RAPID ASSESSMENT OF AVOIDABLE BLINDNESS AND DIABETIC RETINOPATHY REPORT

Papua New Guinea 2017

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Glossary of Terms

Aphakia – The absence of the lens in the eye

Blindness – Visual acuity < 3/60 in the better eye with available or best correction or with pinhole. Definition provided by World Health Organization International Classification of Diseases – version 10. Visual fields are not taken into account in this report.

Early vision impairment (EVI) – Visual acuity < 6/12 – 6/18 in the better eye with available or best correction or with pinhole. Definition provided by Rapid Assessment of Avoidable Blindness Manual – version 6.

Moderate vision impairment (MVI) – Visual acuity < 6/18 – 6/60 in the better eye with available or best correction or with pinhole. Definition provided by World Health Organization International Classification of Diseases – version 10. Visual fields are not taken into account in this report.

Pseudophakia – The presence of an artificial lens in the eye

Severe vision impairment (SVI) – Visual acuity < 6/60 – 3/60 in the better eye with available or best correction or with pinhole. Definition provided by World Health Organization International Classification of Diseases – version 10. Visual fields are not taken into account in this report.

Visual acuity – The capacity of the eye to resolve detail and often represented as a fraction. The numerator of the fraction indicates the testing distance, while the denominator indicates the smallest letter that can be seen by someone with 'normal' vision.

List of Abbreviations

95% CI	95% confidence interval
AMD	Age-related macular degeneration
BCVA	Best corrected visual acuity
CSC	Cataract surgical coverage
DR	Diabetic retinopathy
EVI	Early vision impairment
IOL	Intraocular lens
MVI	Moderate vision impairment
NCD	National Capital District
PNG	Papua New Guinea
PVA	Presenting visual acuity
RAAB	Rapid assessment of avoidable blindness
RBG	Random blood glucose
SVI	Severe vision impairment
VA	Visual acuity

Key Messages

National prevalence of blindness and vision impairment (VI):
• The estimated national prevalence (age-sex adjusted) of blindness, SVI, MVI and EVI in adults aged 50 years and older in PNG is 5.6% (95%CI 4.9 – 6.3%), 2.9% (95%CI 2.5 – 3.4%), 10.9% (95%CI 9.9 – 11.9%) and 7.3% (95%CI 6.6 – 8.0%), respectively. • Prevalence (age-sex adjusted) of blindness in adults aged 50 and older is significantly higher in females (7.0%, 95%CI 6.2 – 7.8%) compared to males (4.4%, 95%CI 3.4 – 5.4%) • Prevalence of blindness is highest in females in the Highlands (11.1%, 95%CI 8.1 – 14.0%) and lowest in males in the Islands (0.7%, 95%CI 0.0 – 1.7%)
Causes of blindness and VI nationally:
• Untreated cataract is the most common primary cause of blindness, SVI and MVI (88.6% of all blindness, 89.3% of all SVI, 76.2% of all MVI) • Refractive error is the most common cause of EVI (45.3%) and the second most common cause of MVI (16.1%)
Cataract surgical coverage (CSC) and outcomes:
• National CSC (VA<6/60) is 32.3%, compared to the global median of 53.7% (based on available RAAB repository data). • Lowest CSC in individuals is in the Highlands (females 9.2%, males 25.0%, p=0.02) • Highest CSC in individuals is in the Islands (females 46.7% female, males 78.3%, p=0.35) • Nationally, 61.3% of cataract operated eyes have good outcomes (BCVA ≥6/18) – WHO recommend postoperative outcomes to have BCVA ≥6/18 in ≥90% operated eyes. • Increasing human resources and having biometry at all surgical locations may assist in increasing CSC and improving outcomes.
Barriers to cataract surgery:
• The most commonly reported barriers to cataract surgery are ‘unaware treatment is possible’, ‘need not felt’ and ‘cost’. • Although not significant (p>0.05), ‘unaware treatment is possible’ and ‘need not felt’ are reported proportionally more by females compared to males in all regions and more commonly reported in all regions excluding Coastal. • Cost is the most notable barrier for males in the Coastal region • Health education and increasing affordability could improve CSC and uptake.
Spectacle coverage:
• 72.7% of participants with distance refractive error do not have correction (females 79.1%, males 61.3%, p<0.001); approximately 80% of participants do not have near correction (females 86.4%, males 79.3%, p>0.05) • Increasing access to refractive services and spectacles are required in all regions, in particular for females.
Diabetes and diabetic retinopathy (DR):
• Prevalence of diabetes* (age-sex adjusted) is estimated to be 8.1% (95%CI 5.7 – 10.4%) in adults aged 50 years and older in NCD, which is lower than expected • Almost half (46.4%) of those with diabetes have some form of DR and or maculopathy • Over 80% of those with known diabetes have never had an eye examination for DR

- These outcomes highlight the need for increased awareness in diabetes and eye health, and working together with other diabetes health professionals.

Blindness indicates VA <3/60; Severe vision impairment (SVI) indicates VA <6/60 but ≥3/60; Moderate vision impairment (MVI) indicates VA <6/18 but ≥6/60; Early vision impairment (EVI) indicates VA <6/12 but ≥6/18
*A previous diagnosis of diabetes or having had a random blood glucose reading of ≥200mg/dL

Executive Summary

Background: Vision impairment and blindness are health concerns both globally, and in Papua New Guinea (PNG). Due to the absence of any population data related to vision impairment and blindness in the last decade in PNG, and considering the objectives of the WHO Global Action Plan towards Universal Eye Health, new estimates are required to advocate for the development of appropriate intervention programs.

A Rapid Assessment of Avoidable Blindness survey (RAAB) is intended to provide the prevalence of blindness and vision impairment, its main causes, cataract surgical coverage (CSC), cataract surgery outcomes, barriers to accessing services, and other indicators of eye care services in a specific geographical area. Recently, the standard RAAB protocol has been updated to include an optional module for assessing diabetes and diabetic retinopathy (DR). Non-communicable diseases such as diabetes, pose an increasing threat in PNG, as the burden of diabetes is now significant in urban areas. This study assessed the prevalence and main causes of blindness and vision impairment in people aged 50 years and older in four regions that make up PNG, as well as the prevalence of diabetes and DR in adults aged 50 years and older in the National Capital District (NCD) – the most urbanized and populated area in PNG.

The aim of this project is to contribute to the development of eye care services in PNG through gathering evidence on the prevalence of avoidable blindness and vision impairment in all four regions in PNG, and the prevalence of DR in the NCD.

Methods: This was a cross-sectional population-based survey completed in all regions of PNG. With appropriate local guidance, it was decided that four RAAB surveys be conducted at the regional level, as each of the four regions in PNG was likely to portray different patterns of vision impairment, and comparison at the regional level was desirable. The regions were the Highlands (all provinces within the administrative region, Islands (all provinces within the administrative region and Milne Bay Province), Coastal (Momase and Papua administrative regions combined but excluding Milne Bay Province) and NCD. In addition, the increasing prevalence of diabetes particularly in the urban areas prompted the inclusion of the DR module with the RAAB in the NCD. Inclusion criteria were adults aged 50 or above who had resided in the household within the selected cluster sampling unit for a minimum of 6 months.

Twenty-five clusters (census units) were systematically selected with a probability proportional to the size of each cluster in each of the four regions. Within each cluster, 50 people aged 50 years or older were recruited. The study protocol was conducted according to the standard RAAB protocol. Where appropriate, the survey form was modified to reflect the PNG local environment. For example, onchocerciasis was replaced with Eales disease, as the former was not found in PNG.

In NCD, participants additionally underwent a random blood glucose (RBG) test and were classified as having diabetes if they were previously diagnosed with diabetes, were receiving

treatment for glucose control, or if they were found to have a RBG level of ≥200 mg/dL (equivalent to ≥11.1 mmol/L) at the time of data collection. Those with a previous diagnosis were surveyed on past eye examinations. For those classified with diabetes, a dilated fundus examination was conducted to assess presence of DR.

Data cleaning, consistency checks and analysis were conducted with RAAB6 Software (Version 6, London School of Hygiene & Tropical Medicine, UK) and SPSS Statistical software (IBM, Version 24.0, USA)

Results: Of the 5,000 eligible participants sampled from the four regions of PNG, a total of 4,818 participants (96.4%) consented to the eye examination and survey. Overall, the PNG-wide predicted age- and sex-standardised prevalence of blindness was 5.6% (95% CI 4.9 – 6.3%), with a significantly greater proportion of females being blind (7.0%, 95% CI 6.2 – 7.8%) compared to males (4.4%, 95%CI 3.4 – 5.4%). Regionally, the prevalence of blindness was highest in females in the Highlands (11.1%, 95%CI 8.1 – 14.0%) and lowest in males in the Islands (0.7%, 95%CI 0.0 – 1.7%).

For all regions, untreated cataract was the most common cause of blindness (81.8% in NCD, 90.4% in the Highlands, 91.0% in Coastal, and 81.0% in Islands), severe (77.8% in NCD, 95.7% in Highlands, 90.7% in Coastal, and 73.3% in Islands), and moderate vision impairment (58.9% in NCD, 89.3% in Highlands, 76.6% in Coastal and 62.1% in Islands). Refractive error was observed to be the main cause of early vision impairment (58.3% in NCD, 13.5% in Highlands, 41.1% in Coastal and 70.6% in Islands). Across all regions, as the level of vision impairment became less severe, an increasing proportion of vision impairment was due to refractive error rather than untreated cataract. Other posterior segment eye diseases leading to reduced visual acuity (VA) were the second most common cause of blindness nationally (3.9%). Age-related macular degeneration (AMD) associated with early vision impairment was most commonly seen in the Islands region (80% of those with AMD as the primary cause of early vision impairment were from the Islands region). Trachomatous corneal opacity leading to bilateral blindness was only seen in one participant in the Islands. No occurrences of presenting VA of <6/12 where the primary cause was due to uncorrected aphakia, Eales' disease or glaucoma were observed.

After adjusting for age and sex, a significantly greater prevalence of cataracts resulting in VA <3/60 was observed in females (9.2%, 95%CI 8.4 – 10.0) compared to males (6.2%, 95%CI 5.3 – 7.2). However, the difference between sexes was only statistically significant in the Highlands, based on comparing 95% confidence intervals for overlap between sexes for each region (male 8.6%, 95%CI 6.0 – 11.1%; female 14.6%, 95%CI 11.2 – 18.0%).

The national weighted average for CSC was 32.3% (VA<6/60), but ranged from 9.2% (females in the Highlands) to 78.3% (males in the Islands). Males had better CSC (VA<6/60) in the Highlands (25% versus 9.2%, p=0.04). When comparing regions, the Islands (65.8%) had highest coverage followed by NCD (35.9%), Coastal (32.6%) and the Highlands (18.1%).

Just over 60% of the participants' eyes that have had cataract surgery have resulted in a good visual outcome (best-corrected VA≥6/18). However, 25.1% of operated eyes have resulted in a very poor visual outcome (best-corrected VA<6/60).

No statistically significant difference in reasons for not accessing cataract surgery services were observed between genders, however females reported '*unaware [cataract] treatment is possible*' more commonly than males (33.6% versus 26.7%). '*Need not felt*' for cataract surgery was a commonly reported response for both sexes in all regions (NCD: 42.4%; Highlands: 38.1%; Islands: 33.3%;) except the Coastal region (16.3%). Cost was considered the most prominent barrier to cataract surgery in the Coastal region (35.0%). Fear of surgery was not reported as a barrier to cataract surgery in the Highlands, however a notable proportion reported 'need not felt' or 'unaware treatment is possible' as the main barriers (38.1% and 42.6%, respectively). 'Cannot access treatment' was reported by participants in all regions other than NCD. No reports of treatment denial or 'local beliefs', which pertain to local cultural fears such as a fear of sorcery were provided as reasons for not accessing cataract surgery services.

The prevalence of distance refractive error was estimated to be 8.2% in adults aged 50 years and above. The lowest spectacle coverage was found in females in the Highlands (distance spectacles: 5.3%; near spectacles: 2.9%) and the Islands (distance spectacles: 19.6%, near spectacles: 29.5%) regions. For males and females with distance refractive error, 65.7% and 71.2% were uncorrected, respectively. For presbyopia, spectacle coverage was 17.5% of the sample population.

In our sample, 7.8% (95%CI 5.5-10.1%) of adults aged 50 years and above were defined as having diabetes. After adjusting for age and sex, the estimated prevalence of diabetes in the NCD was 8.1% (95%CI 5.7-10.4%) in adults aged 50 years and above. Of those with diabetes, 62.4% were 'newly-diagnosed' (reported that he/she did not have diabetes, but RBG level was ≥200mg/dL) and 37.6% had a previous diagnosis. Of the 35 participants with known diabetes, 71.4% had poor control of their blood sugar levels (indicated by RBG ≥200mg/dL). Over 80% of participants with known diabetes reported never having had an eye examination for DR, while only 11.4% had an eye examination within the last 12 months. Of all participants with diabetes (known and newly-diagnosed), almost half (46.4%) had some form of DR or maculopathy.

Discussion: This was the first national survey of vision impairment and blindness to have been conducted in PNG. The estimated prevalence of blindness in people aged 50 years and older in PNG was 5.6% (95% CI 4.9 – 6.3%) and although not statistically significant, was higher than the previous estimation of 3.9% (95%CI 3.4 – 6.1%) in Koki and Rigo. Considering the different surveyed areas, comparisons are to be taken with caution.

The primary cause of vision impairment in PNG was untreated cataract. Burden of disease was high across all regions, but particularly in the Highlands region, and especially for females. Based on current WHO recommendation, PNG is below the recommended target that at least

90% of people who had cataract surgery should have postoperative best-corrected VA of 6/18 or better and at most 5% postoperative best-corrected VA worse than 6/60. However, based on available RAAB data from other countries, these recommended rates have yet to be achieved elsewhere in the region, or in fact globally. While developing approaches to improve cataract surgery outcomes in PNG are essential, we have identified that there is also a need to provide eye health education to the older population on the availability and potential benefits of cataract surgery. In addition, education to improve attitudes towards spectacles may be required, as spectacle presentation was relatively low in general, but particularly for females and for those in the Highlands region.

