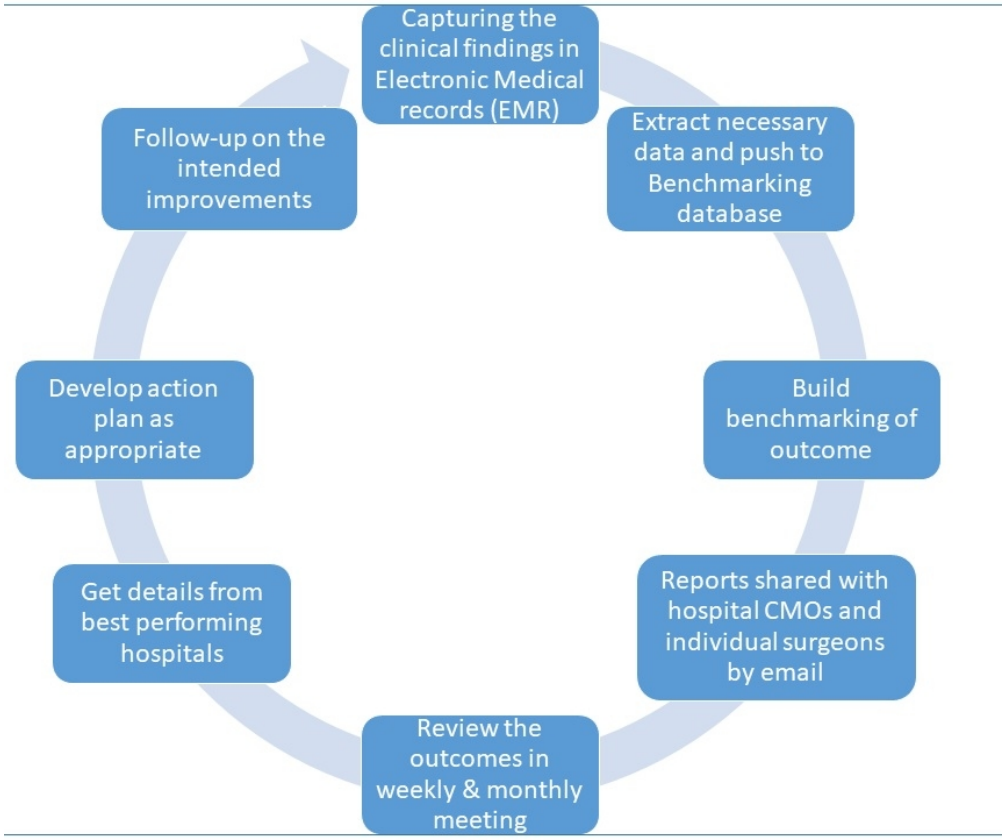
34. Bilgic E, Sc B, Watanabe Y, D M, Mckendy K, D M, et al. Reliable assessment of operative performance. Am J Surg [Internet]. 2015; Available from: http://dx.doi.org/10.1016/j.amjsurg.2015.10.008

35. Angelo ADD, Law KE, Cohen ER. The use of error analysis to assess resident performance. Surgery [Internet]. 158(5):1408–14. Available from: http://dx.doi.org/10.1016/j.surg.2015.04.010

36. Murzi M, Cerillo AG, Gilmanov D, Concistr G. Exploring the learning curve for minimally invasive sutureless aortic valve replacement Data Analysis and Cumulative Sum Analysis. 2016;

37. Collins GS, Jibawi A, Mcculloch P. Control chart methods for monitoring surgical performance : A case study from gastro-oesophageal surgery. Eur J Surg Oncol [Internet]. 2011;37(6):473–80. Available from: http://dx.doi.org/10.1016/j.ejso.2010.10.008

Figure-1: Outcome improvement process flow



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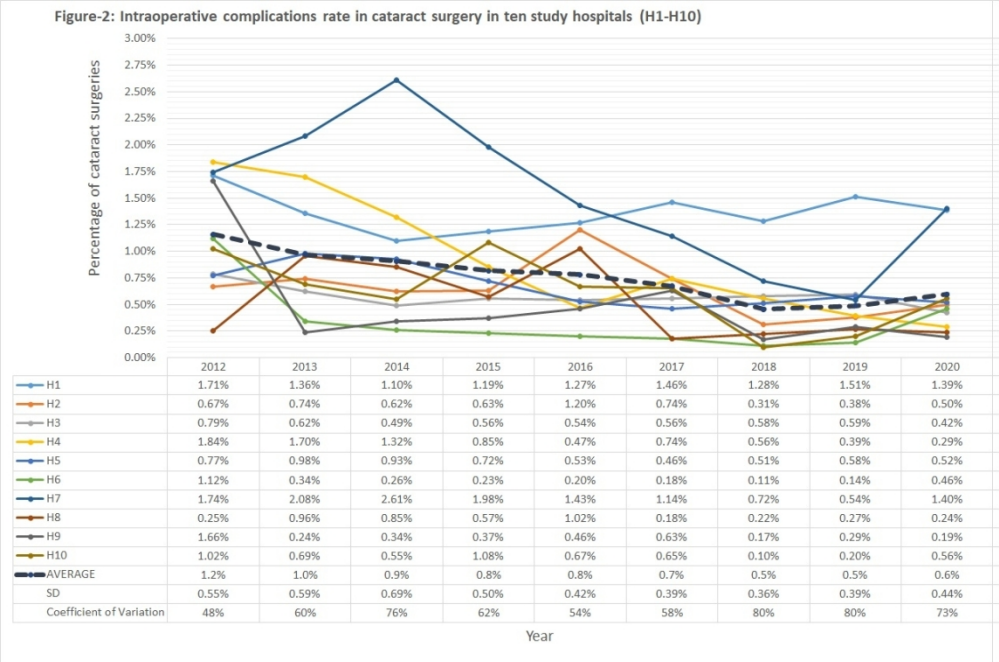
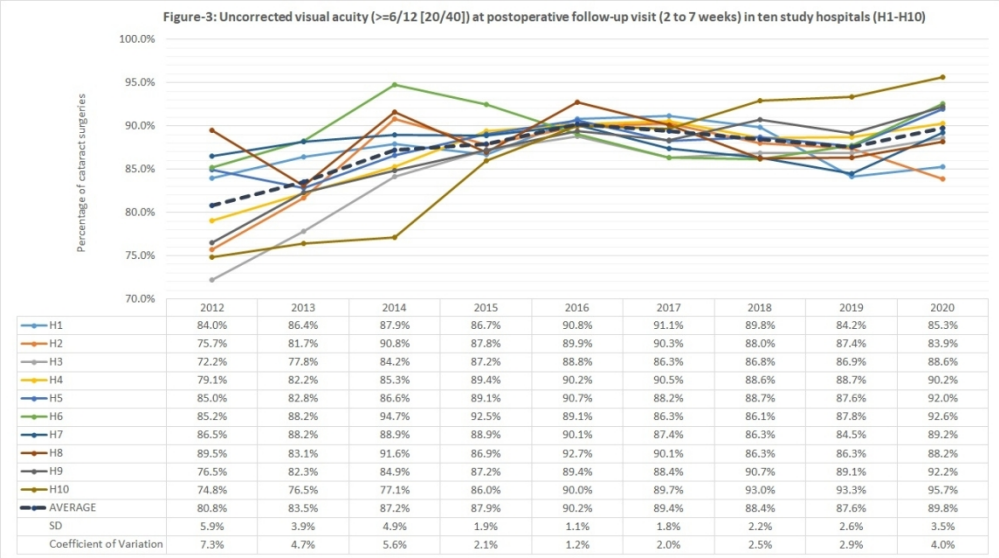


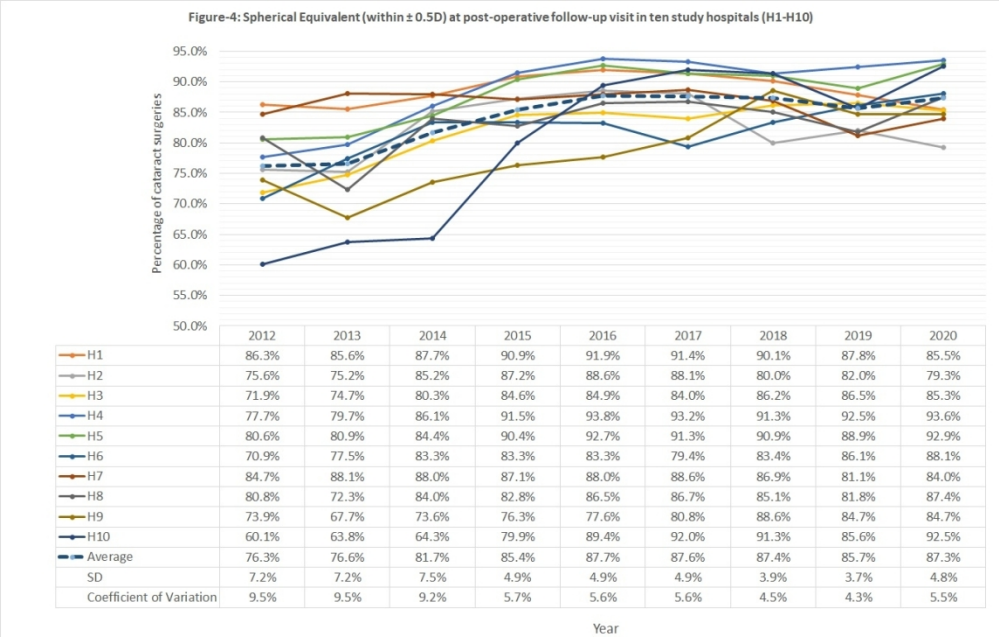
	2012	2013	2014	2015	2016	2017	2018	2019	2020
H1	1.71%	1.36%	1.10%	1.19%	1.27%	1.46%	1.28%	1.51%	1.39%
H2	0.67%	0.74%	0.62%	0.63%	1.20%	0.74%	0.31%	0.38%	0.50%
H3	0.79%	0.62%	0.49%	0.56%	0.54%	0.56%	0.58%	0.59%	0.42%
H4	1.84%	1.70%	1.32%	0.85%	0.47%	0.74%	0.56%	0.39%	0.29%
H5	0.77%	0.98%	0.93%	0.72%	0.53%	0.46%	0.51%	0.58%	0.52%
H6	1.12%	0.34%	0.26%	0.23%	0.20%	0.18%	0.11%	0.14%	0.46%
H7	1.74%	2.08%	2.61%	1.98%	1.43%	1.14%	0.72%	0.54%	1.40%
H8	0.25%	0.96%	0.85%	0.57%	1.02%	0.18%	0.22%	0.27%	0.24%
H9	1.66%	0.24%	0.34%	0.37%	0.46%	0.63%	0.17%	0.29%	0.19%
H10	1.02%	0.69%	0.55%	1.08%	0.67%	0.65%	0.10%	0.20%	0.56%
AVERAGE	1.2%	1.0%	0.9%	0.8%	0.8%	0.7%	0.5%	0.5%	0.6%
SD	0.55%	0.59%	0.69%	0.50%	0.42%	0.39%	0.36%	0.39%	0.44%
Coefficient of Variation	48%	60%	76%	62%	54%	58%	80%	80%	73%

