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# BIGDATA ANALYSIS THE IMPORTANCE OF TRACKING PHACOEMULSIFICATION SURGERY COSTS

*Analisis Bigdata tentang Pentingnya Pelacakan Biaya Bedah Phacoemulsification*

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**ABSTRAK**

*Katarak adalah penyebab utama kebutaan yang dapat dicegah secara global, dengan proporsi kasus yang signifikan terjadi di negara berpenghasilan rendah akibat keterbatasan akses terhadap solusi bedah yang terjangkau. Phacoemulsifikasi telah menjadi standar emas untuk operasi katarak karena hasilnya yang superior dan efisiensinya. Namun, biaya tinggi yang terkait dengan prosedur menjadi hambatan signifikan bagi aksesibilitas, terutama di lingkungan dengan sumber daya terbatas. Penelitian ini menganalisis tren global dalam studi terkait biaya phacoemulsifikasi, mengidentifikasi kontributor utama, mengevaluasi fokus tematik, dan menyoroti kesenjangan penelitian. Tujuannya untuk memberikan informasi strategi optimalisasi biaya dan akses yang adil terhadap operasi katarak. Pendekatan bibliometrik dan deskriptif kuantitatif digunakan dalam penelitian ini. Data dikumpulkan dari publikasi yang terindeks di Scopus (2018–2024) menggunakan kata kunci "phacoemulsification" dan "cost". Artikel berbahasa Inggris yang telah ditinjau sejawat dimasukkan, dan data dianalisis menggunakan alat Scopus dan VOSviewer untuk analisis tema dan tren. Penelitian ini menganalisis 208 publikasi, mengungkapkan peningkatan penelitian terkait biaya phacoemulsifikasi, dengan puncaknya pada tahun 2021 sebanyak 38 artikel. Jurnal berdampak tinggi, seperti Journal of Cataract and Refractive Surgery, mendominasi lanskap publikasi. Tema utama yang diidentifikasi meliputi efektivitas biaya, akses layanan kesehatan, dan hasil bedah, dengan kesenjangan signifikan pada strategi pengurangan biaya dan adaptasi untuk lingkungan dengan sumber daya terbatas. Institusi dari negara berpenghasilan tinggi memimpin kontribusi, sementara upaya penelitian dari negara berpenghasilan menengah berfokus pada keterjangkauan dan aksesibilitas.Temuan ini menekankan perlunya penelitian terfokus pada pengurangan biaya, kolaborasi multidisiplin, dan kerangka kebijakan untuk meningkatkan aksesibilitas. Mengatasi kesenjangan ini dapat mengurangi disparitas dan mendukung Cakupan Kesehatan Semesta (Universal Health Coverage/UHC).*

***Kata kunci**: phacoemulsifikasi, operasi katarak, biaya, akses layanan kesehatan, analisis bibliometrik, big data*

***ABSTRACT***

Cataracts are the leading cause of preventable blindness globally, with a significant proportion of cases occurring in low- and middle-income countries due to limited access to affordable surgical solutions. Phacoemulsification has become the gold standard for cataract surgery due to its superior outcomes and efficiency. However, the high costs associated with this procedure present significant barriers to accessibility, particularly in resource-constrained settings. This research analyzes global trends in phacoemulsification cost-related studies, identifies key contributors, evaluates thematic focuses, and highlights research gaps. It aims to inform strategies for cost optimization and equitable access to cataract surgery. A bibliometric and quantitative descriptive



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approach was employed. Data were collected from Scopus-indexed publications (2018–2024) using the keywords "phacoemulsification" and "cost." Peer-reviewed, English-language articles were included, and data were analyzed using Scopus tools and VOSviewer for thematic and trend analysis. The study analyzed 208 publications, revealing a steady increase in phacoemulsification cost-related research, peaking in 2021 with 38 articles. High-impact journals, such as the Journal of Cataract and Refractive Surgery, dominated the publication landscape. Key themes identified include cost-effectiveness, healthcare access, and surgical outcomes, with significant gaps in research addressing low-resource settings and cost-reduction strategies. Institutions from high-income countries contributed while emerging research efforts in middle-income countries focused on affordability and accessibility. The findings emphasize the need for targeted cost-reduction research, multidisciplinary collaboration, and policy frameworks to improve accessibility. Addressing these gaps can reduce disparities and support Universal Health Coverage (UHC).

**Keywords**: phacoemulsification, cataract surgery, costs, healthcare access, bibliometric analysis, big data

## INTRODUCTION

Cataracts are the leading cause of preventable blindness globally, with more than 50% of blindness cases caused by this condition, according to the World Health Organization (WHO) [1],[2]. Cataracts result from clouding the eye's lens, leading to decreased vision and blindness if left untreated [3],[4]. The condition mainly affects the elderly population but can also occur at a young age due to genetic factors, trauma, or certain diseases such as diabetes [5]. With increasing global life expectancy, the prevalence of cataracts is expected to continue to rise, posing a significant public health burden.

Phacoemulsification is one of the most commonly used eye surgery techniques to treat cataracts, a condition in which the eye lens becomes cloudy, causing visual impairment or even blindness[2]. The technique involves using an ultrasonic device to shatter the cloudy lens (cataract) into tiny particles, which are then suctioned through a small incision in the cornea [6]. An artificial intraocular lens (IOL) is fitted to replace the removed natural lens[7]. This procedure offers several advantages, including a quick recovery time, a high success rate, and a low risk of complications if performed well.

Phacoemulsification has become the gold standard in cataract treatment due to its advantages of providing good clinical outcomes, short recovery time, and low risk of complications[8]. However, despite the effectiveness of this procedure, the main challenge lies in its high cost. The cost of phacoemulsification surgery is influenced by various factors, such as the advanced technology used, the price of the intraocular lens (IOL), and the healthcare facility where the surgery is performed[8]. The surgery is often affordable in developed countries due to insurance support and government subsidies. However, in developing countries or regions with limited healthcare systems, the cost of these surgeries is a significant barrier for patients in need.

The increasing need for phacoemulsification surgery is of increasing concern amidst a growing elderly population at high risk of cataracts. According to data from the World Health Organization (WHO), cataracts are the leading preventable cause of global blindness, with more than 50% of blindness cases caused by this condition [9]. Improving accessibility to phacoemulsification surgery is a significant challenge, especially in resource-constrained developing countries.

The inability of a large proportion of the population to afford phacoemulsification surgery leads to disparities in access to eye health services. In many developing countries, the limited number of eye surgeons, lack of adequate healthcare facilities, and high surgery costs prevent millions of patients from accessing the care they need[10].



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This exacerbates the burden of blindness, which affects individuals' quality of life and has far-reaching economic impacts, such as lost productivity and increased burden on families and communities. The WHO report highlights that 94 million people are living with visual impairment due to inoperable cataracts, with the majority coming from low- and middle-income countries[3]. This situation highlights significant inequalities in access to eye health care, primarily due to cost barriers.

