MAIN DISSERTATION

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CATARACT SURGICAL SERVICES IN MADAGASCAR

By

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DECLARATION

I, ...ERIC NDAULE..., hereby declare that the work on which this dissertation/thesis is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other university.

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CHAPTERS

PART A: This part presented the protocol of the research study approved by the Faculty of Health Sciences Human Research Ethics Committee at the University of Cape Town. The main purpose of this study was to evaluate cataract surgical services in Madagascar to help guide the national eye health program.

PART B: Comprised of a structured literature review to provide the research with organised information from reliable and relevant source through different database. This study used different databases and articles were filtered using year of publication and English language.

PART C: The main article of the research study; the methodology, results, discussion and conclusion of the findings.

PART D: Comprised of supplementary tables, ophthalmic epidemiology instructions and ethical approval letter

PART A

PROTOCOL

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LIST OF ABBREVIATIONS

CSR : Cataract Surgical Rate

ECCE : Extra-capsular cataract extraction

IAPB : International Agency for the Prevention Blindness

IOL : Intra-ocular lens

KCCO : Kilimanjaro Center for Community Ophthalmology

NLP : No Light Perception

PC : Posterior Capsular

RAAB : Rapid Assessment of Avoidable Blindness

SICS : Small Incision Cataract Surgery

VA : Visual Acuity

WHO : World Health Organisation

PURPOSE OF THE STUDY

Broad objectives

The main purpose of this study was to evaluate cataract surgical services in Madagascar to help guide the national eye health program

Specific objectives

1. To determine the cataract surgical rate in regional capitals/districts of Madagascar in 2012
2. To assess pre- and post-operative visual outcomes of the cataract surgery cases in regional capitals/districts of Madagascar in 2012
3. To assess cataract surgery distribution by sex in regional capitals/districts of Madagascar in 2012

BACKGROUND

Introduction

Cataract is the leading cause of blindness worldwide. It also represents the second major cause of global visual impairment. A systematic review study for global visual impairment observed that cataract is responsible for 51% of blindness and 43% of visual impairment cases.[1] World Health Organization estimated that 39 million people worldwide are blind and cataract still remains the leading cause of blindness in low and middle incomes countries.[2] More recent study showed that the number of blind people and visually impaired changed between 2010 and 2015 because of improved statistical analysis and inclusion of precise data. Accordingly, there are 253 million visually impaired people of whom 36 million are blind.[3] Cataract still remains the commonest cause of avoidable blindness in the world.

Cataract in Africa

7.3 million blind people live in the African continent of which half of them are blind due to cataract, which represents a significant public health problem.[1] Therefore, planning for its treatment is a priority of the VISION 2020 initiative to eliminate avoidable blindness by the year 2020.[4] The number of individuals with cataract is likely to increase with increasing population growth and life expectancy.

Cataract surgery is the only intervention in managing cataract patients. Cataract surgery is aimed at restoring sight of the blind and visually impaired people as close as possible

to normal. This is because cataract surgery improves the well-being of the patients as patients experience a significant improvement in visual functioning and quality of life.[5]

Cataract Surgery Rate (CSR) is defined as the number of cataract surgeries that are done per million populations per year. The African continent has the lowest CSR.[6] Most studies have indicated that CSR in low-income countries is very low as compared to the middle-income countries. However, Lewallen et al., (2010) found that CSR needs are varied significantly in different sites and was lower in some areas than expected.[4] Cataract surgical rate needed is not uniform across Africa and may depend on genetic factors, migration of people across the continent, environmental factors or cultural variations with diet transition and lifestyle changes as well as population structure.[4]

The study conducted in 2009 in Madagascar found that CSR for 2009 was very low at 363.[7] Other studies in African countries observed an increase in CSR values since the introduction of cataract surgery programs between 2002 and 2004 through improved infrastructure and human resources for eye health as well as increased cataract awareness. CSR had risen to 1583 from 644 in Kwale District in Kenya, and CSR of 1165 from 313 in Kilimanjaro Region in Tanzania.[8]

Literature review for cataract surgeries in developing countries for sex characteristics using a meta-analysis of cataract survey found that the cataract surgical distribution was 1.5 times higher for males than for females.[9] Among the cataract surgery patients in their study, females were 0.67 times less likely to have had cataract surgery compared to males. Lewallen & Courtright (2002) further suggested that prevalence of cataract blindness would be reduced if females had received cataract surgery at the same rate as males.[9]

"The cataract surgery visual acuity outcome can be used as an indicator required by ophthalmologists, to measure performance so as to monitor the quality of their services".[10] According to the WHO, the visual acuity outcome can be assessed with available correction ('functioning vision') or full spectacle correction ('best vision') at 6 weeks post-operatively.[11] The WHO defines good outcome as post-operative VA of 6/6-6/18 in >80% with available correction and >90 with best correction. The borderline outcome as post-op VA of 6/24-6/60 in <15% with available correction and <5% with best correction, and poor outcome as post-op VA of <6/60 in <5% with available correction.[11]

In a study in Ghana of 1288 cataract surgeries performed, 283 had good post-operative visual acuity outcomes (6/6-6/18) after 2 days and 528 after 30 days.[12] The outcome in Ghana demonstrated a below WHO benchmark because the post-operative visual acuity outcome was poor (VA <6/60) in 29.2% within 48 hours of surgery and 9.5% at 4-6 weeks follow-up.[12] Another study in Kenya showed that 82% of patients who underwent cataract surgeries in Loresho achieved good post-operative uncorrected visual acuity after 28 days.[13]

Conclusion

Cataract surgery remains the only treatment for cataracts. Literature reviews in African studies have shown that CSR has been low mostly with post-operative visual outcome that does not meet WHO recommendations. However, social-economic factors, religious

norms & values and other sectors influenced access and affordability of a cataract surgery. Males had more cataract operated eyes compared to females.

METHODOLOGY

Study design and data analysis

This was retrospective research study using existing data of the cataract surgeries done between January 1st and December 31st, 2012 in 8 regional capitals of Madagascar. Data was imported into Microsoft Excel 2007 and analyzed using STATA version 14.0 software. Data was analysed per region/district based on the capital where data was collected. These include Ambanja, Anstiranana, Fiananstota, Fort Dauphin, Moramanga, Morondova, Sambava, and Tulear.

