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Master of Public Health (Community Eye Health)
Mini dissertation

Supply-side Determinants of Cataract Surgery Output in South Africa

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Introduction

Globally, there are 295 million people with moderate and severe visual impairment (MSVI) and 43 million people who are blind[1]. Cataracts are the leading cause of blindness (17 million; 95% uncertainty level (UI) 14.40, 19.93 million) and the second most common cause of MSVI (83.5 million; 95% UI 29.69, 39.95 million)[1]. Cataracts are opacities of the normally transparent lens of the eye, the majority related to ageing, that leads to progressive vision loss and blindness[2]. Surgery is the only effective treatment, replacing the opaque lens with an artificial intra-ocular lens, restoring vision[2].

More than 90% of blind people live in low- and middle-income countries (LMICs), highlighting socioeconomic inequality as a significant contributing factor to cataract-related blindness[3]. Sub-Saharan Africa has the second highest age-standardised prevalence of cataracts in the world, 1.49% (95% UI 1.24%, 1.78%), compared to the lowest prevalence of 0.09% (95% UI 0.07%, 0.11%) in regions of high-income countries (HICs)[1]. Population-based indicators for cataract surgery show low productivity in Sub-Saharan Africa, which can partially be explained by the low ratio of human resources compared to the population[4,5]. The region has the lowest estimated mean density of ophthalmologists in the world (2.5 per million population), compared to a mean density of 3.7 per million in LMICs and 76.2 per million in HICs[6].

South Africa is a Sub-Saharan African country with a population of 62 million[7], and is classified as an LMIC by the World Bank[8]. However, South Africa has the highest income inequality in the world, reflected by an approximate Gini coefficient of 0.67[9]. Currently, South Africa has parallel private and public health sectors. Most citizens rely on the public sector, with only 15,7% having access to medical aid coverage to use the private sector[7]. The *Vision 2020: Right to Sight* strategy recommended a target of 4 ophthalmologists per million population[10]. South Africa meets the target with 9.3 ophthalmologists per million people registered with the Health Professions Council of South Africa[11]. Ophthalmology Society of South Africa (OSSA) represents approximately 65%[i] of ophthalmologists in South Africa[12]. However, 85% of ophthalmologists who are OSSA members the work in private practice[12]. It is unclear whether South Africa has consistently met the *Vision 2020: Right to Sight* target of 2,000 cataract surgeries per million people per year (CSR)[10], as the private sector's output is not accounted for in the country's reported CSR figures. The most recent publicly available reported CSR was 847 per million, reported to the International Agency for the Prevention of Blindness in 2015[14,15]. The CSR was 1226 per million population in 2009[5], indicating a decrease in CSR of 31% between 2009 and 2015. No statistics about the private sector's cataract surgery

[i]OSSA reports that in some multi-practitioner practices only the senior doctor is a member to derive membership benefits for the practice and spare the membership expense for junior colleagues. Which may contribute to why only 65% of South African ophthalmologists are OSSA members.

output are publicly available. South Africa is transitioning from the parallel healthcare system to a universal healthcare coverage (UHC) model, specifically through the implementation of National Health Insurance (NHI)[13] which may increase the reported CSR due to inclusion of the private sector's data.

Barriers to performing cataract surgery are reported for both the patient demand and provider supply side in Africa[4]. Patient barriers reported include a lack of awareness about the surgery, limited access to services, and patient acceptance of their condition as normal aging[4]. However, South Africa's public sector has a surplus in demand, evidenced by long patient waiting lists for surgery, and thus, increasing cataract surgical rates is likely limited by cataract surgery supply factors[5]. Therefore, this study aimed to explore the supply-side determinants of cataract surgery output by examining provider characteristics and perceived barriers, enablers, and strategies to increase surgical volume.

Methods

During May and June 2024, a cross-sectional study using convenient sampling was conducted on all medically trained members of the OSSA. The 399 members consist of ophthalmologists, registrars and ophthalmology medical officers. Ophthalmologists are specialists who have completed postgraduate training in ophthalmology and possess the most surgical experience. Registrars are doctors currently undergoing formal postgraduate training in ophthalmology. Ophthalmology medical officers are doctors working within ophthalmology departments who have completed undergraduate medical training. Thus, all medically trained members can potentially perform cataract surgery in South Africa. Participants were not excluded if they did not perform cataract surgery.

An online REDCap questionnaire was developed to collect data about the study objectives[14,15]. The questionnaire was self-administered, anonymous and only available in English. The questionnaire consisted of three sections with 48 questions in total. Demographic, employment environment, 2023 cataract surgical output, barriers, enablers and implementation strategy data were collected. Cataract surgical output was collected as a categorical variable. The questionnaire was distributed internally by OSSA via email to eligible members. Each participant received an introductory message with a hyperlink to an informed consent form followed by the questionnaire.