Obesity Currently, the government collaborates with various hospitals and runs the INA-CBG's program as a guideline for calculating the cost of BPJS patient claims. The INA-CBG system consists of several components that are interrelated with each other. Components that are directly related to service output are clinical pathway, coding, and information technology, while separately there is a posting component that indirectly affects the process of preparing INA-CBG rates for each case group [11]. Payment procedures using the INA-CBG's system, both hospitals and payers no longer itemize bills based on the details of services provided, but only by submitting the patient's discharge diagnosis and INA-CBG's code [12]. The amount of reimbursement for the diagnosis has also been agreed upon by the government and is expected to control health costs, encourage quality services in accordance with standards, limit unnecessary or excessive services and encourage providers to carry out cost containment. Meanwhile, in general, the payment system applied in hospitals in Indonesia is a fee for service system. Where through this system, health service providers charge fees for each type of service provided so that each patient pays according to each service received. Each examination and action will be charged according to the existing hospital tariff. In the fee for service payment system, the more services provided, the greater the costs that must be incurred. As a result, there is an increase in the cost of each health service [12].

In setting rates or planning a budget for a service program, the calculation of unit costs plays a key role. Unit cost refers to the total cost divided by the number of units of the product or service produced. In the context of healthcare, unit cost can be applied to measure the average cost per unit of medical service or per unit of a specific activity [13]. Unit cost is an important metric in cost analysis and financial management, providing an understanding of the efficiency and effectiveness of resource use in providing a particular service or product. The determination of unit cost in cost analysis is essential to determine the amount of cost that is actually required to produce a product, be it a good or service. In addition, the unit cost calculation also has another purpose, which is to evaluate the efficiency of budget allocation [14]. Challenges arising from inconsistent application of calculation methods, data problems, lack of integration between calculations and budgets require a holistic approach in determining cost calculations [15]. Tariff setting is also a form of health policy change and global economic dynamics can affect patient satisfaction in response to financial demands and improving service quality [16]. Unit cost calculation with Activity Based Costing (ABC) is an approach in cost accounting that focuses on activities. This concept aims to control costs by providing information related to activities that cause costs. This approach becomes relevant because of the various cost drivers used in allocating overhead costs. As a result, the use of Activity Based Costing can increase the level of accuracy in cost breakdown and accuracy in cost allocation, making it more accurate and precise [17]. The ABC method and cost analysis are the most widely used major payment systems today [18]. Costs controlled by an activity-related approach are believed to result in cost efficiency and improved healthcare outcomes [19].

A study conducted showed significant differences in medical action rates in a hospital calculated using the Activity-Based Costing (ABC) method compared to the Traditional Cost System (TCS) method. The ABC method produces higher prices at the level of these actions, becomes a reference for evaluating hospital costs and helps improve the


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quality of health services [20]. In another study conducted, there was a difference in unit costs for Sectio Caesarea actions between the ABC method and the rates determined by the Hospital with a lower ABC method [21]. Time-Driven Activity-Based Costing (TDABC) is an innovative approach to measuring costs more accurately and overcoming cost challenges. This method estimates the amount of time and cost per unit of time of each resource (for example, equipment and personnel) used during an episode of care which is a development of the ABC method. In a study conducted on Total Hip Replacement (THA) surgery, TDABC proved to be an accurate method to measure the cost of the healthcare process for THA considering the facilities, equipment, and staff involved [22].

The calculation of unit costs using the Activity-Based-Costing method can be a consideration for management in setting tariffs, taking into account other units involved, such as inpatient units, in the evaluation framework. The BPJS era requires hospitals to be careful in calculating rates, because BPJS will only pay according to the number of claims that have been determined. By knowing the unit costs, hospitals can more easily estimate the costs in the area to organize more comprehensive services. The phacoemulsification technique is currently the most commonly used extracapsular cataract extraction method in developed countries. In this technique, an ultrasonic vibrator is used to crush the hard cataract core, allowing the core and cortex material to be sucked out through a small incision of about 2.5 to 3 mm [23]. Cataract is a clouding disease of the lens of the eye that occurs due to trauma, toxins, systemic diseases, smoking and heredity [23]. Cataract is the leading cause of visual impairment in Indonesia. A large proportion, about 70-80%, of severe visual impairment leading to blindness is caused by cataracts. Therefore, the Ministry of Health prioritizes the Vision Impairment Control Program to reduce the prevalence of vision impairment due to cataracts, while making efforts to reduce vision impairment caused by other factors [24].

This study offers novelty in two main aspects: the analytic approach and the specific focus on phacoemulsification surgery costs. First, this study uses big data analysis to track and analyze costs, which has not been widely applied in ophthalmology until now. Big data enables collecting information on a large scale and from multiple sources, thus providing a more comprehensive picture of cost patterns and the factors influencing them. Secondly, this study analyzed surgery costs in general and focused on phacoemulsification surgery, the most common procedure for treating cataracts. By focusing on this procedure, the study generated more in-depth and relevant insights for policy-making.

This research is important to address the challenges of accessibility and efficiency of eye health services. Systematically tracking the cost of phacoemulsification surgery can help identify opportunities to lower expenditure and reduce access disparities, especially in developing countries. In addition, the results of this study serve as a basis for recommending more inclusive policies, such as subsidizing surgeries, optimizing operational processes, or using alternative technologies that are more economical.

On the other hand, the big data approach enables evidence-based decision-making in managing eye health resources. By understanding the factors that most significantly affect costs, governments, healthcare providers, and donor agencies can design more effective interventions to improve affordability. This study also contributes to the development of limited scientific literature in the field of eye health cost analysis, especially in the field of big data technologies. As such, this research is expected to directly impact the improvement of access to and quality of eye health services worldwide.

This research answers the problems: (1) how is the development of international scientific publications on phacoemulsification from 2018-2024 on Scopus, (2) how is the core journal of scientific publications on phacoemulsification, (3) How is the number of


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productive researchers who make scientific publications on phacoemulsification, (4) how is the number of scientific publications on phacoemulsification based on affiliation/institution, (5) how is the number of scientific publications on phacoemulsification based on country, (6) how is the number of scientific publications on phacoemulsification based on subject, (7) how is the author collaboration analysis, (8) how is the keyword analysis, and (9) how is the analysis based on country.

This research aims to address these challenges by utilizing a big data approach to track and analyze the cost of phacoemulsification surgery. As such, this research will contribute to improving the efficiency and affordability of cataract surgery and potentially reduce the global burden of preventable blindness.

## METHODS

This study integrates bibliometric analysis with a quantitative descriptive approach to examine trends and patterns in scientific research related to phacoemulsification. The unit of analysis consists of scientific articles, with research data from international publications indexed in the Scopus database. Scopus was chosen due to its high credibility, global recognition among academic and research institutions, and its provision of aggregate citation data that reflects the significance of journals and institutions within scientific research. Furthermore, Scopus offers aggregate data that illustrates a journal's or institution's degree of importance in the field of scientific publications. This is predicated on the relationship between citations to and from journal articles or works by scholars at a particular institution [25].