The paired t-test was done using STATA 14.0 software to observe the hypothesis that tells there was no mean difference between pre- and post-operative visual acuity thus before and after cataract surgery. It was done in all categories with/without corrected vision with respect to a day, data was collected. The post-operative visual acuity was categorized based on follow up as follows; a day after cataract surgery, 7 days after cataract surgery and 30 days after cataract surgery. The researcher used WHO cataract surgery visual acuity category to assess the visual outcome after cataract surgery. Blindness and visual impairment prevalence was calculated using the preoperative visual acuity to find the magnitude of visual acuities that underwent cataract surgery and contributed to burden of cataract blindness.

Cataract surgery distribution by sex was analysed using a frequency table using STATA 14.0 software and the output was imported into Microsoft Excel to produce visual graphs to show the difference. The distribution by sex was analysed per region/district

of Madagascar. Sex was categorized into male or female. Age was assembled into two age categories; ≤49 yrs old and ≥ 50 yrs old.

Study population

Cataract surgical data covered all individuals who underwent cataract surgery in 8 capitals of Madagascar in 2012 between January 1st and December 31st. Consent from Madagascar government Ministry of Health was obtained by Kilimanjaro Center for Community Ophthalmology.

Inclusion criteria

All cataract surgery cases done in 2012 between January 1st and December 31st in the 8 regional capitals were included for analysis.

Exclusion criteria

All cataract surgical cases that were not done in 2012 between January 1st and December 31st were excluded.

Data collection

Cataract surgical data collection was done by Kilimanjaro Center for Community Ophthalmology (KCCO) in Madagascar in 2012 between January 1st and December 31st. Kilimanjaro Center for Community Ophthalmology supports centers in regions of Madagascar with satellite centers for cataract surgeries. Data was collected from 8 capitals that had cataract surgery supported by KCCO namely Ambanja, Moramanga,

Sambava, Tulear, Anstiranana, Dauphin, Morondava, and Fianstrarana. Variables collected were names, address, sex, age, month and day of operation, the operated eye, pre- and post-operative visual acuity, and center where the operation was done.

Risks and discomfort

There was no any form of risk or discomfort because the study used secondary data.

Potential benefits

This was retrospective study in which the outcomes would guide and inform the policy makers and/or implementers of the cataract surgery service program in Madagascar.

Informed consent

This study used secondary data, therefore, no informed consent was required. Data was released from the Kilimanjaro Center for Community Ophthalmology.

Withholding information

Information was released to Kilimanjaro Center for Community Ophthalmology and Madagascar government about the purpose of the research study.

Privacy and Confidentiality

The dataset was kept in the researcher's protected UCT student account and personal computer. The student UCT account had a protected password that was accessed by the researcher only. No name was used during analysis and dissemination of results.

SIGNIFICANCE OF THE STUDY

The results of this research study would inform the Ministry of Health of Madagascar to develop proper planning and strategies to address cataract blindness in the country. This information could be used to advocate for cataract surgery services as well as address gender inequity.

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PART B

STRUCTURED LITERATURE REVIEW

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SUMMARY

Globally, there are 253 million visually impaired people of whom 36 million people are blind and 217 million people have moderate to severe visual impairment. Cataract is the leading cause of blindness globally and it is also considered to be a second leading cause of visual impairment in the world.

In Africa, there are an increasing number of blind people due to cataract estimated at 600,000 cases every year. In Sub-Saharan Africa, CSR was much lower than the recommended CSR of 2000. However, other studies suggested that the needed CSR target for Sub-Saharan Africa may depend on genetic factors, migration of people across the continent, environmental factors or cultural variations, which is not uniform across Africa. It was further suggested that CSR is closely linked to cataract surgery affordability that depends on someone's financial muscle to pay the cost of a cataract surgery.

Literature review on visual outcome of cataract surgery showed that most of the postoperative visual outcome does not match the recommended WHO visual acuity outcome after cataract surgery with available correction ('functioning vision') or full spectacle correction ('best vision').

Distribution of cataract surgery by sex demonstrated that males were more likely to have had their eyes operated due to cataract than females.

THE AIM OF LITERATURE REVIEW

The purpose of a literature review was to extract relevant information from different studies that explained the variation of post-operative visual outcome, Cataract Surgery Rate, distribution of cataract surgery by sex.

STUDY QUESTION

What was the CSR in the studies searched?

What was the visual acuity outcome after cataract surgery?

What was the cataract surgery distribution by sex?

LITERATURE SEARCH STRATEGY

Studies that aimed at cataract surgery rate, post-operative visual outcome for cataract surgery and proportion of sex distribution were included in the search strategy. The search was done using the following PubMed database, Hinari, database, Google Scholar and Scopus. Articles were filtered using year of publication and English language was used to filter the publications.

Keywords: Cataract Surgical Rate, Visual acuity outcome, blindness, visual impairment, sex distribution.

- Cataract surgical rate; terms searched *(Cataract surgical rate, post-operative outcome, CSR in Africa, CSR worldwide, CSR in Sub-Saharan Africa*
- Visual acuity outcome; terms searched *(visual acuity after cataract surgery, , cataract pre-operative visual acuity, cataract post-operative visual outcome)*

- Blindness; terms searched *(global blindness, cataract blindness, cataract blindness in Africa)*
- Visual Impairment; terms searched *(global visual impairment, Africa visual impairment)*

  Sex distribution; terms searched *(cataract surgery distribution by sex, cataract surgery distribution by sex, cataract surgery distribution by gender)*

LITERATURE REVIEW

Blindness and Visual Impairment

World Health Organisation defined blindness and low vision as "Presenting Visual Acuity (PVA) of less than 3/60 in the better eye and PVA of less than 6/18 but not less than 3/60 in the better eye".[1]

The statistical study showed that the number of blind people and visually impaired had changed between 2010 and 2015 with improved statistical analysis and inclusion of precise data. There are 253 million visually impaired people of whom 36 million people are blind and 217 million people have moderate to severe visual impairment.[2] However, the global visual impairment figures were slightly higher than the estimated figures.[3] The figures were slight different because of the change in data availability, affordability and accessibility of eye care services since the implementation of VISION 2020 programmes in elimination of avoidable blindness. Data from population based studies provided more accurate estimates than the projected estimates.