The questionnaire was reviewed by a South African trained ophthalmologist who was not an OSSA member to enhance the validity of the questionnaire prior to the study's data collection. The experience question was revised to better capture surgical experience, as most participants likely began performing cataract surgery before starting their registrar training. Cataract surgical output

was validated by whether the surgeon estimated the number of surgeries, reviewed personal records or reviewed their facilities' records. Only 2023's cataract surgery output was collected to reduce recall bias and minimise low output due to the COVID-19 pandemic.

The response rate was determined by dividing the number of participants who completed all three questionnaire sections by the total number of eligible OSSA members. Data analysis was performed on completed questionnaires using *R* statistical software version 4.2.2[16]. The minimum sample size required for statistical analysis for a finite population was 78 participants (population: 399; Z-score: 1.96; margin of error: 0.1; proportion: 0.5). Frequencies and percentages were used to summarise categorical variables. Continuous variables were summarised as means with standard deviations or medians with interquartile ranges (IQR) according to their data distributions. For further analysis, providers were stratified into two approximately even groups, "lower" and "higher" productivity groups relative to each other, by the number of cataract surgeries they performed in 2023 (≤200 and ≥201, respectively). This categorisation facilitated statistical comparison between the two groups and allowed comparison to previous study which used the same grouping[17]. The Shapiro-Wilk test was used to determine if the data was parametric or nonparametric. The Wilcoxon Rank Sum Exact Test was used to determine which nonparametric continuous variables were associated with performing ≥201 surgeries ($p \leq 0.05$). Whereas, the Fisher Exact and Pearson's Chi-squared Tests were used to determine which categorical variables were associated with performing ≥201 surgeries ($p \leq 0.05$). Barriers, enablers, and implementation strategies were summarised as the percentage agreement amongst participants. The free-text responses were classified into the following categories: human resources, equipment, facilities, financial factors, and patient-related factors. The responses could be categorised into more than one category.

The protocol and consent-taking process was approved by the University of Cape Town's Human Ethics Review Committee (Reference: 256/2024. Permission was obtained from OSSA's research committee to perform the research on its members. Participation was voluntary, anonymous and there was no financial incentive for participation. These specifications were emphasised to promote honest responses and limit bias.

Results

The study aimed to explore the supply-side determinants of cataract surgery output. At the end of the data collection period, 79 (19,7%) participants completed all three questionnaire sections, while 112 participants (28%) only partially completed the questionnaire (*Figure 1*).

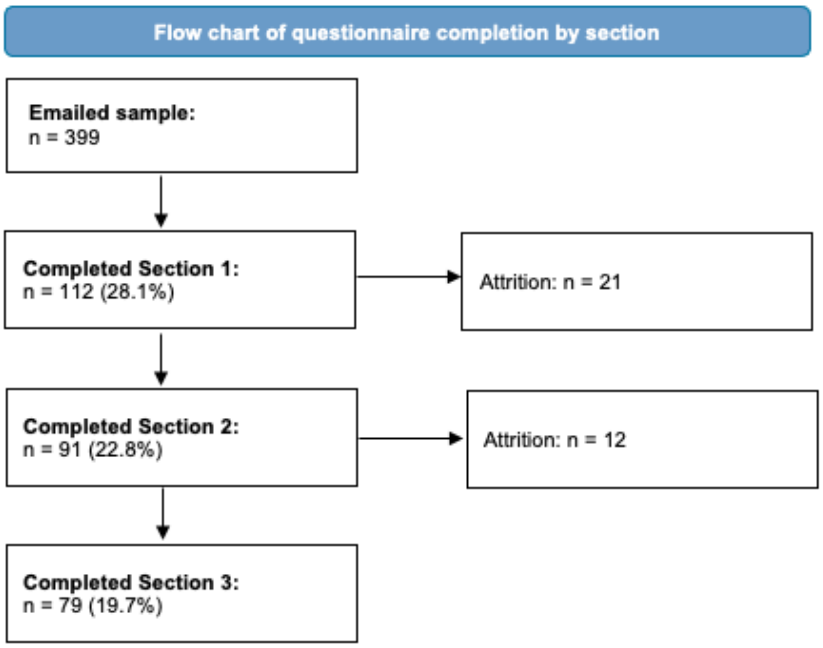

Figure 1: Flow chart of questionnaire section completion by participants

Table 1 presents the demographic and professional characteristics of the sample. The sample's age ranged from 26 to 75 years. Males and females were equally represented, 53% and 47% respectively. The majority of the participants were qualified ophthalmologists (72%). Most participants (96%) worked in predominantly urban or peri-urban facilities, and nearly half of the participants (49%) were employed full-time in the private sector.

