FACTORS AFFECTING THE IMPROVEMENT OF VISUAL ACUITY AFTER CATARACT SURGERY AMONG CATARACT PATIENTS IN MALAYSIA BASED ON THE NATIONAL EYE DATABASE 2014-2018

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2021

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by

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Thesis submitted in fulfilment of the requirement for the Degree of Master of Science (Medical Statistics)

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2021

ACKNOWLEDGEMENT

In the name of Allah, the Most Gracious and the Most Merciful, I have reached this moment when all my wishes and hopes come together, and I am going to submit my dissertation. At this point, I have many people to thank from the bottom of my heart for their help, and probably my words of gratitude will fall short of what they deserve.

First, I would like to express my sincere gratitude to my supervisors Dr. Anis Kausar bt Ghazali and Dr. Najib Majdi bin Yaacob for their continuous support, guidance, comments, and advice regarding my research studies. Their guidance helped me throughout my research and the writing of this thesis.

Next, this dissertation is dedicated to my parents (Pn. Mozlifah binti A. Hamid and *Arwah* En. Sa'at bin Shahid), who taught me the value of education and always encouraged me to get as much education as I could. I would also like to thank my family members for their support and for giving me all the encouragement I needed to continue. Also, thanks to all lecturers and friends, that kept on comforting and guiding me when I am lost and need an extra hand in finishing this research.

Last but not least, I would like to express my gratitude to Dr. Mohamad Aziz bin Salowi for his support and encouragement in completing the writing up of my thesis. He also approved using the National Eye Database (NED) data in this research and taught me a lot in clinical terms. I gratefully acknowledged the NED teams for smoothly cooperating in-process transfer of data.

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LIST OF SYMBOLS

ɑ	Level of significance
1-β	Power of study
p	Expected Proportion / Prevalence
d	Precision
n	Sample size
P_0	Proportion from literature
P_1	Proportion from researcher
r	Ratio of control to cases group
PP	proportion of pairs (P_1+P_0)
Z	Level of confidence
$\mathcal{X}^2$	Chi-square test
vs	Versus
k	Constant
ln	Natural logarithm
p-value	Probability value
$\hat{y}$	Fitted y / Predicted outcome
X_i	Variables
CP	Covariate pattern
Δβ	Pregibon Delta- Beta influence statistic
Δχ2	Hosmer and Lemeshow Delta chi-squared influential statistic
ΔD	Delta D influential statistic
h	Leverage
b	Regression coefficient
%	Percentage
df	Degree of freedom

$=$	Equal to
$<$	Less than
$>$	More than
$\leq$	Less than and equal to
$\geq$	More than and equal to
$\approx$	Approximately equal to

LIST OF ABBREVIATIONS

ARMD	Age-Related Macular Degeneration
AUC	Area Under the Curve
CF	Counting Fingers
CI	Confidence Interval
CSR	Cataract Surgery Registry
ECCE	Extracapsular Cataract Extraction
ETDRS	Early Treatment Diabetic Retinopathy Study
GOF	Goodness of Fit
HM	Hand Movement
ICCE	Intracapsular Cataract Extraction
ID	Patients' Identifier
IOL	Intraocular Lens
IOP	Intraocular Pressure
JEPeM	Jabatan Etika Penyelidikan Manusia
KK-KKM	Klinik Katarak – Kemeneterian Kesihatan Malaysia
LP	Light Perception
MC	Multicollinearity
MOH	Ministry of Health
MREC	Medical Research and Ethics Committee
NED	National Eye Database
NLP	No Light Perception
OR	Odds Ratio
PCO	Posterior Capsular Opacification

Phaco	Phacoemulsification
ROC	Receiver Operating Characteristic
SD	Standard Deviation
SDP	Source Data Providers
SE	Standard Error
VA	Visual Acuity
VI	Visual Impairment
VIF	Variance Inflation Factor
WHO	World Health Organization
HL	Hosmer-Lemeshow

FAKTOR MEMPENGARUHI PENINGKATAN KETAJAMAN PENGLIHATAN SELEPAS PEMBEDAHAN KATARAK DI KALANGAN PESAKIT KATARAK DI MALAYSIA BERDASARKAN PANGKALAN DATA MATA KEBANGSAAN 2014-2018

ABSTRAK

Pendahuluan: Kebutaan dan masalah penglihatan adalah sebahagian daripada penyakit mata global. Katarak adalah salah satu penyebab utama kepada kebutaan.

Objektif: Untuk menentukan perkadaran dan faktor-faktor yang berkaitan dengan peningkatan ketajaman penglihatan di kalangan pesakit katarak selepas pembedahan di Malaysia menggunakan data dari Pangkalan Data Mata Kebangsaan.

Kaedah: Ini adalah kajian kohort retrospektif yang menggunakan data dari pangkalan data mata nasional. Pesakit katarak yang menjalani pembedahan dan didaftarkan dari Januari 2014 hingga Disember 2018 berusia lebih dari 18 tahun diekstrak dari pangkalan data. Sosiodemografi pesakit, komorbiditi, faktor pembedahan, dan faktor komplikasi yang berkaitan diambil dari pangkalan data. Hasilnya diukur dari perbezaan ketajaman penglihatan pra dan pasca operasi dan dikategorikan sebagai ada peningkatan, tiada perubahan, dan lebih buruk. Perbezaan perkadaran ketajaman penglihatan di antara sebelum dan selepas pembedahan dianalisa menggunakan ujian *Marginal Homogeneity Stuart-Maxwell*. Regresi logistik ordinal digunakan untuk mengenal pasti perkaitan antara faktor dan hasilnya. Pembentangan hasil menggunakan nisbah kemungkinan dan 95% selang keyakinan.

Keputusan: Seramai 199,826 pesakit yang mempunyai purata umur 66.5 (9.57) tahun terlibat dalam kajian ini dan sebanyak 96.2% mencapai peningkatan ketajaman penglihatan setelah menjalani pembedahan katarak. Keputusan dari ujian *marginal homogeneity* terhadap ketajaman penglihatan pada sebelum dan selepas pembedahan mempunyai perbezaan yang significant ($p<0.001$). Terdapat 80.9% perubahan ketajaman penglihatan dari garis sempadan ke baik dan teruk ke garis sempadan dan baik. Analisis multivariabel menunjukkan peningkatan ketajaman penglihatan jauh lebih tinggi pada pesakit yang berumur diantara 41-60 tahun (OR: 1.15; 95% CI: 1.03, 1.29), pesakit wanita (OR: 1.07; 95% CI: 1.02, 1.13), pesakit Melayu (OR: 1.63; 95% CI: 1.54, 1.73) dan nyanyuk penyebab katarak (OR: 1.39; 95% CI: 1.12, 1.73). Kemungkinan peningkatan ketajaman penglihatan disebabkan tanpa adanya komorbiditi okular (OR: 1.67; 95% CI: 1.58, 1.77), pembedahan menggunakan ECCE (OR: 1.98; 95% CI: 1.36, 2.86), kehadiran IOL (OR: 1.95; 95% CI: 1.67, 2.27), pembedahan <30 minit (OR: 1.42; 95% CI: 1.26, 1.61), dan pembedahan yang dilakukan oleh pegawai perubatan (OR: 1.47; 95% CI: 1.28, 1.68). Pesakit tanpa komplikasi intraoperatif dan pasca operasi mempunyai 1.21 (95% CI: 1.08, 1.34) dan 10.85 (95% CI: 10.24, 11.51) kali ganda lebih tinggi dapat peningkatan ketajaman penglihatan.