Cataract Blindness

Cataract can be defined as the clouding part of the crystalline lens because of age related condition and this causes blurred vision. “Cataract surgery is a successful, cost effective intervention”.[4 5]

Worldwide Cataract Blindness

Cataract is globally the first and second leading cause of blindness and visual impairment respectively. A systematic review study for global estimates of visual impairment found that cataract blindness is estimated at 51% and visual impairment at 43%.[3] According to the World Health Organization (WHO), “39 million people worldwide were blind”.[6] Cataract treatment is believed to be surgical process only.

Cataract blindness in Africa

7.3 million blind people live in African continent of which half of them are blind due to cataract.[3] Therefore, planning for its treatment is a priority of the VISION 2020 initiative to eliminate avoidable blindness by the year 2020.[7] World Health Organisation (WHO) Global initiative further concluded that cataract is, therefore, a significant public health problem.

A case-control study on relationship between poverty and visual impairment from cataract in Kenya and Bangladesh supported Pascolini & Mariotti study that cataract accounts for about half of blindness in a low income country and has a major impact on poverty.[8 9]

Cataract Surgical Rate (CSR)

"Cataract Surgery Rate which is defined as the number of cataract surgeries per million people per year, is a critical index used to show that cataract blindness is being eliminated; the rate is higher in well-developed countries, while it is still very low in some parts of Africa and Asia".[3] CSR is used as an indicator to measure the progress of cataract surgery services in a country or continent. This can be related to its acceptability by the society, accessibility, and how affordable cataract is on to the community.[10] Shaheer & Courtright (2016) observed the lowest CSR to be in African continent.[11] However, CSR needs to be varied significantly in different sites and was lower in some than expected.[7] The same study suggested that CSR may depend on migration of people across the continent, environmental factors, cultural variations and lifestyle of which it is not uniform across Africa. It was further suggested that CSR is closely linked to individual's financial muscle to pay the cost of a cataract surgery. A study in Madagascar found a low CSR of 363 in 2009.[12] Several studies in African countries observed an increase of CSR since the introduction of cataract surgery programs between 2002 and 2004 that boost infrastructure and cataract awareness. CSR had risen to 1583 from 644 in Kwale District in Kenya, and CSR of 1165 from 313 in Kilimanjaro Region in Tanzania.[13]

Visual Acuity Outcome

Post-operative cataract surgery visual acuity is used as an indicator required by cataract surgeons or ophthalmologists to measure performance in monitoring the quality of their services.[14] According to World Health Organisation (WHO), the post-operative visual acuity outcome can be assessed with available correction ('functioning vision') or full

spectacle correction ('best vision'). The World Health Organisation (WHO) defines good outcome as post-operative VA of 6/66/18 in >80% with available correction and >90 with best correction. The borderline outcome as post-op VA of 6/24-6/60 in <15% with available correction and <5% with best correction, and poor outcome as post-op VA of <6/60 in <5% with available correction.[15]

An evaluation of cataract surgery outcome in Western Nigeria found that 58% of the participants were blind before surgery and 6.3% remained blind after cataract surgery was done. It was further observed that 47.5% had good visual outcome with best correction, 37.6% had moderate visual outcome with best correction and 155 had poor visual outcome with best correction.[14]

A survey in Ghana that had 1288 cataract surgeries within a 3-year-period found that 283 cataract surgeries had good post-operative visual acuity outcome (6/6-6/18) after 2 days and 528 cataract surgeries had good post-operative visual acuity outcome after 30 days.[16] This study demonstrated a below WHO visual acuity benchmark with poor VA within 48 hours of surgery and 4-6 weeks follow up.[16] Another study in Kenya showed that 81.8% of patients who underwent cataract surgeries in Loresho achieved a good post-operative uncorrected visual acuity after 28 days with VA of 6/18 and better.[17]

Distribution by sex

A meta-analysis study in 2001 demonstrated that women constituted almost two-thirds of the world's blind.[18] Women in most developing countries, did not have access to cataract surgical services the same way as men did. A systematic review study by Lewallen et al., (2009) showed unequal distribution of cataract surgery by gender; women in developing countries were less likely to have cataract surgeries as compared to men.[20] "Men were

1.71 times (95% CI 1.48 to 1.97) more likely to have cataract surgery than women".[19] It was suggested that gender inequality may have played a role in lowering the cataract sex coverage in women.

A RAAB survey in Bangladesh found a higher sex distribution for males than females with a proportion of 76.6% and 64.3% respectively.[20] Studies in developing countries for sex characteristics of cataract survey demonstrated that males were 1.5 times more likely to have cataract surgery compared to females.[21] In this study females were 0.67 times less likely to have had cataract surgery compared to males. Despite their low distribution, there was evidence of a cataract blindness prevalence reduction if females had received more cataract surgeries the same way males received their cataract surgeries.[21]

A Western Nigeria study on evaluation of cataract surgery outcome of 283 participants demonstrated that males had more access to cataract surgery services than females with proportion of 60% and 40% for males and females respectively, giving a male to female ratio of 1.4:1.[14] Women were less likely to receive surgery than men.[22] Men had more cataract operated eyes than females with a proportion of 40.9% for men and 31.7% for females.[22]

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PART C

MAIN ARTICLE

(JOURNAL MANUSCRIPT)

OPHTHALMIC EPIDEMIOLOGY

MAIN ARTICLE

CATARACT SURGICAL SERVICES IN MADAGASCAR

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Contents

ABSTRACT

Objective: The main purpose of this study was to evaluate cataract surgical services in Madagascar to help guide the national eye health program.

Methods: A retrospective study that used cataract surgical data collected between January 1st and December 31st, 2012 in 8 regional capitals (districts) of Madagascar. 1072 cataract operated eyes from 8 regional capitals supported by Kilimanjaro Centre for Community Ophthalmology (KCCO) satellite centers were analysed.