336x223mm (96 x 96 DPI)



	2012	2013	2014	2015	2016	2017	2018	2019	2020
H1	84.0%	86.4%	87.9%	86.7%	90.8%	91.1%	89.8%	84.2%	85.3%
H2	75.7%	81.7%	90.8%	87.8%	89.9%	90.3%	88.0%	87.4%	83.9%
H3	72.2%	77.8%	84.2%	87.2%	88.8%	86.3%	86.8%	86.9%	88.6%
H4	79.1%	82.2%	85.3%	89.4%	90.2%	90.5%	88.6%	88.7%	90.2%
H5	85.0%	82.8%	86.6%	89.1%	90.7%	88.2%	88.7%	87.6%	92.0%
H6	85.2%	88.2%	94.7%	92.5%	89.1%	86.3%	86.1%	87.8%	92.6%
H7	86.5%	88.2%	88.9%	88.9%	90.1%	87.4%	86.3%	84.5%	89.2%
H8	89.5%	83.1%	91.6%	86.9%	92.7%	90.1%	86.3%	86.3%	88.2%
H9	76.5%	82.3%	84.9%	87.2%	89.4%	88.4%	90.7%	89.1%	92.2%
H10	74.8%	76.5%	77.1%	86.0%	90.0%	89.7%	93.0%	93.3%	95.7%
AVERAGE	80.8%	83.5%	87.2%	87.9%	90.2%	89.4%	88.4%	87.6%	89.8%
SD	5.9%	3.9%	4.9%	1.9%	1.1%	1.8%	2.2%	2.6%	3.5%
Coefficient of Variation	7.3%	4.7%	5.6%	2.1%	1.2%	2.0%	2.5%	2.9%	4.0%

348x194mm (96 x 96 DPI)



	2012	2013	2014	2015	2016	2017	2018	2019	2020
H1	86.3%	85.6%	87.7%	90.9%	91.9%	91.4%	90.1%	87.8%	85.5%
H2	75.6%	75.2%	85.2%	87.2%	88.6%	88.1%	80.0%	82.0%	79.3%
H3	71.9%	74.7%	80.3%	84.6%	84.9%	84.0%	86.2%	86.5%	85.3%
H4	77.7%	79.7%	86.1%	91.5%	93.8%	93.2%	91.3%	92.5%	93.6%
H5	80.6%	80.9%	84.4%	90.4%	92.7%	91.3%	90.9%	88.9%	92.9%
H6	70.9%	77.5%	83.3%	83.3%	83.3%	79.4%	83.4%	86.1%	88.1%
H7	84.7%	88.1%	88.0%	87.1%	88.0%	88.6%	86.9%	81.1%	84.0%
H8	80.8%	72.3%	84.0%	82.8%	86.5%	86.7%	85.1%	81.8%	87.4%
H9	73.9%	67.7%	73.6%	76.3%	77.6%	80.8%	88.6%	84.7%	84.7%
H10	60.1%	63.8%	64.3%	79.9%	89.4%	92.0%	91.3%	85.6%	92.5%
Average	76.3%	76.6%	81.7%	85.4%	87.7%	87.6%	87.4%	85.7%	87.3%
SD	7.2%	7.2%	7.5%	4.9%	4.9%	4.9%	3.9%	3.7%	4.8%
Coefficient of Variation	9.5%	9.5%	9.2%	5.7%	5.6%	5.6%	4.5%	4.3%	5.5%

358x228mm (96 x 96 DPI)

Supplementary Figure-1: Automated email to individual surgeon with cataract surgery results

Dear Doctor,

Sharing the details of your cataract surgical volume and outcome for the month of **Jan 2021** .Kindly log on aecscatqa.aravind.org , aecscatqa.aravind.org to find a much more detailed report on complications and visual outcome. Please feel free to log in and change your password. You will also be able to benchmark yourself with your colleagues while the individual surgeon's performance details will be kept confidential.We have designed this system with the hope that you will be able to use this information to improve the quality of your surgery specifically the uncorrected visual outcome.

If you are not fully familiar with using the system, please contact **Ms Arumugaselvi / Ms Mariammal, IOL Clinic** for a quick demo.

If your surgical data and outcome data are not correct, kindly send the details of what needs to be corrected to iolclinic@aravind.org.

If you have any suggestions regarding the improvement of the system, kindly send them to iolcoord@aravind.org.

Surgical Volume	
No.of ECCE surgeries	0
No.of SICS surgeries	74
No.of Phaco surgeries	28
Complication Rate	
Intra operative complication rate	1.96%
Post-operative complication rate	6.86%
Resurgery rate	0.98%
Endophthalmitis rate	0.00%
Follow-up unaided distance visual outcome	
6/18 & better visual acuity percentage (For ECCE & SICS cases)	80%
6/12 & Better visual acuity percentage (For Phaco cases)	83.33 %
Follow-up best-corrected distance visual outcome	
6/9 & Better visual acuity percentage (For ECCE & SICS cases)	86.67 %
6/9 & Better visual acuity percentage (For Phaco cases)	95.83 %

With Warm Regards,
Cataract Surgery Outcome Monitoring Team.

Supplementary Figure-2: Trend of outcome parameters of a surgeon comparing average and best performed surgeon

aecscatqa.aravind.org/Report/Catractindicator1.aspx

Cataract Surgery Outcome Monitoring

Home | Patient Data | Summary data | Masters | Bench Marking | Change Password | Logout

Bench Marking Report

Starting Month: Jan 2020 | Source: ALL | Surgery Types: PHACO | Hospital Category: Large Hospital

Ending Month: Dec 2020 | Surgeons: ALL | IOL Model: ALL | Risk Catogery: ALL | Submit

Parameters	Yours	Over All	Best
Total Surgeries	**18,430**	**54,446**	
% with < 6/60 Pre - op Vision	36.01	40.41	
% with Advance Cataract	7.54	10.99	
Surgery Types			
% Phaco Surgeries	100.00	100.00	100.00
% SICS Surgeries	0.00	0.00	0.00
% ECCE Surgeries	0.00	0.00	0.00
% Lens removal Surgeries	0.00	0.00	0.00
% Femto Laser Surgeries	0.00	0.00	0.00
Anaesthesia			
% of surgeries under topical anaesthesia	57.49	66.75	95.00
⊞ % of Patients With Intra OP Complication	1.42	0.82	0.42
Intra OP Complication Score	10.65	5.97	2.91
⊞ % of Patients with Post-OP complication	2.72	2.05	0.92
Post-OP complication Score	7.68	6.69	2.75
⊞ % Resurgeries	0.28	0.18	0.00
Immediate Post OP Pinhole VA - (Discharge)			
6/6	51.35	54.44	62.01
6/9 and Better	77.30	77.60	80.42
6/12 and Better	88.83	87.42	86.84
6/18 and Better	91.69	90.96	90.01
6/24-6/60	4.44	4.55	0.00
<=5/60	2.95	2.69	0.00
Follow-Up Visual Outcome			
UCVA - (6/6)	42.34	47.01	53.08
UCVA - (6/9 and Better)	66.78	73.81	79.52
UCVA - (6/12 and Better)	85.30	88.93	92.01
UCVA - (6/18 and Better)	94.97	95.85	96.78
UCVA - (6/24-6/60)	4.41	3.42	2.48
UCVA - (<=5/60)	0.62	0.73	0.73
BCVA - (6/6)	78.25	81.36	86.73
BCVA - (6/9 and Better)	93.11	93.57	96.55
BCVA - (6/12 and Better)	96.16	96.46	98.36
BCVA - (6/18 and Better)	97.76	97.84	99.45
BCVA - (6/24-6/60)	1.71	1.53	0.55
BCVA - (<=5/60)	0.53	0.63	0.00
⊞ % of Patients with Followup Complication	0.24	0.14	0.00
Followup Complication Score	1.39	0.84	0.00
Spherical Equivalent at Followup			
(>=-0.5D To <=0.5D) (S.E)	85.50	88.81	93.48
(>=-1D To <=1D) (S.E)	97.94	98.70	99.61
(< -1D and >=-2D) and (>1D and <=2D) (S.E)	1.94	1.19	0.34
(< -2D AND > 2D) (S.E)	0.12	0.11	0.05

Research and reporting methodology

Revised **Standards for QUality Improvement Reporting Excellence** (**SQUIRE 2.0**) publication guidelines

Text section and item name	**Page/line no(s). info is located**
Title and abstract	
1. **Title**	1
Indicate that the manuscript concerns an initiative to improve healthcare (broadly defined to include the quality, safety, effectiveness, patient-centredness, timeliness, cost, efficiency and equity of healthcare).	
2. **Abstract**	2
a. Provide adequate information to aid in searching and indexing.	3
b. Summarise all key information from various sections of the text using the abstract format of the intended publication or a structured summary such as: background, local problem, methods, interventions, results, conclusions.	
Introduction: Why did you start?	**4**
3. **Problem description** - Nature and significance of the local problem.	4
4. **Available knowledge** - Summary of what is currently known about the problem, including relevant previous studies.	4
5. **Rationale** - Informal or formal frameworks, models, concepts and/or theories used to explain the problem, any reasons or assumptions that were used to develop the intervention(s) and reasons why the intervention(s) was expected to work	5
6. **Specific aims** - Purpose of the project and of this report.	5
Methods: What did you do?	4
7. **Context** - Contextual elements considered important at the outset of introducing the intervention(s).	6
8. **Intervention(s)**	6
a. Description of the intervention(s) in sufficient detail that others could reproduce it.	
b. Specifics of the team involved in the work.	
9. **Study of the intervention(s)**	
a. Approach chosen for assessing the impact of the intervention(s).	8
b. Approach used to establish whether the observed outcomes were due to the intervention(s).	
10. **Measures**	9
a. Measures chosen for studying processes and outcomes of the intervention(s), including rationale for choosing them, their operational definitions and their validity and reliability.	
b. Description of the approach to the ongoing assessment of contextual elements that contributed to the success, failure, efficiency and cost.	
c. Methods employed for assessing completeness and accuracy of data.	
11. **Analysis**	9
a. Qualitative and quantitative methods used to draw inferences from the data.	
b. Methods for understanding variation within the data, including the effects of time as a variable.	