Kesimpulan: Peratusan peningkatan ketajaman penglihatan selepas pembedahan di kalangan pesakit katarak di Malaysia adalah tinggi. Hasil daripada kajian ini dapat membimbing doktor, pakar oftalmologi, dan penyelidik untuk mengenal pasti pesakit yang mempunyai faktor-faktor yang berkaitan dengan penambahbaikan ketajaman penglihatan setelah menjalani pembedahan.

Kata kunci: Pembedahan katarak, Ketajaman visual, Peningkatan, Faktor-faktor, Regresi Logistik Ordinal

FACTORS AFFECTING THE IMPROVEMENT OF VISUAL ACUITY AFTER CATARACT SURGERY AMONG CATARACT PATIENTS IN MALAYSIA BASED ON THE NATIONAL EYE DATABASE 2014-2018

ABSTRACT

Introduction: Blindness and visual impairment are part of a global burden of eyes disease. Cataract is one of leading causes of blindness.

Objective: To determine the proportion and factors associated with visual acuity (VA) improvement among cataract patients after surgery in Malaysia using data from the National Eye Database.

Method: This was a retrospective cohort study using data from National Eye Database (NED). Cataract patients who underwent surgery and were registered from January 2014 to December 2018 with age over 18 years old were extracted from database. Patients' sociodemographic, comorbidities, surgical factors, and related complication factors were extracted from the database. The outcome was measure from pre-and postoperative VA differences and categorised as improve, no change, and worse. Differences proportion in VA between before and after surgery were analysed using the Stuart-Maxwell Marginal Homogeneity test. Ordinal logistic regression was used to identify the association between the factors and the outcome. Result presentation using odds ratio and 95% confidence interval (CI).

Results: A total of 199,826 patients with a mean age of 66.5(9.57) years involved in this study and 96.2% achieved improvement VA after undergoing cataract surgery. Results from marginal homogeneity test on VA before and after surgery had significant differences (p <0.001). There were 80.9% VA change from borderline to good and poor to borderline and good. Multivariable analysis showed improvement of VA was significantly higher in patients with age group 41-60 years old (OR: 1.15; 95% CI: 1.03, 1.29), female patients (OR: 1.07; 95% CI: 1.02, 1.13), Malay groups (OR: 1.63; 95% CI: 1.54, 1.73) and senile cause of cataract (OR: 1.39; 95% CI: 1.12, 1.73). The likelihood of improvement VA in the absence of ocular comorbidities (OR: 1.67; 95% CI: 1.58, 1.77), surgery using ECCE (OR: 1.98; 95% CI: 1.36, 2.86), presence of IOL (OR: 1.95; 95% CI: 1.67, 2.27), surgery of <30 minutes (OR: 1.42; 95% CI: 1.26, 1.61), and surgeries performed by a medical officer (OR: 1.47; 95% CI: 1.28, 1.68). Patients without intraoperative and postoperative complications had 1.21 (95% CI: 1.08,1.34) and 10.85 (95% CI: 10.24,11.51) times higher odds of improving VA.

Conclusion: The percentage of improved VA after surgery among cataract patients in Malaysia was high. The findings from this study can guide the doctors, ophthalmologists, and researchers to identify the patients who have the associated factors that are highly likely to get improvement in VA after surgery.

Keywords: Cataract surgery, Visual Acuity, Improvement, Factors, Ordinal Logistic Regression

CHAPTER 1: INTRODUCTION

1.1 Background of the study

World Health Organization (WHO) classified visual impairment (VI) into two groups; distant and near VI. In distant VI there are four levels of visual acuity (VA); mild (VA worse than 6/12 to 6/18), moderate (VA worse than 6/18 to 6/60), severe (VA is worse than 6/60 to 3/60), and blindness (VA is worse than 3/60). In near VI, VA measured at near distance is worse than N6 or M.08 at 40cm (World Health Organization (WHO), 2021).

According to the literature on the global burden of disease study, the prevalence of blindness and impaired VA in 2010 was 270.5 million people. The article estimated that in 2020, globally, 43.3 million people were blind, and 295 million had vision impairment (Bourne, Steinmetz, Flaxman, *et al.*, 2021). In the current global situation, cataract is the leading causes of blindness among 50 years (more than 90%) and older followed by glaucoma, undercorrected refractive error, age-related macular degeneration, and diabetic retinopathy (Bourne, Steinmetz, Saylan, *et al.*, 2021).

The results of the National Eye Survey (NES) done in 2014, revealed that the main causes of blindness in Malaysia were untreated cataract (58.6%), diabetic retinopathy (10.4%), other posterior segment diseases (8.4%), and glaucoma (6.6%) (Chew *et al.*, 2018). In the same survey, the prevalence of blindness was reported as 1.2%, severe VI of 1.0%, and moderate VI was 5.9%. Sabah and Sarawak (located on the Malaysian part of the Borneo Island) had the highest prevalence of blindness and moderate and severe VI possibly because these two states had the most inadequate access to ophthalmological services in the country (Chew *et al.*, 2018). In another study, it was reported that the leading cause of blindness in Malaysia was cataract (39%) followed by retinal disease (24%) (Chandrasekhara Reddy & Thevi, 2017).

A cataract occurs when the natural lens of the eye becomes cloudy. Ageing is the most common cause of cataracts. This is due to the normal eye changes that start around the age of 40. It happens when the normal proteins in the lens begin to break down and clump together. The lens gets cloudy because of the clumps as shown in Figure 1.1 (National Eye Institute (NEI), 2019). Other eye conditions that can cause cataracts are due to a person's health condition such as diabetes or past eye surgery (Mayo Clinic, 2018). The figure below shows the condition and difference between cataract eyes and normal eyes.