Results: The study findings demonstrated a borderline post-operative visual acuity outcome after 24 hours but showed visual improvements 4 weeks after follow up. Males were more likely to have cataract surgeries compared to females. The cataract surgery rate (CSR) was 1467 in 8 regional capitals of Madagascar.

Conclusion: This study demonstrated unequal distribution of cataract surgical services in Madagascar. Therefore, the findings of this study could be used to advocate for equitable provision of cataract surgery across all regions in Madagascar.

Keywords: Cataract, visual acuity outcome, cataract surgery distribution by sex, cataract surgical rate, Madagascar.

INTRODUCTION

Globally, there are 253 million people with visual impairment of whom 36 million are blind and 217 million people have moderate to severe visual impairment.[1] It was further suggested that Cataract is responsible for 33% of blindness and 18% of Visual Impairments globally; however, studies have observed that having access to good quality eye health services is a key determinant of avoidable vision loss due to cataract.[2] "The World Health Organisation (WHO) and the International Agency for the Prevention of Blindness (IAPB) was the first global effort to eliminate blindness from avoidable causes, including cataract which can only be treated surgically".[3]

"7.3 million blind people live in African continent of which half of them are blind due to cataract".[4] Individuals with cataract are likely to increase with increased life expectancy and rapid population growth. However, cataract can manifest across one's lifespan but the backlog and new cases for cataract rise with increasing age.[5]

Even though studies in some Asian and South American populations indicate a higher cataract prevalence, the studies still showed that their cataract prevalence were on average lower than Africa".[6]

Cataract Surgery Rate (CSR) is a key indicator of eye care services to show that cataract blindness is being eliminated. "CSR is an internationally recognized measure of cataract surgery service activity and an indicator of the availability and acceptability of the service to the population".[7] In a well developed countries, CSR ranges between 4000 and 6000 cataract surgeries.[8] And it is lower in many developing countries in Africa and Asia between 500 and 2000.[9] "The CSR is closely related to an individual's financial ability to

afford cataract surgery".[10] However, in most African countries, CSR remains the lowest regardless of financial ability to afford the surgery.[11] CSR needs to be varied significantly in different sites and was lower in some than expected.[12] Successful cataract surgery programmes that uses specialist in identifying individuals to undergo cataract surgery are mostly linked with the community based and hospital based services that provide cataract surgery service.[13]

Proportion of blindness presenting with visual acuity <3/60 in better eye due to cataract ranged between 21% and 67% in SSA countries from a systematic review of population based studies published between 2000 and 2012.[14]

This manuscript focused on CSR and the visual acuity outcome of cataract surgery to see the proportion of operated eyes that were able to achieve very good visual outcome. And it will also provide a statistical coverage for gender and age against the cataract operated eyes.

MATERIALS AND METHODS

Study Design

This was a retrospective study using existing data of the cataract surgeries done in 2012 between January 1st and December 31st in the district/regional capitals of Madagascar.

Study population

This study covered all individuals who underwent cataract surgery in 8 regional capitals/districts of Madagascar in 2012 between January 1st and December 31st. There were 1072 cataract operated eyes in 8 districts/regions of Madagascar in 2012 between January 1st and December 31st. The total population across all 8 regional capitals of Madagascar were 730,764.

Data collection

Data was collected in 2012 from January 1st to December 31st from 8 districts/regional capitals of Madagascar that had cataract surgery by KCCO-supported projects namely in Ambanja, Moramanga, Sambava, Tulear, Anstiranana, Dauphin, Morondava, and Fianstrarana. Variables collected were names, address, sex, age, month and day of operation, the operated eye, pre-and post-operative visual acuity, census, and center where the operation was done.

Inclusion and Exclusion criteria

This study only included all cataract eyes that were operated in 2012 between January 1st and December 31st in 8 regional capitals/districts of Madagascar.

Statistical analysis

Data was imported into STATA version14.0 and Microsoft Excel 2007 for analysis.

To observe the number of cataract operations per million populations per year, data was assembled per district/regional capitals of Madagascar and then assessed the cataract surgeries against the district/regional capital populations by a million to give us CSR.

$$CSR = \frac{\text{number of operated eyes}}{\text{regional capital total population}} \times \text{Million population}$$

Descriptive analysis was done for post-operative visual acuity with respect to preoperative visual acuity. Hypothesis testing was done for visual acuity to find out if there is a significant mean difference between paired observation before and after cataract surgery. This was done using paired t-test analysis and the probability p-value of less than 0.05 was set as significant level.

Pre-operative visual acuity across the regional capitals was categorized as Normal visual acuity, visual impairment and blindness. Visual acuity of 6/6-6/18 as normal visual acuity, <6/18-3/60 as visual impairment and <3/60 as blindness.

To find post-operative visual acuity that were recorded after 24hrs, 7 days with or without correction and after 30 days, data was entered into STATA 14 software to help in

extracting information for each district. Different post-operative visual acuities were merged together into a single category using a software namely STATA 14.0 version and categorize visual acuity as per (WHO) visual acuity assessment as follows; 6/6-6/18 as normal VA, <6/18-6/60 as borderline and <6/60-PL as poor. No Perception of Light (NPL) status not included in VA category because no participant had NPL status

The table 1 below shows post-operative visual acuity assessment

Table 1 post-operative visual acuity

VA TYPE	RESULT	DAY 1 POST-OP	30 DAYS POST-OP
6/6-6/18	Good	40% +	85% +
<6/18-6/60	Borderline	50%	10%
<6/60	Poor	10% (5% due to surgical complications)	5%

Cataract surgery distribution by sex was analysed through descriptive analysis using Stata 14.0 software. Then STATA output findings were then imported into Microsoft Excel to produce visible graphs to appreciate the difference. Sex was categorized into male or female. Age was assembled into age categories as follows; ≤ 49 years and ≥50 years.

RESULTS

A total of 1087 cataract operated eyes were registered between January 1st and December 31st in 2012 in 8 regional capitals of Madagascar from a total population of 730,674 people.

Cataract surgical rate (CSR)

Ambanja regional capital had a higher population of 190435 people compared to other regional capitals followed by Fianaranstoa with 167227 populations. Moramanga regional capital had the least number of populations.