The research question, framed using the PICo framework, focuses on publications related to phacoemulsification surgery with a specific emphasis on costs. The interest lies in analyzing trends in research development, citation impact, and cost-related factors associated with phacoemulsification. The context encompasses global scientific publications indexed in the Scopus database from 2018 to 2024. The sample includes all scientific articles retrieved using the Scopus database that meet the search criteria "phacoemulsification" and "cost" within titles, abstracts, and keywords. The total number of samples depends on the search results returned from the database query. These articles were analyzed to identify trends, collaborations, and the geographic distribution of research. The inclusion criteria encompass articles published between 2018 and 2024, those explicitly mentioning phacoemulsification and cost in the title, abstract, or keywords, and peer-reviewed publications such as original research articles, reviews, and systematic analyses. Only publications available in English were included to ensure accessibility and standardization in data interpretation. Exclusion criteria ruled out articles unrelated to phacoemulsification or lacking a clear focus on costs, abstract-only records, conference papers, or grey literature without peer-reviewed status, duplicate records retrieved from the database, and publications in languages other than English unless translations were available.

### Data Collection and Analysis

The research utilized data from the Scopus database *(www.scopus.com)* collected between 2018 and 2024. A targeted search was conducted using the keywords "phacoemulsification" and "cost," applied to article titles, abstracts, and keywords. After retrieving the search results, researchers systematically analyzed the dataset to uncover trends in research development and thematic focus, the impact of prominent journals, researcher productivity, and collaboration patterns, publication growth by institution or affiliation, and the geographical distribution of publications by country. The Scopus *Analyze* menu facilitated the generation of graphical outputs and statistics in JPEG format. Secondary data exported in CSV format was further processed using Microsoft Excel and VOSviewer software for advanced bibliometric visualization. VOSviewer was used to create keyword maps, highlighting relationships between


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recurring terms to identify core themes and research gaps. By integrating a structured framework (PICo), clear sample parameters, and systematic criteria for inclusion and exclusion, the methodology ensures robustness and reliability in uncovering global trends related to the costs of phacoemulsification surgery.

## RESULT

The results of this study reveal several key insights into the global research landscape surrounding phacoemulsification and its associated costs, as derived from the bibliometric analysis and descriptive data interpretation. The following findings were obtained:

### Trends in Research Development

The average total cost for phacoemulsification was US$ 416, whereas the estimated cost for extracapsular cataract extraction was US$ 284 (as of December 30, 2011). The mean preoperative spectacle-corrected visual acuity was significantly worse for eyes scheduled for extracapsular cataract extraction (1.73 ± 0.62) compared to those expected for phacoemulsification (0.74 ± 0.54 logMAR) ($p<0.01$). Postoperatively, visual acuity was significantly better for phacoemulsification (0.21 ± 0.36 logMAR) than for extracapsular cataract extraction (0.63 ± 0.63 logMAR) ($p<0.01$). In a study of patients undergoing phacoemulsification, 85% achieved postoperative spectacle-corrected visual acuities of ≥0.30 logMAR. In contrast, only 45% of patients who underwent extracapsular cataract extractions reached the same level of postoperative visual acuity ($p<0.01$). The incidence of intraoperative complications was markedly elevated following extracapsular cataract extractions (21%) compared to phacoemulsifications (7.6%) ($p<0.01$). Additionally, the average number of postoperative visits was more significant after extracapsular cataract extractions (5.6 ± 2.3) than after phacoemulsifications (4.5 ± 2.4) ($p<0.01$) [26]. This condition is supported by the number of scientific publications obtained regarding phacoemulsification indexed in the Scopus database from 2018 - 2024, which is 208 documents, which can be seen in Figure 1 below.

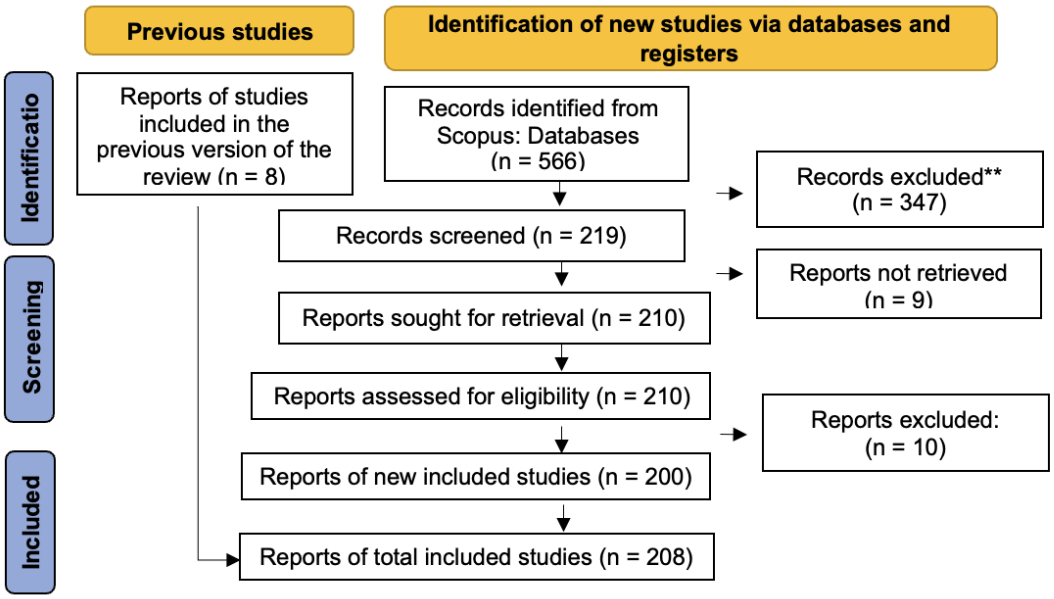


**Figure 1. Publication selection in Scopus**

The data suggest that cataract surgery conducted by ophthalmology trainees utilizing phacoemulsification is costly; however, in comparison to extracapsular cataract extraction outcomes, instructing in phacoemulsification results in an approximately three-



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fold reduction in complication rates, fewer postoperative visits, and, crucially, superior visual acuities. The trend of phacoemulsification-related scientific publications is more clearly displayed in Figure 2.