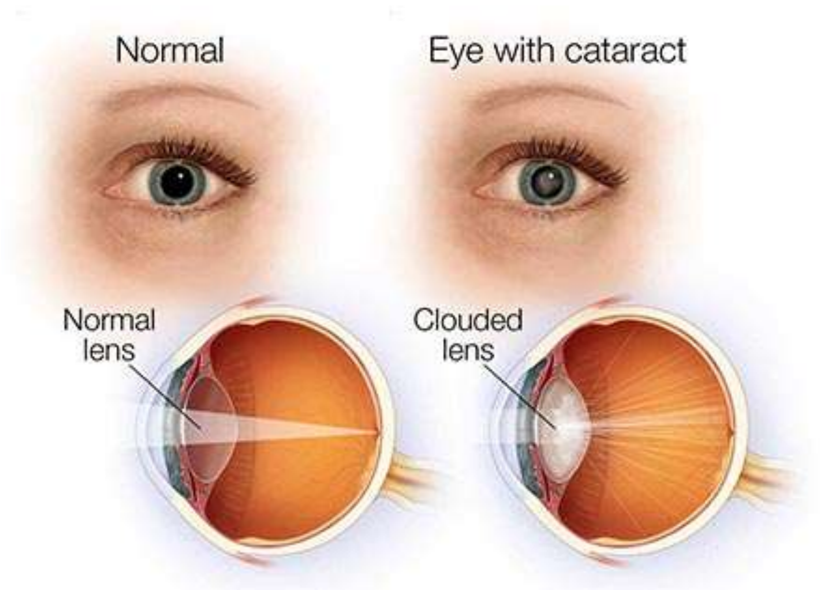


Figure 1.1: Differences Normal and Cataract Eye Condition
Retrieved from https://www.eyedoctorophthalmologistnyc.com/treatment/cataracts/

In the National Eye Database (NED), a web-based password protected surveillance system used by the Malaysian Ministry of Health (MOH) surgeons to collect and monitor patients' data, among all the Source Data Providers (SDP) in 2018, Ipoh Hospital contributed the highest number cataract cases (n=3747), followed by Kuala Lumpur Hospital (n=2965), Likas Hospital contributed the lowest number with only 34 cases. The number of cases in other SDPs are as in Figure 1.2 (Salowi *et al.*, 2020).

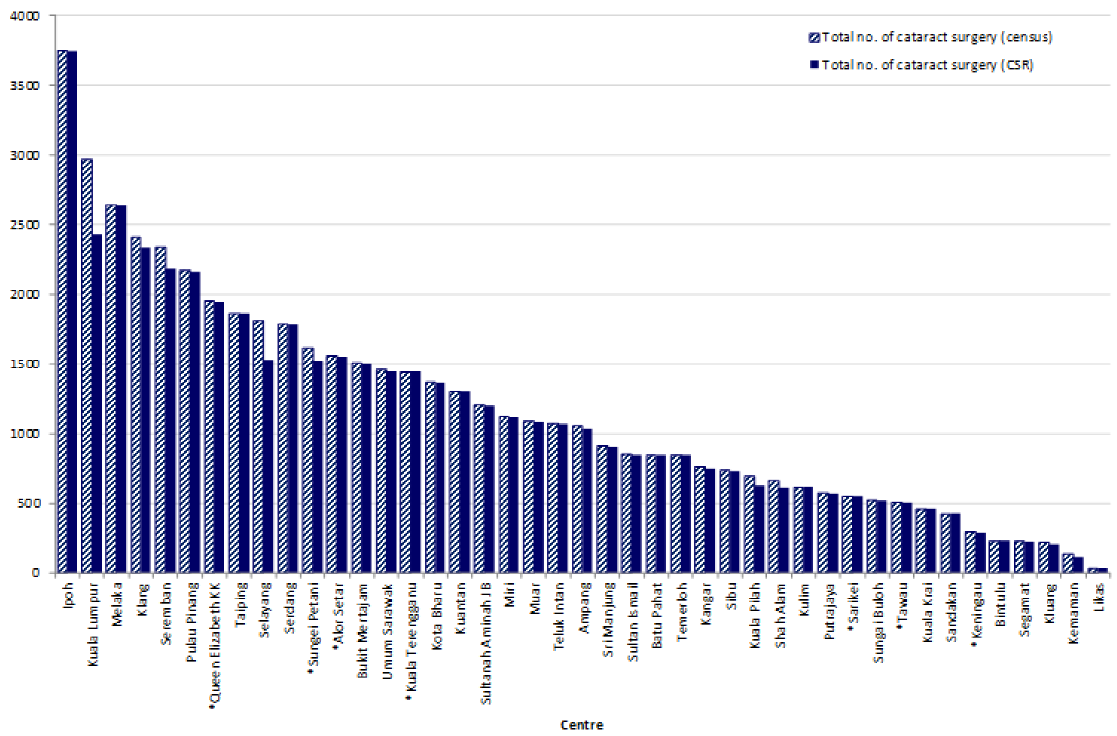


Figure 1.2: Cataract Cases According to SDP

Salowi, M., Mokhtar, A., et. Al (2020) The 12th Report of the National Eye Database 2018. Available at: http://acrm.org.my.ned.

The effective way to treat cataract which causes VI is cataract surgery. It is the most common ocular procedure performed in the world (Davis, 2016). Surgical technique has evolved from manual cataract extraction (intracapsular cataract extraction (ICCE), extracapsular cataract extraction (ECCE), and small incision cataract) to a modern method such as phacoemulsification (Davis, 2016). The standard technique for cataract surgery in Malaysia is phacoemulsification (Salowi *et al.*, 2020). According to a global study, 72% of the eyes undergoing surgery presented with blindness or severe VI (Shah *et al.*, 2011). Research in Europe showed that 61.2% of patients achieved a good postoperative VA after surgery (Lundström *et al.*, 2013). Another study in India also showed a better outcome as 91.7% of the patients recover from cataract surgery (Matta *et al.*, 2016). The proportion in Malaysia for good outcomes after cataract surgery is 91.3% (Salowi *et al.*, 2020).

1.2 Problem statement & study rationale

The total number of cataract surgery performed in Malaysia showed an increasing trend, as showed in Figure 1.3. While the percentage of patients presenting with poor vision was high as illustrated in Figure 1.4. The proportion of eyes with postoperative VA with good vision after surgery were slowly increasing from 2009 to 2018 (as showed in Figure 1.5) (Salowi *et al.*, 2020). According to the WHO, targeted guidelines on visual outcomes of cataract surgery should be to get over 90% for good vision, 5% for vision borderline and severe (Limburg *et al.*, 2005). In the NED 2020 report, the percentage for good vision (86.6%) was reaching the WHO target, while for borderline (10.4%) and severe (3.0%) vision did not reach the target set by the WHO (Salowi *et al.*, 2020). In this study, we would like to evaluate the changes in VA by comparing the VA achieved post-operatively as compared to the VA at presentation (pre-operatively).

Most previous studies focused on the associated factors for poor and good visual outcomes (Meiers, Kursīte & Laganovska, 2017; Thevi & Godinho, 2017; Khanna *et al.*, 2020). In this study, we will be focusing on the improvement of VA and the associated factors. VA improvement can be measured by a drop of 0.1 unit in LogMAR value for each patient preoperative and 12 weeks postoperative. These changes will be helpful for the doctors, ophthalmologists, and researchers to identify the patients who have the associated factors that are highly at chance to get improvement of VA after surgery.