The population size for each regional capital of Madagascar were shown figure 1.

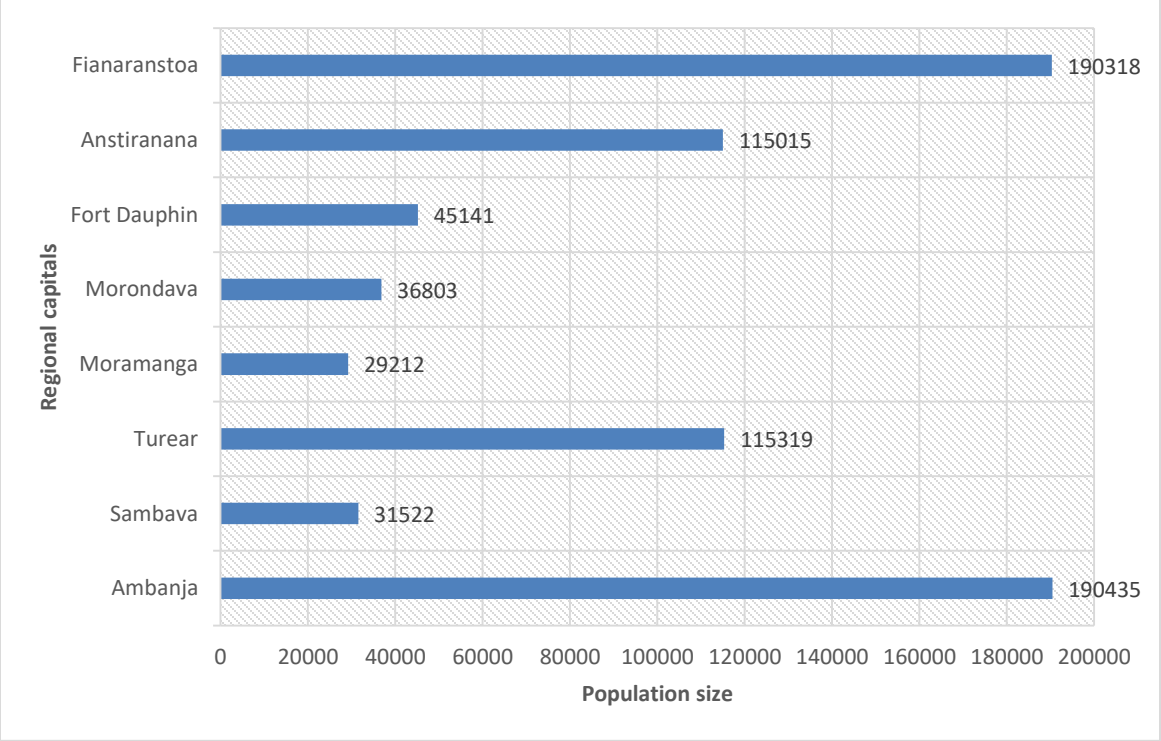

Figure 1: Showing the population size

Figure 2 shows the number of cataract operated eyes for each regional capital of Madagascar to calculate the CSR.