The diabetes prevalence in adults aged 50 years and older was lower than previous reports in NCD (8.1% versus 14.4%). The difference in reports might be due to the fact that different methods were employed to diagnose diabetes; assessment in this study was based on a single RBG test and diagnostic criteria of ≥200mg/dL. The rates of adults aged 50 year or older who were newly diagnosed based on this test was high (62.4%), and almost half of those with diabetes had some form of DR or maculopathy; this indicates that undiagnosed diabetes and DR are likely to be increasingly significant public health issues in PNG with increasing rates of diabetes. As we detected low levels of awareness and previous treatment for diabetes and DR in this NCD population, better education, and prevention services for early detection, prevention and treatment will be required. Importantly, those with diabetes will need specific awareness messages about the risk of visual loss from DR. Developing and evaluating a comprehensive model of eye care, which includes eye care services for people with diabetes will be important next steps for improving the eye health of people in PNG.

Achieving equitable access to eye care services for both males and females and those from remote areas will be a long-term goal in PNG. Ongoing advocacy to increase services and improve services and support, particularly for women and those from rural areas, to engage with eye care services is required to reduce the inequities in eye health that exist in PNG.

Introduction

Vision impairment and blindness are worldwide health concerns affecting approximately 401 million and 36 million respectively; (1)the most affected communities and countries are those with limited resources and poor accessibility to services. Papua New Guinea (PNG) is the largest and most populous country in the South Pacific with a population of over seven million.(2) PNG is a geographically and socio-demographically diverse country divided into 19 provinces and with over 800 distinctive, mutually unintelligible languages, each representing a distinct culture.(2, 3) An estimated 87% of the population lives in rural areas and is partially or substantially living a subsistence lifestyle.(4) Administratively, PNG is divided into 22 province-level divisions spread across four regions: Highlands, Islands, Momase, and Papua region.

1.1 The current eye care and diabetes situation in Papua New Guinea

Currently, there are approximately 14 practicing ophthalmologists, two primary eye care ophthalmologists, five ophthalmologists in training, five optometrists in private practice, seven refractionists, and 67 ophthalmic clinicians across PNG. The majority of eye health clinics are located in Port Moresby, the country's capital, and in the provincial capitals including Mendi, Mt Hagen, Goroka, Lae, Madang, Wewak, Rabaul and Kimbe. However, outreach services are provided across some regions on an ad-hoc basis.

The most recent vision related epidemiological eye study was conducted over 10 years ago (2004-2005) and established that PNG has high rates of vision impairment (29%) and blindness (3.9) in older adults. Uncorrected refractive error and cataract were reported as the two most common causes of vision impairment in people aged 50 years and older.(5) This survey, however, was only conducted in one rural and one urban sample in the proximity of Port Moresby.

Adults living in rural PNG have reported expensive travel costs to be a notable barrier to attending clinics.(6) Therefore, exploring the prevalence of blindness and vision impairment across the whole country can assist in planning where to develop eye care services to improve access.

The World Health Organization (WHO) has estimated that the prevalence of diabetes in PNG is approximately 11.8%, almost equal between genders, and appears to be increasing.(7) It has been suggested diabetes tends to be more prevalent in urban and coastal areas and that it is associated with westernisation.(8, 9) Despite diabetes in the PNG population being investigated since the 1960s, the most recent epidemiological study was conducted in 2008, and found that 14.7% of males and 14.4% of females had elevated blood glucose levels or were currently on medication for diabetes.(10)

1.2 Justification of the research

One of the WHO Global Action Plan objectives for Universal Eye Health is "generating evidence on the magnitude and causes of vision impairment and eye care services".(11) The previous survey of blindness and vision impairment in PNG was only conducted in areas within and surrounding Port Moresby, PNG's capital. Due to the absence of any population data related to vision impairment and blindness in at least the last decade, new estimates are required to advocate for the development of appropriate intervention programs.

Surveys assessing blindness and vision impairment have previously been avoided due to perception that they involve lengthy, costly, and complex processes, and that they require expert assistance from epidemiologists or statisticians to produce reports. The Rapid Assessment of Avoidable Blindness survey (RAAB) methodology was developed to address these challenges. The RAAB provides evidence on the prevalence of blindness and vision impairment, their main causes, cataract surgical coverage (CSC), cataract surgery outcomes, barriers to accessing cataract services, and other eye health indicators in a specific geographical area. Recently, the standard RAAB protocol has been updated to include an optional module for assessing diabetes and diabetic retinopathy (DR). Taking into consideration the concerning issue of the increasing prevalence of diabetes, particularly in urban areas, assessing the prevalence of DR is vital to planning eye care services and eye health education in PNG.

The aim of this project is to contribute to the development of eye care services in PNG through gathering evidence on the prevalence of avoidable blindness and vision impairment in all four regions in PNG, and the prevalence of DR in the National Capital District (NCD).

Research design and methodology

1.3 Objectives

- To determine the prevalence and main causes of blindness and vision impairment in people aged 50 years and older in four regions of PNG.
- To determine the CSC, surgery outcomes, and barriers to accessing services in people aged 50 years and older in all regions of PNG.
- To determine the prevalence of diabetes and DR in people aged 50 years and older in the NCD region of PNG

1.4 Protocol design

This was a cross-sectional population-based survey completed in all regions of PNG. With appropriate local guidance, it was decided that four RAAB surveys be conducted at the regional level which would all contribute to national data. The four regions are: Highlands, Islands (including Milne Bay Province), Coastal (Momase and Papua combined but excluding Milne Bay Province) and National Capital District (NCD). As it was felt that regions in PNG portrayed different patterns of vision impairment, comparison at regional level was desirable.

In addition, because of the increasing prevalence of diabetes particularly in the urban areas, the DR module was included in the RAAB only in the NCD.

In order to be able to have sufficient sample size to estimate 'blindness' in each region, four separate RAAB surveys would have been required, each with a sample of approximately 4000 participants. As a compromise, based on available personnel and funding, the protocol was designed to estimate the level of both blindness and vision impairment nationally, but to also have the sample sufficiently powered in each region to estimate and compare the prevalence of 'vision impairment'.

Inclusion criteria were adults aged 50 years or older who had resided in the household within the cluster for a minimum of six months.

1.4.1 RAAB Survey – Determining visual acuity and cause of blindness

All participants were interviewed on whether any problems were experienced with their eyes, whether spectacles (distance and near) were used, and education level. Presenting visual acuity (VA) was then checked in broad daylight. Pinhole VA was checked if the eye had presenting VA <6/12. All participants were directed into a shaded area or indoors for lens examination with direct ophthalmoscopy. If pinhole VA was <6/12, the participant's pupils were dilated with tropicamide 0.5% solution and direct ophthalmoscopy was performed to determine the cause of reduced vision for each eye. The overall primary cause of VA <6/12 was determined to be the cause that was most easily treatable. For example, if one eye had vision impairment due to refractive error, while the other had reduced VA due to significant cataract, refractive error was chosen to be the overall primary cause. Should the participant be noted to have had or in need of cataract surgery, details of the surgery or reasons for not having had surgery done were surveyed. Participants identified as requiring further eye care were referred to appropriate services.

1.4.2 Local Modifications to RAAB form

During the training program, it was noted that onchocerciasis is not present in PNG – it was decided to replace onchocerciases on the record survey with Eales disease, as there were reports of significant cases. For barriers to cataract surgery, the field 'local beliefs' was included to capture specific local beliefs around the fear or sorcery.

1.4.3 Diabetes and DR component

All participants in NCD were invited to undergo a diabetes assessment, which involved asking whether they had previously been diagnosed with the disease and having a random blood glucose (RBG) test (finger prick). Those determined as having diabetes were also surveyed on the type of treatment (if any) they were receiving for the disease, when first diagnosis was made, and whether an eye examination had been conducted since being diagnosed with diabetes.

Participants determined as being 'newly-diagnosed' with diabetes were those who reported not being previously diagnosed and had a RBG level ≥200mg/dL. All known and newly-diagnosed diabetes participants had their pupils dilated with 0.5% tropicamide solution for a DR assessment. The Scottish Diabetic Retinopathy Grading Scheme was used to record and grade the observations. All participants with elevated RBG levels (whether known or newly diagnosed diabetes) and signs of DR were referred to the appropriate health facility for further management.

1.4.4 Survey teams

Five survey teams, two for the NCD region and one for each of the other regions, were formed to complete data collection. Each survey team consisted of an ophthalmologist, a research assistant/student co-investigator and local commune health worker. In the NCD region, an additional diabetes officer certified in DR grading accompanied the survey team to conduct diabetes and DR screenings.

1.5 Sample size calculation and sampling

A total of 5,000 participants, with a sample of 1,250 persons within each of the four regions was required to estimate a prevalence of blindness at 3.9%(5) at a 95% confidence level, with relative precision of 20%, design effect of 1.5, and drop-out or refusal rate of 10%. For each region, 25 clusters (census units) were selected and 50 adults were recruited within each cluster.

Cluster sampling was applied to determine sampling areas. Four sampling frames were developed (one for each region), with each frame including the list of census units obtained from the National Statistical Office, PNG. This stage involved selecting 25 clusters systematically from the sampling frame with a probability according to their population size. This procedure is known to be self-weighing and also ensures that the selection of clusters is evenly spread over the entire population.(12) In clusters where less than 50 adults aged 50 years and older resided, examination continued in the geographically nearest population unit to complete the cluster. The distribution of clusters selected across PNG is shown in Figure 1 and Figure 2.

Survey teams went door-to-door to identify eligible participants. If eligible participant were identified, yet were not available at the time of visit, up to three attempts to arrange and contact them at the household were conducted. Should participants continue to not be available, a neighbour or relative willing to complete a portion of the survey were interviewed on the likely vision status of the eligible participant.

In some clusters, households members spontaneously self-presented to the teams when they arrived in a village. This is common practice in PNG when there are visiting health or research teams, and it was not considered acceptable to turn an entire village away. In these instances, in order to avoid selection bias, the survey teams enquired as to whether any other eligible

adults were living in a participant's household. If so, these households were visited in order to appropriately sample all eligible adults in the cluster.

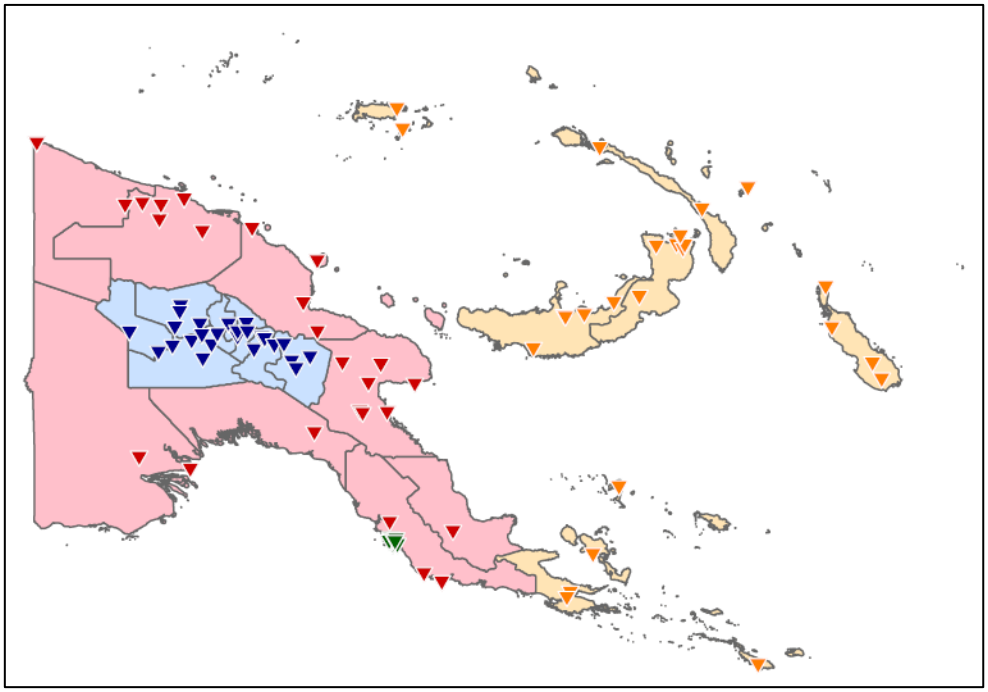

Figure 1: Location of RAAB clusters in National Capital District (green), Coastal (red), Highlands (blue) and Islands (yellow) region

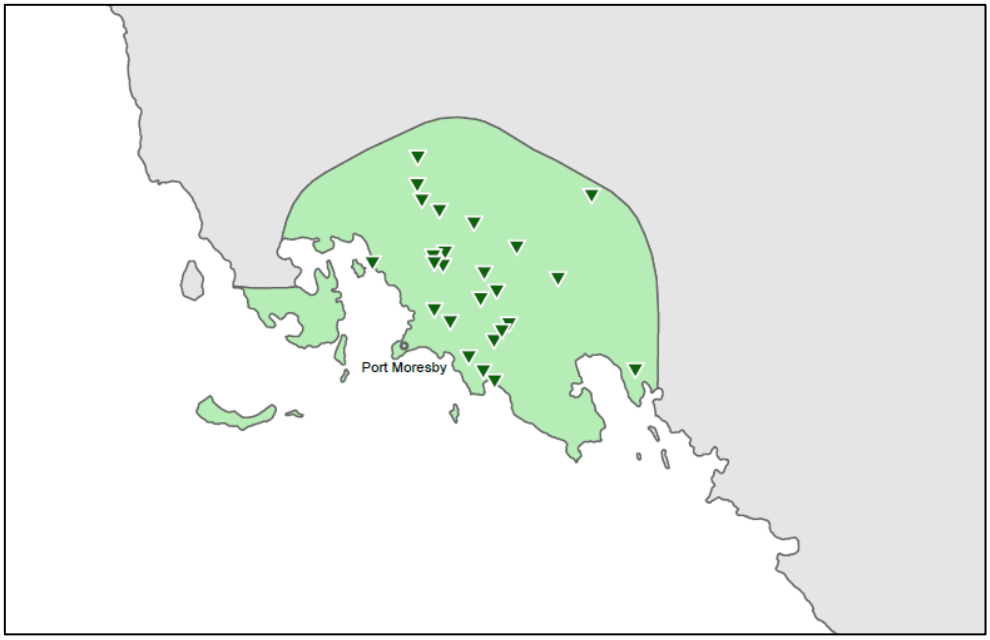

Figure 2: Location of RAAB clusters in NCD Region

1.6 RAAB training and quality control

Dr Hans Limburg, Dr Anthea Burnett, and Dr Ana Cama conducted training of data collectors in Port Moresby over a one-week period. Training included the provision of an overview of the RAAB protocol, discussions about logistics, and training to obtain informed consent from participants, examine participants' eye health, record data, assess inter-observer agreement on VA measurement, and grade DR. Practical exercises and a village visit were conducted to ensure that the survey teams had hands-on experience in the field prior to commencement of data collection.