Table 1: Characteristics of the sample

Characteristics	Overall, n = 79[1]
Age category (years)	
26 - ≤35	20 (25%)
36 - ≤45	21 (27%)
45 -≤55	17 (22%)
56 - ≤65	19 (24%)
66 - ≤75	2 (2.5%)
Sex	
Male	42 (53%)
Female	37 (47%)
Qualification	
Specialist General Ophthalmologist	46 (58%)
Sub-specialist Ophthalmologist (Performs cataract surgery)	11 (14%)
Ophthalmology Registrar	15 (19%)
Medical Officer	7 (8.9%)
Employment type	
Full-time public sector	34 (43%)
Full-time private sector	39 (49%)
Part-time public and part-time private sector	6 (7.6%)
Employment area	
Predominantly urban	61 (77%)
Predominantly peri-urban	15 (19%)
Predominantly rural	3 (3.8%)

[1] n (%)

Objective 1: Determine the cataract surgery output per year amongst cataract surgery providers in South Africa.

The number of cataract surgeries performed per surgeon in 2023 showed a right-skewed distribution (*Figure 2)*. Among the 79 participants, 50% performed 200 or fewer cataract surgeries, and only 12 (15%) performed 500 or more surgeries in 2023. Two participants performed more than 1500 cataract surgeries. Both were experienced ophthalmologists with over 10 years of experience in private practice, one being male and the other female. Surprisingly, one medical officer working in a rural district hospital performed between 801 and 900 cataract surgeries.

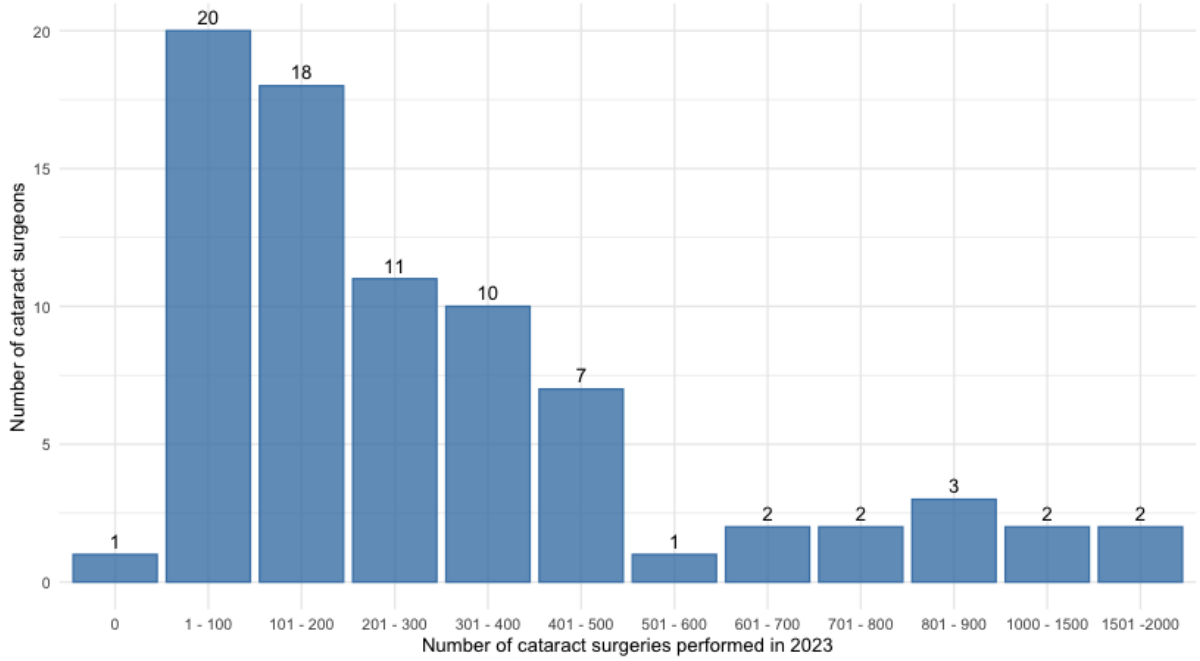

Figure 2: Bar graph of the number of cataract surgeons performing by the number of cataract surgeries performed in 2023

Objective 2: Determine which factors were associated with higher cataract surgery output (≥201 cataract surgeries in 2023|)

Of the sample, 78 participants performed cataract surgery in 2023. *Table 2* compares statistically significant provider and facility factors between two cataract surgery productivity groups in the sample: lower productivity (≤200) and higher productivity (≥201). Older, more experienced male surgeons were more likely to perform at least 201 cataract surgeries. This group was predominantly composed of qualified ophthalmologists working in full-time private practice, performing phacoemulsification cataract surgery. Key facility factors contributing to higher productivity included fewer than ten surgeons, and no microscopes needing repair. Additionally, these surgeons dedicated more time to surgeries, and less to administrative and educational tasks than the lower productivity group. Unexpectedly, performing MSICS cataract surgery or having a dedicated eye theatre were statistically significantly associated with the lower productivity group.