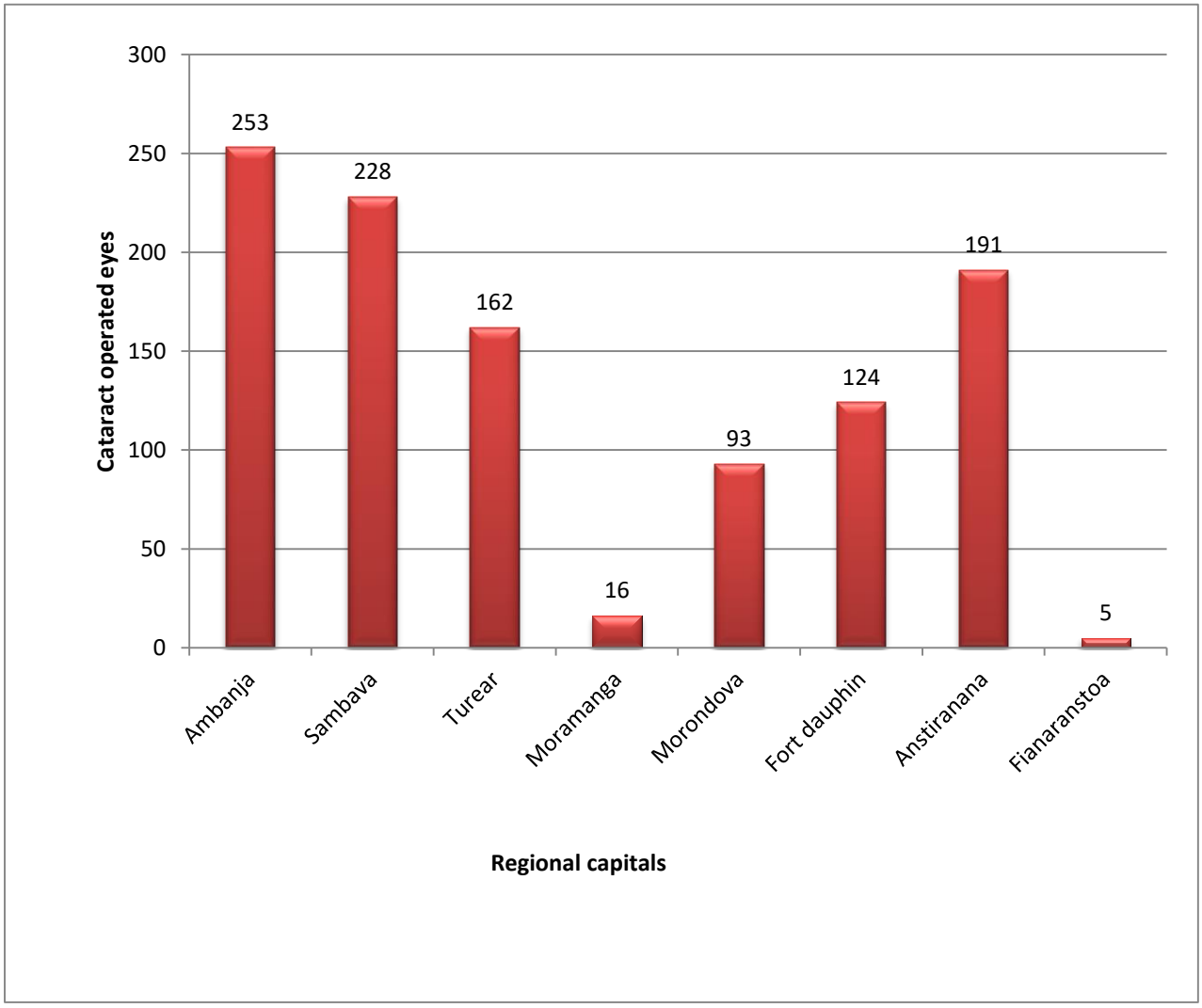

Figure 2: showing number of cataract operated eyes

Ambanja regional capital had the highest number of cataract operated eyes with 253 cataract operated eyes followed by Sambava regional capital with 228 cataract operated eyes. Fianaranstoa regional capital had the lowest number of cataract operated eyes.

CSR results

Sambava regional capital had the highest CSR with 7233 followed by Fort Dauphin with CSR of 2747 and Fianaranstoa regional capital had the least CSR of 26.

CSR was calculated with respect to the regional capital population and the number of cataract operated eyes.

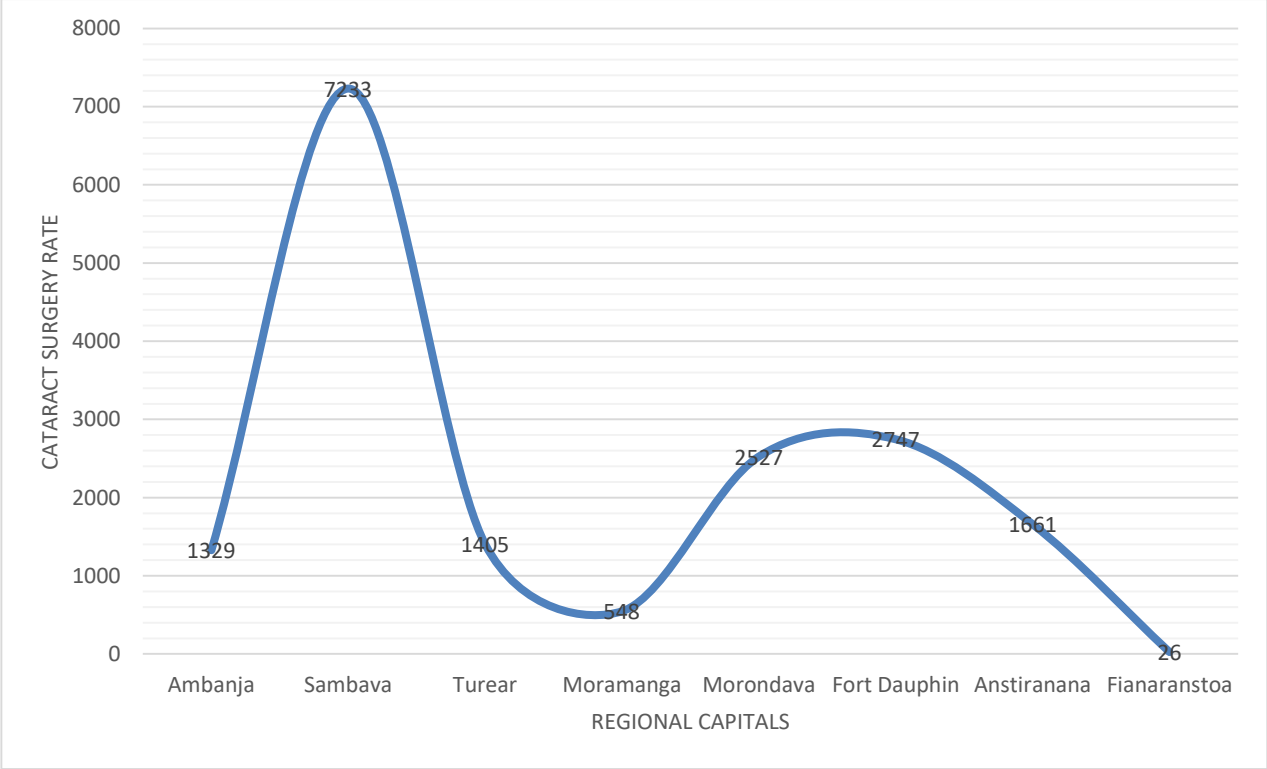

Figure 3: CSR across regional capitals

Table 1 shows us the distribution of cataract operated eyes and the population of each regional capital of Madagascar. The last column shows the calculated CSR and the last row shows the final CSR of all 8 regional capitals in Madagascar.

Table 1: Cataract surgery rate

Regional capitals (Districts)	Cataract operated eyes	Total population	CSR
Ambanja	253	190435	1329
Anstiranana	191	115015	1661
Fort Dauphin	124	45141	2747
Fianaranstoa	5	19318	26
Sambava	228	31522	7233
Tureal	162	115319	1405
Moramanga	16	29212	548
Morondava	93	36803	2527
Total	**1072**	**730674**	**1467**

Visual Acuity Outcome

There were 1087 recorded visual acuities for cataract surgery. However, there were no participants with normal visual acuity before surgery. Figure 4 shows that visually impaired category registered 233 cataracts and the blindness category registered 854 cataracts for cataract surgery.