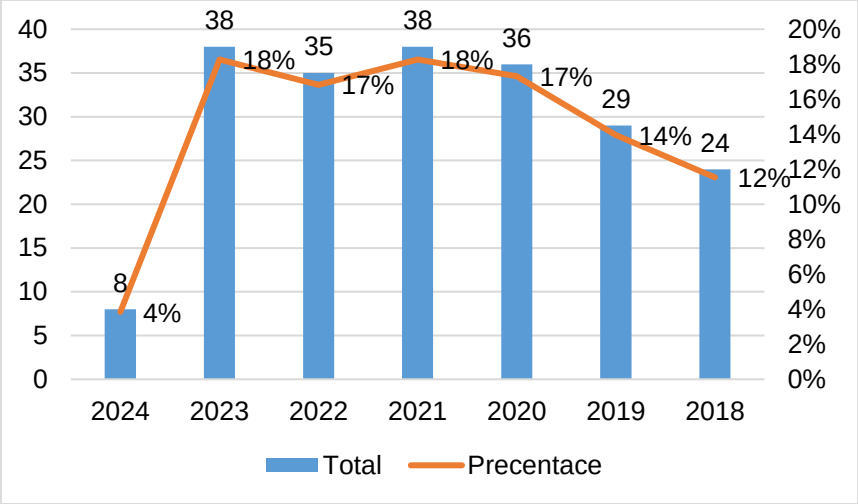


**Figure 2. The trend of Scientific Publications on Phacoemulsification**

There are as many as thirty-nine (18.75%) scientific papers on phacoemulsification that are indexed on Scopus in 2021, making them the most numerous. The following is a list of the number of publications by year: up to 38 publications (18.27%) in 2023; up to 36 publications (17.31%) in 2020; up to 35 publications (16.83%) in 2022; up to 29 publications (13.94%) in 2019; up to 23 publications (13.52%) in 2018; and up to 8 publications (3.85%) in 2024. Cost tracking also creates transparency in the health system. With precise data, patients can know the details of their expenses, which builds trust in healthcare providers [27]. This transparency also allows the comparison of cost efficiencies between service providers in different regions, which can motivate improvements in overall service quality [27].

Research on phacoemulsification and its associated costs shows a consistent increase in publication volume from 2018 to 2024. This growth reflects the growing global interest in understanding and addressing the economic aspects of phacoemulsification surgery, especially in healthcare accessibility and efficiency. The number of scientific publications related to phacoemulsification continues to increase, with significant peaks occurring in 2021 and 2023, which recorded the highest number of publications at 38 papers. This trend highlights the growing recognition of the importance of cost analysis in surgical procedures. In addition, this increase in research volume reflects broader concerns regarding healthcare costs and the need for efficient resource allocation in medical practice. Researchers are increasingly examining how cost tracking can improve the accessibility and sustainability of healthcare services, particularly in the context of Universal Health Coverage (UHC). Contributions to this body of research are predominantly from developed countries, suggesting a concentrated effort to explore and refine the economic implications of phacoemulsification surgery in the region. In addition, the significant number of authors and collaborative efforts noted in this research suggest that interdisciplinary approaches are being applied to address the complexities of cost management in healthcare. These collaborations are critical to driving innovation and developing best practices in this area. Overall, this trend in research development emphasizes the crucial role of economic analysis in improving the quality and accessibility of phacoemulsification surgery, with the ultimate goal of reducing the financial burden on patients and improving health outcomes.



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In terms of quality, cost tracking helps identify more efficient methods or tools without compromising the quality of care [27]. With complete data, the relationship between costs and clinical outcomes can be analyzed to ensure that cost savings do not come at the expense of patient outcomes. This encourages innovation and the application of best practices in health services.

**Central Journals and Research Impact**

A significant portion of the publications on phacoemulsification and its costs are concentrated in high-impact journals specializing in ophthalmology and healthcare economics. These journals serve as critical platforms for disseminating research findings, highlighting their role in shaping the scientific discourse around cataract surgery and its financial aspects. Notable journals such as the Journal of Cataract and Refractive Surgery lead the field, publishing the most significant number of articles on the subject, followed by other reputable platforms like the Indian Journal of Ophthalmology, BMC Ophthalmology, Clinical Ophthalmology, and Current Opinion in Ophthalmology. Publications on phacoemulsification in scientific journals are shown clearly in Figure 3.

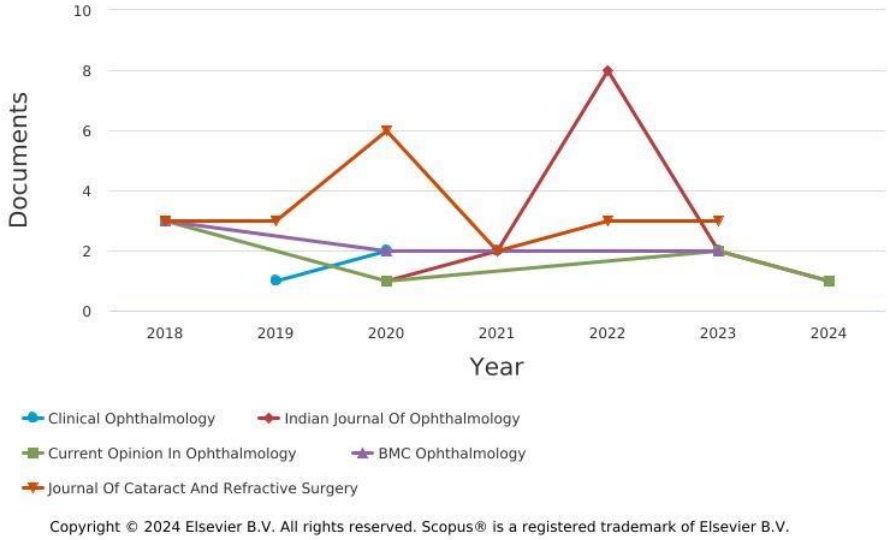


**Figure 3. Journal of Scientific Publications on Phacoemulsification**

Number of Scientific Publications on Phacoemulsification by Subject. There are ten subjects with the highest order. These findings are consistent with phacoemulsification, the most commonly used cataract surgical procedure and very effective in restoring vision. However, tracking the costs of these procedures plays an important role in various aspects of healthcare. Cost tracking allows hospitals and health systems to identify the most significant cost elements in the procedure, such as devices, consumables and operative time. With this information, healthcare institutions can optimize resource allocation, reduce waste, and manage budgets more efficiently.

The prominence of these journals underscores the topic's substantial relevance within the scientific community. Publications on such platforms often undergo rigorous peer-review processes, ensuring the reliability and credibility of the findings. This concentration in high-impact journals also reflects the growing recognition of phacoemulsification's importance as a clinical procedure and as a subject of economic analysis.

Furthermore, the journals' international reach facilitates a broad dissemination of research findings, enabling collaboration across geographic and institutional boundaries. These publications often serve as reference points for policymakers, healthcare practitioners, and researchers aiming to improve clinical outcomes while addressing cost-related challenges. Including articles in journals with wide readership and high



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citation rates amplifies their impact, influencing clinical practices and health policy discussions.

In addition, articles on phacoemulsification costs in healthcare economics journals demonstrate the topic's interdisciplinary nature. This crossover indicates that cataract surgery costs are not confined to medical discourse but also involve economic evaluations and system-wide implications, further solidifying its critical role in global healthcare challenges. This multidisciplinary relevance enhances the visibility and applicability of the research, contributing to strategic advancements in medical and economic domains.