To maintain high quality data collection processes, additional activities and information were provided, including:

- A refresher quiz was provided to all survey team members prior to data collection
- "Tips and Tricks" emails on noted deviations or misunderstandings from the protocol were sent on a weekly basis to remind survey team members

1.7 Ethical considerations

All participants were required to provide written or thumbprint consent to participate in the RAAB and, if in the NCD region, DR component. The study was approved by the Medical Research Advisory Committee of PNG (Ref. MRAC No.16.35) and The University of New South Wales Human Research Ethics Committee (Ref. HC16804). Additional ethics approval was obtained for data collection in Milne Bay Province through the Milne Bay Provincial Health Authority (Ref. DPA:3-15).

1.8 Data management and analysis

For all regions excluding NCD, data were recorded on android mobile phones using the mRAAB application. Data from the mRAAB application were emailed to the research team, and then imported into the RAAB6 software (Version 6, London School of Hygiene & Tropical Medicine, UK), which is then used for data analyses. Due to the additional DR component, data collected in the NCD were recorded on paper survey forms and then entered into the RAAB6 software (the mRAAB app does not yet allow for the collection of DR data). The data were assessed regularly with the RAAB6 in-built consistency check. Any discrepancies identified were immediately reported back to the survey teams for clarification.

Data cleaning, and analysis was conducted with RAAB6 Software. For all four regions, the following reports were generated:

1) Summary report (Appendix 4)
2) Prevalence of blindness and vision impairment - unadjusted sample population
3) Prevalence of blindness and vision impairment – age- and sex-adjusted
4) Tables on prevalence of blindness and vision impairment by age groups and gender
5) Barriers to cataract surgery
6) Cataract surgical coverage and outcomes

7) Calculations on sampling error and design effect

For the NCD region, an additional report on diabetes and DR prevalence was generated with RAAB6 Software (Appendix 4).

Unadjusted calculations for uncorrected distance and near refractive error only included participants achieving presenting or pinhole VA of ≥6/12 to exclude those with vision impairment due to non-refractive causes.

1.8.1 Sample versus general population

Representativeness of the sample was evaluated by comparing the sample profile with the 2011 census regional and country population figures using the chi-squared test.

1.8.2 National estimation of prevalence data

Estimates of the national prevalence of blindness and vision impairment (at each VA level), CSC and uncorrected refractive error, were determined by calculating a weighted average, using census data for males and females aged 50 years or older in each region.

Where applicable, 95% confidence intervals (95%CIs) were calculated using the weighted average outcomes and corresponding standard errors (SEcrs) for cluster sampling. Standard errors were calculated by combining data from the four regions and generating the 'Sampling Error and Design Effect' report from the RAAB6 software.

1.8.3 Regional estimations

Regional data were generated by creating separate databases for each region in RAAB6 and generating the analysis reports. Differences in the regional estimates were determined by non-overlapping 95%CIs for the following variables: unadjusted prevalence of blindness, vision impairment and distance refractive error, as well as the adjusted prevalence of blindness, vision impairment and cataract.

1.8.4 Sex comparisons

Differences between males and females were assessed by overlapping 95% CIs or chi-square tests. Outcomes analysed by assessing 95%CIs included unadjusted prevalence of blindness, vision impairment and distance refractive error, as well as adjusted prevalence of blindness, vision impairment and cataract. Outcomes analysed with the chi-square test included unadjusted data of cataract surgical coverage and barriers to accessing surgery.

P values < 0.05 or no overlap of 95%CI were considered statistically significant.

Results

1.9 Response rate

Of the 5,000 eligible participants sampled from the four regions of PNG, a total of 4,818 participants (96.4%) consented to the eye examination and survey. Table 1 shows the sample coverage in each region and Table 10 (Appendix 1) details the age and sex distribution of the surveyed region and sample population. A significantly greater proportion of older age groups (70-79 years and 80+ years) were in the sample in comparison to the population distribution ($p < 0.001$). This occurred in all regions except NCD where participants were predominantly in the 50-59 age group. In terms of gender, males were significantly overrepresented in the Highlands, whereas females were overrepresented in the NCD, compared to regional distributions (both $p < 0.001$).

Table 1 Sample size and coverage of the regions in Papua New Guinea

Region	Sample size	Examined	Coverage (%)
National Capital District	1,250	1,192	95.4
Highlands	1,250	1,205	96.4
Coastal	1,250	1,242	99.4
Islands	1,250	1,179	94.3
Papua New Guinea (combined)	5,000	4,818	96.4

1.10 Prevalence of blindness and vision impairment – sample population

Overall, 6.1% (95%CI 5.0 – 7.1%) of the sample population had bilateral blindness. Although not statistically significant, females (7.0%, 95%CI: 5.6 – 8.4%) appeared to have a greater prevalence of bilateral blindness compared to males (5.3%, 95%CI: 4.0 – 6.6%). A breakdown of the prevalence of blindness and severity of vision impairment by gender is presented in Table 2, with regional data presented in Appendix 1, Table 11.

Table 2 Sample prevalence of blindness and vision impairment in Papua New Guinea - By eyes and individuals with available correction

	Papua New Guinea – Frequency and weighted average					
	Male		Female		Total	
	n	% (95%CI)	n	% (95%CI)	n	% (95%CI)
Blindness[a]						
Individuals*	106	5.3 (4.0-6.6)	119	7.0 (5.6-8.4)	225	6.1 (5.0-7.1)
Eyes	469	10.8 (9.6-12.0)	437	12.1 (11.1-13.1)	906	11.3 (10.4-12.3)
Severe vision impairment[b]						
Individuals	70	3.3 (2.3-4.4)	52	3.0 (1.9-4.0)	112	3.2 (2.4-3.9)
Eyes	209	4.7 (4.1-5.4)	141	3.7 (3.0-4.3)	350	4.3 (3.9-4.7)
Moderate vision impairment[c]						
Individuals	248	11.5 (10.0-13.1)	244	12.4 (10.2-14.6)	492	11.9 (10.5-13.3)
Eyes	537	12.1 (11.0-13.3)	528	12.9 (11.8-14.1)	1,101	12.6 (11.6-13.6)
Early vision impairment[d]						
Individuals	209	8.5 (7.2-9.8)	156	6.9 (5.5-8.3)	365	7.8 (6.7-8.8)
Eyes	463	9.4 (8.1-10.6)	360	7.6 (6.6-8.7)	823	8.6 (7.7-9.4)

*Data for individuals refers to bilateral cases; 95% CI = 95% confidence interval

[a] Blindness: VA <3/60; [b] Severe vision impairment: VA <6/60 but ≥3/60; [c] Moderate vision impairment: VA <6/18 but ≥6/60, [d] Early vision impairment VA <6/12 but ≥6/18

Moderate vision impairment was the most commonly observed form of vision impairment, while severe vision impairment was the least observed. For blindness and each vision impairment severity, a statistically significant association of increasing prevalence was seen with increasing age (all $p < 0.001$, linear-by-linear association test).

1.11 Prevalence of blindness and vision impairment – age- and sex-adjusted

Overall, as shown in Table 3, the predicted age- and sex-standardised prevalence of blindness was 5.6% (95%CI 4.9 – 6.3%) in PNG. Prevalence of blindness was significantly greater among females (7.0%, 95%CI 6.2 – 7.8%) than males (4.4%, 95%CI 3.4 – 5.4%). Regionally, prevalence of blindness was highest in females in the Highlands (11.1%, 95%CI 8.1 – 14.0) and lowest in males in the Islands (0.7%, 95%CI 0.0 – 1.7). A detailed breakdown of each region by gender is shown in Appendix 1, Table 13.

Table 3 Age- and sex- adjusted prevalence of blindness and vision impairment in individuals and eyes with available correction in Papua New Guinea

	Papua New Guinea – Frequency and weighted average					
	Male		Female		Total	
	n	% (95%CI)	n	% (95%CI)	n	% (95%CI)
Blindness[a]						
Individuals*	17,495	4.4 (3.4 - 5.4)	23,251	7.0 (6.2 - 7.8)	40,746	5.6 (4.9 - 6.3)
Eyes	76,740	9.6 (8.4 - 10.8)	77,945	11.8 (10.8 - 12.7)	154,685	10.6 (9.7 - 11.5)
Severe vision impairment[b]						
Individuals	11,858	3.0 (2.4 - 3.6)	9,661	2.9 (2.1 - 3.7)	21,519	2.9 (2.5 - 3.4)
Eyes	34,900	4.4 (3.8 - 5.0)	23,499	3.4 (2.9 - 4.2)	58,399	4.0 (3.6 - 4.4)
Moderate vision impairment[c]						
Individuals	40,670	10.2 (9.1 - 11.3)	38,793	11.7 (10.4 - 13.0)	79,463	10.9 (9.9 - 11.9)
Eyes	88,250	11.1 (9.9 - 12.2)	83,027	12.5 (11.2 - 13.8)	171,277	11.7 (10.7 - 12.7)
Early vision impairment[d]						
Individuals	31,455	7.9 (6.8 - 8.9)	21,679	6.5 (5.7 - 7.4)	53,134	7.3 (6.6 - 8.0)
Eyes	70,861	8.9 (7.7 - 10.1)	49,564	7.5 (6.5 - 8.5)	120,425	8.2 (7.4 - 9.1)

[a] Blindness indicates VA <3/60; [b] Severe vision impairment (SVI) indicates VA <6/60 but ≥3/60; [c] Moderate vision impairment (MVI) indicates VA <6/18 but ≥6/60; [d] Early vision impairment (EVI) indicates VA <6/12 but ≥6/18

1.12 Causes of blindness and vision impairment – sample population

Table 4 presents the primary causes of blindness and vision impairment of participants nationally. The equivalent regional data is presented in Appendix 1, Table 12. For all regions, the most common cause of blindness, severe, and moderate vision impairment was untreated cataract. Refractive error was found to be the main cause of EVI. In all regions, as the severity of vision impairment reduced, the proportion of vision impairment due to untreated cataract also reduced. . Nationally, the second most common cause of blindness and reduced visual acuity was 'other posterior segment eye diseases'. Age-related macular degeneration associated with early vision impairment was most commonly seen in the Islands region. Trachomatous corneal opacity leading to bilateral blindness was only seen in one participant in the Islands. There were no occurrences of presenting visual acuity of <6/12, where the primary cause was due to uncorrected aphakia, Eales' disease, or glaucoma.

Table 4 Principal causes of blindness and vision impairment in individuals in Papua New Guinea

Primary Cause	Papua New Guinea, Frequency (weighted average, %)			
	Blindness, (n=225) n (%)	**SVI, (n=122) n (%)**	**MVI, (n=492) n (%)**	**EVI, (n=365) n (%)**
Refractive error	0 (0.0)	2 (1.4)	92 (16.1)	190 (45.3)
Cataract, untreated	199 (88.6)	108 (89.3)	360 (76.2)	130 (43.6)
Cataract surgical complications	3 (1.1)	1 (1.2)	7 (1.4)	3 (1.5)
Trachomatous corneal opacity	1 (0.8)	0 (0.0)	0 (0.0)	0 (0.0)
Non-trachomatous corneal opacity	4 (2.1)	2 (1.7)	0 (0.0)	0 (0.0)
Phthisis	0 (0.0)	1 (1.0)	0 (0.0)	0 (0.0)
Diabetic retinopathy	0 (0.0)	1 (1.2)	0 (0.0)	1 (0.2)
Age-related macular degeneration	2 (0.5)	1 (1.2)	6 (1.5)	10 (2.0)
Other posterior segment disease	10 (3.9)	4 (1.5)	27 (4.8)	31 (7.4)
All other globe/CNS abnormalities	6 (2.9)	2 (1.6)	0 (0.0)	0 (0.0)

NOTE: No occurrences of presenting visual acuity of <6/12 were the primary cause due to uncorrected aphakia, Eales' disease or glaucoma

[a] Blindness indicates VA <3/60; [b] Severe vision impairment (SVI) indicates VA <6/60 but ≥3/60; [c] Moderate vision impairment (MVI) indicates VA <6/18 but ≥6/60; [d] Early vision impairment (EVI) indicates VA <6/12 but ≥6/18

1.13 Cataract

1.13.1 Cataract prevalence

Almost half of all eyes (48.4%; 4,662 eyes) were observed to have notable cataract resulting in visual acuity worse than 6/12. After adjusting for age and sex, a significantly greater prevalence of cataracts resulting in visual acuity worse than 3/60 was observed in females compared to males (Table 5). However, the difference between sexes was only statistically significant in the Highlands, based on comparing 95%CI for overlap between sexes for each region. The prevalence of cataract was significantly higher in the Highlands and Coastal regions for both genders compared to NCD and the Islands. A detailed breakdown on the age- and sex-adjusted prevalence of cataracts grouped by best-corrected visual acuity, gender and region is presented in Appendix 1, Table 14.

Table 5 Age- and sex-adjusted prevalence of cataract (bilateral individuals and total cataract eyes) in Papua New Guinea - with best-corrected or pinhole visual acuity

	Papua New Guinea – Frequency and weighted average					
	Male		Female		Total	
Visual acuity	**n**	**% (95%CI)**	**n**	**% (95%CI)**	**n**	**% (95%CI)**
< 3/60						
Individuals	12,411	3.1 (2.4-3.9)	19,544	5.9 (5.3-6.5)	31,955	4.4 (3.8-4.9)
Eyes	49,845	6.2 (5.3-7.2)	60,922	9.2 (8.4-10.0)	110,767	7.6 (6.8-8.3)
< 6/60 – 3/60						
Individuals	6,235	1.6 (1.1-2.0)	5,868	1.8 (1.1-2.4)	12,103	1.7 (1.3-2.0)
Eyes	20,588	2.6 (2.1-3.0)	14,292	2.2 (1.7-2.7)	34,880	2.4 (2.0-2.7)
< 6/18 – 6/60						
Individuals	21,619	5.4 (4.6-6.2)	18,967	5.7 (4.6-6.9)	40,586	5.6 (4.7-6.4)
Eyes	53,032	6.6 (5.8-7.5)	43,058	6.5 (5.4-7.6)	96,090	6.6 (5.7-7.4)
< 6/12 – 6/18						
Individuals	23,829	6.0 (5.1-6.8)	21,015	6.3 (5.6-7.1)	44,844	6.1 (5.5-6.8)
Eyes	55,072	6.9 (6.0-7.8)	44,926	6.8 (5.8-7.7)	99,998	6.8 (6.0-7.7)

1.13.2 Cataract surgical coverage (CSC)

Cataract surgical coverage is the proportion of individuals or eyes that have had cataract surgery (pseudophakia or aphakia) amongst individuals or eyes that have operable cataract for a specified level of visual acuity. Unadjusted average national coverage was 32.3% (VA<6/60, Table 6), but ranged from 9.2% (female in the Highlands) to 78.3% (males in the Islands) (Appendix 1, Table 15). When comparing regions, the Islands had significantly higher average CSC compared to all other regions (65.8% compared to 18.1 – 35.9%, $p < 0.001$). At all levels of VA, CSC for individuals was significantly lower in females compared to males in the Highlands. At all levels of VA, CSC of eyes was significantly lower in females compared to males in the Highlands and Islands, as well as in NCD but only for VA < 6/60 (all $p<0.05$).