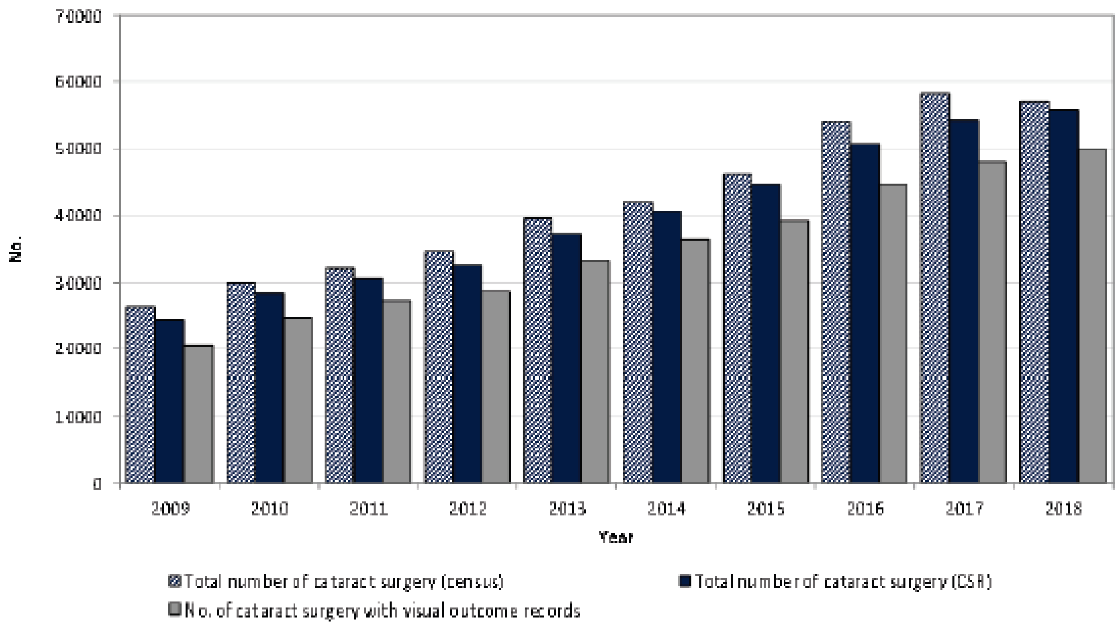


Figure 1.3: Stock and Flow, Number of Cataract 2009-2018

Salowi, M., Mokhtar, A., et. Al (2020) The 12th Report of the National Eye Database 2018. Available at: http://acrm.org.my.ned.

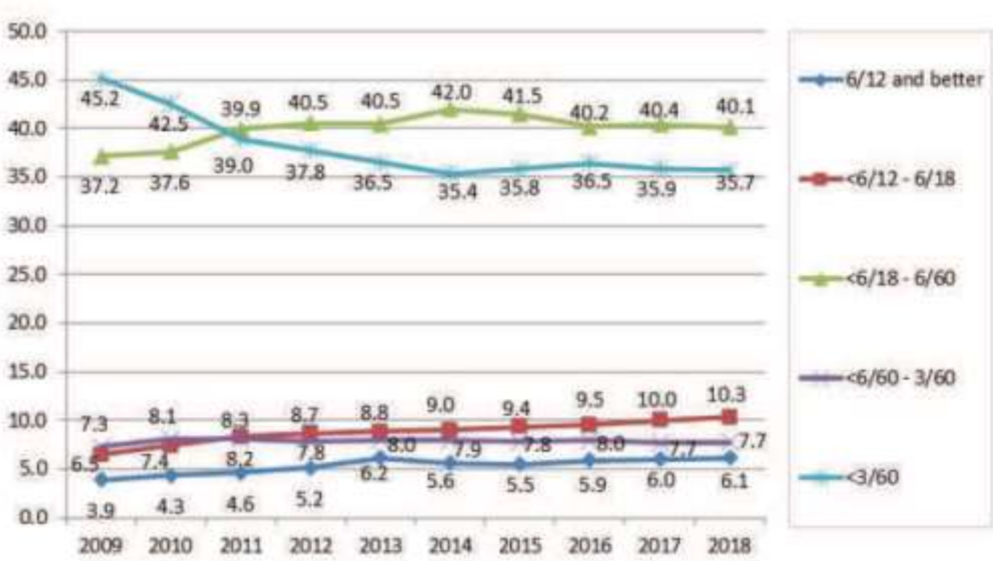


Figure 1.4: Distribution of Pre-operative Vision (Unaided), 2009-2018

Salowi, M., Mokhtar, A., et. Al (2020) The 12th Report of the National Eye Database 2018. Available at: http://acrm.org.my.ned.

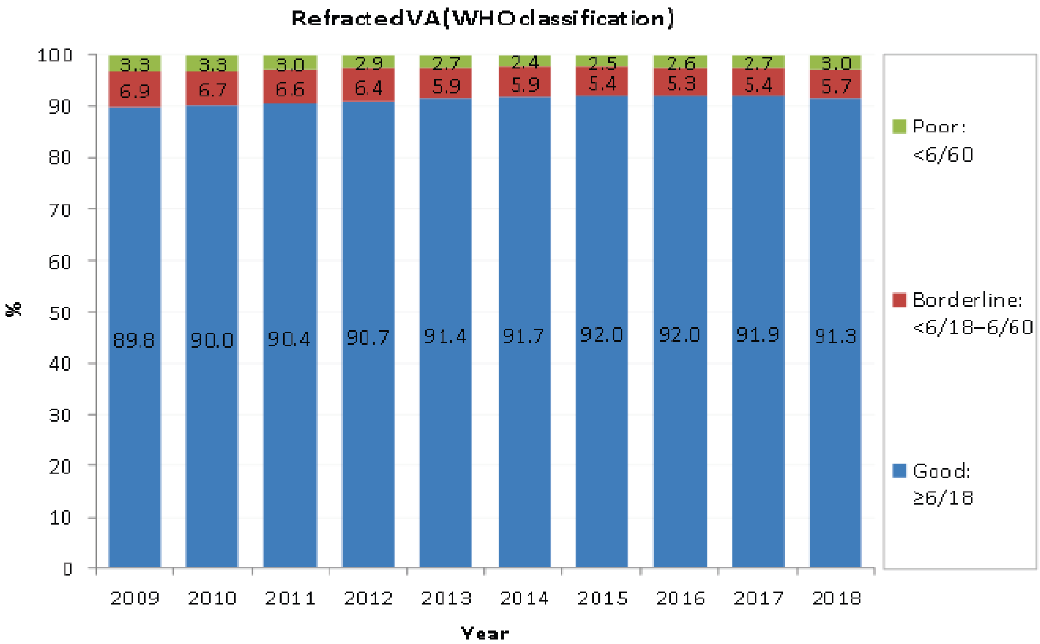


Figure 1.5: Post-operative Best Corrected VA by Vision Category (All Eyes), 2009-2018

Salowi, M., Mokhtar, A., et. Al (2020) The 12th Report of the National Eye Database 2018. Available at: http://acrm.org.my.ned.