In addition, cost tracking also impacts the accessibility of services for the wider community. This procedure can be made more affordable by recognizing and reducing unnecessary costs, thereby reducing the financial burden on patients, especially those from lower-middle economic groups. Accurate data on costs also supports policymakers in designing more appropriate subsidies or health insurance programs, ensuring all levels of society can access these services

**Researcher Productivity and Collaboration**

The analysis highlights a concentrated effort by key researchers and institutions significantly contributing to the field of phacoemulsification, particularly in cost analysis. Among the most productive contributors are researchers with six publications, like Bunce, C., Day, A.C., Dirksen, C.D., Nuijts, R.M.M.A., and Simons, R.W.P. These researchers are affiliated with prominent institutions such as Moorfields Eye Hospital NHS Foundation Trust, UCL Institute of Ophthalmology, and King's College London, reflecting their active role in advancing ophthalmic research. Number of Productive Researchers Conducting Scientific Publications on Phacoemulsification. There are ten researchers who are productive in publishing research results on phacoemulsification.

**Table 1. Number of Productive Researchers with Scientific Publications on Phacoemulsification**

| Researcher Name | Number of Publications |
|---|---|
| Bunce, C. | 6 |
| Day, A.C. | 6 |
| Dirksen, C.D. | 6 |
| Nuijts, R.M.M.A. | 6 |
| Simons, R.W.P. | 6 |
| Hunter, R. | 5 |
| Nanavaty, M.A. | 5 |
| Winkens, B. | 5 |
| Thiel, C.L. | 4 |
| Van Den Biggelaar, F.J.H.M. | 4 |

Source. Scopus data processing by Author (2024)

Bunce, C., Day, A.C., Dirksen, C.D., Nuijts, R.M.M.A., and Simons, R.W.P. each have six scientific publications to their names, as Table 1 demonstrates. Each of Hunter, Nanavaty, and Winkens has published five scientific articles. Each of Thiel, C.L., and Van Den Biggelaar, F.J.H.M., has published four scientific works. The quantity of fruitful researchers who have published in scientific journals on phacoemulsification is more clearly depicted. Number of Scientific Publications on Phacoemulsification by Country. There are ten countries are productive in publishing research results on phacoemulsification. Based on the number of publications, the journals are ranked as follows: Journal of Cataract and Refractive Surgery (with twenty), Indian Journal of Ophthalmology (with fourteen), BMC Ophthalmology (with seven), Clinical Ophthalmology (with seven), and Current Opinion in Ophthalmology (with seven).

A notable and impactful trend is the high prevalence of international collaborations within this domain. Researchers from different countries and institutions are increasingly


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working together, leveraging diverse expertise and resources to address the economic challenges of phacoemulsification. This trend underscores the global nature of the issue, as phacoemulsification is widely regarded as a gold-standard treatment for cataract surgery. However, its costs remain a significant barrier, especially in low- and middle-income countries.

International collaborations have also facilitated sharing data, methodologies, and innovative solutions. For example, partnerships between developed and developing nations have enabled researchers to explore cost variability across regions, identify cost-efficient practices, and address disparities in access to phacoemulsification. These efforts contribute to scientific progress and practical policy recommendations that can make this essential surgery more accessible worldwide.

Furthermore, bibliometric data reveal clusters of active collaborations visualized using tools like VOSviewer. These clusters often involve multidisciplinary teams, combining expertise in ophthalmology, healthcare economics, and public health. Such diverse collaborations have proven essential for a holistic understanding of cost dynamics and proposing strategies to optimize resource allocation, improve affordability, and enhance surgical outcomes. In summary, the productivity of key researchers and the prevalence of international collaboration emphasize the global commitment to understanding and addressing the costs of phacoemulsification. These efforts are pivotal for bridging knowledge gaps, fostering innovation, and promoting equitable access to cataract care globally.

Since cooperation in research is greatly desired, agencies and researchers must work together to share ideas, funding, facilities, infrastructure, and chances for the exchange of scientific information and methodologies [17]. There were 875 authors in this study, and 87 of them had a close tie with the ownership of at least two documents. Figure shows a visualization of the author collaboration in this work.

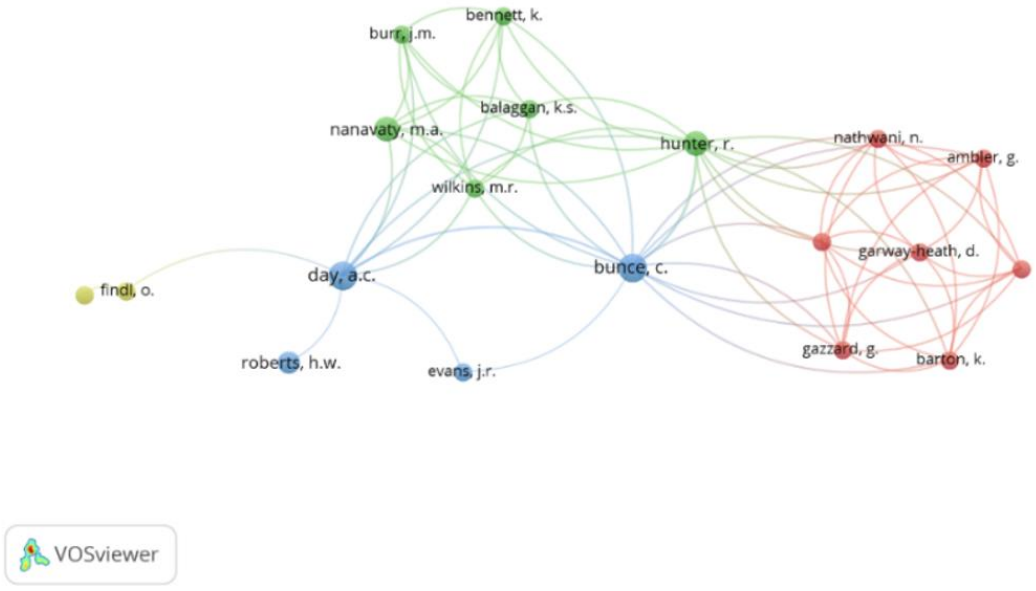


**Figure 4. Visualization of Author's Collaboration**

## Publication Growth by Institution or Affiliation

The publication landscape in phacoemulsification research is heavily dominated by institutions from high-income countries, which often possess robust healthcare systems, advanced ophthalmology research centers, and significant funding for research and development. These institutions, such as Moorfields Eye Hospital NHS Foundation Trust and UCL Institute of Ophthalmology, have consistently led the field, leveraging their expertise and resources to explore innovations in cataract surgery, including cost



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optimization and clinical outcomes. Such dominance underscores the advantages of established healthcare infrastructures and sustained investment in medical research. Number of Scientific Publications on Phacoemulsification by Affiliation/Institution. There are ten affiliates/institutions that are productive in publishing research results on phacoemulsification.