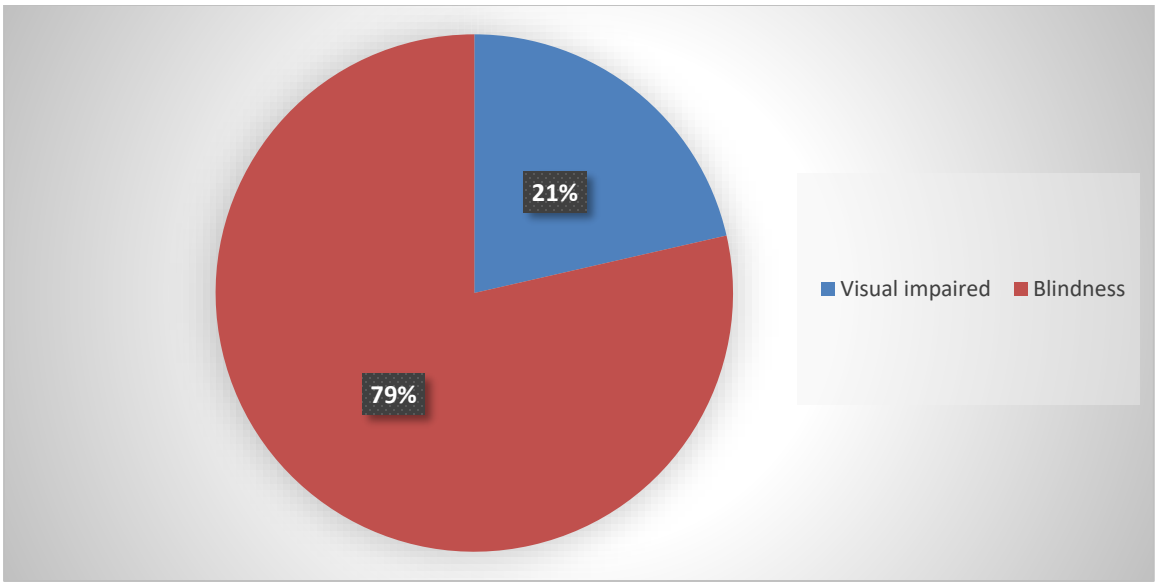

Figure 4: showing pre-operative visual acuity cataract eyes

Table 2 below shows significant change for pre- and post- operative visual outcome across all the days the visual outcome was recorded. The confidence intervals were so narrow showing precision of the result.

Table 2: Description of variables

VARIABLE	Surgeries	MEAN DIFFERENCE	95% CI	P VALUE
24 hr	703	10.9	10.2 - 11.7	0.00013
7 days uncorrected	1000	12.5	11.8 - 13.1	0.00023
7 days corrected	1005	12.4	11.7 - 13.1	0.00034
30 days uncorrected	965	11.4	10.7 - 12.1	0.000057

Table 3 shows the transition of visual acuity outcome recorded after surgery from day 1 without refraction, day 7 thus with or without refraction and day 30 without refraction.

Table 3: Post-operative visual acuity transition

Regional capitals	VA category	Uncorrected vision at 24 hours		Uncorrected vision at day 7		Corrected vision at day 7		Uncorrected vision at day 30	
		Cases	Percent	Cases	Percent	Cases	Percent	Cases	Percent
Ambanja	Good			248	97%	248	97%	248	97%
	Borderline			8	3%	8	3%	8	3%
Anstiranana	Good	66	35%	166	87%	190	99%	187	98%
	Borderline	125	65%	25	13%	1	1%	4	2%
Fianaranstoa	Good			1	20%	2	40%	2	40%
	Borderline	1	20%	2	40%	3	60%	3	60%
	Poor	4	80%	2	40%				
Fort Dauphin	Good	1	1%	33	27%	87	70%	124	100%
	Borderline	90	72%	90	73%	37	30%		
	Poor	33	27%						
Moramanga	Good	6	28%					13	82%
	Borderline	9	56%					2	13%
	Poor	1	6%					1	6%
Morondava	Good	68	73%	74	80%	55	59%	73	78%
	Borderline	25	27%	19	20%	38	41%	20	22%
Sambava	Good	228	100%	133	58%	189	83%	145	64%
	Borderline			77	34%	8	4%	38	17%
	Poor			18	8%	31	14%	45	19%
Tureal	Good	171	100%	66	39%	121	71%	152	89%
	Borderline			94	55%	40	23%	11	6%
	Poor			11	6%	10	6%	8	5%

Post-operative visual acuity outcome across regional capitals shows improved visual acuity with a series of follow up. However, post-operative visual acuity outcome was borderline at 24 hours.

Distribution by sex

The number of cataract operated eyes by sex shows that cataract surgery distribution varied with the regional capital and there was no uniform distribution of sex across the regional capitals.

Table 5: Cataract surgery distribution by sex

Sex	Ambanja	Anstiranana	Fianaranstoa	Dauphin	Moramanaga	Morondava	Sambava	Tureal
M	134	89	1	70	8	59	117	82
F	119	102	4	54	8	34	111	80

However, the number of cataract operated eyes in some regional capitals were insufficient to make the difference and compare with other regional capitals. Only in Sambava and Ambanja region had more cataract operated eyes compared to other regions. Comparison would not make sense with a district that 5 cataract operated eyes. Male to female ratio is approximately 1:1 in 6 regional capitals, however, in Fianaranstroa, the ratio was 4:1 with female having more cataract operated eyes.

DISCUSSION

The prevalence of blindness due to cataract increases with age.[15] It is quite reasonable to see that the majority of the cataract operated eyes were found in age group above 50 years old with the mean age of 52 for cataract operated eyes. CSR in regional capitals of Madagascar varied with the population as *table 2* showed different CSR across the region capitals. In some regional capitals it exceeded the WHO benchmark of 2000 per million populations per year. However, the overall CSR was below the WHO benchmark. This could have happened in such way depending on some factors that could lead to poor access of cataract services in some regional capitals. Distance travelled to surgical center, lack of awareness and cost of surgery could also contribute to lower CSR.[16] A previous study in Anstiranana region in 2010 compared CSR in remote and urban areas; CSR was lower in a remote district of Manapotsy (CSR 35) as compared to urban district of Toamasina (CSR 750).[17] This research study looked at 8 regional capitals of Madagascar and observed a CSR in total. However, *figure 3* showed that 3 out of the 8 regional capitals produced good CSR. And the results of this CSR analysis are quite similar to those from other RAAB surveys in eastern Africa.[18] The population under study was sufficient to make plan for CSR programs in Madagascar. In 8 regional capitals, there were 730,674 people of which 1087 cataract surgeries were done in 2012. The sample size was enough and population estimate was accurate because it was the updated 2012 census of regional capitals. The population estimate could not affect the CSR findings of this study in the population estimate data were to change because the estimate accurate.