Table 6 Cataract surgery coverage as a percentage of individuals and eyes

	Papua New Guinea, Weighted average		
Visual acuity	**Male (%)**	**Female (%)**	**Total (%)**
< 3/60			
Individuals	44.0	29.6	37.4
Eyes	33.5	19.7	27.3
< 6/60			
Individuals	39.2	23.9	32.3
Eyes	28.2	16.2	22.8
< 6/18			
Individuals	27.7	15.5	22.2
Eyes	18.1	10.2	14.7

1.13.3 Cataract surgery outcomes

Over 60% of the participants' eyes (61.3%) that have had cataract surgery have resulted in a good visual outcome (VA>6/18) with best corrected visual acuity. However approximately one quarter of operated eyes have resulted in a very poor visual outcome (VA<6/60) (Table 7). Combined data for surgical outcomes across the country, as well as a breakdown outcome data for each region are presented in Appendix 1, Table 16.

Of those who had poor cataract surgical outcomes (VA<6/60), 53.3% had long-term complications such as posterior capsular opacification or retinal detachment, 28.3% had operative complications and 18.3% had ocular co-morbidities.

1.13.4 Barriers to accessing surgery

Barriers to cataract surgery were variable between sexes and regions and proportions are presented in Figure 3 and Figure 4. Although not statistically significantly different, '*unaware [cataract] treatment is possible'* and *'need not felt'* were reported proportionally more by females compared to males. The same two barriers were more commonly reported in all regions except the Coastal region. '*Cost'* was considered the most prominent barrier to cataract surgery in the Coastal region. *'Fear'* was not reported as a barrier to cataract surgery in the Highlands, however a notable proportion reported 'need not felt' or 'unaware treatment is possible' as the main barriers. *'Cannot access treatment'* was reported by participants in all regions other than NCD. No reports of treatment denial or 'local beliefs', which pertain to local cultural fears such as a fear of sorcery were provided as reasons for not accessing cataract surgery services.

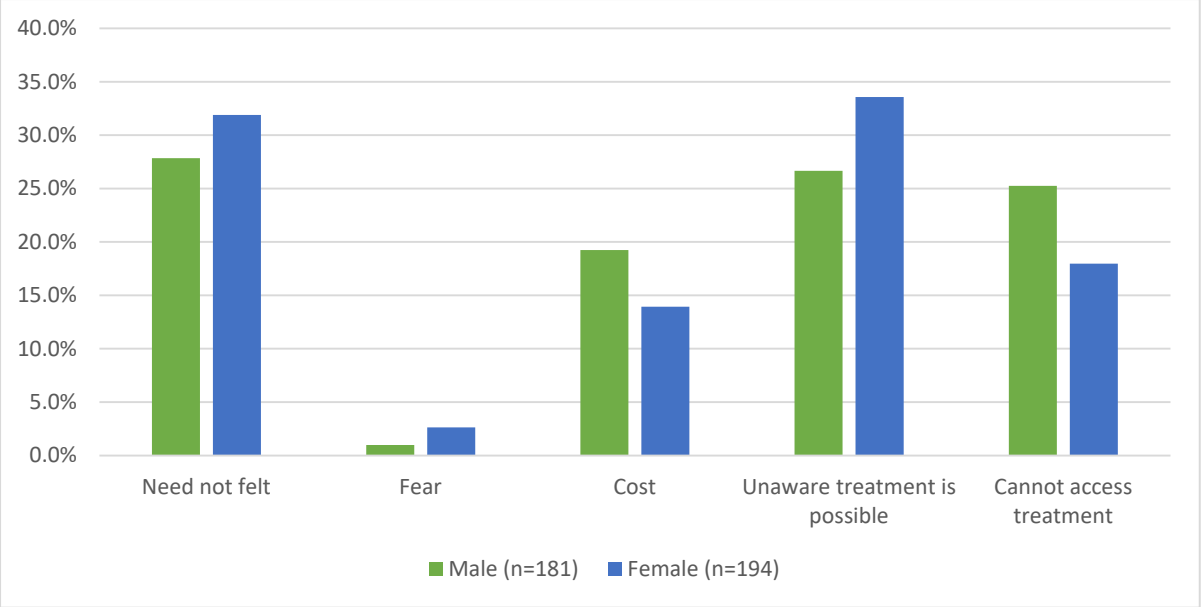

Figure 3 Reported barriers to cataract surgery by sex

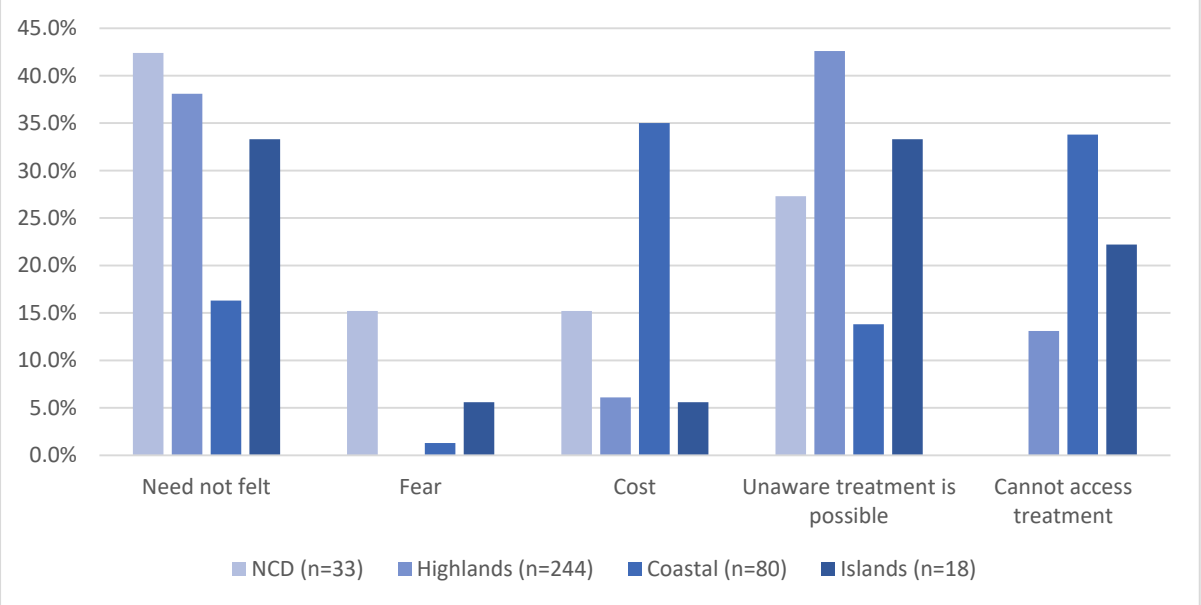

Figure 4 Reported barriers to cataract surgery by region

Table 7 Cataract surgical outcomes in Papua New Guinea - by presenting visual acuity (PVA) and best-corrected visual acuity (BCVA)

Visual acuity	Papua New Guinea, weighted average	
	PVA	BCVA
	Eyes (%)	Eyes (%)
Can see 6/12	93 (36.4)	112 (44.6)
Cannot see 6/12 but can see 6/18	29 (13.6)	36 (16.7)
Cannot see 6/18 but can see 6/60	44 (21.5)	27 (13.6)
Cannot see 6/60	60 (28.2)	51 (25.1)

1.14 Refractive error and spectacle coverage

The unadjusted prevalence of distance refractive error in PNG was estimated to be 8.2% (95%CI 6.7 – 9.7%) in adults aged 50 years and above. In each region, there was a higher prevalence of refractive error in males compared to females (Appendix 1,

Table 17). This however, was not statistically significant. Between regions, the prevalence of refractive error was significantly lower in the Highlands (4.3%, 95%CI 3.1 – 5.5%) compared to the other three regions (NCD: 10.2%, 95%CI 8.0-12.3%; Islands: 11.1%, 95%CI 9.1 – 13.2%; Coastal: 11.4%, 95%CI 7.6 – 15.3%).

Upon presentation, 3.4% of the study population had distance spectacles, although approximately 10% of these did not achieve VA of 6/12 or better. The lowest spectacle coverage was found in females in the Highlands (5.3%) and Islands (33.3%) regions. For males and females with distance refractive error, 65.7% and 71.2% were uncorrected, respectively (Appendix 1, Table 17)

For presbyopia, spectacle coverage was 17.5% of the sample population. Of those with near spectacles, a greater percentage of males (57.7%) presented with their spectacles compared to females (42.3%).

Table 8 Prevalence of refractive error and uncorrected presbyopia of the sample population in Papua New Guinea

	Papua New Guinea, weighted average					
	Total		Male		Female	
Prevalence of	**n**	**%**	**n**	**%**	**n**	**%**
Distance refractive error	416	8.2	225	8.8	191	7.6
Uncorrected distance refractive error	263	72.7	134	61.3	129	79.1
Uncorrected near refractive error	2,963	82.5	1,454	79.3	1,509	86.4

1.15 Diabetes and DR in National Capital District

In our sample, 7.8% (95%CI 5.5 – 10.1%) of adults aged 50 years or older were defined as having diabetes. After adjusting for sex and age, the estimated prevalence of diabetes in the National Capital District was 8.1% (95%CI 5.7 – 10.4%) in adults aged 50 years or older. Of those with diabetes, 62.4% were newly-diagnosed (reported that they did not have diabetes, but RBG level was found to be ≥200mg/dL) and 37.6% reported that they had been previously diagnosed. Of the 35 participants with known diabetes, 71.4% had a RBG level of ≥200mg/dL; this suggested poor management of the disease. Table 9 presents the types of treatment reported by those with a previous diagnosis of diabetes. No participants reported management with insulin. Although participants with diabetes were surveyed on the type of treatment prescribed for diabetes management, no further questions were asked regarding how well management was adhered to. It is possible that those who reported not receiving treatment, might in fact not be adhering to treatment previously prescribed.

Table 9 Types of diabetes treatment reported in people with known diabetes

	Male		Female		Total	
Treatment	**n**	**%**	**n**	**%**	**n**	**%**
Tablets	7	50.0	12	57.1	19	54.3
Diet only	3	21.4	4	19.0	7	20.0
None	4	28.6	5	23.8	9	25.7

Figure 5 shows the distribution of participants with known diabetes and the last eye examination for DR. Over 80% of participants with known diabetes reported never having had an eye examination for DR, while only 11.4% had an eye examination within the last 12 months. No participants reported having an eye examination 13 to 24 months prior.

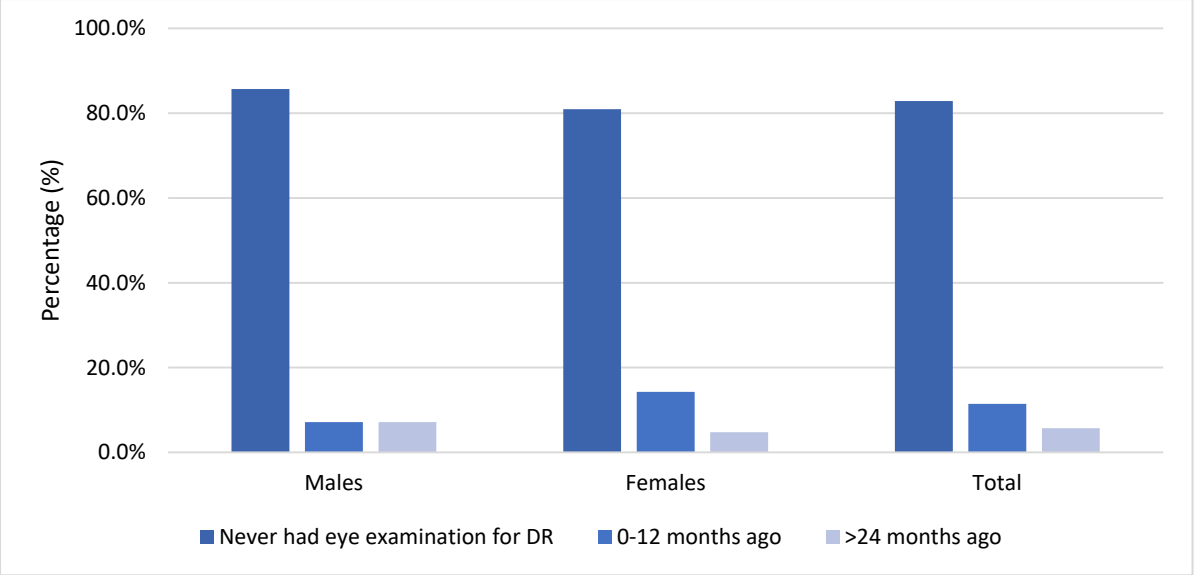

Figure 5 Proportion of participants with known diabetes and last eye examination for DR

Of all participants with diabetes (known and newly-diagnosed), almost half (46.4%) had some form of DR or maculopathy. Figure 6 provides a breakdown on the type and severity of DR.