**Table 2. Affiliates/Institutions that are Productive in Scientific Publications on Phacoemulsification**

| Affiliation/Institution Name | Number of Publications |
|---|---|
| Moorfields Eye Hospital NHS Foundation Trust | 16 |
| UCL Institute of Ophthalmology | 11 |
| King's College London | 9 |
| University College London | 8 |
| Maastricht Universitair Medisch Centrum+ | 7 |
| Sussex Eye Hospital | 7 |
| University Hospitals Sussex NHS Foundation Trust | 7 |
| Universiteit Maastricht | 6 |
| University of Miami Leonard M. Miller School of Medicine | 6 |
| London School of Hygiene & Tropical Medicine | 6 |

Source. Scopus data processing by Author (2024)

As shown in Table 2, the most prolific affiliates/institutions in terms of phacoemulsification scientific publications are as follows: Sussex Eye Hospital (with seven publications), King's College London (with nine publications), University College London (with eight publications), Maastricht Universitair Medisch Centrum+ (with seven publications), and UCL Institute of Ophthalmology (with eleven publications).

However, a notable shift is occurring with the increasing contributions from institutions in middle-income countries. These regions, faced with a disproportionately high prevalence of cataract-induced blindness, are beginning to recognize the economic and social burden of cataract surgeries. Emerging institutions in countries such as India, Brazil, and Southeast Asia contribute to the growing body of research, often focusing on cost-effective solutions and accessibility in resource-constrained settings.

This emerging trend highlights a dual focus in global research efforts: while high-income countries continue to innovate in technology and clinical protocols, middle-income countries are addressing real-world challenges of affordability, access, and resource allocation. For instance, institutions in these regions are investigating lower-cost phacoemulsification techniques, alternative funding models, and training programs for ophthalmologists to scale the delivery of cataract surgeries.

Moreover, international collaborations are becoming more frequent, bridging the gap between resource-rich and resource-constrained regions. These partnerships facilitate knowledge transfer, capacity building, and shared innovation, ultimately aiming to reduce the global burden of cataract-related visual impairment. The involvement of middle-income countries also underscores the universality of the issue and reflects a growing global acknowledgment of the need for equitable healthcare solutions.This evolving publication landscape points to a promising future where diverse contributions from institutions worldwide can collectively address the multifaceted challenges of phacoemulsification surgery, including its economic, clinical, and societal impacts**.**

**Subject Distribution**

The subject distribution of scientific publications on phacoemulsification highlights the interdisciplinary nature of this research field, with a dominant focus on medicine. Of the 208 publications analyzed, medicine emerged as the leading subject area, contributing 200 articles. This prominence reflects the central role of phacoemulsification in


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ophthalmology and its impact on clinical outcomes, healthcare delivery, and cost management. Research in this domain primarily concerns improving surgical techniques, enhancing patient outcomes, and optimizing resource utilization in healthcare systems.. The quantity of scientific publications on phacoemulsification by subject is more clearly displayed in Figure 5.

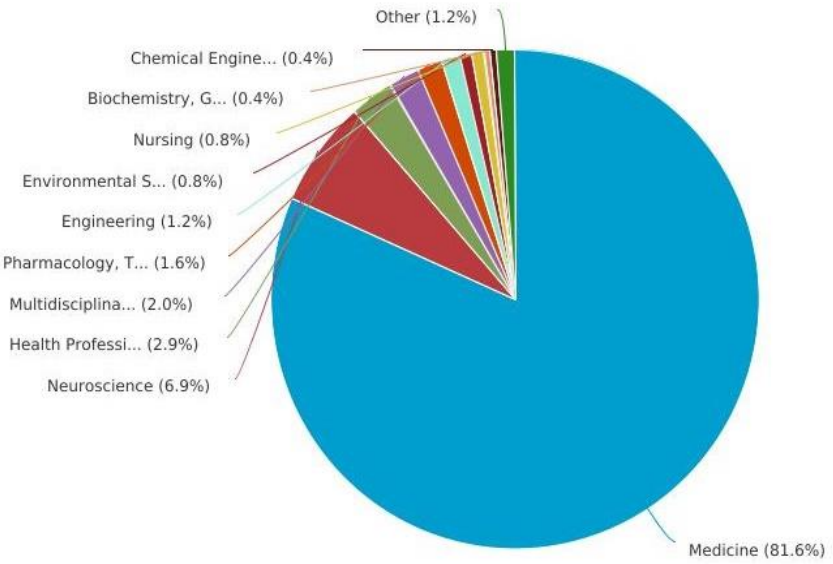




**Figure 5. Number of Scientific Publications on Phacoemulsification by Subject**

The distribution of scientific publications on phacoemulsification reflects its multidisciplinary nature, with a predominant focus on medicine, which accounts for 81.6% of the total publications. This overwhelming majority underscores the central role of phacoemulsification as a clinical procedure within the field of ophthalmology, with research primarily aiming to enhance surgical techniques, improve postoperative outcomes, and optimize healthcare delivery, particularly in addressing cataract-related blindness. The second-largest contributor, neuroscience (6.9%), highlights an emerging area of interest that explores the broader implications of cataract surgery, such as its impact on neural processing, cognitive functions, and sensory integration, especially among elderly patients. This research is significant as it connects vision restoration to overall quality-of-life improvements.

The health professions category (2.9%) emphasizes the role of healthcare workers in delivering high-quality phacoemulsification services. Research in this area often examines workforce training, efficiency, and task-sharing models designed to address the shortage of ophthalmic surgeons, particularly in resource-limited settings. Meanwhile, multidisciplinary studies (2.0%) showcase the integration of various fields to tackle challenges in cataract surgery. These studies often focus on cost modeling, improving healthcare accessibility, and understanding the social implications of cataract-related blindness, reflecting the need for collaborative approaches to address these multifaceted challenges.

Pharmacology, toxicology, and pharmaceutics (1.6%) contribute to the research on preoperative and postoperative medications, such as anesthesia, anti-inflammatory drugs, and antibiotics, which are crucial in enhancing recovery and minimizing complications. Engineering-related studies (1.2%) focus on technological innovations, including developing advanced surgical instruments, ultrasound devices, and intraocular lens materials, which are instrumental in improving procedural efficiency and outcomes. In comparison, a minor contributor, environmental science (0.8%), addresses



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sustainability in surgical practices by investigating waste reduction strategies and the environmental impact of disposable surgical supplies—an area of growing concern in modern healthcare systems.

Nursing (0.8%) research highlights the critical role of nurses in supporting surgical procedures and postoperative care. This includes initiatives led by nursing professionals to improve patient outcomes and streamline the care process. Biochemistry, genetics, and molecular biology (0.4%) delve into the molecular and genetic factors contributing to cataract formation, potentially offering new insights into prevention strategies or targeted therapies to delay cataract onset. Similarly, chemical engineering (0.4%) contributes to developing innovative materials for surgical tools and intraocular lenses to enhance precision and patient satisfaction.