1.3 Research question(s)

1. What is the proportion of improvement of VA among post-surgery cataract patients in Malaysia?
2. Is there any difference in proportion of VA pre-and post-surgery among cataract patients in Malaysia?
3. What are the factors associated with the improvement of VA among cataract patients in Malaysia?

1.4 Objective

1.4.1 General:

To determine the proportion and factors associated with VA improvement among cataract patients after surgery in Malaysia using data from the NED.

1.4.2 Specific:

1. To determine the proportion of improvement of VA among post-surgery cataract patients in Malaysia.
2. To determine the proportion differences in VA between pre-and post-cataract surgery among cataract patients in Malaysia.
3. To determine the factors (age, gender, races, cause of cataract, ocular comorbid, systemic comorbid, surgeon grade, surgery type, duration surgery, anaesthesia, IOL, intraoperative and postoperative complication) associated with the improvement of VA among cataract patients after surgery in Malaysia.

1.5 Research hypothesis

The research hypothesis (RH) in this study is only applicable to objective 2 and 3. The first RH is related to the second objective and the second RH is related to the third objective

1. There are differences in proportion of VA between pre-and post-cataract surgery among cataract patients in Malaysia
2. There is an association between factors (age, gender, races, cause of cataract, ocular comorbid, systemic comorbid, surgeon grade, surgery type, duration surgery, anaesthesia, IOL, intraoperative and postoperative complication) with the improvement of VA among cataract patients in Malaysia.

CHAPTER 2: LITERATURE REVIEW

2.1 National Eye Database Report

The NED database is an eye health information system supported by the MOH. The sources of data eye care providers were mainly from the public hospital and clinics. The Ministry of Health provides cataract services in three different concepts, which can be divided into hospital-based (available at all MOH Hospitals with Ophthalmology Services), satellite cataract centres (available at PPKM-HS and KK KKM Kedah-Hospital Jitra) and convenient service reach over (KK-KKM Mobile). The latest annual NED report was published in April 2020 (Salowi *et al.*, 2020). The report involved 72 source data providers (SDP) from 2002 until 2018. The latest report shows median age of the patient cataract was 67 years old. The number of patients with systemic comorbid increases from 56.9% in 2002 to 81.6% on 2018. Senile cataract was the common causes of primary cataract (97.2%) and diabetic retinopathy was the major ocular comorbidity in the report. The bimodal pattern of preoperative vision was consistently observed over many years with one peak in the range between 6/18 to 6/36 and another peak in counting finger (CF) to hand movement (HM). The rate of increase in surgery using the phaco method increased from 39.7% in 2002 to 92.3% in 2018. The percentage of ECCE decreased from 54.0% in 2002 to 5.8% in 2018. The percentage of intra-operative complication reduced to 4.7% (2018) from 4.9% (2017). Patients with phaco have better post-op visual outcomes when compared to other types of surgery. 94.7%of phaco patients experienced a 6/12 or better vision decline in 2018 compared to ECCE (79.3%), lens aspiration (77.2%) and ICCE (55.3%).

2.2 Measure vision preoperative and postoperative

Visual Acuity (VA) is measured using Snellen Eye Test Chart (Appendix E). The VA of every patient will be taken two times, before and after surgery. After surgery, the visual outcome is recorded as the best-corrected visual acuity (BCVA), based on the refraction performed by optometrists, recorded within 12 weeks postoperatively (Salowi *et al.*, 2019). According to WHO classification, VA is classified as good (presenting VA more 6/18 and better), borderline (presenting VA between less 6/18 to 6/60), and severe (presenting VA less than 6/60, HM, LP, and NLP). In Malaysia, postoperative VA for good vision is 86.6%, moderate vision 10.4%, and severe vision is 3.0% (Salowi *et al.*, 2020)

The majority of patients with cataract have poor vision; 38.7% were blind (VA<3/60) before undergoing cataract surgery (Salowi *et al.*, 2020). Those with poorer preoperative VA have a higher risk of getting poor outcomes (Norregaard *et al.*, 1998; Konstantopoulos *et al.*, 2009). However, not all patients with poor preoperative vision (6/12 and better) achieve a good visual outcome after surgery. According to Lundström *et al.*, (2015), 1335 (81.8%) cases have poor preoperative vision, and after surgery, the number of cases has good postoperative vision only 1077 (66.0%). The data above, proved that not all patients are getting good VA after surgery.

Based on Lai *et al.*, (2014) study, VA improved after surgery was 79.7%. The improvement in VA was measured by the ETDRS chart, which was defined as a drop in LogMAR acuity of 0.1. There was significant difference between pre and postoperative VA. Study from Thailand involved 72 hospitals, shows that mean

LogMAR before surgery was 1.628 (equivalence to VA 1/60) and mean after surgery was 0.5208 (equivalence to VA 6/18) and they find out that there was statistically significant. It prove that the postoperative VA was better than preoperative VA (Raiyawa *et al.*, 2008).

2.3 Factors associated with the improvement of VA

Several publications worldwide, including Malaysia, have shown that several factors are associated with the severity of vision before and after cataract surgery (Lundström *et al.*, 2013; Lai *et al.*, 2014; Thanigasalam, Reddy & Zaki, 2015; Matta *et al.*, 2016; Thevi & Godinho, 2017; Khanna *et al.*, 2020).

2.3.1 Socio-demographic factors

In most cases, patients with cataract presenting for surgery are older than 50 years, and the average age is 66 years old (Salowi *et al.*, 2019). Some studies reported that older patients have a risk of getting poor vision after surgery. According to Lundström *et al.*, (2013), the age group of 85-89 years old shows 61.1% have poor vision after surgery, and age is a significant risk factor for getting worse visual outcomes. A study in Malaysia shows that patients over 80 years old are at greater risk of a poor visual outcome, with an odds ratio of 1.51 times (95% CI: 1.15-1.97). This occurs because older patients experience uncontrolled ocular comorbidities (Thevi & Godinho, 2017).

Most patients with cataract are female, there are 76.3 % of female patients undergoing cataract surgery, but many studies show gender is not a significant factor in postoperative VA (Lai *et al.*, 2014). However, according to Matta et al. (2016), poor visual outcomes were significantly higher in female patients with odds of 1.58 than males (95% CI: 1.04, 2.41). There were fewer studies that use ethnicity as a risk factor. A survey by Thevi & Godinho (2017) shows that Malays has a higher risk for a poor visual outcome than Chinese and Indian.