Table 2: Provider and Facility factors by number of cataract surgeries performed in 2023 (≤200 and ≥201), overall n = 78

Characteristic	Number of Surgeries		p-value[2]
	≤200, n = 38[1]	**≥201,** n = 40[1]	
Age category (years)			**<0.001**
26 - ≤35	16 (42%)	3 (7.5%)	
36 - ≤45	10 (26%)	11 (28%)	
45 -≤55	8 (21%)	9 (23%)	
56 - ≤65	4 (11%)	15 (38%)	
66 - ≤75	0 (0%)	2 (5.0%)	
Sex			**<0.001**
Male	13 (34%)	29 (73%)	
Female	25 (66%)	11 (28%)	
Qualification			**<0.001**
Specialist General Ophthalmologist	13 (34%)	33 (83%)	
Sub-specialist Ophthalmologist	6 (16%)	4 (10%)	
Ophthalmology Registrar	14 (37%)	1 (2.5%)	
Medical Officer	4 (11%)	2 (5.0%)	
Employment type			**<0.001**
Full-time public sector	28 (74%)	6 (15%)	
Full-time private sector	8 (21%)	31 (78%)	
Part-time public and part-time private sector	2 (5.3%)	4 (10%)	
Cataract surgery technique performed[3, 4]			
MSICS	29 (74%)	17 (43%)	**0.004**
Phaco	32 (82%)	40 (100%)	**0.005**
Experience performing cataract surgery (years)			**<0.001**
0 - 5	18 (47%)	2 (5.0%)	
5 - 10	5 (13%)	7 (18%)	
>10	15 (40%)	31 (78%)	
Number of Cataract surgeons at the facility			**0.001**
1 - 4	8 (21%)	16 (40%)	
5 - 9	1 (2.6%)	10 (25%)	
≥10	29 (76%)	14 (35%)	
Separate dedicated eye theatre	35 (92%)	30 (75%)	**0.038**
Surgical microscopes[5]			
1 or more in working order	37 (97%)	40 (100%)	0.082
1 or more needing repair	5 (13%)	1 (2.5%)	**0.026**
Percentage time spent per week (%)[3]			
Cataract surgery	15 (10, 20)	20 (15, 27)	**<0.001**
Administrative tasks	20 (10, 30)	15 (10, 20)	**0.019**
Education of other cadres	10 (4, 25)	5 (0, 10)	**0.004**
In- and out-patient consultations	61 (36, 78)	60 (46, 73)	0.7

[1] n (%)
[2] Wilcoxon rank sum exact test; Fisher's exact test; Pearson's Chi-squared test;
[3] Median (IQR)
[4] Manual Small Incision Cataract Surgery (MSICS), Phacoemulsification Cataract Surgery (Phaco)
[5] Participants could select more than one option (mark all that apply)

Objective 3: Providers' views on perceived barriers, enablers and implementation strategies

Facility and equipment factors were the most agreed upon barriers to increasing cataract surgery output, with competing non-surgical responsibilities most frequently reported. No barriers were reported by 24% of the sample, all working in the private sector. The public sector showed greater agreement for barriers related to human resources, equipment, and facility factors compared to the private sector and dual employment ($p < 0.05$).

Table 3: Barriers to increasing cataract surgery output, overall, and by employment type.

Barriers	Overall, n = 79[1]	Employment type			p-value[2]
		Full-time public sector, n = 34[1]	Full-time private sector, n = 39[1]	Part-time public and private sector, n = 6[1]	
No barriers experienced	19 (24%)	0 (0%)	19 (49%)	0 (0%)	**<0.001**
Human resources					
Inadequate number of theatre nurses and support staff during cataract surgery	15 (19%)	11 (32%)	2 (5.1%)	2 (33%)	**0.004**
Equipment					
Broken or malfunctioning theatre equipment necessary for cataract surgery	10 (13%)	10 (29%)	0 (0%)	0 (0%)	**<0.001**
Lack of consistent consumables supply, such as intraocular lenses.	17 (22%)	16 (47%)	0 (0%)	1 (17%)	**<0.001**
Facility					
Lack of theatre time allocated for cataract surgery	20 (25%)	15 (44%)	3 (7.7%)	2 (33%)	**<0.001**
Competing non-surgical responsibilities (admin, research, education and clinical work)	22 (28%)	12 (35%)	8 (21%)	2 (33%)	0.3
Patients					
Patients' ability to access services is limited by financial, geographical, or sociocultural barriers	19 (24%)	4 (12%)	14 (36%)	1 (17%)	0.052
Other	15 (19%)	6 (18%)	8 (21%)	1 (17%)	>0.9

[1] n (%)
[2] Fisher's exact test; Pearson's Chi-squared

Table 4 ranks the categories in the 18 free text responses about barriers. Excerpts of responses for barriers are listed in the table. Facility factors were also the most frequently mentioned category in free-text responses, and barriers to patients accessing care were reported by private sector participants.