Finally, the remaining 1.2% of publications are distributed across other disciplines, demonstrating the diverse approaches to understanding and improving phacoemulsification. This multidisciplinary engagement reflects the complexity of addressing cataract-related challenges and emphasizes the importance of integrating perspectives from various fields to foster innovation and achieve comprehensive solutions. Despite the robust focus on medicine, the relatively minor contributions from environmental science and genetics indicate potential research gaps that could provide valuable insights into the broader implications and optimization of phacoemulsification procedures. By addressing these gaps and encouraging collaboration across disciplines, phacoemulsification research can continue to drive advancements in cataract surgery, promoting better health outcomes and equity in healthcare access worldwide.

**Keyword and Research Focus Visualization**

The study employed VOSviewer to perform keyword mapping, enabling a detailed analysis of research themes and trends in the field of phacoemulsification and its associated costs. The keyword analysis in this study was based on 2,007 keywords, which were then filtered with a minimum occurrence threshold of 5, resulting in 239 keywords with strong relationships. The most frequently used keyword by the authors is "human." A visualization of the keyword analysis in this study can be seen in Figure 6.

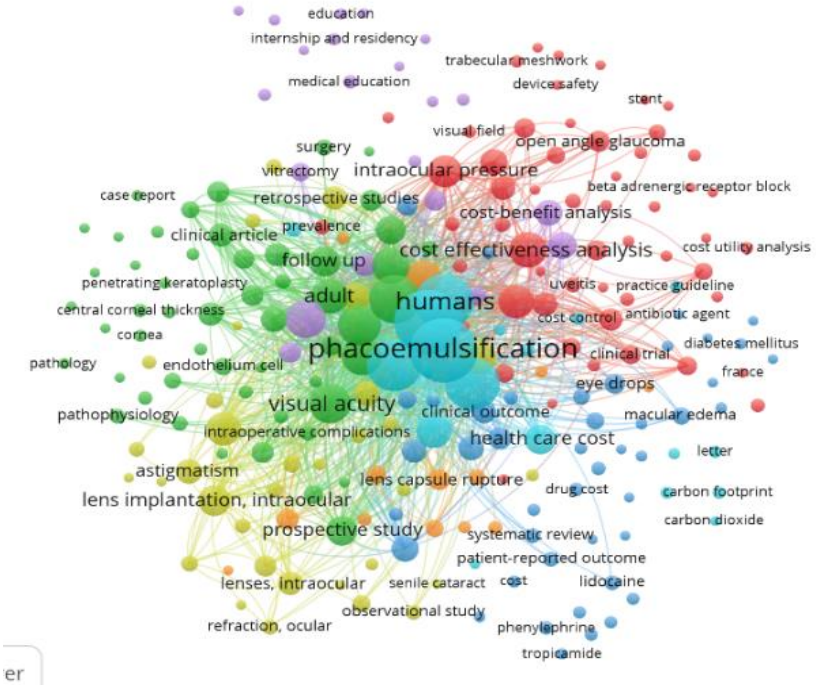


**Figure 6. Keywords Visualization**



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Figure 6 illustrates how the development map of phacoemulsification research publications indexed in the Scopus database from 2018 to 2024 generated seven clusters based on search results using the term. Cluster 1 has 55 keywords in red, Cluster 2 has 53 keywords in green, Cluster 3 has 44 keywords in blue, Cluster 4 has 33 keywords in yellow, Cluster 5 has 21 keywords in purple, Cluster 6 has 20 keywords in light blue, and Cluster 7 has 13 keywords in orange. Keyword density as shown via density visualization can be seen with VOSviewer. The increased keyword density suggests that there has been much research done on the subject. On the other hand, a low density may present a chance for fresh investigation.

The visualization revealed several dominant themes. The first theme, cost-effectiveness, highlights the ongoing exploration of strategies to maximize the value of phacoemulsification procedures relative to their cost. Researchers are focusing on identifying cost drivers, such as surgical tools, consumables, and operative time, and determining how these factors influence overall cost efficiency. Publications in this area often examine the balance between maintaining high-quality surgical outcomes and reducing financial burdens on healthcare systems and patients. The second theme is healthcare access, which emphasizes the recurring focus on providing affordable and effective phacoemulsification services. This research area reflects concerns over disparities in service availability, particularly in low-income and underserved regions. Studies addressing this theme frequently explore barriers to accessing care, such as high costs, insufficient healthcare infrastructure, and the need for policy interventions to ensure equitable distribution of services. The third theme centers on surgical outcomes, including visual acuity improvements, complication rates, and recovery times, as critical metrics for evaluating the success of phacoemulsification. Research in this area underscores the importance of linking clinical efficacy with economic evaluations to ensure that cost savings do not come at the expense of patient outcomes.

The keyword analysis, visualized through VOSviewer, identified seven thematic clusters representing interconnected research areas. Among these, the red cluster focuses on resource allocation, emphasizing the optimization of resource use and the minimization of waste in surgical practices. The green cluster pertains to health policy, addressing healthcare financing, subsidy mechanisms, and policy frameworks aimed at enhancing service accessibility. The blue cluster centers on clinical outcomes, exploring the relationship between surgical techniques, patient recovery, and long-term visual acuity. The yellow cluster investigates technological innovations, particularly advances in surgical tools and techniques designed to improve efficiency and affordability. Additionally, other clusters highlight diverse areas such as patient satisfaction, training programs for ophthalmologists, and regional disparities in healthcare delivery.

In addition to the dominant themes, the keyword mapping highlighted notable gaps in the literature. One significant gap pertains to low-resource settings, where limited research addresses the unique challenges faced by healthcare providers in resource-constrained environments. This includes the adaptation of phacoemulsification techniques to settings with restricted access to advanced surgical equipment and trained personnel, as well as the exploration of cost-effective alternatives tailored to these conditions. Another gap lies in cost-reduction strategies. Although cost-effectiveness is a prevalent theme, there is a lack of targeted studies focusing on actionable approaches to reduce the costs of phacoemulsification. Future research could explore innovations such as low-cost surgical instruments, locally sourced consumables, and streamlined procedural workflows to minimize expenses without compromising the quality of care.

Cost tracking also provides a solid basis for strategic decision-making at the managerial level [27]. The information obtained allows hospitals to make investment plans, such as procuring new technology or improving medical personnel training [28]. This data also provides important evidence for developing health policies, including price


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regulation or providing incentives to improve service efficiency. In the Universal Health Coverage (UHC) context, cost tracking is crucial in ensuring that phacoemulsification procedures are accessible to everyone without facing financial barriers. With data-based planning, health insurance programs can be designed sustainably, keeping services affordable and of high quality. Tracking phacoemulsification costs is a tool for economic efficiency and a strategic step toward realizing a more equitable, transparent and inclusive health system [29].