12. **Ethical considerations** - Ethical aspects of implementing and studying the intervention(s) and how they were addressed, including, but not limited to, formal ethics review and potential conflict(s) of interest.	13
Results: What did you find?	
13. **Results**	9
a. Initial steps of the intervention(s) and their evolution over time (eg, time-line diagram, flow chart or table), including modifications made to the intervention during the project.	
b. Details of the process measures and outcomes.	9
c. Contextual elements that interacted with the intervention(s).	
d. Observed associations between outcomes, interventions and relevant contextual elements.	10
e. Unintended consequences such as unexpected benefits, problems, failures or costs associated with the intervention(s).	
f. Details about missing data.	
Discussion: What does it mean?	
14. **Summary**	**11**
a. Key findings, including relevance to the rationale and specific aims.	
b. Particular strengths of the project.	
15. **Interpretation**	11
a. Nature of the association between the intervention(s) and the outcomes.	
b. Comparison of results with findings from other publications.	
c. Impact of the project on people and systems.	
d. Reasons for any differences between observed and anticipated outcomes, including the influence of context.	
e. Costs and strategic trade-offs, including opportunity costs.	
16. **Limitations**	
a. Limits to the generalisability of the work.	12
b. Factors that might have limited internal validity such as confounding, bias or imprecision in the design, methods, measurement or analysis.	
c. Efforts made to minimise and adjust for limitations.	
Conclusions	
a. Usefulness of the work.	12
b. Sustainability.	
c. Potential for spread to other contexts.	
d. Implications for practice and for further study in the field.	
e. Suggested next steps.	
Other information	
18. **Funding** - Sources of funding that supported this work. Role, if any, of the funding organization in the design, implementation, interpretation and reporting.	13
19. Authors Contribution Statement	13

BMJ Open

Impact of practicing internal benchmarking on continuous improvement of cataract surgery outcomes: a retrospective observational study at Aravind Eye Hospitals, India

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Primary Subject Heading:	Evidence based practice
Secondary Subject Heading:	Ophthalmology
Keywords:	OPHTHALMOLOGY, Cataract and refractive surgery < OPHTHALMOLOGY, Quality in health care < HEALTH SERVICES ADMINISTRATION & MANAGEMENT

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Impact of practicing internal benchmarking on continuous improvement of cataract surgery outcomes: a retrospective observational study at Aravind Eye Hospitals, India

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Abstract

Objective: We aim to assess the effectiveness of a cataract surgery outcome monitoring tool used for continuous quality improvement. The objectives are to study: 1) the quality parameters, 2) the monitoring process followed, and 3) the impact on outcomes.

Design and procedures: In this retrospective observational study we evaluated a quality improvement method which has been practiced at the focal institution since 2012: internal benchmarking of cataract surgery outcomes (CATQA). We evaluated quality parameters, procedures followed, and clinical outcomes. We created tables and line charts to examine trends in key outcomes.

Setting: Aravind Eye Care System, India.

Participants: Phacoemulsification surgeries performed on 718,120 eyes at 10 centres (five tertiary and five secondary eye centres) from 2012 to 2020 were included.

Interventions: An internal benchmarking of surgery outcome parameters, to assess variations among the hospitals and compare with the best hospital.

Outcome measures: Intraoperative complications, unaided visual acuity at post-operative follow-up visit and residual post-operative refractive error (within ± 0.5D).

Results: Over the study period the intraoperative complication rate decreased from 1.2% to 0.6%, surgeries with uncorrected visual acuity of 6/12 or better increased from 80.8% to 89.8%, and surgeries with postoperative refractive error within ± 0.5D increased from 76.3% to 87.3%. Variability in outcome measures across hospitals declined. Additionally, benchmarking was associated with improvements in facilities, protocols, and processes.

Conclusion: Internal benchmarking was found to be an effective quality improvement method that enabled the practice of evidence-based management and allowed for harnessing the available information. Continuous improvement in clinical outcomes requires systematic and regular review of results, identifying gaps between hospitals, comparisons with the best hospital, and implementing lessons learned from peers.

Strengths and limitations of this study

- The study is based on comprehensive data of eye hospitals that have been benchmarking outcomes for continuous improvement for the past decade.
- Relatively complete data on all factors that influence quality of surgical outcomes were gathered and included in this study.
- Although the process is based on eye hospitals, it can be applied usefully to other clinical disciplines.
- Benchmarking results must be interpreted carefully, considering inclusion and exclusion criteria followed by hospitals and the definitions of outcome variables.
- Since a retrospective, observational study design was employed, not all confounding factors can be ruled out.

Keywords: Benchmarking, quality improvement method, internal benchmarking, continuous improvement

INTRODUCTION

Quality healthcare increases the likelihood of desirable health outcomes. High quality of health care services is essential to create trust(1) and increase demand.(2,3) Delivering quality healthcare services is also important for Universal Health Coverage.(1) Further, intensifying competition in healthcare markets(4) is increasing pressure on providers to deliver high quality, cost-effective and patient-centred care.(5)

In the context of eye health, cataract is the leading cause of blindness in the world, accounting for 45.5% of all blindness, and the second leading cause of moderate to severe visual impairment. (6) The success of cataract surgery is generally equated to achieving a threshold level of postoperative best corrected distance visual acuity (BCVA). However, significant concerns remain about quality of surgical outcomes, especially in developing countries.(7) For instance, a summary (8) of eight population-based studies in sub-Saharan Africa reports that the percentage of eyes with "good" vision, defined by the World Health Organization (WHO)(9) as postoperative visual acuity (VA) ≥ 6/18, ranged from 23 to 59 percent compared to the recommended level of 90%. The same summary also reports that the percentage of eyes that had "poor" vision (WHO definition is postoperative VA < 6/60) after surgery ranged from 23 to 64 percent compared to the recommend level of <5%.

The use of health information systems that enable evidence-based management is a critical foundational element to deliver quality healthcare services.(1) Measurement and reporting of outcomes is crucial for a hospital to learn and improve care over time.

Background and context

The Aravind Eye Care System (Aravind) is a network of fourteen specialty eye-care hospitals in Southern India. In 2019-20, Aravind hospitals served over 4.6 million outpatient visits and performed 515,000 treatment procedures including 317,500 cataract surgeries. A third of the cataract surgeries are performed on patients brought in as part of outreach programs. These programs are conducted in remote areas, primarily on weekends. Being a post-graduate training and research institute, a significant number of cataract surgeries are performed by senior post-graduate students (15%) and post-graduate fellows (25%) who are undergoing specialization training. The volume of surgeries performed by each surgeon varies from 250 to 3,500 a year. Moreover, as a referral centre, a tertiary centre treats patients with advanced conditions and comorbidities referred by its satellite centres and other eye care providers. Considering all these factors, Continuous Quality Improvement (CQI) is critical to ensure that outcomes are not compromised.

In 1999, Aravind began using its own software tool to track quality parameters and improve cataract surgery outcomes. While each hospital in the network was able to generate reports and improve outcomes, a casual comparison of outcomes across hospitals revealed a significant difference; this prompted the need for further actions for improvement.

While measuring outcomes that report the current status is necessary, comparing outcomes with peers both inside and outside the organization helps to identify variations and hence generate

opportunities to improve outcomes.(4) CQI is practiced in hospitals by leveraging variability to optimize clinical care, reduce costs, and enhance customer service quality.(10) A systematic review of quality improvement (QI) methods(11) for health outcomes identified six commonly used methods: benchmarking, collaborative care model, chronic care model, Information Technology (IT) driven interventions, plan-do-check-act, and learning and leadership collaborative.

Rationale

QI is not a one-time event. What is a standard of excellence today may be the expected minimum norm of tomorrow. For instance, in 2021 the World Health Organization (WHO) revised the visual acuity threshold for a good visual outcome following cataract surgery to 6/12 or better from the previous norm of 6/18 or better.(12) Therefore, improvement should be an ongoing process, and benchmarking should be considered one part of that process.(13) A hospital can benchmark against itself by measuring variation in outcomes and tracking over time using control charts.(14) Understanding the variation and its cause and taking appropriate actions would help to raise the bar and improve the outcome.(14)

Benchmarking involves ascertaining the gap in our performance compared with the best performing organizations. It provides an opportunity to learn new working methods and practices from others, and subsequently adapting and adopting appropriate practices in our settings.(13) Existing literature primarily focuses on developing benchmarks(15–17) as a one-time exercise(11,18,19), and comparing with published reports.(20) Benchmarking is often described as comparing measurements in a limited time frame, but it also emphasizes gathering indicators over the long term, making this a real CQI approach.(21)

To exploit the opportunities of benchmarking in improving quality, Aravind upgraded its Cataract Surgical Quality Assurance (CATQA) platform as a benchmarking tool in 2011, thus allowing hospitals and surgeons to compare themselves against each other and against the best performer within the Aravind network. This initiative aimed to narrow the variation between hospitals and between surgeons, so that quality of care could be improved across the system in a standard, consistent, and continuous manner.

Benchmarking has been discussed in a variety of disciplines; however, there has been little research on continuous quality improvement in the healthcare sector. A successful implementation of QI initiatives involves several factors that have been discussed.(22–25) The objective of this study was to present and evaluate an internal benchmarking system whose goal is to improve quality of outcomes of cataract surgery in the network of eye hospitals of the Aravind Eye Care System (AECS).

METHODS

Design

We conducted a longitudinal retrospective observational study to evaluate the quality improvement methods practiced in a network of hospitals of AECS, India.