Table 4: Ranked categories of Free text responses for barriers.

Barriers	Excerpts of responses	Overall, n = 18[1]
Facility	"System failures: loadshedding / generators, linen shortages, admin delays with issuing of files, staff - slow turnaround time between cases, sometimes no porters to bring patients from the ward to theatre, ward delays with prep of cases."	8

Human resources	"Apathy of nursing and general theatre staff - late arrivals, slow starts in theatre and very slow changeover times, cancellations when there is any danger of the lists continuing past 4 pm."	6
Financial	"Patients without funding for care in private; limits to the number of pro bono cases that can be accommodated"	4
Patient factors	"Not enough patients requiring surgery? "	1
Equipment	"Lacking staff, equipment, theatre time. Too much other work."	1

[1] n

Human resources and equipment factors were seen as enablers for cataract surgery (*Table 5*). Having sufficient theatre support staff was the most widely recognised enabler. The public sector viewed a sufficient number of cataract surgeons and high patient demand as key enablers compared to the private sector and dual employment ($p < 0.05$). The private sector was more likely to report having functioning theatre equipment as an enabler ($p < 0.05$). The public sector's agreement on performing cataract surgery at outreach camps as an enabler was borderline statistically significant compared to the private sector and dual employment ($p = 0.049$).

Table 5: Enablers for cataract surgery output, overall, and by employment type.

Enablers	**Overall,** n = 79[1]	**Employment type**			**p-value[2]**
		Full-time public sector, n = 34[1]	**Full-time private sector,** n = 39[1]	**Part-time public and private sector,** n = 6[1]	
No enablers experienced	7 (8.9%)	1 (2.9%)	6 (15%)	0 (0%)	0.2
Human resources					
Having an eye services manager	8 (10%)	6 (18%)	2 (5.1%)	0 (0%)	0.2
Adequate number of theatre nurses and support staff during cataract surgery	44 (56%)	18 (53%)	23 (59%)	3 (50%)	0.8
Adequate number of medically trained cataract surgery providers	19 (24%)	13 (38%)	5 (13%)	1 (17%)	**0.030**
Having staff who are motivated to perform cataract surgery	32 (41%)	14 (41%)	15 (38%)	3 (50%)	0.9
Equipment					
Having an adequate amount of instrument sets to reduce delays due to sterilisation between cases.	33 (42%)	11 (32%)	18 (46%)	3 (50%)	0.5
Having the necessary working theatre equipment for cataract surgery	34 (43%)	9 (26%)	23 (59%)	2 (33%)	**0.018**
Facility					
Having a dedicated eye theatre	39 (49%)	17 (50%)	18 (46%)	4 (67%)	0.7
Performing cataract surgery at outreach cataract surgery camps	16 (20%)	11 (32%)	4 (10%)	1 (17%)	**0.049**
Patients					
Patient demand for cataract surgery is more than the facility's capacity to supply cataract surgery.	15 (19%)	12 (35%)	2 (5.1%)	1 (17%)	**0.003**

[1] n (%)
[2] Fisher's exact test; Pearson's Chi-squared

Equipment and facility strategies were the most frequently recommended to increase cataract surgery output (*Table 6*). Sixteen percent of the sample had no opinion on strategies, which was significantly more common in the private sector than in the public sector. The public sector showed greater agreement for securing a stable supply of intraocular lenses, increasing theatre time, and improving staff motivation as strategies to increase cataract surgery output compared to the private sector and dual employment ($p < 0.05$). The private sector was more likely to agree on increasing patient demand for cataract surgery than the public sector which was also reported in the free text responses.

Table 6: Implementation strategies for cataract surgery output, overall, and by employment type.