The study used cataract surgery data from satellite cataract surgical centers supported by Kilimanjaro Center for Community Ophthalmology (KCCO). This research study was limited to data accessed from KCCO centers only and this could affect external validity of the study findings because the study could not have access to data from other private hospitals or any public hospitals not supported by KCCO. However, findings from this study could still be used for the management and strategic plan for cataract services because the data gathered was sufficient enough to infer and make use of the information. Sample size under this study was adequate to represent the entire population of the regional capitals.

Many retrospective cataract studies were conducted on post-operative visual acuity outcome after cataract programmes were initiated in most African countries.[19] Pre-operative visual acuity of other studies is similar to this study. Majority of the patients seek medical service at the hospital when they are already blind or severe visually impaired. This is the reason why most studies have a poor pre- operative visual acuity. It was also observed that patients accepted cataract surgery when visual acuity is less than 6/60 in either eye as compared to European countries where they seek early medical attention.[20] The findings of this study have demonstrated a borderline visual acuity 24hrs after cataract surgery except in 3 regional capitals as shown in *table 4*. However, visual acuity was good on day 30 as recorded after 4 weeks of follow up.

In this study, males had more cataract operated eyes in this study compared to females across all regional capitals. However, distribution by sex was different in regional capitals because in 2 out of 8 regional capitals; females had more cataract operated eyes compared to males. We also note that in these 2 regional capitals, female had more

cataract operated eyes in the age group of less than 50 years old. It may also happen that girls or women empowerment campaign could have been progressing well in the 2 region capitals and it was well accepted. Research studies recommend that if females get more access to cataract service usage, it may boost the fight in elimination of blindness and visually impairment.[21 22]

CONCLUSION

This study demonstrated low CSR in most of the regional capitals and that there is a need for cataract program planners to put strategic plans on how to increase the uptake of cataract surgeries in Madagascar. This study has shown unequal distribution of cataract surgical services as evidenced with CSR outcome across the regional capitals in Madagascar. Cataract surgery programs need to be intensified in these regional capitals of Madagascar and reach the rural masses that have no access to cataract surgery services to improve the cataract service delivery. Setting up satellite cataract clinics and outreach cataract services will help to increase the surgery uptake and improve CSR.

To maintain and improve the visual acuity outcome standard, the cataract planners need to introduce cataract surgical outcome self-monitoring forms for surgeons to assess themselves how effective the cataract surgery was and find a way to make it better.

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PART D: APPENDICES

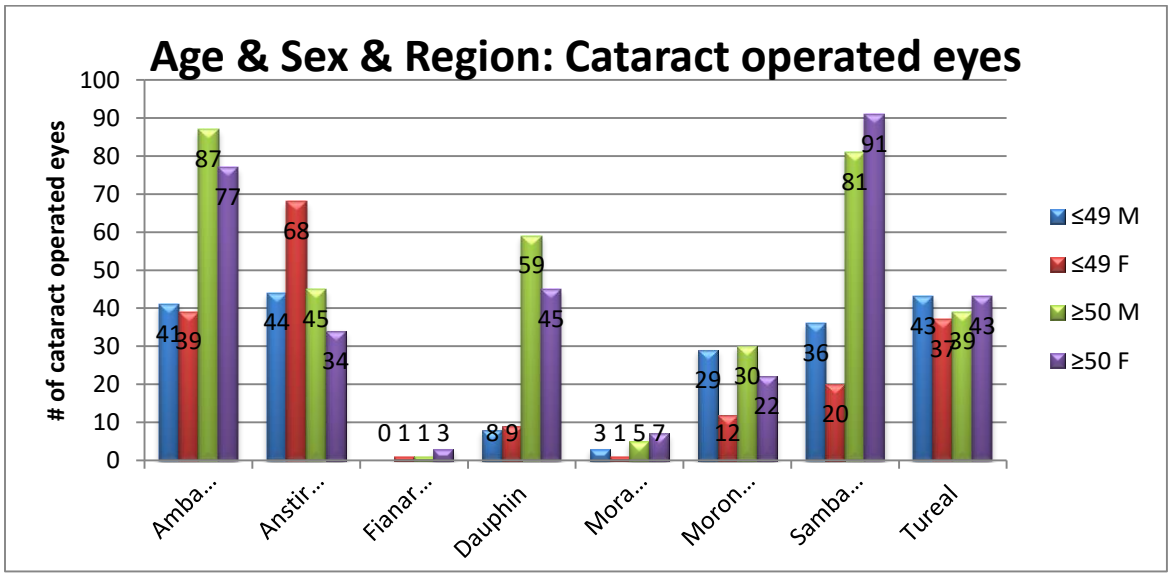
Contents

Supplementary table and figure

Pre-operative visual acuity table

Pre-op VA	# of cases	Percent
Visual Impaired	233	21.4%
Blindness	854	78.6%
Total	1087	

Age and Sex: cataract operated eyes



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Subject : Authorization

Dear Professor Courtright,

The Kilimanjaro Centre for Community Ophthalmology (KCCO) was supporting the Ministry of Health and three centres in Madagascar over the past few years in delivering cataract surgical services and it would be important to be able to reflect on their productivity, compared to the rest of the eye units also whether they have better gender equity. There is a desire to analyse data in terms of type of cataract surgeries done and post-operative visual outcome to draw learnings to inform the national eye health programme to achieve better understanding of the cataract situation and allow for evidence based planning.

With this letter we are approving the use of the data on cataract surgeries (with no details to identify patients involved) for analysis by Eric Ndaule (UCT Masters student) under the supervision of Dr. Amir Bedri Kello to carry out this analysis.

We are grateful for the collaboration and look forward to working with Eric Ndaule and you on the project.

Sincerely,

LE DIRECTEUR DU PARTENARIAT

MINISTERE DE LA SANTE PUBLIQUE
REPOBLIKAN'I MADAGASIKARA
DIRECTION

Dr. ANDRIAMANJATO Hery Harimanitra
Diplômé de Santé Publique