Setting

AECS was established in 1976 in Madurai, India and currently has a network of 7 tertiary, 7 secondary, 6 community and 108 primary eye care centres across Tamil Nadu, Andhra Pradesh and Pondicherry states in India. Since its inception, AECS has been serving over half of its patients at deeply subsidized prices or for free. Online hospital management system (HMS) was implemented in 1991 to automate the patient care functions, capture necessary data, and make the information available for real-time monitoring, planning and decision-making.

eyeNotes, a comprehensive electronic medical record (EMR) system, was introduced in 2016. It was developed by AECS's in-house information technology team, using Microsoft (MS) technology (asp.net) and Google Angular for frontend with MS SQL server 2016 database at the backend. HTML, MS SQL server reporting services and Google charts were used for reports and dashboards. Using eyeNotes all the findings of clinical examinations and investigations are recorded in a structured way as part of examination processes. A/Scan, B/Scan, and other investigation reports from the equipment are inserted into eyeNotes in real-time. Surgery notes, including any intraoperative complications, are entered immediately after the surgery. Immediate postoperative findings are recorded by the examining doctor. eyeNotes has been undergoing regular upgrades based on feedback from the users. During the study period, CATQA database was not changed much.

Intervention

Introduction of benchmarking

In 2011, Aravind's internal IT team upgraded the Cataract Surgical Quality Assurance system (CATQA) as benchmarking tool and deployed it into the cloud. Benchmarking parameters for this study were selected from existing outcome monitoring variables and some additional variables were included to make the system more comprehensive. The data can be uploaded using Microsoft Excel files, which are populated with information extracted from hospital management systems and electronic medical records.

Quality parameters selected for benchmarking

Benchmarking is done for a number of outcome variables, with the option of filtering the outputs either individually or combined across factors that affect outcomes. Details of the parameters and filters included for benchmarking are shown in Table 1.

Table 1. List of outcome variables and variables to filter the outputs

Sl.no	Quality parameters (Facts)	Description of the parameter
1	Pre-operative uncorrected visual acuity in operated eye (<6/60)	To measure the proportion of patients with poor pre-operative visual acuity

2	Cataract diagnosis in operated eye	To measure the proportion of patients with advanced conditions of cataract (mature cataract, hyper mature cataract, etc.) who underwent surgery
3	Surgical procedure	Phacoemulsification (Phaco), manual small incision (SICS), extra-capsular extraction (ECCE), femto Laser assisted (FLACS), and others
4	Anaesthesia	General, local or topical anaesthesia
5	Anaesthesia complications	These include the multitude of ocular or systemic complications that could occur during or after administration of local injectable or topical anaesthesia
6	Intra-operative complications	Complications occurring during the surgery
7	Post-operative complications	Post-operative complications noted a few hours after surgery or on first post-operative day
8	Re-surgeries	Procedures performed to manage complications occurring intra-operatively or post-operatively (immediately or later, but within six months) to enhance the outcome of surgery.
9	Immediate post-operative (Day-1 or discharge) pinhole visual acuity	Visual acuity measured at the time of discharge (or day after surgery for day-care patients)
10	Post-operative follow-up visit (2 to 8 weeks)	Whether patient was examined 2 to 8 weeks after cataract surgery
11	Complications at follow-up	Complications developed after discharge and found during the follow-up examination
12	Uncorrected distance visual acuity at follow-up visit	Uncorrected distance visual acuity in the operated eye
13	Best corrected distance visual acuity at follow-up visit	Best corrected distance visual acuity in the operated eye
14	Spherical equivalent	Spherical + 0.5 (Cylinder value) of refraction
15	Infection	Patient is identified with endophthalmitis
16	Culture test	Result of the culture test
17	Visual recovery post infection treated	Vision acuity after managing the infection

Sl.no	**Filter options (Dimensions)**	**Description of filters**
1	Period	Duration of report
2	Patient source	Paying, free (walk-in), outreach
3	Surgical procedure	Phaco, SICS, ECCE, others
4	Lens type	PMMA (polymethyl methacrylate), acrylic, aspheric, toric, multifocal etc.
5	Surgeon type	Medical officer/consultants, fellows, residents, trainees
6	Surgeon	Name of the surgeon
7	Surgery volume	Number of cataract surgeries performed by a surgeon in a year

Several factors that have not been measured, measured inadequately, or are mis-specified, such as surgeons' skill, clinical protocol, patient selection, data definition, and data source, can confound the outcome of cataract surgery.(26) Therefore, all relevant variables as well as details of all patients who have undergone cataract surgery are included in Aravind's benchmarking platform. Across the system

the surgeon mix has been maintained consistently. All hospitals used standardized protocols and forms for recording findings. With these measures, the risks associated with uneven collection and definition of data, and the chance of including patients selectively, are reduced.

The continuous outcomes monitoring and improvement process

The following processes are used in all AECS hospitals. The process flow is given in Figure 1.

Data extraction and uploading: Data from electronic medical records is extracted and uploaded twice per surgery into the benchmarking platform. Data up to the point of discharge is extracted during the first week following surgery. A second extraction is performed at the beginning of the eighth week following surgery to ensure that all data has been included for patients who have returned to the clinic for routine follow-up within 49 days after surgery.

Data verification: After uploading the data, a summary report that gives counts of all the variables is generated in the benchmarking platform which is cross verified by the respective hospital with their own reports. In the event of discrepancies in the counts of any variable, a detailed checklist of patients is generated and verified against the electronic medical record database. Each data set is verified and approved by the personnel who generate it; for instance, data on intraoperative complications is generated by staff at the operating theatres and data on postoperative complications by staff at the ward or outpatient clinic.

Data processing for benchmarking of quality parameters: Once the data is uploaded and verified, an internal software routine processes the data to generate summary reports for various parameters (facts) and filters (dimensions); this is referred to as building a data mart (warehousing). In the event of data being uploaded again for the same period for any reason, the process is repeated. This process enables users to access reports in less than a minute.

Communication email: After completing the data processing, an email (Supplementary Figure 1) with the surgery results is sent to each surgeon who performed surgery during a given month. This report includes surgery volume, complication rate, and uncorrected and best-corrected visual outcomes on the follow-up visit. A hyperlink is included in this communication to access complete benchmark performance details, which allows a surgeon to compare their own outcome with either all the other surgeons or with the respective peer group, i.e., a post-graduate can compare the scores with all the surgeons or only with post-graduates. The trend chart (Supplementary Figure 2) compares the surgeon's or hospital's performance with the best and average scores over the past six months.

Internal review meetings: The head of the cataract clinic meets weekly with surgeons, especially those who have had complications during surgery, as well as operating room, ward and outpatient clinic nurses. In these meetings, medical records of patients with complications are reviewed. A monthly meeting is also held with surgeons, operating room nurses, ward nurses, biometry staff, and key staff from outpatient clinics. A monthly meeting agenda typically includes the confirmation of minutes of the last meeting, the status of action taken on the minutes, a review of quality parameters for the hospital, and benchmark reports of complications, visual outcome, spherical equivalent, and infection rates for the entire hospital.

Sharing of better practices: The gaps identified from the benchmarking reports are discussed at the monthly meeting as well as at the weekly meeting of cataract clinic heads from all the centres. Factors contributing to the best-performing hospitals are discussed. In order to implement necessary changes the Director of Quality conducts a detailed review of the protocol, facilities, etc. if the variation persists or is present at multiple sites.

Follow-up on the intended improvements: The implementation plans are developed in accordance with inputs received and needs at each hospital. During the internal meeting, the status of the plans is discussed, and the results of the actions are tracked in benchmarking reports.

Measures

The hospital report compares performance of the focal hospital with the overall average of all the hospitals and the best performing hospital on the key outcomes shown below. (Supplementary Figure 3). The surgeon level outcome report follows the same format.

Preoperative conditions:	% of eyes with advanced cataracts, % of eyes with poor vision
Adverse events:	% of eyes with intraoperative and postoperative complications
Visual outcome:	Following WHO classification, visual acuity groups were created. The following measures of visual acuity are used. - Pinhole visual acuity at discharge or immediate next post-operative day - Uncorrected and best-corrected visual outcome at follow-up visit between 7 and 49 days after surgery
Accuracy of Biometry:	% of surgeries within± 0.5 spherical equivalent (Spherical+ (0.5*Cylinder))
Infection:	% of endophthalmitis per 10,000 surgeries

Data analysis and reporting

Excel was used to create a comparative report across hospitals and calculate average, standard deviation (SD) and coefficient of variation, for the selected outcome variables. We used the SQUIRE guidelines to inform the presentation of this quality improvement report.

Patient and public involvement

None.

RESULTS

For the complete study period of 2012 to 2020, data were available for ten eye hospitals, which performed 718,120 phacoemulsification cataract surgeries. To evaluate the effectiveness of internal benchmarking, we selected the following outcome variables to present in this study: intraoperative complications, unaided visual acuity, and residual post-operative refractive error at the postoperative follow-up visit. We analysed the trends in these three key outcomes variables.

Intraoperative complications

Intraoperative complication is one of the most important factors affecting the visual outcome of cataract surgery. Additionally, it is often a predictor of postoperative complications. Managing high-risk cases by assigning a surgeon with the right level of experience could reduce the likelihood of complications, although it can never be completely eliminated.(27) Results of a comparative analysis of intraoperative complications are presented in Figure 2 and the data table of the figure in Supplementary Table 1 (S1a). The average complication rate across hospitals reduced by half from 1.2% in 2012 to 0.6% in 2020. The standard deviation (SD) across hospitals also showed a declining trend indicating reduced variability. Nevertheless, the coefficient of variation (CV) increased over the study period because the average declined faster than the SD.

Unaided visual acuity at post-operative follow-up visit

Good unaided visual outcomes are more likely to be achieved in surgeries without complications and with accurate biometric measurements. Figure 3 shows the percentage of patients who gained 6/12 vision or better without correction and the data table of the figure is presented in Supplementary Table 1 (S1b). On average all study hospitals improved in terms of this outcome measure over the study period. Further, both the SD and CV showed declining trends indicating reduced variability.

Residual post-operative refractive error (within ± 0.5D)

Postoperative refractive error is caused by inaccurate biometric measurements, using the wrong intraocular lens (IOL) power or surgically induced. Figure 4 shows the percentage of surgeries within ± 0.5D refractive error (without adjusting target refraction) and the data table of the figure is presented in Supplementary Table 1 (S1c). The positive trend in the average is consistent with the improvement in accuracy of biometry in recent years. Moreover, both the SD and CV showed declining trends indicating reduced variability across hospitals.