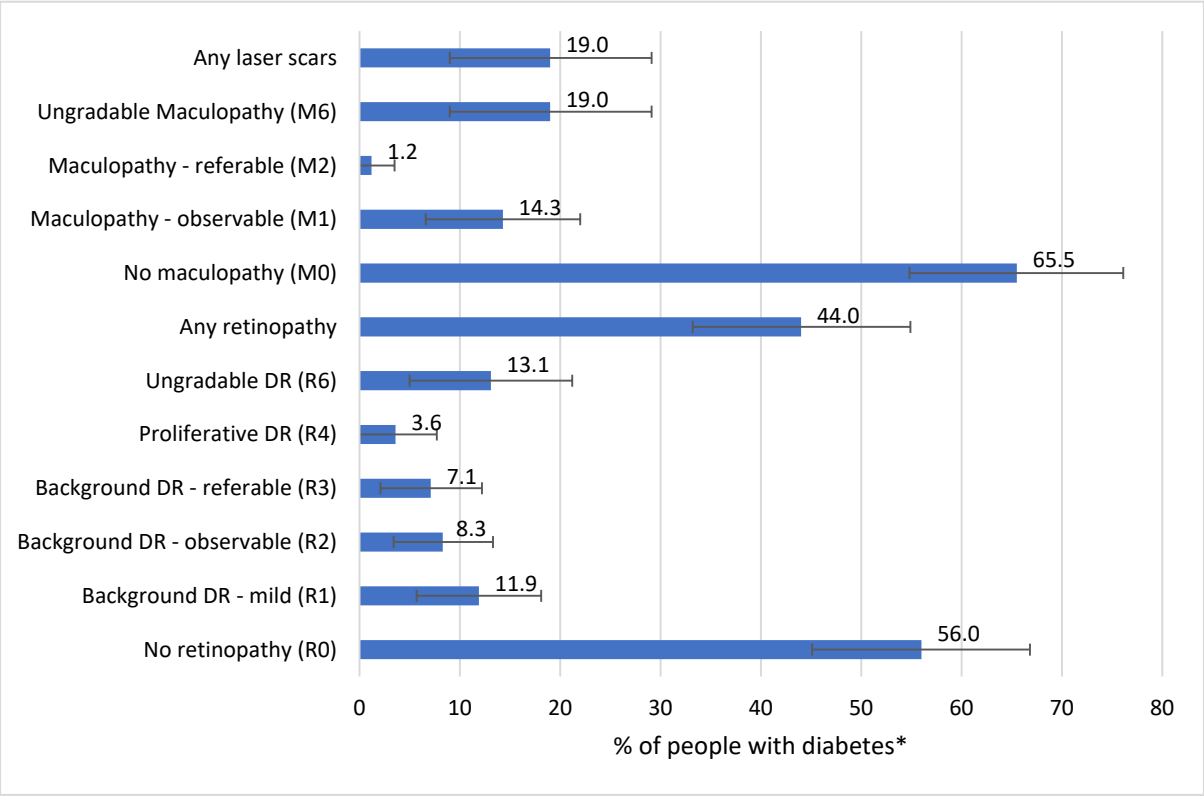

Figure 6 Sample prevalence of DR in National Capital District

** Diabetes indicates those who reported with known a diagnosis or having had a random blood glucose reading of ≥200mg/dL at the time of participation.*

Discussion

The estimated age- and sex-adjusted prevalence of blindness in people aged 50 years and older in PNG is 5.6% (95%CI 4.9 – 6.3%), and higher than the previous estimation of 3.9% (95%CI 3.4 – 6.1%).(5) Although, this suggests an increase in prevalence, this difference is not statistically significant. Direct comparisons between earlier estimates of prevalence of blindness and current estimates are to be taken with caution, as this study recruited a national representative sample, rather than participants from one urban and rural area near Port Moresby.

The prevalence of blindness in PNG is estimated to be higher than other Pacific Islands, which range between 0.5% to 3.6%.(12-14) With the exception of Fiji and Timor-Leste, the majority of these prevalence estimates in the Pacific were obtained at least five years ago. However the Fiji and Timor-Leste RAAB survey used different inclusion criteria (adults aged 40 years and over rather than adults 50 years and over) – as result these prevalence estimates are not directly comparable. Furthermore, whether the same definitions of blindness or whether a similar protocol to the RAAB survey was implemented for the remaining Pacific nations is unknown. In 2014, stakeholders from Samoa and the Solomon Islands have expressed interest in conducting a RAAB, however they are yet to conduct one.(16) RAAB surveys conducted in Cambodia, China, Philippines and Vietnam reported age- and sex-adjusted prevalence of blindness to be 3.4%, 2.7%, 2.5% and 1.8%, respectively.(16-19)

In line with findings from previous PNG, Cambodia, and Vietnam RAAB surveys, the main causes of blindness in this study were found to be untreated cataract (88.6%) and other posterior segment disease (3.9%).(5, 16, 19) The previous estimates of blindness and vision impairment in PNG reported that 73.2% of blindness was due to cataract compared with 81.8% in NCD and 91.0% in the Coastal region of this study. This may suggest an increase in the prevalence of cataract as the leading cause of blindness; however, this finding may also reflect the fact that more remote and rural locations were surveyed within these regions, where there is likely to be a higher frequency of untreated cataract.

The WHO recommend that CSC should be used as an indicator for the quality of care in the context of Universal Health Coverage, as it informs the degree to which services are meeting needs and can be used for monitoring purposes.(11) Based on available RAAB data in the repository, the global median CSC was 53.7% (IQR 46.1 - 66.6%) for operable cataracts where pinhole VA was < 6/60.(21) In comparison to developing countries in Southeast Asia, South Asia, Africa and South America, PNG had an estimated combined national CSC of 33.5%. Although CSC (VA<6/60) was lower than the estimated global median, a wide range was observed, with lowest coverage in females in the Highlands (9.2%) and highest in males in the Islands (78.3%). Previous CSC in PNG were reported to be 45.3%.(21) When compared to the current sample, CSC was approximately 40% in the corresponding regions. However, the comparison must be considered with caution considering the different sampling strategies used in the different studies.

Currently there are no recommended targets for CSC; nonetheless the WHO recommends that at least 80% of people receiving cataract surgery should have postoperative presenting VA of 6/18 or better, and that at most only 5% of patient should have postoperative presenting VA worse than 6/60.(23) From this survey, PNG is below the recommended target. However, available data from the RAAB repository shows that no country has yet achieved the recommended cataract surgery outcome targets.(21) In PNG, Fiji, and Samoa, ophthalmologists and trainees were reviewed on postoperative unaided visual acuity outcomes, which ranged from 41.5% to 74%.(23-25) Although outcomes were higher than this study, these were short-term (12 weeks) postoperative outcomes with variable response rates to follow ups and still below the WHO recommended target. The higher than recommended rate of poor cataract surgery outcome could be due to a number of factors including lack of follow up, as patients are unable to travel the often long distances required to access services, and facilities for the treatment of posterior capsular opacifications are overall limited. Ramke et al.(21) have recently introduced 'effective CSC' as an indicator that combines CSC and outcomes – this may be a useful approach for monitoring future progress in CSC in PNG.

'*Unaware [that cataract] treatment is possible*' and '*Need [for surgery] not felt*' were the most commonly reported barriers to receiving cataract surgery in all regions of PNG, with the exception of the Coastal region. This suggests a need for improving eye health education among the older population on the availability and potential benefits of cataract surgery. For the Coastal region, this included provinces in the Momase and Papua regions (excluding Milne Bay Province). For eye clinics within these regions, participants in Papua region potentially need to travel to Port Moresby, where costs of cataract surgery are highest. The reported barrier of 'cost' to cataract surgery from participants in Coastal region might be a combination of travel and surgical costs. Having no participants reporting '*local beliefs*' as a barrier to cataract surgery might be associated with the simple design. As this is only a rough survey on barriers, such reports on local beliefs might only be elicited with in-depth interviews where participants have the opportunity to elaborate on their challenges to accessing cataract surgical services.

The addition of early vision impairment to the survey highlighted the need for refractive services in all regions. Distance refractive error in adults over 50 years of age was estimated to be 8.2%, however of those with vision impairment due to distance refractive error, only 31.5% had appropriate correction. Near spectacle coverage was 17.5%, which is higher than India (11.1%), but lower than Timor-Leste (26.2%).(26, 27) This measurement of coverage however is assuming all adults 50 years and older need near correction. This calculation did not take into account participants with myopia that could achieve good near VA unaided therefore potentially underestimating coverage. Despite these assumptions though, the coverage is likely to be low. Spectacle coverage for distance and near was lower in females than males across all regions. Previous reports on female attitudes towards spectacle wear in PNG include fear of jealousy and feelings of shame might be attributable to low spectacle

coverage and females not accessing services. Overall, the outcomes indicate a need for accessible refractive error services across the whole country, in particular, the Highlands and for females.

The diabetes prevalence in adults aged 50 years and over was lower than previous reports in PNG (8.1% versus 14.4%), although previous assessments of diabetes have used different blood glucose assessment techniques, and age groups – making comparisons difficult. Previous reports of the prevalence of diabetes have ranged between 9.0% and 33%.(10, 28, 29) It is unclear whether the prevalence of diabetes found in this study is an under estimate, or if the prevalence of diabetes in PNG is significantly less than elsewhere in the Pacific region,(31) which has some of the highest rates globally. Regardless, as the rates of adults over 50 who were newly diagnosed (62.4%) was high, and almost half of those with diabetes had some form of DR or maculopathy, this indicates that undiagnosed diabetes and DR are likely to be increasingly significant public health issue in PNG with increasing rates of diabetes. It is important to note that results are for the NCD region only and can't be generalised to the rest of the country, as there are likely to be diet and lifestyle factors that impact the prevalence of diabetes.(28, 29, 31)

Project Learnings

1.16 Training

Overall the RAAB training with DR component conducted in November 2016 was a success. Although the training week was taxing, the survey team members were engaged and committed to the research project. Key indicators of the success of training include low inter-observer variability associated with RAAB procedures and DR grading. For RAAB processes of measuring visual acuity, lens examination and determining primary cause of reduced VA, all survey teams scored well above the threshold of 0.6 for most examinations, but all groups had up to two out of four examinations that scored below the threshold. These outcomes were attributed to the brief training duration, therefore suggesting future RAAB training could be extended to include additional practical work. For assessing the inter-observer variability in DR grading, it was identified the Certified DR Primary Grader was the only one able to obtain results over the 0.6 kappa coefficient threshold for both grading areas of maculopathy and retinopathy. This outcome might have been due to a grading system unfamiliar or not regularly used amongst the ophthalmologists. However, it suggests the importance of conducting inter-observer variability tests during training to identify whether one passing observer performs all DR screenings or additional training is required to standardise grading amongst ophthalmologists.

1.17 Logistics and study procedures

Although the standardised RAAB manual training instructed survey teams to attend households one by one to identify eligible participants, it was identified that some of the study recruitment occurred in the community centre where people gathered, therefore, affecting

the compact segment sampling strategy. The congregation around a central area may be a common occurrence in Pacific Island communities where people prefer to gather when visitors attend to conduct research. The investigators were aware that having the approach of recruiting in the community centre could bias prevalence outcomes as those willing to attend and participate might be those seeking eye care due to a problem. Therefore, in order to minimise bias, each consenting participant was also asked whether there were other eligible participants within their home. If other eligible adults were present, they were included in the study and followed up with a visit to complete the eye examination. Once the cluster data collection was complete, additional basic eye examinations were delivered to other community members who wished to have an eye examination.

Other challenges faced during this study included uncontrollable environmental conditions such as poor weather, landslides, and rough seas resulting in delays of travelling to the selected clusters, as well as limited ability to communicate with the study teams in some areas due to a lack of telecommunications infrastructure. Additionally, local ethnic clashes resulted in some areas being too unstable for the study teams to visit (in these instances, the next nearest and safe available census unit was selected instead). Finally, the complexities involved with managing the logistics of multiple travelling teams and ensuring that they compensated in a timely manner cannot be underestimated – particularly in a country such as PNG, where there are often extended delays with electronic fund transfers. A key to the success of the survey was to initially train additional people so that the survey wasn't delayed if a team member was unexpectedly unavailable.

1.18 Data collection tools – mobile phones versus paper

Mobile phones and the mRAAB App were to be used to record data in all regions other than NCD. Use of smart phone technology has been mostly positive in this context, as it resulted in high data collection accuracy and low levels missing data due to the internal consistency checks require data collectors to submit all answers before progressing. Data managers outside PNG were able to respond to issues swiftly, increasing agility and decreasing time and cost as teams could quickly address where required.

Paper forms in NCD were required because the DR component was not available within mRAAB survey forms. Recording on paper survey forms required double data entry into the RAAB6 software in order to minimise data entry errors. Needing two entries per participant meant that more resources and time were required to complete data collection, processing and monitoring. In comparison to mRAAB data entry, delays in receiving paper data meant challenges were faced with providing NCD survey teams with immediate feedback or queries regarding data discrepancies.

The widespread nature of the Coastal Region meant some sample clusters were geographically closer to Port Moresby. Logistically, these were more easily accessed by an NCD survey team. As the NCD team were comfortable with recording data on paper survey forms, it became apparent that they continued to do so in the Coastal region clusters rather

than recording in mRAAB. This unfortunately led to additional time and resources in completing double data entry for these clusters and thus highlighting the advantages of using mobile phones for data collection.

With each survey, learnings from the use of mobile phones for data collection have been assessed. Additional time spent on training has mitigated 'fear' of technology. Cultural understanding of the 'communal' use of phones and data has also been taken into account in budgeting. Overall, the experience has been positive through the reduction of time and cost, which therefore is highly recommended for future large population-based studies.

1.19 Other strengths and limitations

This is the first population-based assessment of blindness and vision impairment across all provinces of PNG and assessment of DR in the NCD region. Overall there was a high response rate, as less than 4% refused to participate and despite geographic, logistic and safety issues, there was low missing data and high coverage.

Achieving a national prevalence of blindness of 5.6% was greater the anticipated prevalence of 3.9% ± 0.8% (20% relative precision) suggesting sample size and power were adequate for estimating blindness. Furthermore, taking into account the sample participants age and sex were relatively similar to the census population data, it may be concluded the sample was a good representative of the population. However, as the sample size for each region was not sufficiently powered to estimate the prevalence of blindness at the regional level, caution must be exercised when reviewing these regional blindness estimates.

Due to the standard RAAB protocol for assessing vision, the true prevalence of distance refractive error may have been overestimated without objective or subjective refraction. Those presenting with distance correction were assessed with spectacles, however some spectacles might have had no significant prescription but rather only photochromatic lenses that are worn to alleviate glare symptoms and do not need to be removed indoors.

Similarly for the RAAB+DR standard protocol, newly diagnosed diabetes was dependent on a single RBG level ≥200 mg/dL. While current recommendations for the diagnosis of diabetes can be either a RBG ≥200 mg/dL, which should be accompanied with classic symptoms of hyperglycaemia or hyperglycaemic crisis, or two fasting (>8 hours) blood glucose level measurements ≥126 mg/dL.(33) As diabetes symptoms and fasting questions were not part of the survey, the estimation on the prevalence of diabetes may be under- or over-estimated.