There are other factors can be study which education level and income level. According to study in Malaysia (2017), education level and level of income were not significantly related to blindness and low vision (Chandrasekhara Reddy & Thevi, 2017). There is disagreement from a study in Shanghai, where income levels have a significant correlation with VI but education level is not significant with VI (Xu *et al.*, 2018). For both factors, there was no significant correlation with VA in the eyes that had undergone cataract surgery (Province *et al.*, 2014)

2.3.2 Preoperative factors

The prevalence of patients getting comorbidities is progressively increased with age (Davis, Chung & Juarez, 2011). Seventy-six and two percent of patients with cataract have one or more comorbidities (Thevi & Godinho, 2017). Frequent systemic comorbidities included hypertension, diabetes mellitus, myocardial infarction, and others. According to Thevi & Godinho, (2017), hypertension and diabetes significantly affect the visual outcome. Patients with diabetes had a higher risk of getting poor postoperative visual outcomes compared to patients without diabetes (Tsai *et al.*, 2008). However, other studies reported that although most patients with cataract have systemic comorbidities, the presence of systemic morbidities was not significantly associated with postoperative visual outcomes (Lai *et al.*, 2014; Thanigasalam, Reddy & Zaki, 2015; Khanna *et al.*, 2020).

Ocular comorbidity is one of the risk factors for cataracts. There are many ocular comorbidities such as glaucoma, diabetic retinopathy, phacomorphic / phacolytic, age-related macular degeneration (ARMD), and others. The major ocular comorbidities detected preoperatively are ARMD followed by glaucoma and diabetic retinopathy (Quoc *et al.*, 2004). The eyes with comorbidities have 2.4 (95% CI: 1.38–4.32) more risks to achieve poor visual outcomes compared to those without comorbidities (Konstantopoulos *et al.*, 2009). According to Lai *et al.* (2014), the three most common ocular comorbid are ARMD, glaucoma, and myopic degeneration. The presence of ARMD has significantly reduced the chance of postoperative visual improvement. A study from Thevi & Godinho (2017) has different common ocular comorbidity. The frequent ocular comorbidities in their research are glaucoma, non-proliferative diabetic retinopathy (NPDR), and proliferative diabetic retinopathy (PDR). All the patients with these diseases had a high chance of a poorer visual outcome (Thevi & Godinho, 2017). The factor that was most strongly related to the outcome was ocular comorbidity. The influence of ocular comorbidity seemed to have much stronger on achieving a fair visual outcome compared with an excellent outcome (Lundström *et al.*, 2013).

2.3.3 Surgical factors

Surgery is the primary treatment for cataracts. The types of surgery affect the visual outcome, and the best outcome is by using phacoemulsification technique (Thanigasalam, Reddy & Zaki, 2015). A systematic review study which involved 11 trials, and 1,228 participants found that patients who underwent phacoemulsification are more likely to achieve a good corrected VA of 6/12 or more after three months and one year (Ang, Evans & Mehta, 2014). According to Lai et al. (2014), their study reported that patients who received ECCE and sutureless large incision manual cataract extraction (SLIMCE) were more likely to achieve visual improvement after cataract surgery (Lai *et al.*, 2014). Other surgical methods with a higher chance of getting poor visual outcomes are ICCE and lens aspiration (Thevi & Godinho, 2017).

The duration of surgery can be an associated factor affecting the visual outcome. Patients who have a shorter time of cataract surgery have a high chance of getting a good visual outcome, (mean duration of 17.6 min) (De Lambert *et al.*, 2013). Thevi & Godinho (2017) research had a similar finding. Their study showed a trend in the duration of surgery indicating that shorter surgeries (less than 30 min) were more likely to be associated with a 'good' visual outcome than the 31-60 min. Surgeries which took more than 60 min were 3.28 times more likely to result in a 'poor' visual outcome (OR: 3.28; 95% CI: 1.72, 3.96) (Thevi & Godinho, 2017).

Three categories of anaesthesia have been used: local (with or without intraocular anaesthetics), regional (retrobulbar, peribulbar, and sub-Tenon's), and general anaesthesia. There are limited studies to compare these types of anaesthesia.

Most studies focused only on comparing different types of local anaesthesia, selecting and executing anaesthesia during cataract surgery that depend on the patients' factors, the surgeon's level of expertise, and the surgery facility (Tran & Melissa Severn, 2008). Local anaesthesia was significantly less severe in pain than general anaesthesia (Koay *et al.*, 1992). Furthermore, eyes that receive local anaesthesia had better visual improvement (Thanigasalam, Reddy & Zaki, 2015).

An intraocular lens implant, or IOL, is made of acrylic or polymethyl methacrylate (PMMA). From the NED report (Salowi *et al.*, 2019), there are several IOL placements, which are posterior chamber intraocular lens (PCIOL) (96.7%), anterior chamber intraocular lens (ACIOL) (1.5%), and others. These placements are divided into the foldable and non-foldable types, and the most used is foldable (97.7%). Most materials of IOL used are acrylic (93.6%), PMMA (3.8%), and silicone (0.2%). Patients with an ACIOL were three times more likely to have a poor visual outcome than patients with a PCIOL (Konstantopoulos *et al.*, 2009). A study shows the eyes that underwent no IOL or ACIOL had 12.63 (95% CI: 2.65, 60.25) higher significance getting poor visual outcome (Matta *et al.*, 2016). A randomised clinical trial study found that most of the patients with foldable hydrophilic acrylic IOLs and PMMA IOLs had good visual outcomes (Hennig *et al.*, 2014). Other studies showed a different result; there is no significant difference in postoperative visual outcome between anterior chamber iris-fixated IOL (AC-IFIOL), retropupillary iris-fixated IOL (RF-IFIOL), and scleral-fixated posterior chamber (SF-PCIOL) (Hazar *et al.*, 2013).

2.3.4 Complication factors

Intraoperative and postoperative complications are associated with the risk of ‘poor' visual outcome. The intraoperative complication has odds 2.58 (95% CI: 2.12, 3.14) times to get a high chance of the poor visual outcome, and postoperative complication is 2.74 (95% CI: 1.94, 3.85) times more risk of poor visual outcome (Thevi & Godinho, 2017). Five and eight percent of eyes have an intraoperative complication, and 0.04% of eyes have a postoperative complication (Salowi *et al.*, 2019). Based on Lundström *et al.* (2013), the variables related to a worse outcome and the most strongly related variable was postoperative complications. Endophthalmitis and central corneal oedema showed the highest frequency of a worse visual outcome. Postoperative infectious endophthalmitis was associated with a 4.5 (95% CI: 2.82, 7.30) risk of subjects achieving a poor final VA (Wai *et al.*, 2018). Vitreous loss had half of the risk of poor visual outcomes during the IOL implantation and surgery (Konstantopoulos *et al.*, 2009). According to Lai *et al.* (2014), individuals with surgical complications had a significantly lower chance of obtaining visual improvement after cataract surgery. The most common complication was vitreous loss (8.2%), followed by posterior capsular rupture (7.2%) and zonular rupture (4.8%), and there is a significantly lower chance of postoperative visual improvement (Lai *et al.*, 2014). Patients with intraoperative complications have a lower per cent to reach good visual outcomes (17.6%) compared to those without complication. The main complication was a posterior capsular tear (Kange *et al.*, 2015). A supporting study from Matta *et al.* (2016) suggested intraoperative complications had significantly higher of getting poor visual outcomes (OR 8.01; 95% CI 2.91, 22.04).