Note that COVID19 lockdowns in 2020 resulted in a larger fraction of patients with advanced conditions being operated on, which led to more variability in all three outcome measures studied – intraoperative complications, unaided visual acuity at post-operative follow-up visit, and residual post-operative refractive error.

Besides clinical outcomes, internal benchmarking has also resulted in improvement in processes, inputs and resources. The following are examples of the significant changes that were introduced in processes and resources due to benchmarking.

- *Standardization of refraction:* This was achieved by fixing the correct distance for refraction, upgrading refraction charts with self-illuminated charts, and refining protocols on measuring post-operative patients by introducing a time gap after removing the eye pad and encouraging patients to read as many letters as possible. These changes were implemented both at the base hospitals and at outreach sites.

- *Design improvements for intraocular lenses*: The system detected variations in post-operative visual outcome and related them to a specific IOL model. As a result of the evidence obtained, the IOL manufacturing firm diagnosed the problem as using the wrong A-constant which they subsequently corrected.

- *Biometry equipment upgrade:* This upgrade made it easier for technicians to interact with patients and ensure the measurements were accurate.

- *Strengthen post-operative counselling:* Patients with poor visual outcomes upon discharge were counselled again about the importance of a follow-up visit.

Discussion

Continuous improvement requires a commitment to learning from a structured and evidence-based approach to managing, taking into account one's own experience as well as others' best practices.(28)

In our analysis of outcomes from cataract surgeries over the nine-year study period, we found significant improvements in all quality parameters. The study hospitals' performance and outcomes improved across the board. The percentage of patients with good visual outcomes was better than WHO guidelines.(9) In addition, the percentage of complications was lower than the percentage reported by hospitals in developed countries.(29–31) Moreover, residual post-operative refractive error was reduced and remained well within acceptable limits. A noteworthy finding was the reduced variation and greater consistency in outcomes across hospitals over time, as expected with CQI and aided by internal benchmarking.

Internal benchmarking establishes performance standards within an organization.(32) It demonstrates successes within a hospital's own culture and environment, establishes a communication channel and network for highlighting and sharing improvements and innovations, and stimulates internal competition. It is faster and less complex than external benchmarking. It does not present the challenge of obtaining confidential data; further, internal partners often use a common or similar database and employ uniform definitions of variables. Internal benchmarking is significantly less expensive compared to external benchmarking. Furthermore, it is often the starting point for all benchmarking processes since it is essential to know about internal business processes, services, or products before embarking on an external benchmarking exercise.(33) Using external benchmarks makes sense only when we have access to the details of the process involved in achieving a better outcome, so that a hospital can adopt them and improve the outcomes.

AECS implemented a number of strategies to achieve these improvements besides implementing a benchmarking platform: standardized clinical protocols, simplified forms for data collection, creation of a data quality team, implementation of an EMR to record data in real-time, development of a data

warehouse and benchmarking platform, making information easily accessible to the right people, monthly email to individual surgeons with outcome summary, performing systematic reviews to identify gaps and opportunities for improvement, and implementing improvements. These strategies were developed at different times primarily based on monitoring results.

A benchmarking process based on evidence-based outcome monitoring gives an opportunity to evaluate variations and take appropriate measures to achieve better outcomes, such as changing processes and upgrade inputs, e.g., standardizing equipment across the system, choosing right intraocular lens (IOL), training, etc. Specific interventions at Aravind and their results are as follows. Because of the introduction of immersion biometry in 2013 and its implementation in all centres in the following years, prediction error declined significantly in the immediately following year and thereafter.(34) Since 2012, LED-illuminated vision charts have been introduced in eye camps, and vision drum charts were replaced with digital vision charts at base hospitals. These changes have led to improvement in refraction quality. Similarly, the analysis of outcome based on residual spherical equivalent with individual IOLs prompted changing of the A-constant of Aurovue IOL (hydrophobic acrylic IOL) from 118.4 to 118.7. This change helped to improve the refractive outcome and those within ±0.5D residual spherical equivalent increased from 81.5% in 2014 to 95% in the following years. Following chart is included as Supplementary Figure 4.

Quality improvement is a journey that requires continuous feedback to ensure alignment. Monitoring surgical performance is an important tool to assess trainee progress, explain poor surgical outcomes, refine protocols and strengthen training.(35–38) Internal learnings can be accepted and implemented more easily since the results are backed by evidence. Following standard protocols and processes is the key to delivering care consistently across the organization and improving efficiency.

Hospital networks, whether government, missionary, or private, have unique opportunities for learning and improving their outcomes through internal benchmarking and also reducing variability within the network. Funding organizations that support hospitals also have the opportunity to encourage such a benchmarking process amongst the hospitals they fund to induce cross-learning for overall improvement.

If learning is what makes a hospital outstanding in its field, benchmarking is a way of sharing the experience of improvements among staff members and creating healthy competition among them. To have the desired effect on performance, Gudmundsson et al. (2005) emphasize that findings of benchmarking must be communicated to stakeholders within the organization.(39) Benchmarking encourages users to identify the root cause of variation. Benchmarking as a tool for continuous improvement at AECS has shown both improvement in outcomes and reduced variation among hospitals.

This study's main strength was the use of comprehensive data of eye hospitals that have been benchmarking outcomes for continuous improvement for the past decade. Even though the process is based on eye hospitals, it can be applied usefully to other clinical disciplines. However, benchmarking results must be interpreted carefully, taking into account inclusion and exclusion criteria followed by hospitals and the definitions of outcome variables. We recognize that to conclusively establish the impact of benchmarking, a randomized control study would be required.

The retrospective, observational design in the current study relies on time trends to assess the impact and therefore cannot fully rule out alternative explanations. As a result, our findings are suggestive rather than conclusive. Furthermore, while benchmarking shows opportunities for improvement, but actual improvement can only occur when the causes of deficiencies are identified and addressed. A limitation of this study is that it did not discuss in depth the change management process that was followed for improvement. This will be a subject of further research.

Conclusion

Benchmarking is a quality improvement method that has proven to be very valuable in operationalizing evidence-based management. Benchmarking results invite the attention of the users to focus on analysing and improving inputs and processes for better outcomes. Internal benchmarking allows hospitals to learn from their peers inside the organization. Analysing the root cause for variation, implementing learnings, and regular monitoring ensure continuous improvement in outcomes. The practice of internal benchmarking builds the organization's capacity to confidently engage in external benchmarking.

Statements

Contributors

GBS, TR, CW and FVM conceived and designed the study. GBS acquired data and performed the study. GBS, SG, RR, TR and FVM analysed and interpreted the data. GBS wrote the manuscript. GBS, SG, RR, TR, HM, CW, SVR and FVM reviewed the manuscript. All authors read and approved the manuscript.

Competing interests

The authors declare that there are no conflicts of interest.

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Data availability statement

The data for this study are the reports generated from a database system, which are shared in the results. Surgery-level data are available upon request.

Ethical considerations

The study was performed with adherence to the tenets of the Declaration of Helsinki. Ethical clearance was obtained from the institutional ethics committee at Aravind Eye Hospital, Madurai (reference number: RET202100350).

Patient consent for publication

Not applicable.

References

1. World Health Organization, World Bank Group O. Delivering quality health services [Internet]. World Health Organization, World Bank Group, OECD. 2018. 1–100 p. Available from: http://apps.who.int/bookorders.
2. Sahn DE, Younger SD, Genicot G. The demand for health care services in rural Tanzania. Oxf Bull Econ Stat. 2003;65(2):241–60.
3. Tsegay Wellay, Measho Gebrelassie, Molla mesele, Hailay Gebretinsae, Brhane Ayele AT and YZ. Demand for health care service and associated factors among patients in the community of Tsegedie District, Northern Ethiopia. 2018. p. 18:697.
4. The Strategy That Will Fix Health Care [Internet]. [cited 2021 May 30]. Available from: https://hbr.org/2013/10/the-strategy-that-will-fix-health-care
5. Using Health Outcomes Research to Improve Quality of Care | Executive and Continuing Professional Education | Harvard T.H. Chan School of Public Health [Internet]. [cited 2021 Jun 9]. Available from: https://www.hsph.harvard.edu/ecpe/using-health-outcomes-research-to-improve-quality-of-care/
6. Bourne RRA, Steinmetz JD, Saylan M, Mersha AM, Weldemariam AH, Wondmeneh TG, et al. Causes of blindness and vision impairment in 2020 and trends over 30 years, and prevalence of avoidable blindness in relation to VISION 2020: The Right to Sight: An analysis for the Global Burden of Disease Study. Lancet Glob Heal. 2021;9(2):e144–60.
7. Lewallen S, Thulasiraj RD. Global Public Health : An International Journal for Research , Policy and Practice Eliminating cataract blindness – How do we apply lessons from Asia to sub-Saharan Africa ? (October 2014):37–41.
8. Congdon N, Yan X, Lansingh V, Sisay A, Müller A, Chan V, et al. Assessment of cataract surgical outcomes in settings where follow-up is poor: PRECOG, a multicentre observational study. Lancet Glob Heal. 2013;1(1):37–45.
9. WHO Informal Consultation on Analysis of Blindness Prevention Outcomes (1998: Geneva, Switzerland) & WHO Programme for the Prevention of Blindness and Deafness. (1998). Informal Consultation on Analysis of Blindness Prevention Outcomes, Geneva, 16-18 16-18 February 1998. World Health Organization. WHO PBL Geneva, 16-18 February 1998 [Internet]. 1998. p. 23. Available from: https://apps.who.int/iris/handle/10665/67843
10. Health AC. Healthcare Systems: Supporting and Advancing Child Health. Continuous Quality Improvement. J Hosp Med. 2010;91–2.
11. Kampstra NA, Zipfel N, Van Der Nat PB, Westert GP, Van Der Wees PJ, Groenewoud AS. Health outcomes measurement and organizational readiness support quality improvement: a systematic review. [cited 2021 Jun 7]; Available from: https://doi.org/10.1186/s12913-018-3828-9
12. Keel S, Müller A, Block S, Bourne R, Burton MJ, Chatterji S, et al. Keeping an eye on eye care: monitoring progress towards effective coverage. Lancet Glob Heal. 2021;9(10):e1460–4.
13. Kay JFL, Qid M, Uk M, Medicine F. Health Care Benchmarking. 2007;12(2):22–7.
14. Neuhauser D, Provost L, Bergman B. The meaning of variation to healthcare managers , clinical and health-services researchers , and individual patients. BMJ Qual Saf. 2011;(June 2014).
15. Hahn U, Krummenauer F, Kölbl B, Neuhann T, Schayan-Araghi K, Schmickler S, et al.