By identifying these themes and gaps, this study provides a roadmap for future research to address critical issues in the field of phacoemulsification. The findings underscore the need for a holistic approach that integrates clinical, economic and policy perspectives to ensure sustainable and equitable access to cataract surgery globally. The analysis also highlights the potential for collaborative efforts across institutions and countries to bridge gaps in knowledge and practice.

## DISCUSSION

Phacoemulsification is very important to be the main focus of research to trace the costs a person incurs in getting the best cataract services at the hospital [27]. In Indonesia itself, cataract sufferers reached 81 percent of the results of the Rapid Assessment of Avoidable Blindness (RAAB) survey, and the result is blindness. Where blindness in Indonesia has reached 3 percent caused by cataracts, and this result is the highest in the Southeast Asia region [30]. There needs to be comprehensive prevention in treating cataracts in Indonesia, including providing relatively cheap and affordable costs for all groups. This is important to reduce blindness, especially in the elderly. Other causes are refraction or glaucoma or other eye disorders such as refractive errors, glaucoma, or eye disorders related to diabetes [31]. Apart from that, cataract eye treatment can also be done by using glasses so that you can see well. Consume garlic every day because it contains sulfur and glucosinolates, which can be antioxidants that fight free radicals. Eat more spinach, especially green spinach, which has benefits for maintaining eye health [32]. Drink lemon juice and olive oil because these contain antioxidants, and drink almond milk because it contains vitamin A, vitamin E, and minerals such as magnesium and phosphorus. In China, one of the countries that has good cataract treatment, the service is provided free of charge and has treated 10,000 patients worldwide. The GX Foundation China supports the Cataract treatment program in China. Meanwhile, in Cambodia, the cost of cataract surgery is quite expensive; one eye surgery costs 300 to 500 dollars (1 US dollar = Rp. 15,825). This condition is very difficult for poor and rural people to reach [33].

Thus, phacoemulsification is an important study in providing services to treat cataracts. In particular, it is necessary to encourage the provision of affordable phacoemulsification to the public in order to provide hope for life, especially to the elderly, in line with the cataract treatment program that WHO has carried out through initiatives such as VISION 2020 [34]. Meanwhile, at the national level, the Ministry of Health has provided free cataract surgery through campaigns such as the Healthy Eyes Movement [27]. Plus, the Indonesian Eye Specialist Association (PERDAMI) is active in providing mass cataract operations in various remote areas in Indonesia [27]. However, it does not rule out the possibility that the high rate of blindness is caused by cataracts that are not treated properly. The dominating factor is the costs, which are quite high if there are no free programs from various relevant stakeholders. Therefore, phacoemulsification really needs to be a concrete solution to provide the best service to cataract sufferers in order to give them the hope of seeing the world in old age [35].

In discussing the strengths and limitations of the study on the costs of phacoemulsification surgery, it is essential to provide a comprehensive analysis that


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highlights the validity of the findings while acknowledging factors that may affect their generalizability.

**Strengths of the Study**

The study has several strengths that support the validity of its findings. First, it employs a robust data collection method through a bibliometric approach, utilizing extensive databases to gather a wide range of publications related to phacoemulsification costs. This ensures a comprehensive representation of the existing literature, enhancing the reliability of the findings. Second, significant international collaborations enrich the data pool and provide diverse perspectives on cost dynamics across healthcare systems. This global approach is crucial for understanding the economic challenges developed and developing countries face.

Third, using advanced analytical tools like VOSviewer for keyword analysis and cluster visualization allows for a nuanced understanding of research trends and thematic areas. This methodological rigor strengthens the validity of the findings by providing explicit visual representations of complex data. Fourth, the study's focus on cost tracking highlights an often overlooked aspect of healthcare economics. This emphasis aids in optimizing resource allocation and informs policy decisions to improve accessibility and sustainability in healthcare.

Fifth, the interdisciplinary relevance of the study adds value to its applicability. The findings resonate across various disciplines, such as ophthalmology, healthcare economics, and public health, underscoring the importance of this research in addressing global healthcare challenges. Lastly, the study effectively identifies gaps in the existing literature, particularly regarding low-resource settings and cost-reduction strategies. These insights are valuable for guiding future research efforts and addressing critical areas adequately.

**Limitations of the Study**

However, the study also has several limitations. First, the aggregate nature of big data analysis may mask local variations and contextual factors that significantly influence costs. This limitation affects the applicability of the findings to specific regions or healthcare systems. Second, reliance on published literature introduces a potential publication bias, as studies with significant or positive results are more likely to be published. This bias could skew the understanding of the actual landscape of phacoemulsification costs.

Third, the study primarily focuses on cost tracking and economic evaluations, potentially overlooking the impact of costs on clinical outcomes and patient satisfaction. This omission limits the comprehensiveness of the findings. Fourth, the findings may not be generalizable to all healthcare settings, particularly in low-income countries where healthcare infrastructure and economic conditions differ significantly from those in developed nations. This limitation necessitates caution when applying the results universally.

Fifth, the study's findings are based on data collected during a specific period, which may not reflect recent changes in healthcare policies, economic conditions, or technological advancements that could influence phacoemulsification costs. Lastly, while the study acknowledges technological advancements, it does not thoroughly explore their impact on cost dynamics and surgical outcomes. A deeper analysis of this relationship could provide additional insights into optimizing phacoemulsification practices.

This study presents several strengths, such as robust data collection, international collaboration, and a focus on cost tracking, which support the validity of its findings. However, limitations such as geographical bias, limited focus on patient outcomes, and reliance on aggregate data highlight areas for improvement. Future studies should


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address these gaps and explore the interplay between costs, clinical outcomes, and patient satisfaction to enhance the overall understanding of this critical area in healthcare economics and phacoemulsification.

## CONCLUSION

The conclusion of this study underscores the importance of big data analysis in tracking the costs of phacoemulsification surgery, which serves as a strategic step toward improving the efficiency and accessibility of healthcare services. This research demonstrates that by leveraging comprehensive data, stakeholders including healthcare practitioners, policymakers, and hospital managers can optimize resource allocation and formulate more effective policies within Universal Health Coverage (UHC). The findings also highlight the need for a holistic approach integrating clinical, economic, and policy perspectives to ensure sustainable and equitable access to cataract surgery services.

Based on these findings, further research is recommended to explore the impact of costs on clinical outcomes and patient satisfaction and identify cost variations at local and regional levels. Thus, this study provides new insights into the costs of phacoemulsification and opens opportunities for global collaboration to enhance the quality of healthcare services. Implementing these recommendations is expected to reduce cataract-induced blindness, particularly among vulnerable populations such as the elderly and communities in remote areas. This research emphasizes that various public actors and institutions' roles are critical in providing affordable and accountable healthcare services, thereby meeting the broader societal expectations for well-being.

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