Conclusion

Overall, this is the first population-based assessment of blindness and vision impairment across all provinces of PNG and diabetic retinopathy screening in NCD. The high prevalence of blindness that is largely due to cataracts suggests the need to address the accessibility of cataract surgical services across the country and advocacy for educating elderly patients on avoidable blindness. Furthermore, the low coverage of corrected refractive error indicates the necessity of further developing refractive services. There is a particular need for services for females across the country, and people in the Highlands. Although diabetes rates were lower than expected, the high numbers of participants that were unaware they had diabetes, the high levels of poor diabetes control and high rates of DR, suggest that there is a significant need for primary diabetes and eye care services to provide regular eye examinations among people with diabetes.

Achieving equitable access to eye care services for both males and females and those from remote areas will be a long-term goal in PNG. Ongoing advocacy to increase services and improve services and support, particularly for women and those from rural areas, to engage with eye care services is required to reduce the inequities in eye health that exist in PNG. Developing and evaluating a comprehensive model of eye care, which includes eye care services for people with diabetes will be important next steps for improving the eye health of people in PNG.

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Appendix 1 – Additional results

Table 10 Age and sex distribution of survey region and sample population in Papua New Guinea(2)

Region	Age group (years)	Male n (%)		Female n (%)		Total n (%)	
		RAAB Sample	**Survey region**	**RAAB Sample**	**Survey region**	**RAAB Sample**	**Survey region**
NCD	50 - 59	345 (64.5%)	11,684 (66%)	496 (75.5%)	8,342 (66.9%)	841 (70.6%)	20,026 (66.4%)
	60 - 69	134 (25%)	4,455 (25.2%)	134 (20.4%)	2,984 (23.9%)	268 (22.5%)	7,439 (24.7%)
	70 - 79	46 (8.6%)	1,228 (6.9%)	22 (3.3%)	845 (6.8%)	68 (5.7%)	2,073 (6.9%)
	80 - 99	10 (1.9%)	324 (1.8%)	5 (0.8%)	298 (2.4%)	15 (1.3%)	622 (2.1%)
	Total	535 (100%)	17,691 (100%)	657 (100%)	12,469 (100%)	1,192 (100%)	30,160 (100%)
Highlands	50 - 59	364 (50.8%)	99,089 (54.6%)	311 (63.7%)	82,342 (58.8%)	675 (56%)	181,431 (56.4%)
	60 - 69	224 (31.2%)	58,330 (32.2%)	141 (28.9%)	43,147 (30.8%)	365 (30.3%)	101,477 (31.6%)
	70 - 79	101 (14.1%)	19,350 (10.7%)	22 (4.5%)	11,711 (8.4%)	123 (10.2%)	31,061 (9.7%)
	80 - 99	28 (3.9%)	4,659 (2.6%)	14 (2.9%)	2,863 (2%)	42 (3.5%)	7,522 (2.3%)
	Total	717 (100%)	181,428 (100%)	488 (100%)	140,063 (100%)	1205 (100%)	321,491 (100%)
Coastal	50 - 59	308 (49.1%)	72,289 (55.4%)	287 (46.7%)	66,015 (55.9%)	595 (47.9%)	138,304 (55.6%)
	60 - 69	180 (28.7%)	38,551 (29.6%)	188 (30.6%)	34,951 (29.6%)	368 (29.6%)	73,502 (29.6%)
	70 - 79	104 (16.6%)	15,379 (11.8%)	96 (15.6%)	13,448 (11.4%)	200 (16.1%)	28,827 (11.6%)
	80 - 99	35 (5.6%)	4,188 (3.2%)	44 (7.2%)	3,737 (3.2%)	79 (6.4%)	7,925 (3.2%)
	Total	627 (100%)	130,407 (100%)	615 (100%)	118,151 (100%)	1242 (100%)	248,558 (100%)
Islands	50 - 59	293 (48.9%)	39,511 (57%)	321 (55.3%)	34,776 (57.2%)	614 (52.1%)	74,287 (57.1%)
	60 - 69	181 (30.2%)	19,329 (27.9%)	148 (25.5%)	16,906 (27.8%)	329 (27.9%)	36,235 (27.8%)
	70 - 79	86 (14.4%)	7,908 (11.4%)	72 (12.4%)	6,938 (11.4%)	158 (13.4%)	14,846 (11.4%)
	80 - 99	39 (6.5%)	2,549 (3.7%)	39 (6.7%)	2,204 (3.6%)	78 (6.6%)	4,753 (3.7%)
	Total	599 (100%)	69,297 (100%)	580 (100%)	580 (100%)	1,179 (100%)	130,121 (100%)

Table 11 Sample prevalence of blindness and vision impairment in the four regions of Papua New Guinea - By eyes and individuals with available correction

	National Capital District				Highlands				Coastal				Islands			
	Male		Female		Male		Female		Male		Female		Male		Female	
	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)
Blindness[a]																
Individuals*	19	3.6 (2.2-4.9)	14	2.1 (1.1-3.2)	55	7.7 (5.2-10.2)	49	10.0 (7.1-13.0)	26	4.2 (2.7-5.6)	41	6.7 (4.6-8.7)	6	1.0 (0.0-2.0)	15	2.6 (1.4-3.8)
Eyes	84	7.9 (6.2-9.5)	70	5.3 (3.5-7.1)	187	13.0 (10.1-16.0)	151	15.5 (11.8-19.1)	140	11.2 (9.1-13.2)	147	12.0 (9.7-14.2)	58	4.8 (3.2-6.5)	69	6.0 (4.2-7.7)
Severe vision impairment[b]																
Individuals	13	2.4 (1.2-3.7)	5	0.8 (0.2-1.4)	30	4.2 (2.3-6.1)	16	3.3 (1.6-5.0)	20	3.2 (1.7-4.6)	23	3.7 (1.6-5.8)	7	1.2 (0.4-1.9)	8	1.4 (0.5-2.3)
Eyes	41	3.8 (2.7-5.0)	25	1.9 (1.1-2.7)	88	6.1 (4.4-7.9)	33	3.4 (2.2-4.5)	52	4.2 (2.9-5.4)	64	5.2 (3.2-7.2)	28	2.3 (1.4-3.3)	19	1.6 (0.7-2.5)
Moderate vision impairment[c]																
Individuals	34	6.4 (4.9-7.8)	39	5.9 (3.7-8.1)	83	11.6 (9.6-13.6)	48	9.8 (6.7-13.0)	90	14.4 (10.8-17.9)	111	18.1 (13.6-22.5)	41	6.8 (4.5-9.2)	46	7.9 (5.3-10.6)
Eyes	76	7.1 (5.4-8.8)	84	6.4 (4.6-8.2)	177	2.3 (10.3-14.4)	93	9.5 (7.1-12.0)	178	14.2 (11.4-17.0)	237	19.3 (15.3-23.2)	106	8.9 (6.5-11.2)	114	9.8 (7.3-12.4)
Early vision impairment[d]																
Individuals	46	8.6 (5.8-11.4)	38	5.8 (3.8-7.8)	61	8.5 (6.8-10.2)	28	5.7 (4.0-7.5)	56	8.9 (6.1-11.8)	51	8.3 (5.4-11.2)	46	7.7 (5.3-10.1)	39	6.7 (4.4-9.0)
Eyes	104	9.7 (6.9-12.5)	96	7.3 (5.5-9.1)	129	9.0 (7.4-10.6)	67	6.9 (5.0-8.7)	129	10.3 (7.7-12.8)	102	8.3 (5.8-10.8)	101	8.4 (6.6-10.3)	95	8.2 (6.3-10.1)

*Data for individuals refers to bilateral cases; 95% CI = 95% confidence interval

[a] Blindness: VA <3/60; [b] Severe vision impairment: VA <6/60 but ≥3/60; [c] Moderate vision impairment: VA <6/18 but ≥6/60, [d] Early vision impairment VA <6/12 but ≥6/18

Table 12 Principal causes of blindness and vision impairment of individuals in the four regions of Papua New Guinea

	National Capital District				Highlands				Coastal				Islands			
	Frequency (%)				Frequency (%)				Frequency (%)				Frequency (%)			
Cause	B (n=33)	SVI (n=18)	MVI (n=73)	EVI (n=84)	B (n=104)	SVI (n=46)	MVI (n=131)	EVI (n=89)	B (n=67)	SVI (n=43)	MVI (n=201)	EVI (n=107)	B (n=21)	SVI (n=15)	MVI (n=87)	EVI (n=85)
Refractive error	0 (0.0)	1 (5.6)	19 (26.0)	49 (58.3)	0 (0.0)	0 (0.0)	3 (2.3)	12 (13.5)	0 (0.0)	0 (0.0)	37 (18.4)	44 (41.1)	0 (0.0)	1 (6.7)	24 (27.6)	60 (70.6)
Cataract, untreated	27 (81.8)	14 (77.8)	43 (58.9)	23 (27.4)	94 (90.4)	44 (95.7)	117 (89.3)	66 (74.2)	61 (91.0)	39 (90.7)	154 (76.6)	56 (52.3)	17 (81.0)	11 (73.3)	54 (62.1)	9 (10.6)
Cataract surgical complications	1 (3.0)	0 (0.0)	1 (1.4)	0 (0.0)	1 (1.0)	0 (0.0)	2 (1.5)	4 (4.5)	1 (1.5)	0 (0.0)	3 (1.5)	0 (0.0)	0 (0.0)	1 (6.7)	1 (1.1)	1 (1.2)
Trachomatous corneal opacity	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (4.8)	0 (0.0)	0 (0.0)	0 (0.0)
Non-trachomatous corneal opacity	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (1.9)	1 (2.2)	0 (0.0)	0 (0.0)	0 (0.0)	1 (2.3)	0 (0.0)	0 (0.0)	1 (4.8)	0 (0.0)	0 (0.0)	0 (0.0)
Phthisis	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (2.2)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
DR	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (6.7)	0 (0.0)	1 (1.2)
Age-related macular degeneration	1 (3.0)	0 (0.0)	0 (0.0)	1 (1.2)	1 (1.0)	0 (0.0)	2 (1.5)	0 (0.0)	0 (0.0)	0 (0.0)	2 (1.0)	1 (0.9)	0 (0.0)	1 (6.7)	3 (3.4)	8 (9.4)
Other posterior segment disease	3 (9.1)	3 (16.7)	10 (13.7)	11 (13.1)	4 (3.8)	0 (0.0)	7 (5.3)	7 (7.9)	2 (3.0)	1 (2.3)	5 (2.5)	6 (5.6)	1 (4.8)	0 (0.0)	5 (5.7)	7 (8.2)
All other globe/CNS abnormalities	1 (3.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (1.9)	0 (0.0)	0 (0.0)	0 (0.0)	3 (4.5)	2 (4.7)	0 (0.0)	0 (0.0)	1 (4.8)	0 (0.0)	0 (0.0)	0 (0.0)

NOTE: No occurrences of presenting visual acuity of <6/12 were the primary cause due to uncorrected aphakia, Eales' disease or glaucoma

Table 13 Age- and sex-adjusted prevalence of blindness and vision impairment in individuals and eyes with available correction in the four regions of Papua New Guinea

	National Capital District				Highlands				Coastal				Islands			
	Male		Female		Male		Female		Male		Female		Male		Female	
	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)
Blindness[a]																
Individuals*	607	3.4 (2.1 - 4.7)	375	3.0 (2.0 - 4.0)	11,963	6.6 (4.1 - 9.1)	15,480	11.1 (8.1 - 14.0)	4,438	3.4 (2.0 - 4.8)	6,044	5.1 (3.1 - 7.2)	487	0.7 (0.0 - 1.7)	1,352	2.2 (1.0 - 3.4)
Eyes	2,740	7.7 (6.1 - 9.4)	1,694	6.8 (5.0 - 8.6)	42,632	11.7 (8.8 - 14.7)	46,805	16.7 (13.1 - 20.3)	25,909	9.9 (7.9 - 12.0)	22,688	9.6 (7.4 - 11.8)	5,459	3.9 (2.3 - 5.6)	6,758	5.6 (3.8 - 7.3)
Severe vision impairment[b]																
Individuals	407	2.3 (1.0 - 3.6)	89	0.7 (0.1 - 1.3)	6,912	3.8 (1.9 - 5.7)	5,225	3.7 (2.1 - 5.4)	3,818	2.9 (1.5 - 4.4)	3,578	3.0 (0.9 - 5.1)	721	1.0 (0.3 - 1.8)	769	1.3 (0.3 - 2.2)
Eyes	1,288	3,6 (2.5 - 4.8)	545	2.2 (1.4 - 3.0)	20,892	5.8 (4.0 - 7.5)	10,756	3.8 (2.7 - 5.0)	9,857	3.8 (2.5 - 5.0)	10,503	4.4 (2.4 - 6.5)	2,863	2.1 (1.2 - 3.0)	1,695	1.4 (0.5 - 2.3)
Moderate vision impairment[c]																
Individuals	1,081	6.1 (4.7 - 7.5)	1,019	8.2 (6.0 - 10.4)	19,451	10.7 (8.7 - 12.7)	15,018	10.7 (7.6 - 13.8)	16,232	12.4 (8.9 - 16.0)	18,573	15.7 (11.3 - 20.2)	3,906	5.6 (3.2 - 8.0)	4,183	6.9 (4.3 - 9.5)
Eyes	2,426	6.9 (5.2 - 8.5)	2,052	8.2 (6.4 - 10.0)	42,158	11.6 (9.6 - 13.6)	28,809	10.3 (7.8 - 12.7)	33,181	12.7 (9.9 - 15.5)	41,640	17.6 (13.7 - 21.5)	10,485	7.6 (5.2 - 9.9)	10,526	8.7 (6.1 - 11.2)
Early vision impairment[d]																
Individuals	1,488	8.4 (5.6 - 11.3)	877	7.0 (5.1 - 9.0)	14,615	8.1 (6.4 - 9.7)	8,137	5.8 (4.1 - 7.6)	10,798	8.3 (5.5 - 11.1)	8,921	7.6 (4.7 - 10.4)	4,554	6.6 (4.2 - 8.9)	3,744	6.2 (3.9 - 8.5)
Eyes	3,360	9.5 (6.7 - 12.3)	2,036	8.2 (6.4 - 9.9)	31,615	8.7 (7.1 - 10.3)	19,906	7.1 (5.2 - 9.0)	25,517	9.8 (7.2 - 12.3)	18,132	7.7 (5.2 - 10.2)	10,369	7.5 (5.6 - 9.3)	9,490	7.8 (5.9 - 9.7)