Determination of valid benchmarks for outcome indicators in cataract surgery: A multicenter, prospective cohort trial. Ophthalmology [Internet]. 2011 Nov [cited 2021 Jun 4];118(11):2105–12. Available from: https://pubmed.ncbi.nlm.nih.gov/21856011/

16. Jaycock P, Johnston RL, Taylor H, Adams M, Tole DM, Galloway P, et al. The Cataract National Dataset electronic multi-centre audit of 55 567 operations: Updating benchmark standards of care in the United Kingdom and internationally. Eye. 2009;23(1):38–49.

17. Nihalani BR, Vander Veen DK. Benchmarks for outcome indicators in pediatric cataract surgery [Internet]. Vol. 31, Eye (Basingstoke). Nature Publishing Group; 2017 [cited 2021 Jun 4]. p. 417–21. Available from: https://pubmed.ncbi.nlm.nih.gov/27813517/

18. Staiger RD, Schwandt H, Puhan MA, Clavien PA. Improving surgical outcomes through benchmarking. Br J Surg. 2019;106(1):59–64.

19. De Korne DF, Sol K, Van Wijngaarden JDH, Van Vliet EJ, Custers T, Cubbon M, et al. Evaluation of an international benchmarking initiative in nine eye hospitals. Health Care Manage Rev. 2010;35(1):23–35.

20. Oyewole K, Tsogkas F, Westcott M, Patra S. Benchmarking cataract surgery outcomes in an ethnically diverse and diabetic population: Final post-operative visual acuity and rates of post-operative cystoid macular oedema. Eye [Internet]. 2017 Dec 1 [cited 2021 Jun 4];31(12):1672–7. Available from: https://pubmed.ncbi.nlm.nih.gov/28643796/

21. Na A, Torchi-Tardy ET, Levif M, Michel P. Benchmarking: A Method for Continuous Quality Improvement in Health Le benchmarking : une méthode d' amélioration continue de la qualité en santé. Vol. 7, HEALTHCARE POLICY. 2012.

22. Kaplan HC, Froehle CM, Cassedy A, Provost LP, Margolis PA. An exploratory analysis of the Model for Understanding Success in Quality. Health Care Manage Rev. 2013;38(4):325–38.

23. Dewan M, Parsons A, Tegtmeyer K, Wenger J, Niles D, Raymond T, et al. Contextual Factors Affecting Implementation of In-hospital Pediatric CPR Quality Improvement Interventions in a Resuscitation Collaborative. Pediatr Qual Saf. 2021;6(5):e455.

24. Griffin A, McKeown A, Viney R, Rich A, Welland T, Gafson I, et al. Revalidation and quality assurance: The application of the MUSIQ framework in independent verification visits to healthcare organisations. BMJ Open. 2017;7(2):1–10.

25. Kaplan HC, Provost LP, Froehle CM, Margolis PA. The model for understanding success in quality (MUSIQ): Building a theory of context in healthcare quality improvement. BMJ Qual Saf. 2012;21(1):13–20.

26. Lovaglio PG. The scientific WorldJOURNAL Benchmarking Strategies for Measuring the Quality of Healthcare : Problems and Prospects. 2012;2012(iii).

27. Yorston D. Cataract complications [Internet]. Vol. 21, Community Eye Health Journal. International Centre for Eye Health; 2008 [cited 2021 Jul 3]. p. 1–3. Available from: www.cehjournal.org

28. David A Gravin. Building a Learning Organization. Harvard Business Review. 1993. p. 6.

29. Day AC, Donachie PHJ, Sparrow JM, Johnston RL. The Royal College of Ophthalmologists ' National Ophthalmology Database study of cataract surgery : report 1 , visual outcomes and complications. 2015;44(December 2014):1–9. Available from: http://dx.doi.org/10.1038/eye.2015.3

30. Jaycock P, Taylor H, Adams M, Galloway P, Canning C, Day AC, et al. The Cataract National

Dataset electronic multi- centre audit of updating benchmark standards of care in the United Kingdom and internationally. 2009;3(December 2014):38–49. Available from: http://dx.doi.org/10.1038/eye.2015.3

31. Barry P, Henry Y. Evidence-based guidelines for cataract surgery : Guidelines based on data in the European Registry of Quality Outcomes for Cataract and Refractive Surgery database. 2012;1086–93.

32. Freytag P V., Hollensen S. The process of benchmarking, benchlearning and benchaction. TQM Mag. 2001;13(1):25–33.

33. Yasin MM, Harris R, Zimmerer TW. The role of benchmarking in achieving continuous service quality. Int J Contemp Hosp Manag. 1995;7(4):27–32.

34. Shivkumar C, Aravind H, Ravilla RD. Using a quality improvement process to improve cataract outcomes. Community Eye Heal J. 2022;35(116):12–3.

35. Bilgic E, Sc B, Watanabe Y, D M, Mckendy K, D M, et al. Reliable assessment of operative performance. Am J Surg [Internet]. 2015; Available from: http://dx.doi.org/10.1016/j.amjsurg.2015.10.008

36. Angelo ADD, Law KE, Cohen ER. The use of error analysis to assess resident performance. Surgery [Internet]. 158(5):1408–14. Available from: http://dx.doi.org/10.1016/j.surg.2015.04.010

37. Murzi M, Cerillo AG, Gilmanov D, Concistr G. Exploring the learning curve for minimally invasive sutureless aortic valve replacement Data Analysis and Cumulative Sum Analysis. 2016;

38. Collins GS, Jibawi A, Mcculloch P. Control chart methods for monitoring surgical performance : A case study from gastro-oesophageal surgery. Eur J Surg Oncol [Internet]. 2011;37(6):473–80. Available from: http://dx.doi.org/10.1016/j.ejso.2010.10.008

39. Gudmundsson H, Wyatt A, Gordon L. Benchmarking and sustainable transport policy: Learning from the BEST network. Transp Rev. 2005;25(6):669–90.

Figure titles

Figure 1. Outcome improvement process flow

Figure 2. Intraoperative complications rate in cataract surgery in ten study hospitals (H1 – H10)

Figure 3. Percentage of patients with uncorrected visual acuity (>=6/12 [20/40]) at postoperative follow-up visit (2 to 7 weeks) in ten study hospitals (H1-H10)

Figure 4. Percentage of patients with Spherical Equivalent (within ± 0.5D) at post-operative follow-up visit in ten study hospitals (H1-H10)

Supplementary materials

Supplementary Figure 1. Automated email to individual surgeon with cataract surgery results

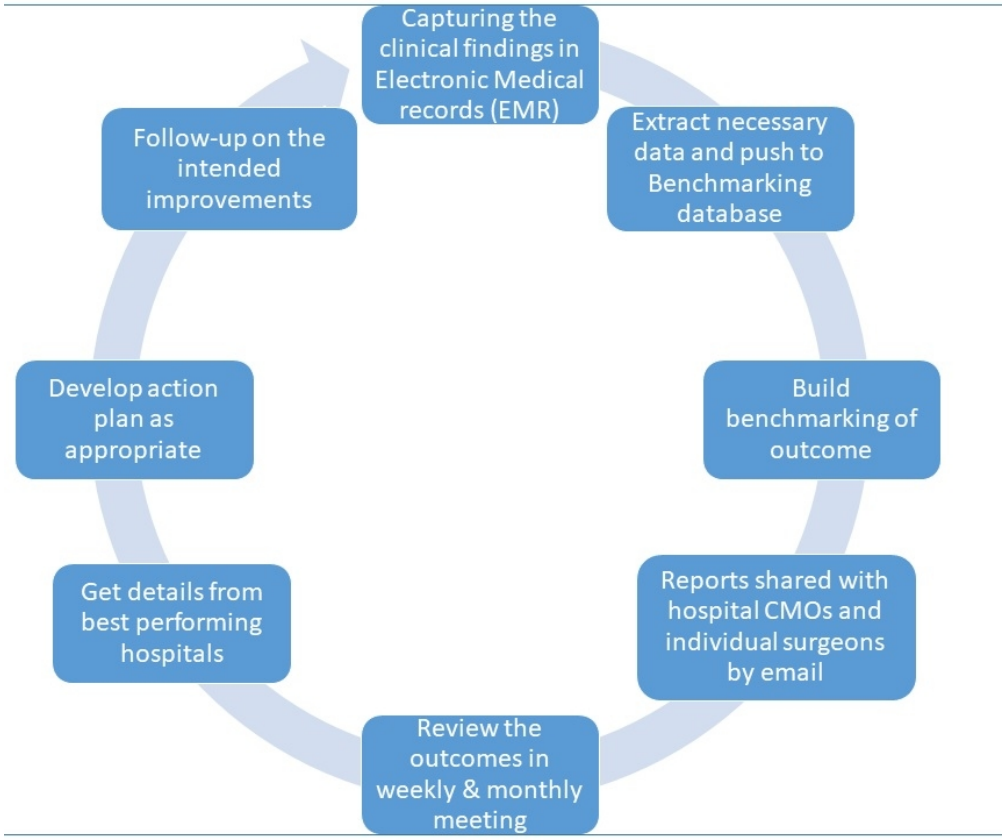
Supplementary Figure 2. Trend of outcome parameter of a surgeon comparing average and best performed surgeon

Supplementary Figure 3. Benchmarking of the outcome of a hospital with the overall average of all the hospitals and the best-performing hospital