Implementation strategies	Overall, N = 79[1]	Employment type			p-value[2]
		Full-time public sector, n = 34[1]	Full-time private sector, n = 39[1]	Part-time public and private sector, n = 6[1]	
No opinion about strategies	13 (16%)	2 (5.9%)	11 (28%)	0 (0%)	**0.023**
Human resources					
Improve staff motivation to perform or increase the number of cataract surgeries	15 (19%)	12 (35%)	3 (7.7%)	0 (0%)	**0.006**
Task shifting of non-surgical responsibilities to other cadres	12 (15%)	6 (18%)	5 (13%)	1 (17%)	0.9
Equipment					
Acquire a stable supply of consumables such as intraocular lenses.	19 (24%)	18 (53%)	1 (2.6%)	0 (0%)	**<0.001**
Facility					
Increase theatre time for cataract surgery	19 (24%)	11 (32%)	6 (15%)	2 (33%)	0.2
Perform more cataract screening outreach to refer to the base hospital	8 (10%)	2 (5.9%)	6 (15%)	0 (0%)	0.3
Perform more cataract screening as well as cataract surgery outreach	4 (5.1%)	1 (2.9%)	3 (7.7%)	0 (0%)	0.7
Financial					
Financial incentives per cataract surgery performed.	10 (13%)	5 (15%)	5 (13%)	0 (0%)	>0.9
Patients					
Strategies to increase patient demand for cataract surgery	6 (7.6%)	0 (0%)	5 (13%)	1 (17%)	**0.047**

[1] n (%)
[2] Fisher's exact test; Pearson's Chi-squared

Discussion

In light of previously low reported cataract surgery output in South Africa[5,18,19], this study aimed to explore the supply-side determinants of cataract surgery output by examining provider characteristics and perceived barriers, enablers, and strategies to increase surgical volume. The study found that nearly 50% of participants performed 200 or fewer cataract surgeries in 2023, with only 15% exceeding 500. Factors significantly associated with performing 201 or more surgeries were male gender, greater surgical experience, working in the private sector, performing

phacoemulsification cataract surgery and spending less time performing non-surgical responsibilities. The barriers to increasing surgical output included non-surgical duties, limited theatre time, and inconsistent consumable supplies, with the public sector facing more challenges than the private sector. Enablers were sufficient theatre staff, dedicated theatres, necessary equipment and consumables, and motivated teams, with the public sector benefiting from higher patient demand. Participants recommended securing stable consumable supplies, increasing individual theatre time, and boosting staff motivation as strategies to improve cataract surgical output.

The study's low surgeon cataract surgery output is consistent with other Sub-Saharan African countries. Herod et al. performed a study in three Sub-Saharan African countries, which reported that only 20% of ophthalmologists performed more than 500 cataract surgeries per year[20]. Further subgroup analysis showed 23% in Ethiopia and 21% in Ghana, but none from Zambia exceeded 500 cataract surgeries per year[20]. Furthermore, the cataract output is low compared to high-volume centres such as Aravind, where 67% of ophthalmologists perform more than 500 cataract surgeries, and 20% perform more than 2000 cataract surgeries per year[21]. Previously, *Vision 2020: Right to Sight* set the target of 500 or more cataract surgeries per surgeon per year to address cataract blindness[22]. The current World Health Organisation's *Eye Care in Health Systems: Guide for Actio*n emphasises broader goals for integrating eye care into health systems and has a recommended list of eye care indicators to be collected but did not set targets for these indicators[23]. Despite the transition beyond *Vision 2020*, its targets is still useful for guiding efforts to reduce preventable blindness. Performing at least 350 cataract surgeries per year has been associated with improved visual outcomes after surgery compared to surgeons performing fewer surgeries, indicating that increasing surgical output per surgeon also leads to better outcomes[19].

"Higher" and "lower" cataract surgery productivity groups are relative terms used to compare participants in this sample by the number of cataract surgeries performed per year. Our study reports several demographic and facility factors statistically significantly associated with the higher productivity group (≥201 cataract surgeries performed in 2023). Greater surgical experience was associated with the higher productivity group and correlates with other studies which reported increased cataract surgical output[20,21]. Male gender was associated with the higher productivity group. Male ophthalmologists and trainees have been reported to perform more cataract surgeries per year[24,25]. However, in our study, males were more likely to be older, more experienced, qualified ophthalmologists, and work in the private sector, all of which are likely confounders. A female participant was also one of the top two most productive participants. Surgeons practising in the private sector were more likely to perform ≥201 cataract surgeries. The private sector has more resources, which is associated with higher cataract surgery output in Africa[17,26]. Higher productivity surgeons in the sample surgeries spend more time operating than those in the lower productivity