NOTE: Data for individuals refers to bilateral cases

[a] Blindness indicates VA <3/60; [b] Severe vision impairment (SVI) indicates VA <6/60 but ≥3/60; [c] Moderate vision impairment (MVI) indicates VA <6/18 but ≥6/60; [d] Early vision impairment (EVI) indicates VA <6/12 but ≥6/18

Table 14 Age- and sex-adjusted prevalence of cataract (bilateral individuals and total cataract eyes) in four regions of Papua New Guinea - with best-corrected or pinhole visual acuity

	National Capital District				Highlands				Coastal				Islands			
	Male		Female		Male		Female		Male		Female		Male		Female	
Visual acuity	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)
< 3/60																
Individuals	253	1.4 (0.6 - 2.3)	215	1.7 (1.0 - 2.4)	8,790	4.8 (2.8 - 6.9)	14,417	10.3 (7.5 - 13.1)	3,038	2.3 (0.8 - 3.9)	4,491	3.8 (2.0 - 5.6)	330	0.5 (0.0 - 1.1)	421	0.7 (0.0 - 1.3)
Eyes	1,225	3.5 (2.4 - 4.5)	969	3.9 (2.9 - 4.9)	31,142	8.6 (6.0 - 11.1)	40,915	14.6 (11.2 -18.0)	14,875	5.7 (3.8 - 7.6)	15,991	6.8 (4.8 - 8.7)	2,603	1.9 (0.9 - 2.8)	3,047	2.5 (1.4 - 3.6)
< 6/60 - 3/60																
Individuals	155	0.9 (0.0 - 1.8)	72	0.6 (0.0 - 1.1)	5,038	2.8 (1.3 - 4.2)	4,349	3.1 (1.6 - 4.6)	977	0.7 (0.0 - 1.5)	1,130	1.0 (0.0 - 2.6)	65	0.1 (0.0 - 0.4)	317	0.5 (0.0 - 1.1)
Eyes	282	0.8 (0.0 - 1.7)	333	1.3 (0.7 - 1.9)	16,955	4.7 (3.3 - 6.0)	9,573	3.4 (2.2 - 4.6)	2,636	1.0 (0.2 - 1.8)	3,294	1.4 (0.0 - 2.9)	715	0.5 (0.0 - 1.0)	1,092	0.9 (0.3 - 1.5)
< 6/18 - 6/60																
Individuals	413	2.3 (1.2 - 3.5)	394	3.2 (1.6 - 4.7)	11,018	6.1 (3.5 - 8.7)	8,816	6.3 (4.1 - 8.5)	9,204	7.1 (4.9 - 9.2)	9,097	7.7 (4.3 - 11.1)	984	1.4 (0.4 - 2.4)	773	1.3 (0.3 - 2.2)
Eyes	1,204	3.4 (2.1 - 4.7)	708	2.8 (1.6 - 4.1)	25,969	7.2 (4.9 - 9.4)	16,166	5.8 (4.0 - 7.6)	22,669	8.7 (6.1 - 11.3)	23,631	10.0 (6.7 - 13.3)	3,190	2.3 (1.2 - 3.4)	2,553	2.1 (1.0 - 3.2)
< 6/12 - 6/18																
Individuals	718	4.1 (2.5 - 5.6)	569	4.6 (3.1 - 6.0)	12,368	6.8 (5.2 - 8.4)	7,448	5.3 (3.6 - 7.1)	8,520	6.5 (3.9 - 9.2)	10,794	9.1 (7.0 - 11.2)	2,223	3.2 (1.5 - 4.9)	2,204	3.6 (1.7 - 5.5)
Eyes	1,550	4.4 (3.0 - 5.8)	1,267	5.1 (3.5 - 6.7)	28,064	7.7 (6.3 - 9.2)	17,196	6.1 (4.5 - 7.8)	19,167	7.3 (5.0 - 9.7)	21,184	9.0 (6.0 - 12.0)	6,261	4.5 (2.7 - 6.4)	5,279	4.3 (2.5 - 6.1)

Table 15 Cataract surgical coverage (unadjusted) as a percentage of individuals and eyes in the four regions of Papua New Guinea

Visual acuity	National Capital District			Highlands			Coastal			Islands		
	Male (%)	Female (%)	*p*	Male (%)	Female (%)	*p*	Male (%)	Female (%)	*p*	Male (%)	Female (%)	*p*
< 3/60												
Individuals	50.0	42.9	0.81	30.5	11.5	0.02	42.4	34.0	0.45	81.0	60.0	0.62
Eyes	38.7	21.6	0.05	21.5	7.8	<0.001	33.3	23.7	0.08	64.0	38.8	0.01
< 6/60												
Individuals	38.1	33.3	0.82	25.0	9.2	0.04	38.5	28.6	0.48	78.3	46.7	0.35
Eyes	33.8	16.9	0.02	15.3	6.5	0.01	29.8	20.2	0.05	57.8	30.6	0.001
< 6/18												
Individuals	27.8	18.2	0.45	18.5	6.5	0.02	23.5	14.8	0.18	59.5	37.0	0.30
Eyes	22.0	12.0	0.06	10.6	5.0	0.02	15.9	10.8	0.07	41.0	20.9	0.002

Table 16 Cataract surgical outcomes in the four regions of Papua New Guinea – by presenting (PVA) and best-corrected visual acuity (BCVA)

	National Capital District (n=35)		Highlands (n=49)		Coastal (n=75)		Islands (n=67)	
	PVA	BCVA	PVA	BCVA	PVA	BCVA	PVA	BCVA
Visual acuity	Eyes (%)	Eyes (%)	Eyes (%)	Eyes (%)	Eyes (%)	Eyes (%)	Eyes (%)	Eyes (%)
Can see 6/12	13 (37.1)	17 (48.6)	12 (24.5)	15 (30.6)	33 (44.0)	42 (56.0)	35 (52.2)	38 (56.7)
Cannot see 6/12 but can see 6/18	4 (11.4)	5 (14.3)	7 (14.3)	10 (20.4)	11 (14.7)	8 (10.7)	7 (10.4)	13 (19.4)
Cannot see 6/18 but can see 6/60	5 (14.3)	3 (8.6)	12 (24.5)	7 (14.3)	16 (21.3)	13 (17.3)	11 (16.4)	4 (6.0)
Cannot see 6/60	13 (37.1)	10 (28.6)	18 (36.7)	17 (34.7)	15 (20.0)	12 (16.0)	14 (20.9)	12 (17.9)

Table 17 Prevalence of refractive error of the sample population in the four regions of Papua New Guinea

Refractive error type	National Capital District				Highlands				Coastal				Islands			
	Male		Female		Male		Female		Male		Female		Male		Female	
	n	% (95%CI)	n	% (95%CI)	n	% (95%CI)	n	% (95%CI)	n	% (95%CI)	n	% (95%CI)	n	% (95%CI)	n	% (95%CI)
Distance refractive error	68	12.7 (9.5 - 15.9)	53	8.1 (5.0 - 11.2)	33	4.6 (3.0 - 6.2)	19	3.9 (2.4 - 5.4)	79	12.6 (7.9 - 17.3)	63	10.2 (6.7 - 13.8)	75	12.5 (9.6 - 15.4)	56	9.7 (7.4 - 11.9)
Uncorrected distance refractive error	38	55.9	31	58.5	26	78.8	18	94.7	44	55.7	42	66.7	40	53.3	45	80.4
Uncorrected near refractive error	344	64.3	477	72.6	671	93.6	474	97.1	469	74.8	531	86.3	422	70.5	438	75.5

Appendix 2 – Project Contributors

Steering Committee Members	
Dr Anthea Burnett	Principal investigator, Research Manager at Brien Holden Vision Institute
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Dr Ling Lee	Research Officer at Brien Holden Vision Institute
Dr Jambi Garap	Ophthalmologist, Board President, PNG Eye Care and President of National Prevention of Blindness Committee PNG
Dr Geoffrey Wabulembo	Paediatric Ophthalmologist, University of Papua New Guinea and CBM
Mr Samuel Koim	Senior Manager at PNG Eye Care
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Ms Marleen Nelisse	Program Director at Fred Hollows Foundation New Zealand
Ms Grace Johnstone	Data, Information and Research Coordinator at Fred Hollows Foundation New Zealand

Management and data collection teams:	
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Mr Drew Keys	Regional Program Manager (Western Pacific) at the International Agency for the Prevention of Blindness. Formerly, Project Manager Papua New Guinea at Brien Holden Vision Institute, General Manager at PNG Eye Care
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Dr Jambi Garap	Ophthalmologist, Board President, PNG Eye Care and President of National Prevention of Blindness Committee PNG
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Ms Stephanie Koriapi	Health Extension Officer at Boram General Hospital
Mr Loamin Ikilik	Nurse at Nonga General Hospital
Ms Anita John	Refractionist at PNG Eye Care
Mr Jonah Jerry	Eye Nursing Officer at Port Moresby General Hospital
Ms Alison Poffley	Research Assistant at Brien Holden Vision Institute

Appendix 3 – Randomly Selected Clusters

RANDOMLY SELECTED POPULATION UNITS IN SURVEY AREA – COASTAL REGION

Cluster No.	Code	Name of population unit	Population
1	0101031 1401	Western Province Middle Fly District Gogodala Rural LLG Kawito Station Kawito Mission	150
2	0103122 1014	Western Province South Fly District Kiwai Rural LLG Maipani Maipani	773
3	0201050 9007	Gulf Province Kerema District Kotidanga Rural LLG Anea Tamdekengo	514
4	0301020 5047	Central Province Abau District Aroma Rural LLG Waro/Iruone Waro	137
5	0303071 5011	Central Province Kairuku - Hiri District Hiri Rural LLG Vanapa Kanobada No. 1	128
6	0304121 3026	Central Province Rigo District Rigo Coastal Rural LLG Gemo Gemo	792
7	0601031 4030	Northern (Oro) Province Ijivitari District Afore Rural LLG Ufia Umuwate	152
8	1201048 0004	Morobe Province Bulolo District Wau/Bulolo Urban LLG Bulolo Urban Klinkii Drive	132
9	1205168 2105	Morobe Province Lae District Lae Urban LLG Lae City Erema Street	706
10	1201050 1404	Morobe Province Bulolo District Wau Rural LLG Maus Bokis Tin Biscuit Settlement	295
11	1203100 6025	Morobe Province Huon District Salamaua Rural LLG Mubo Muekup	35
12*	1206170 4005	Morobe Province Markham District Onga/Waffa Rural LLG Siaga Siaga Warungao	310
13*	1207300 2002	Morobe Province Menyamya District Kapao Rural LLG Langamar Tuwatatila	143
14*	1209270 2021	Morobe Province Tawae/Siassi District Siassi Rural LLG Masele Masele	395
15	1301030 3008	Madang Province Bogia District Yawar Rural LLG Boroi Gabun	341
16	1302060 8401	Madang Province Madang District Transgogol Rural LLG Buroa Lagogen C/Sch	45
17	1304110 4026	Madang Province Rai Coast District Naho Rawa Rural LLG Boro Moguta	208
18	1305133 1410	Madang Province Sumkar District Karkar Rural LLG Bujon/Kurumtaur Kuburne Comm. Sch.	37
19	1404178 3630	East Sepik Province Wewak District Wewak Rural LLG Wewak Town Saure 2	398
20	1402051 0014	East Sepik Province Angoram District Angoram/Middle Sepik LLG Moim Moim	1,012
21	1403110 4025	East Sepik Province Maprik District Bumbita/Muhian Rural LLG Salata Salata	437
22	1405190 9009	East Sepik Province Wosera Gawi District Burui/Kunai Rural LLG Kwimba Nangutimbit	386

23	14062610006	East Sepik Province Yangoru Saussia District West Yangoru Rural LLG Bukitu Walgai	182
24	15020513001	West Sepik (Sandaun) Province Nuku District Mawase Rural LLG Abigu Abigu	366
25	15041301401	West Sepik (Sandaun) Province Vanimo/Green River District Bewani/Wutung Onei Rural LLG Wutung	76
RANDOMLY SELECTED POPULATION UNITS IN SURVEY AREA – HIGHALNDS REGION			
Cluster No.	**Code**	**Name of population unit**	**Population**
1	07020611012	Southern Highlands Province Imbonggu District Imbongu Rural LLG Piambil 1 Inaipe	683
2	07033245013	Southern Highlands Province Kagua/Erave District Aiya Rural LLG Ripu/Maguta Omborama	78
3	07062110001	Southern Highlands Province Mendi/Munihu District Upper Mendi Rural LLG Birop 2 Birop 2	1,630
4	07072531003	Southern Highlands Province Nipa/Kutubu District Nipa Rural LLG Pulim 3 Minjakom	190
5	08010206401	Enga Province Kandep District Wage Rural LLG Porokale Potokale Sch	24
6	08030624009	Enga Province Lagaip/Pogera District Lagaip Rural LLG Yomondi Yomondi	798
7	08031516003	Enga Province Lagaip/Pogera District Pilikambi Rural LLG Kanak Wanepop (Wanepap)	678
8	08051330005	Enga Province Wapenamanda District Wapenamanda Rural LLG Unda Aiakalis	817
9	09020329001	Western Highlands Province Dei District Dei Rural LLG Kindal Kindal	536
10	09030437014	Western Highlands Province Mt Hagen District Mt Hagen Rural LLG Kugl Kulg	444
11	09071234001	Western Highlands Province Tambul/Nebilyer District Mt Giluwe Rural LLG Alkena 1 Purunupul	277
12	10020411002	Chimbu (Simbu) Province Gumine District Bomai/Gumai Rural LLG Kawaleku Boromil	649
13	10041007005	Chimbu (Simbu) Province Kerowagi District Gena/Waugla Rural LLG Dimbinyaundo Dibindiyaudo	272
14	10051601002	Chimbu (Simbu) Province Kundiawa/Gembogl District Waiye LLG Kupau Ombondo	305
15	11010101026	Eastern Highlands Province Daulo District Watabung Rural LLG Mangiro Monoga	24
16	11021404005	Eastern Highlands Province Goroka District Mimanalo Rural LLG Kabiufa No.2 Alinipayufa	532
17	11041706023	Eastern Highlands Province Kainanatu District Kamano No. 1 Rural LLG Bush Kamano Bara-Onofi	1,275
18	11052101072	Eastern Highlands Province Lufa District Yagaria Rural LLG Higivavi Bopa No 2	124
19	11072204035	Eastern Highlands Province Okapa District West Okapa Rural LLG Tarabo Ketaga	159
20	21041111006	Hela Province Komo/Magarima District Hulia Rural LLG Hol'la Homa	868