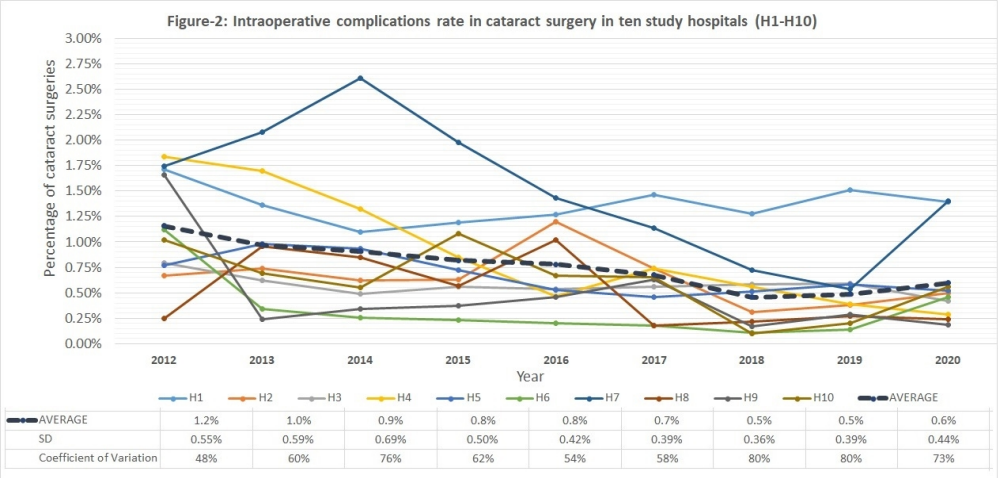
Supplementary Figure 4. Residual Spherical Equivalent (±0.5D) - % of cataract surgeries with Aurovue intraocular lens

Supplementary Table 1. Data tables of Figures 2 to 4

Figure-1: Outcome improvement process flow



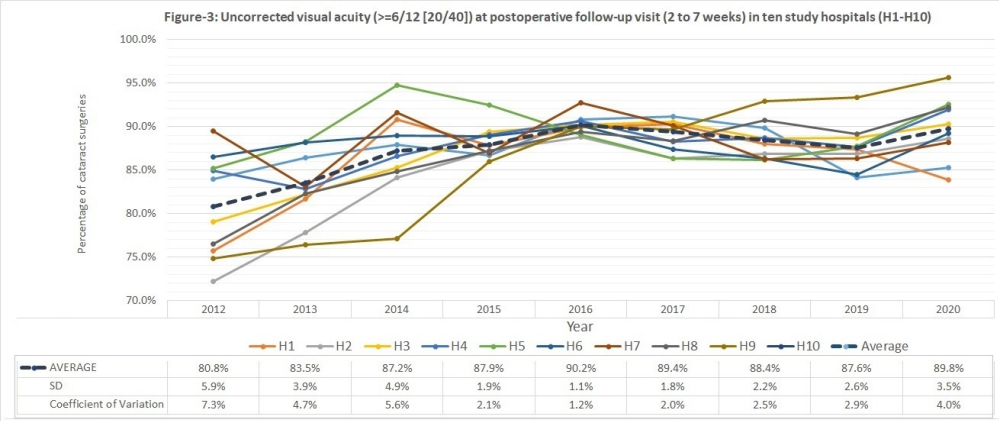
227x203mm (96 x 96 DPI)



AVERAGE	1.2%	1.0%	0.9%	0.8%	0.8%	0.7%	0.5%	0.5%	0.6%
SD	0.55%	0.59%	0.69%	0.50%	0.42%	0.39%	0.36%	0.39%	0.44%
Coefficient of Variation	48%	60%	76%	62%	54%	58%	80%	80%	73%

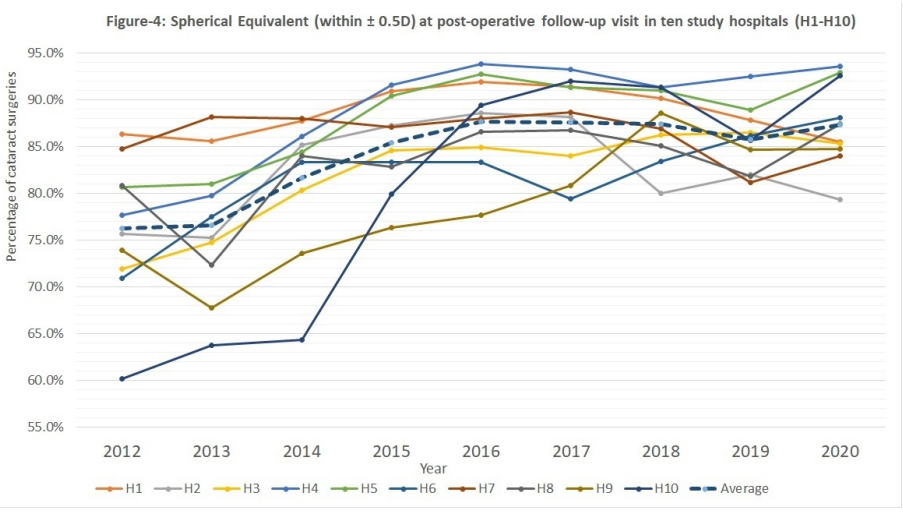
Intraoperative complications rate in cataract surgery in ten study hospitals (H1-H10)

334x159mm (96 x 96 DPI)



Uncorrected visual acuity (>=6/12 [20/40]) at postoperative follow-up visit (2 to 7 weeks) in ten study hospitals (H1-H10)

346x146mm (96 x 96 DPI)



Average	76.3%	76.6%	81.7%	85.4%	87.7%	87.6%	87.4%	85.7%	87.3%
SD	7.2%	7.2%	7.5%	4.9%	4.9%	4.9%	3.9%	3.7%	4.8%
Coefficient of Variation	9.5%	9.5%	9.2%	5.7%	5.6%	5.6%	4.5%	4.3%	5.5%

Spherical Equivalent (within ±0.5D) at postoperative follow-up visit in ten study hospitals (H1-H10)

339x201mm (96 x 96 DPI)

Supplementary Figure-1: Automated email to individual surgeon with cataract surgery results

Dear Doctor,

Sharing the details of your cataract surgical volume and outcome for the month of **Jan 2021** .Kindly log on aecscatqa.aravind.org , aecscatqa.aravind.org to find a much more detailed report on complications and visual outcome. Please feel free to log in and change your password. You will also be able to benchmark yourself with your colleagues while the individual surgeon's performance details will be kept confidential.We have designed this system with the hope that you will be able to use this information to improve the quality of your surgery specifically the uncorrected visual outcome.

If you are not fully familiar with using the system, please contact **Ms Arumugaselvi / Ms Mariammal, IOL Clinic** for a quick demo.

If your surgical data and outcome data are not correct, kindly send the details of what needs to be corrected to iolclinic@aravind.org.

If you have any suggestions regarding the improvement of the system, kindly send them to iolcoord@aravind.org.

Surgical Volume	
No.of ECCE surgeries	0
No.of SICS surgeries	74
No.of Phaco surgeries	28
Complication Rate	
Intra operative complication rate	1.96%
Post-operative complication rate	6.86%
Resurgery rate	0.98%
Endophthalmitis rate	0.00%
Follow-up unaided distance visual outcome	
6/18 & better visual acuity percentage (For ECCE & SICS cases)	80%
6/12 & Better visual acuity percentage (For Phaco cases)	83.33 %
Follow-up best-corrected distance visual outcome	
6/9 & Better visual acuity percentage (For ECCE & SICS cases)	86.67 %
6/9 & Better visual acuity percentage (For Phaco cases)	95.83 %

With Warm Regards,
Cataract Surgery Outcome Monitoring Team.

Supplementary Figure-2: Trend of outcome parameters of a surgeon comparing average and best performed surgeon

Supplementary Figure-3: Benchmarking of the outcome of the select hospital with the overall average of all the hospitals and the best-performing hospital

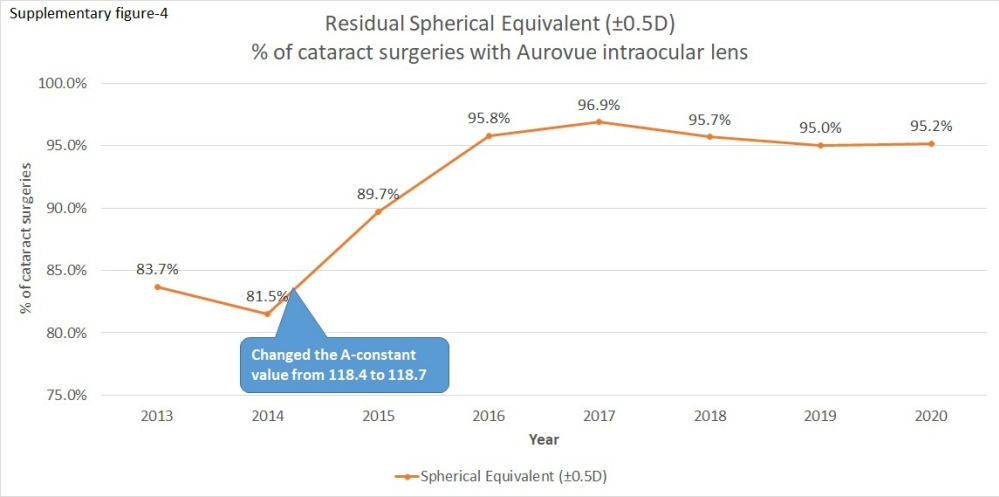
Cataract Surgery Outcome Monitoring

Home | Patient Data | Summary data | Masters | Bench Marking | Change Password | Logout

Bench Marking Report

Starting Month: Jan 2020 | Source: ALL | Surgery Types: PHACO | Hospital Category: Large Hospital
Ending Month: Dec 2020 | Surgeons: ALL | IOL Model: ALL | Risk Catogery: ALL | Submit

Parameters	Yours	Over All	Best
Total Surgeries	**18,430**	**54,446**	
% with < 6/60 Pre - op Vision	36.01	40.41	
% with Advance Cataract	7.54	10.99	
Surgery Types			
% Phaco Surgeries	100.00	100.00	100.00
% SICS Surgeries	0.00	0.00	0.00
% ECCE Surgeries	0.00	0.00	0.00
% Lens removal Surgeries	0.00	0.00	0.00
% Femto Laser Surgeries	0.00	0.00	0.00
Anaesthesia			
% of surgeries under topical anaesthesia	57.49	66.75	95.00
⊞ % of Patients With Intra OP Complication	1.42	0.82	0.42
Intra OP Complication Score	10.65	5.97	2.91
⊞ % of Patients with Post-OP complication	2.72	2.05	0.92
Post-OP complication Score	7.68	6.69	2.75
⊞ % Resurgeries	0.28	0.18	0.00
Immediate Post OP Pinhole VA - (Discharge)			
6/6	51.35	54.44	62.01
6/9 and Better	77.30	77.60	80.42
6/12 and Better	88.83	87.42	86.84
6/18 and Better	91.69	90.96	90.01
6/24-6/60	4.44	4.55	0.00
<=5/60	2.95	2.69	0.00
Follow-Up Visual Outcome			
UCVA - (6/6)	42.34	47.01	53.08
UCVA - (6/9 and Better)	66.78	73.81	79.52
UCVA - (6/12 and Better)	85.30	88.93	92.01
UCVA - (6/18 and Better)	94.97	95.85	96.78
UCVA - (6/24-6/60)	4.41	3.42	2.48
UCVA - (<=5/60)	0.62	0.73	0.73
BCVA - (6/6)	78.25	81.36	86.73
BCVA - (6/9 and Better)	93.11	93.57	96.55
BCVA - (6/12 and Better)	96.16	96.46	98.36
BCVA - (6/18 and Better)	97.76	97.84	99.45
BCVA - (6/24-6/60)	1.71	1.53	0.55
BCVA - (<=5/60)	0.53	0.63	0.00
⊞ % of Patients with Followup Complication	0.24	0.14	0.00
Followup Complication Score	1.39	0.84	0.00
Spherical Equivalent at Followup			
(>=-0.5D To <=0.5D) (S.E)	85.50	88.81	93.48
(>=-1D To <=1D) (S.E)	97.94	98.70	99.61
(< -1D and >=-2D) and (>1D and <=2D) (S.E)	1.94	1.19	0.34
(< -2D AND > 2D) (S.E)	0.12	0.11	0.05