group. Although the difference in time spent doing other tasks was not statistically significantly less, freeing up time to perform more surgeries leads to higher output. The Aravind model uses task shifting of non-clinical responsibilities to other cadres to increase cataract surgical output[27]. The phacoemulsification cataract surgery technique was associated with increased cataract productivity. Trainees in South Africa are first taught MSICS cataract surgery and then progress to phacoemulsification once surgically more competent. Thus, the technique is used by more experienced surgeons and is primarily available in most settings in the country. Therefore, MSICS was associated with the lower productivity group because experience is likely a confounder. The *Lancet Commission on Global Eye Health* recommended that low-resource settings continue using the MSICS cataract surgery technique due to its lower cost than the phacoemulsification technique[3]. Other African studies have reported only 50% access to phacoemulsification, with the majority performing MSICS[20]. In contrast, phacoemulsification is the predominant technique used by the sample in South Africa (92%), suggesting greater availability of resources for cataract surgery compared to other African countries. Unexpectedly, a dedicated eye theatre was not associated with a higher cataract surgical productivity group. The finding may be influenced by the distribution within the sample, as the majority (83%) of the study's sample have a dedicated ophthalmology theatre, compared to a study demonstrating a positive association, where only 57% of the sample had have access to such a theatre[17]. Furthermore, the fact that 83% sample have a dedicated eye theatre also suggests that South Africa may have comparatively better infrastructure than other African countries. However, despite greater resources for cataract surgery, South African providers report barriers similar to those in other African countries.

Previous reported barriers for cataract surgery on the continent focused on patient factors and are mainly based on the Rapid Assessment of Avoidable Blindness methodology[4]. The top three barriers reported by providers in Africa were patient distance to a cataract facility, lack of cataract surgery facilities, and lack of equipment for surgery[20]. The provider barriers reported in our study are consistent with barriers previously reported in relation to the low CSR in South Africa: insufficient theatre time, consumable supply chain issues and shortage of ophthalmic nurses, and surgeons performing non-surgical work[5]. However, previously reported theatre staff unfamiliar with cataract surgery and shortages of cataract surgeons[5] had low agreement as barriers in our study. No literature proves that cataract surgery knowledge amongst theatre staff in South Africa has improved. However, the low agreement in our study may result from other options being regarded as more important barriers and not necessarily from theatre staff being more familiar with cataract surgery. In our study, only 7.6% of participants reported a shortage of surgeons as a barrier. Additionally, those working in facilities with over ten cataract surgeons were more likely to perform 200 or fewer cataract surgeries in 2023, likely due to competition for surgical time. Participants may have responded to the surgeon shortage question based on their own productivity, rather than considering the broader CSR needed to combat avoidable blindness. Moreover, the ratio of ophthalmologists to

the population in South Africa is higher than in other Sub-Saharan African countries[11,6], which could explain why a shortage of surgeons is not perceived as an issue. Previously reported inadequate commitment by hospitals or provincial managers to increase surgery[5] was not a barrier option provided to participants but was also not reported in the free text responses. An eye service manager was not seen as an enabler, although it has previously been associated with increased cataract surgery coverage (CSC) in sub-Saharan Africa[28]. The lack of a stable consumable supply and equipment was a key barrier reported in our study and a known challenge for cataract surgery in LMICs and Africa[3,20,29]. Barriers were more agreed upon by the public sector, indicating fewer eye care resources than the private sector.

The enablers and implementation strategies suggested align with overcoming the barriers participants encountered. A systematic review of interventions for increasing cataract surgery uptake in LMICs reported conducting awareness campaigns, eliminating direct and indirect patient costs, using successfully operated individuals as champions, conducting community outreach, and high quality surgical outcomes[30]. These strategies target increasing demand for the service. In a 2017 study, capacity-building interventions improved the average number of cataract surgeries per surgeon by 54% after four years in 25 underperforming eye hospitals in three continents[31]. Seven hospitals were in Africa, where the number of cataract surgeries per surgeon increased by 131% after four years[31]. The capacity-building interventions were a needs assessment visit, a vision building workshop with a strategic and action plan, ongoing consultation to improve services, and monitoring key performance indicators[31]. Thus, implementing changes in the health system to address specific barriers can increase cataract surgical output. Participants recommended increasing theatre to increase cataract surgery output. In a 2023 study, the theatre utilisation rate of a South African tertiary ophthalmology hospital was 62%, with a case cancellation rate of 16%[32]. The primary cause for case cancellation was the lack of available theatre time, despite the median starting time occurring 15 minutes later than scheduled[32]. Lack of equipment for cataract surgery was the second most common cause of cancellation[32]. Improving existing theatre efficiency, such as starting on time, may improve cataract surgery output. Staff motivation was reported as an enabler and strategy to increase productivity, especially by the public sector. The public and private sectors are remunerated differently, which may act as a financial incentive. In the public sector, employees receive a fixed salary irrespective of the number of cataract surgeries performed. Employees in the private sector are reimbursed per surgery performed. Providers in other African countries have indicated that the private sector provides the best financial reimbursement model for incentivising productivity[20]. South Africa's private sector has the capacity to increase cataract surgery output, as demonstrated by the low number of patients on the waiting list and short waiting times for cataract surgery. This study also shows that South Africa's reported CSR is not representative of the true CSR as it does not account for the private sector, which was associated with higher productivity surgeons in the sample. UHC increased CSR in Thailand, with the private sector performing almost

80% of national cataract surgeries[33]. Therefore, transitioning to NHI may improve cataract surgery output in South Africa by increasing patient access to the private sector. However, despite financial protection by UHC, only 60% of patients who accept appointments for cataract surgery access their appointments in Rwanda[34]. Thus, even in a UHC setting, patients still experience barriers such as indirect costs or co-payments, lack of an escort and insufficient information about the appointment[34].