2.4 Statistical analysis approach from previous study

Regression analysis is a conceptually simple method to investigate the functional relationship between the variables. Relationships are expressed in the form of equations or models connecting the dependent variable and one or more predictor variables. The dependent variable is represented by Y and the independent variable can be represented by X_1, X_2, ..., X_p where p refers to the number of independent variables (Porzio, 2013). The general equation for regression can be expressed as below:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_p X_p + \varepsilon$$

The above equation refers to the general equation for linear regression where Y is the dependent variable in the form of numerical or continuous data and X is the predictor factors. Another regression analysis commonly used is logistic regression models. Logistic regression is the relationship between predictor variables and categorical response variables.

There are three types of logistic regression and the differences depend on the nature of the categorical response variable. Binary logistic regression is used when the respond variable has only two groups or dichotomous for example alive and death. Multinomial logistic regression is used when the dependent variable has three or more categories without a natural order to the level, for example disease A, disease B and disease C. Ordinal logistic regression is used when the outcome variable has three or more categories with a natural ordering to the levels, for example level of body mass index (BMI); underweight, normal, overweight and obese (W.Hosmer & Lemeshow, 2007).

Majority in the previous studies have used binary logistic regression to examine the relationship between visual outcomes and the factors influencing visual outcomes. The dependent variable was categorised into improve and no improve VA. This is because no change and worse vision after surgery can be categorized as no improvement in vision and is easy to analyse. (Konstantopoulos *et al.*, 2009; Lai *et al.*, 2014; Matta *et al.*, 2016; Khanna *et al.*, 2020). Logistic regression equations are developed and modified slightly from linear regression equations. The proof of the equation is as follows:

$$odds = \frac{Success}{Failure} = \frac{P}{1-P}$$

$$Y = \beta_0 + \beta_1 X$$

$$\ln\left(\frac{P}{1-P}\right) = \beta_0 + \beta_1 X$$

$$\frac{P}{1-P} = e^{\beta_0 + \beta_1 X}$$

$$P = \frac{e^{\beta_0 + \beta_1 X}}{1 + e^{\beta_0 + \beta_1 X}}$$

Ordinal logistic regression is the extended analysis from binary logistic regression when the dependent variable has more than two groups, and the outcome is ordinal (Chan, 2005). For example, instead of predicting only obese and non-obese, any study may have three or more groups, and it is ordinal: underweight, normal, and overweight. The dependent variable in ordinal regression does not need to select a reference group. The dependent variable needs to be ordered correctly according to the nature of the ordinal data (Chan, 2005).

In binary logistic regression, there are only two groups of outcomes. The outcome was coded as Y=0 and Y=1, so there is one comparison (1 vs 0). The comparison of the dependent group in ordinal logistic regression expands based on the number of groups. For example, BMI as the dependent and the coding for BMI is underweight is equal to group one. While normal and overweight are coding as group two and three, respectively. Some models can be developed from the analysis with two logit functions and follow with the three conditional probabilities of each outcome category (Silva Abreu, Siqueira & Caiaffa, 2009; Adeleke & Adepoju, 2010; Adejumo & Adetunji, 2013). Below is the formula of ordinal logistics regression:

$$\ln P(Y \leq 1|x) = \ln\left[\frac{\sum pr(Y \leq 1|x)}{1 - \sum pr(Y \leq 1|x)}\right] = \alpha_1 + \sum\beta_i x_i, \qquad i = 1 \ldots k$$

$$P(Y \leq 1|x) = \frac{\sum pr(Y \leq 1|x)}{1 - \sum pr(Y \leq 1|x)} = e^{\alpha_1 + \sum\beta_i x_i}, \qquad i = 1 \ldots k$$

$$P(Y \leq 1|x) = \sum pr(Y \leq 1|x) = \frac{e^{\alpha_1 + \sum\beta_i x_i}}{1 + e^{\alpha_1 + \sum\beta_i x_i}}, \qquad i = 1 \ldots k$$

$$\ln P(Y \leq 2|x) = \ln\left[\frac{\sum pr(Y \leq 2|x)}{1 - \sum pr(Y \leq 2|x)}\right] = \alpha_2 + \sum\beta_i x_i, \qquad i = 1 \ldots k$$