Residual Spherical Equivalent (±0.5D)
% of cataract surgeries with Aurovue intraocular lens

303x150mm (96 x 96 DPI)

Supplementary Table-1: Data tables of Figures 2 to 4

S1a. Figure-2 Data Table: % of patients with Intraoperative complications in cataract surgery in ten study hospitals (H1-H10)

Year	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	AVERAGE	SD	Coefficient of Variation
2012	1.71%	0.67%	0.79%	1.84%	0.77%	1.12%	1.74%	0.25%	1.66%	1.02%	1.2%	0.55%	48%
2013	1.36%	0.74%	0.62%	1.70%	0.98%	0.34%	2.08%	0.96%	0.24%	0.69%	1.0%	0.59%	60%
2014	1.10%	0.62%	0.49%	1.32%	0.93%	0.26%	2.61%	0.85%	0.34%	0.55%	0.9%	0.69%	76%
2015	1.19%	0.63%	0.56%	0.85%	0.72%	0.23%	1.98%	0.57%	0.37%	1.08%	0.8%	0.50%	62%
2016	1.27%	1.20%	0.54%	0.47%	0.53%	0.20%	1.43%	1.02%	0.46%	0.67%	0.8%	0.42%	54%
2017	1.46%	0.74%	0.56%	0.74%	0.46%	0.18%	1.14%	0.18%	0.63%	0.65%	0.7%	0.39%	58%
2018	1.28%	0.31%	0.58%	0.56%	0.51%	0.11%	0.72%	0.22%	0.17%	0.10%	0.5%	0.36%	80%
2019	1.51%	0.38%	0.59%	0.39%	0.58%	0.14%	0.54%	0.27%	0.29%	0.20%	0.5%	0.39%	80%
2020	1.39%	0.50%	0.42%	0.29%	0.52%	0.46%	1.40%	0.24%	0.19%	0.56%	0.6%	0.44%	73%

S1b. Figure-3 Data Table: % of patients with uncorrected visual acuity (>=6/12 [20/40]) at postoperative follow-up visit (2 to 7 weeks) in ten study hospitals (H1-H10)

Year	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	AVERAGE	SD	Coefficient of Variation
2012	84.0%	75.7%	72.2%	79.1%	85.0%	85.2%	86.5%	89.5%	76.5%	74.8%	80.8%	5.9%	7.3%
2013	86.4%	81.7%	77.8%	82.2%	82.8%	88.2%	88.2%	83.1%	82.3%	76.5%	83.5%	3.9%	4.7%
2014	87.9%	90.8%	84.2%	85.3%	86.6%	94.7%	88.9%	91.6%	84.9%	77.1%	87.2%	4.9%	5.6%
2015	86.7%	87.8%	87.2%	89.4%	89.1%	92.5%	88.9%	86.9%	87.2%	86.0%	87.9%	1.9%	2.1%
2016	90.8%	89.9%	88.8%	90.2%	90.7%	89.1%	90.1%	92.7%	89.4%	90.0%	90.2%	1.1%	1.2%
2017	91.1%	90.3%	86.3%	90.5%	88.2%	86.3%	87.4%	90.1%	88.4%	89.7%	89.4%	1.8%	2.0%
2018	89.8%	88.0%	86.8%	88.6%	88.7%	86.1%	86.3%	86.3%	90.7%	93.0%	88.4%	2.2%	2.5%
2019	84.2%	87.4%	86.9%	88.7%	87.6%	87.8%	84.5%	86.3%	89.1%	93.3%	87.6%	2.6%	2.9%
2020	85.3%	83.9%	88.6%	90.2%	92.0%	92.6%	89.2%	88.2%	92.2%	95.7%	89.8%	3.5%	4.0%

S1c. Figure-4 Data Table: % of patients with Spherical Equivalent (within ± 0.5D) at post-operative follow-up visit in ten study hospitals (H1-H10)

Year	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	AVERAGE	SD	Coefficient of Variation
2012	86.3%	75.6%	71.9%	77.7%	80.6%	70.9%	84.7%	80.8%	73.9%	60.1%	76.3%	7.2%	9.5%
2013	85.6%	75.2%	74.7%	79.7%	80.9%	77.5%	88.1%	72.3%	67.7%	63.8%	76.6%	7.2%	9.5%
2014	87.7%	85.2%	80.3%	86.1%	84.4%	83.3%	88.0%	84.0%	73.6%	64.3%	81.7%	7.5%	9.2%
2015	90.9%	87.2%	84.6%	91.5%	90.4%	83.3%	87.1%	82.8%	76.3%	79.9%	85.4%	4.9%	5.7%
2016	91.9%	88.6%	84.9%	93.8%	92.7%	83.3%	88.0%	86.5%	77.6%	89.4%	87.7%	4.9%	5.6%
2017	91.4%	88.1%	84.0%	93.2%	91.3%	79.4%	88.6%	86.7%	80.8%	92.0%	87.6%	4.9%	5.6%
2018	90.1%	80.0%	86.2%	91.3%	90.9%	83.4%	86.9%	85.1%	88.6%	91.3%	87.4%	3.9%	4.5%
2019	87.8%	82.0%	86.5%	92.5%	88.9%	86.1%	81.1%	81.8%	84.7%	85.6%	85.7%	3.7%	4.3%
2020	85.5%	79.3%	85.3%	93.6%	92.9%	88.1%	84.0%	87.4%	84.7%	92.5%	87.3%	4.8%	5.5%

Research and reporting methodology

Revised **Standards for QUality Improvement Reporting Excellence** (**SQUIRE 2.0**) publication guidelines

Text section and item name	**Page/line no(s). info is located**
Title and abstract	
1. **Title**	1
Indicate that the manuscript concerns an initiative to improve healthcare (broadly defined to include the quality, safety, effectiveness, patient-centredness, timeliness, cost, efficiency and equity of healthcare).	
2. **Abstract**	2
a. Provide adequate information to aid in searching and indexing.	3
b. Summarise all key information from various sections of the text using the abstract format of the intended publication or a structured summary such as: background, local problem, methods, interventions, results, conclusions.	
Introduction: Why did you start?	**4**
3. **Problem description** - Nature and significance of the local problem.	4
4. **Available knowledge** - Summary of what is currently known about the problem, including relevant previous studies.	4
5. **Rationale** - Informal or formal frameworks, models, concepts and/or theories used to explain the problem, any reasons or assumptions that were used to develop the intervention(s) and reasons why the intervention(s) was expected to work	5
6. **Specific aims** - Purpose of the project and of this report.	5
Methods: What did you do?	4
7. **Context** - Contextual elements considered important at the outset of introducing the intervention(s).	6
8. **Intervention(s)**	6
a. Description of the intervention(s) in sufficient detail that others could reproduce it.	
b. Specifics of the team involved in the work.	
9. **Study of the intervention(s)**	
a. Approach chosen for assessing the impact of the intervention(s).	8
b. Approach used to establish whether the observed outcomes were due to the intervention(s).	
10. **Measures**	9
a. Measures chosen for studying processes and outcomes of the intervention(s), including rationale for choosing them, their operational definitions and their validity and reliability.	
b. Description of the approach to the ongoing assessment of contextual elements that contributed to the success, failure, efficiency and cost.	
c. Methods employed for assessing completeness and accuracy of data.	
11. **Analysis**	9
a. Qualitative and quantitative methods used to draw inferences from the data.	
b. Methods for understanding variation within the data, including the effects of time as a variable.	

12. **Ethical considerations** - Ethical aspects of implementing and studying the intervention(s) and how they were addressed, including, but not limited to, formal ethics review and potential conflict(s) of interest.	13
Results: What did you find?	
13. **Results**	9
a. Initial steps of the intervention(s) and their evolution over time (eg, time-line diagram, flow chart or table), including modifications made to the intervention during the project.	
b. Details of the process measures and outcomes.	9
c. Contextual elements that interacted with the intervention(s).	
d. Observed associations between outcomes, interventions and relevant contextual elements.	10
e. Unintended consequences such as unexpected benefits, problems, failures or costs associated with the intervention(s).	
f. Details about missing data.	
Discussion: What does it mean?	
14. **Summary**	**11**
a. Key findings, including relevance to the rationale and specific aims.	
b. Particular strengths of the project.	
15. **Interpretation**	11
a. Nature of the association between the intervention(s) and the outcomes.	
b. Comparison of results with findings from other publications.	
c. Impact of the project on people and systems.	
d. Reasons for any differences between observed and anticipated outcomes, including the influence of context.	
e. Costs and strategic trade-offs, including opportunity costs.	
16. **Limitations**	
a. Limits to the generalisability of the work.	12
b. Factors that might have limited internal validity such as confounding, bias or imprecision in the design, methods, measurement or analysis.	
c. Efforts made to minimise and adjust for limitations.	
Conclusions	
a. Usefulness of the work.	12
b. Sustainability.	
c. Potential for spread to other contexts.	
d. Implications for practice and for further study in the field.	
e. Suggested next steps.	
Other information	
18. **Funding** - Sources of funding that supported this work. Role, if any, of the funding organization in the design, implementation, interpretation and reporting.	13
19. Authors Contribution Statement	13