Unexpectedly, patients' barriers to accessing cataract surgery services had low agreement amongst public sector participants as a barrier for increasing cataract surgery output. Public sector participants also reported demand exceeding facility's capacity as an enabler for cataract surgery. Although there is significant demand in the public sector, patients likely face similar barriers to care as those reported in other African countries[4]. A quarter of participants did not report any barriers for cataract surgery. These participants all work in private sectors, highlighting differences in resources for cataract surgery between the public and private sectors. Most of the sample (96%) worked in urban or peri-urban areas. In other African countries 70% of ophthalmologists work in their capital city[22]. This can be explained by South Africa's centralised public sector healthcare workforce, where specialists are predominantly employed in tertiary and regional hospitals which are situated predominantly in urban areas[11]. Private ophthalmology practices are also more financially feasible in densely populated urban areas. The majority of the rural population don't have permanent eye services and rely on outreach cataract surgery camps for surgery[35]. Despite this, outreach cataract surgery camps and providing transport for patients to the hospital for cataract surgery ranked low among agreed-upon strategies to increase cataract surgery output. Outreach camps and patient transport to the hospital for surgery have been key strategies to increase cataract surgery output and coverage in LMICs and Africa[17,20,27]. Participants also spent most of their time performing non-surgical responsibilities and reported non-surgical responsibilities as a barrier. However, task shifting of these responsibilities as an implementation strategy had lower than expected agreement. The Aravind model successfully uses task shifting of non-clinical responsibilities to other cadres to increase cataract surgical output[27]. Furthermore, financial incentives per cataract surgery had low agreement as strategy for increasing cataract surgery. Other providers in Africa have reported that their current financial reimbursements did not incentivise individual or support staff productivity[20].

Study limitations

The study used non-randomised sampling which limits generalisability of the results to the sample. Furthermore, OSSA only represents two-thirds of ophthalmologists in the country. This, coupled with the study's low response rate, may have resulted in an underrepresented group of providers. The attrition during the questionnaire also contributed to the low response rate. Despite this, the response rate was higher than a previous study on OSSA ophthalmologists using a similar methodology[36] but lower than studies performed on South African ophthalmology registrars[37,38]. Only

42% of the participants confirmed their cataract surgery output using records. The remaining 58% of participants estimated their cataract surgery output. Thus, self-reported figures may not accurately reflect actual surgical output. Furthermore, half of the sample worked in facilities where ten or more surgeons performed cataract surgeries, suggesting facility cluster responses which father limits the studies generalisability. Despite the low response rate, the number of participants (79) met the minimum required sample size of 78 for statistical analysis. However, the low response rate does limit the statistical analysis as non-parametric tests were needed and resulting in lower precision than parametric tests on a larger sample.

Conclusion

The study highlights the importance of providers' views of barriers, facilitators, and implementation strategies to inform health system interventions to increase cataract surgery rates. Despite several limitations, the study revealed that cataract surgery output per surgeon in South Africa is low, identified possible reasons for this low output based on providers' perspectives on barriers, and proposed solutions by promoting providers' enablers and implementation strategies to improve cataract surgery rates. The study emphasises that surgeons working in better-resourced environments were more likely to be classified in higher productivity group in the sample. There is an unequal distribution of ophthalmologists and resources between the current private and public health sector. An appropriately implemented UHC system can potentially improve access to cataract surgery and thus increase national cataract surgery output. Based on our findings, we recommend that key stakeholders engage in discussions to advance the proposed enablers and implement suggested strategies to improve cataract surgery in the country.

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Abbreviations and definitions

Blindness	"Visual acuity of less than 3/60 on a Snellen chart (metres) in the better eye with best available correction and/or visual field constriction to less than 10° around central fixation in the better eye" [39].
CSR	Cataract Surgery Rate (number of cataract surgeries performed per million population per year)
HIC	High Income Country
HPCSA	Health Professions Council of South Africa
IAPB	International Agency for the Prevention of Blindness
IQR	Interquartile range (Presented as Q1 – Q 3)
LMIC	Low- and middle-income country
MSVI	Moderate and severe vision impairment ("Visual acuity of less than 6/18 but equal or better than 3/60 on a Snellen chart (metres) in the better eye" [39]).
NHI	National Health Insurance
OSSA	Ophthalmological Society of South Africa
UHC	Universal Healthcare Coverage
UMIC	Upper middle-income country

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