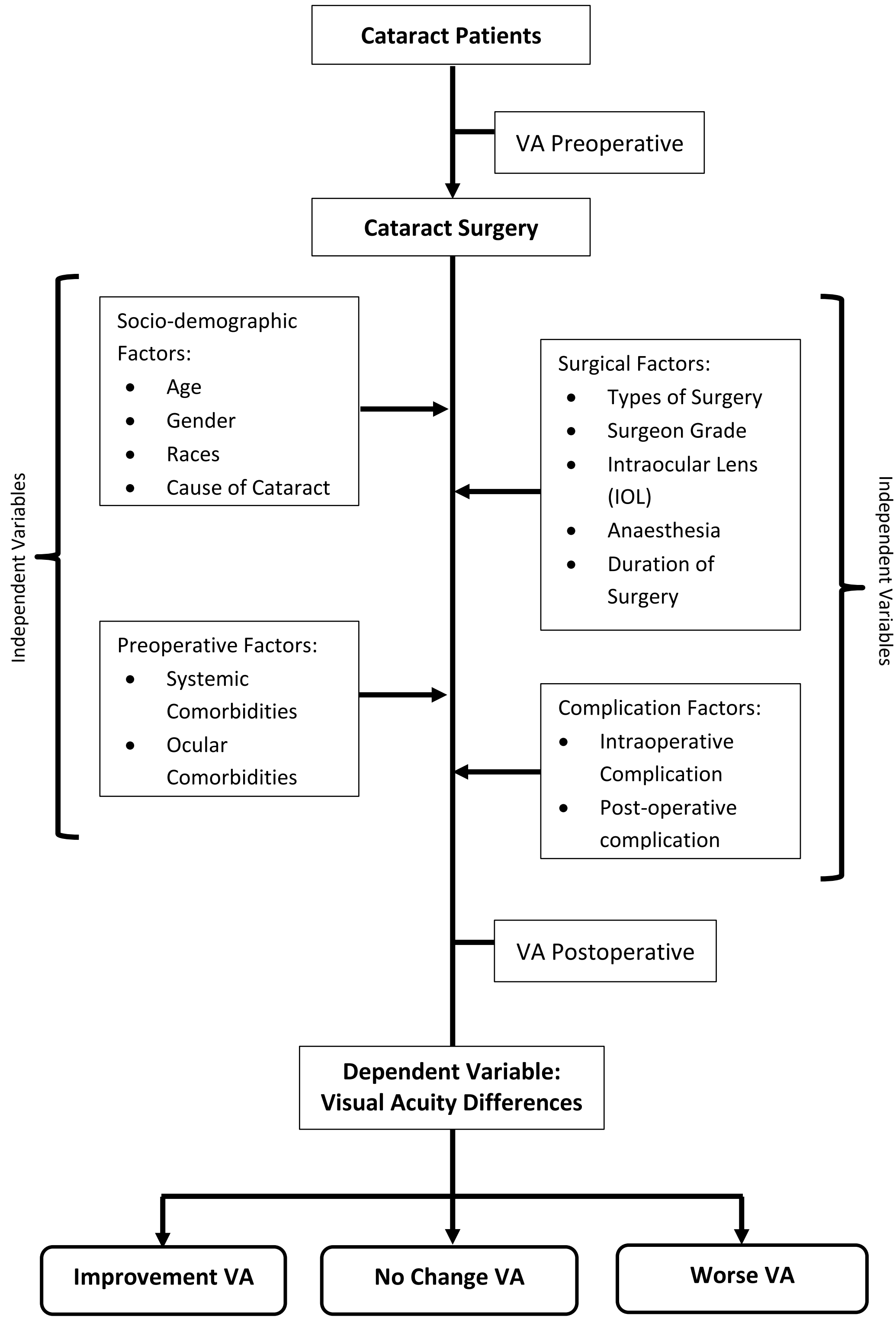
$$P(Y \leq 2|x) = \sum pr(Y \leq 2|x) = \frac{e^{\alpha_2 + \sum\beta_i x_{i,1}}}{1 + e^{\alpha_2 + \sum\beta_i x_{i,1}}}, \qquad i = 1 \ldots k$$

$$P(Y = 1|x) = P(Y \leq 1|x)$$

$$P(Y = 2|x) = P(Y \leq 2|x) - P(Y \leq 1|x)$$

$$P(Y = 3|x) = 1 - P(Y \leq 2|x)$$

2.5 Conceptual framework



CHAPTER 3: METHODOLOGY

3.1 Introduction

In this chapter describes how the study to determine the proportion of patients' VA before and after surgery and factors associated with the improvement of VA among cataract patients in Malaysia was conducted. It covers the study design, samples size calculation, data collection, data management, data analysis and reporting the finding. A flowchart of the study is presented in Figure 3.4.

3.2 Study design

This study was designed a retrospective cohort study where the patients' data from 2014 to 2018 were extracted from NED Malaysia. Retrospective cohort study is comparing exposure and non-exposure by using historical data from the past. The exposure is determined from past records and the outcome is determined at the time the study begun (Gordis, 2014). In this study, the patients' outcomes and all clinical information are assessed from the system.

3.3 Study duration

The study duration started from 1st September 2020 to 31st May 2021. NED data was retrieved between 1st January 2014 until 31st December 2018.

3.4 Study population

3.4.1 Reference population

The reference population for this study was all cataract patients who undergone cataract surgery in Malaysia from the year 2014 to 2018

3.4.2 Source population

The source population was all cataract patients who undergone cataract surgery registered in the NED in Malaysia from 1st January 2014 until 31st December 2018

3.4.3 Sampling frame

All listed cataract patients undergone surgery in Malaysia registered in NED from January 2014 to December 2018 that fulfilled the inclusion and exclusion criteria of the study.

3.4.4 Subject criteria

Inclusion Criteria

1. Adults' cataract patients (> 18 years old).
2. Patient with undergone cataract surgery who register in NED

Exclusion Criteria

1. Patients without preoperative, postoperative or both VA.

3.4.5 Sample size estimation

The sample size was calculated according to the objectives. Samples were chosen based on the highest sample size calculation. Additional of 20% dropout rate for every calculation was made to cover if there are any incomplete data or missing data more than 10% (Bennett, 2001).

Objective 1:

To determine the proportion of VA improvement among post-surgery cataract patients in Malaysia, sample size estimation was calculated using the population proportion formula (Ogston *et al.*, 1991). Using the level of confidence and precision 0.95 and 0.01 respectively, the largest sample size needed to study is 6216 samples with a 0.797 proportion of good visual improvement (Lundström *et al.*, 2013). With an additional 20% dropout rate, 7770 samples should be collected in this study. Table 3.1 show the detail calculation.

Table 3.1: Sample Size Calculation for Objective One

VA	p[a]	Level of confidence	d (precision)	n	Total sample size with 20% of missing data
Improved	0.926	0.95	0.05	106	133
Unchanged	0.057	0.95	0.05	83	104
Worse	0.017	0.95	0.05	26	33

[a]proportion of the group reported (Lundström *et al.*, 2013)

$$\frac{\left(Z_{1-\frac{a}{2}}\right)^2 p(1-p)}{d^2} = \frac{\left(Z_{1-\frac{0.05}{2}}\right)^2 0.926(1-0.926)}{(0.05)^2}$$

$$= \frac{(1.96)^2(0.0685)}{0.002500} \approx 106\ smples$$

Objective 2:

The estimated sample size to determine the differences in VA between pre-and post-cataract surgery was calculated using two correlated proportions formula (NCSS, 2018). Data from previous report indicate that the proportion of poor VA before surgery is 0.845 (Salowi *et al.*, 2020). In this study the proportion after surgery was decided to use 0.895 Thus, a minimum sample size of 5494 samples is used to reject the null hypothesis with power 0.8 and the Type I error of this null hypothesis is 0.05. With an additional 20% dropout rate, the sample size is 6868 samples.

P_0 = proportion poor VA from literature = 0.845

P_1 = proportion poor VA decided by researcher = 0.895

OR = odds ratio $\left(\frac{P_1}{P_0}\right) = 1.059$

PP = proportion of pairs $(P_1 + P_0) = 1.740$

$$\frac{\left\{Z_{1-\frac{\alpha}{2}}(OR+1) + Z_{1-\beta}\sqrt{(OR+1)^2 - (OR-1)^2 PP}\right\}^2}{(OR-1)^2 PP}$$

$$= \frac{\left\{Z_{1-\frac{0.05}{2}}(1.059+1) + Z_{1-0.20}\sqrt{(1.059+1)^2 - (1.059-1)^2 1.740}\right\}^2}{(1.059-1)^2 1.740}$$

$$= \frac{\left\{1.96(2.059) + 0.85\sqrt{4.234}\right\}^2}{0.006092} \approx 5494\ samples$$