21	21051517022	Hela Province Koroba/Kopiago District Lake Kopiago Rural LLG Wanakipi Wane 1	130
22*	22010282005	Jiwaka Province Anglimp/South Waghi District South Waghi Rural LLG Minj Urban DPI Compound	65
23	22010203401	Jiwaka Province Anglimp/South Waghi District South Waghi Rural LLG Aviamp 2 Nazarene Cir.	24
24	22040631007	Jiwaka Province Jimi District Jimi Rural LLG Korenju Borgol	506
25	22061521025	Jiwaka Province North Waghi District Nondugl Rural LLG Onil 1 Konskan Nol Egel	404
RANDOMLY SELECTED POPULATION UNITS IN SURVEY AREA – ISLANDS REGION			
Cluster No.	**Code**	**Name of population unit**	**Population**
1	05010585013	Milne Bay Province Alotau District Huhu Rural LLG Hagita Estate Hagita Nursery	426
2	05010501009	Milne Bay Province Alotau District Huhu Rural LLG Mutu'uwa Mutuyuwa	778
3	05020901008	Milne Bay Province Samarai-Murua District Louisiade Rural LLG Mwabua Gelagela	110
4	05031209029	Milne Bay Province Kiriwina-Goodenough District Kiriwina Rural LLG Okaikoda Walesi	273
5	05041401009	Milne Bay Province Esa'ala District West Ferguson Rural LLG Fayayana Asagamwana	279
6	16010680002	Manus Province Manus District Lorengau Urban LLG Lorengau Urban Manus High School	466
7	16011109002	Manus Province Manus District Balopa LLG Lako Lako	182
8	17010302033	New Ireland Province Kavieng District Tikana Rural LLG Nonovaul Limanak/Usen	335
9	17020514023	New Ireland Province Namatanai District Namatanai Rural LLG Sopau Sopau	308
10	17020802009	New Ireland Province Namatanai District Tanir Rural LLG Fonli Fonli	634
11	18010104002	East New Britain Province Gazelle District Central Gazelle Rural LLG Napapar No. 4 Napapar No.4 Vill	1,051
12	18010315023	East New Britain Province Gazelle District Lassul Baining Rural LLG Komgi Komgi	422
13	18010521506	East New Britain Province Gazelle District Vunadidir/Toma Rural LLG Wariki No.3 Oisca	57
14	18020804003	East New Britain Province Kokopo District Kokopo/Vunamami Urban LLG Vunabalbal Vunabalbal	819
15	18031029041	East New Britain Province Pomio District Central/Inland Pomio LLG Marmu Pelly	99
16	18041501401	East New Britain Province Rabaul District Balanataman Rural LLG Ratung Ratung Asing Settlmnt	128
17	19020980056	West New Britain Province Talasea District Kimbe Urban LLG Kimbe Urban Sect. 83	456
18	19010407018	West New Britain Province Kandrian/Gloucester District Kandrian Inland Rural LLG Awon Lapalam	222

19	19020610028	West New Britain Province Talasea District Bialla Rural LLG Bialla Waigo Vop	117
20	19020804006	West New Britain Province Talasea District Hoskins Rural LLG Kalu Gavaiva	1,188
21	19021101402	West New Britain Province Talasea District Talasea Rural LLG Nalabu Huveni / Lobe	1,072
22	20010203007	Autonomous Region of Bougainville North Bougainville District Kunua LLG Rapois Kopaei	349
23	20010405009	Autonomous Region of Bougainville North Bougainville District Buka LLG Halia Tohatsi	1,462
24	20020806001	Autonomous Region of Bougainville Central Bougainville District Arawa LLG Avaipa Siuema	559
25	20030905008	Autonomous Region of Bougainville South Bougainville District Buin LLG Lenoke Oremutsi	289
RANDOMLY SELECTED POPULATION UNITS IN SURVEY AREA – NATIONAL CAPITAL DISTRICT			
Cluster No.	**Code**	**Name of population unit**	**Population**
1	04010180014	National Capital District National Capital District National Capital District Gerehu Urban Maika Str	857
2	04010180036	National Capital District National Capital District National Capital District Gerehu Urban Toliman C	532
3	04010180059	National Capital District National Capital District National Capital District Gerehu Urban Rainbow 5	526
4	04010181014	National Capital District National Capital District National Capital District Waigani/University Ono	629
5	04010181041	National Capital District National Capital District National Capital District Waigani/University For	519
6	04010182002	National Capital District National Capital District National Capital District Tokarara/Hohola Urban	2,181
7	04010182021	National Capital District National Capital District National Capital District Tokarara/Hohola Urban	767
8	04010182040	National Capital District National Capital District National Capital District Tokarara/Hohola Urban	428
9	04010182060	National Capital District National Capital District National Capital District Tokarara/Hohola Urban	612
10	04010183020	National Capital District National Capital District National Capital District Gordons/Saraga Urban D	439
11	04010183043	National Capital District National Capital District National Capital District Gordons/Saraga Urban H	303
12	04010183056	National Capital District National Capital District National Capital District Gordons/Saraga Urban G	218
13	04010184010	National Capital District National Capital District National Capital District Boroko / Korobosea Urb	317
14	04010184049	National Capital District National Capital District National Capital District Boroko / Korobosea Urb	210
15	04010184075	National Capital District National Capital District National Capital District Boroko / Korobosea Urb	3,073
16	04010185003	National Capital District National Capital District National Capital District Kilakila / Kaugere Urb	1,187

17	0401018 5022	National Capital District National Capital District National Capital District Kilakila / Kaugere Urb	539
18	0401018 5039	National Capital District National Capital District National Capital District Kilakila / Kaugere Urb	950
19	0401018 6003	National Capital District National Capital District National Capital District Town / Hanuabada Urban	1,162
20	0401018 6030	National Capital District National Capital District National Capital District Town / Hanuabada Urban	2,035
21	0401018 6039	National Capital District National Capital District National Capital District Town / Hanuabada Urban	2,039
22	0401018 7505	National Capital District National Capital District National Capital District Laloki / Napanapa Urba	384
23	0401018 8402	National Capital District National Capital District National Capital District Bomana Urban Bomana Tr	46
24	0401018 8414	National Capital District National Capital District National Capital District Bomana Urban Kobaena	252
25	0401018 8524	National Capital District National Capital District National Capital District Bomana Urban Popondett	2,386

* Clusters were not accessible – the nearest closest geographical census unit was selected instead.

Appendix 4 – Regional Reports

RESULTS OF RAPID ASSESSMENT OF AVOIDABLE BLINDNESS

SUMMARY REPORT

Date and time of report: 14/03/2017 5:53:14 PM

This report is for the survey area: NCD

Year and month when survey was conducted: 2017- 2 until 2017- 2

This report shows the most important results from all the other reports. The 95% confidence interval (95% CI) is based on the sampling error in cluster sampling. More detailed information is provided in the other reports.

1. Eligible persons, coverage, absentees and refusals

	Examined		Not available		Refused		Not capable		Total	
	n	%	n	%	n	%	n	%	n	%
Males	535	92.6%	14	2.4%	29	5.0%	0	0.0%	578	100.0%
Females	657	97.8%	1	0.1%	14	2.1%	0	0.0%	672	100.0%
Total	**1,192**	95.4%	**15**	1.2%	**43**	3.4%	**0**	0.0%	**1,250**	100.0%

2. Age and gender distribution of people examined in the sample

	Males		Females		Total	
	n	%	n	%	n	%
50 - 59 years	345	64.5%	496	75.5%	**841**	70.6%
60 - 69 years	134	25.0%	134	20.4%	**268**	22.5%
70 - 79 years	46	8.6%	22	3.3%	**68**	5.7%
80+ years	10	1.9%	5	0.8%	**15**	1.3%
Total	**535**	100.0%	**657**	100.0%	**1,192**	100.0%

3. Sample prevalence of blindness, severe (SVI), moderate (MVI) and early (EVI) visual impairment - bilateral PVA

	Males		Females		Total	
	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)
Blindness	19	3.6 (2.2 - 4.9)	14	2.1 (1.1 - 3.2)	33	2.8 (1.9 - 3.7)
Severe VI	13	2.4 (1.2 - 3.7)	5	0.8 (0.2 - 1.4)	18	1.5 (0.9 - 2.2)
Moderate VI	34	6.4 (4.9 - 7.8)	39	5.9 (3.7 - 8.1)	73	6.1 (4.6 - 7.6)
Early VI	46	8.6 (5.8 - 11.4)	38	5.8 (3.8 - 7.8)	84	7.1 (5.3 - 8.8)
Functional Low Vision	6	1.1 (0.3 - 1.9)	3	0.5 (0.0 - 1.0)	9	0.8 (0.3 - 1.2)

4. Extrapolated magnitude of blindness, severe (SVI), moderate (MVI) and early (EVI) visual impairment - bilateral PVA

	Males		Females		Total	
	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)
Blindness	606	3.4 (2.1 - 4.7)	377	3.0 (2.0 - 4.1)	983	3.3 (2.4 - 4.1)
Severe VI	407	2.3 (1.0 - 3.6)	90	0.7 (0.1 - 1.3)	497	1.7 (1.0 - 2.3)
Moderate VI	1,081	6.1 (4.7 - 7.5)	1,016	8.2 (6.0 - 10.3)	2,098	7.0 (5.5 - 8.5)
Early VI	1,489	8.4 (5.6 - 11.3)	877	7.0 (5.1 - 9.0)	2,366	7.8 (6.1 - 9.6)
Functional Low Vision	193	1.1 (0.3 - 1.9)	99	0.8 (0.3 - 1.3)	292	1.0 (0.5 - 1.4)

5. Blindness prevalence (PVA<3/60 in better eye) by age group

	Males		Females		Total	
	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)
50 - 59 years	5	1.5 (0.0 - 2.9)	5	1.0 (0.2 - 1.8)	10	1.2 (0.4 - 1.9)
60 - 69 years	8	6.0 (2.5 - 9.4)	6	4.5 (0.8 - 8.1)	14	5.2 (2.7 - 7.7)
70 - 79 years	4	8.7 (1.0 - 16.4)	1	4.6 (0.0 - 12.8)	5	7.4 (2.4 - 12.3)
80+ years	2	20.0 (0.0 - 43.3)	2	40.0 (0.0 - 83.8)	4	26.7 (4.2 - 49.1)
All 50+ years	19	3.6 (2.2 - 4.9)	14	2.1 (1.1 - 3.2)	33	2.8 (1.9 - 3.7)

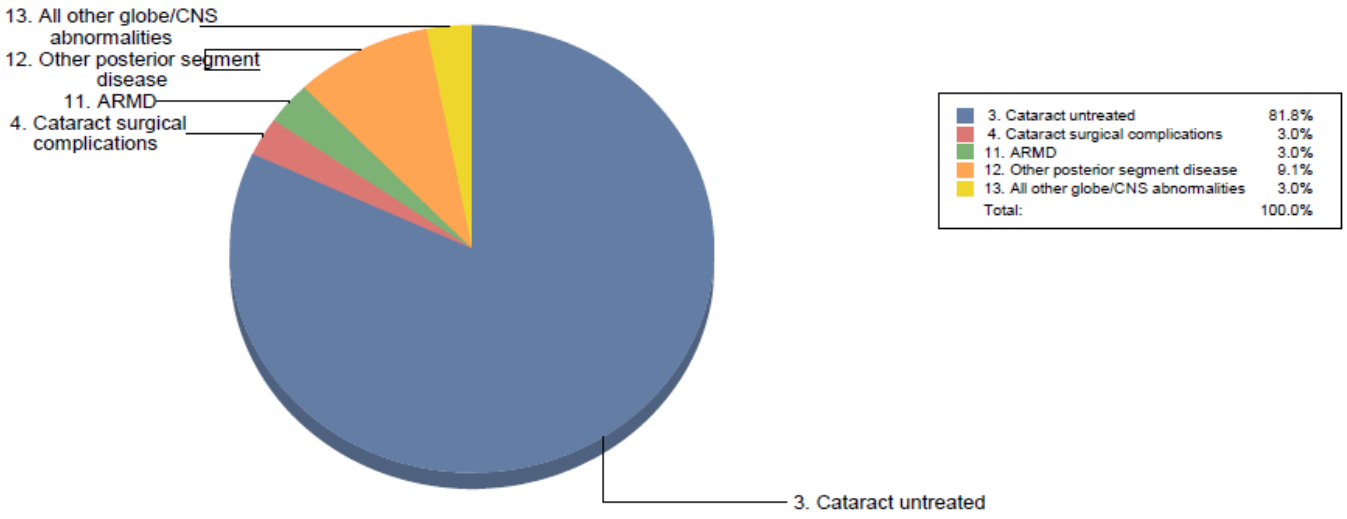
6. Principal cause of blindness, severe (SVI), moderate (MVI) and early (EVI) visual impairment in persons (PVA)

	Blindness		Severe VI		Moderate VI		Early VI	
	n	%	n	%	n	%	n	%
1. Refractive error	0	0.0%	1	5.6%	19	26.0%	49	58.3%
2. Aphakia uncorrected	0	0.0%	0	0.0%	0	0.0%	0	0.0%
3. Cataract untreated	27	81.8%	14	77.8%	43	58.9%	23	27.4%
4. Cataract surgical complications	1	3.0%	0	0.0%	1	1.4%	0	0.0%
5. Trachomatous corneal opacity	0	0.0%	0	0.0%	0	0.0%	0	0.0%
6. Non Trachomatous corneal opacity	0	0.0%	0	0.0%	0	0.0%	0	0.0%
7. Phthisis	0	0.0%	0	0.0%	0	0.0%	0	0.0%
8. Onchocerciasis	0	0.0%	0	0.0%	0	0.0%	0	0.0%
9. Glaucoma	0	0.0%	0	0.0%	0	0.0%	0	0.0%
10. Diabetic retinopathy	0	0.0%	0	0.0%	0	0.0%	0	0.0%
11. ARMD	1	3.0%	0	0.0%	0	0.0%	1	1.2%
12. Other posterior segment disease	3	9.1%	3	16.7%	10	13.7%	11	13.1%
13. All other globe/CNS abnormalities	1	3.0%	0	0.0%	0	0.0%	0	0.0%
Total	**33**	**100.0%**	**18**	**100.0%**	**73**	**100.0%**	**84**	**100.0%**

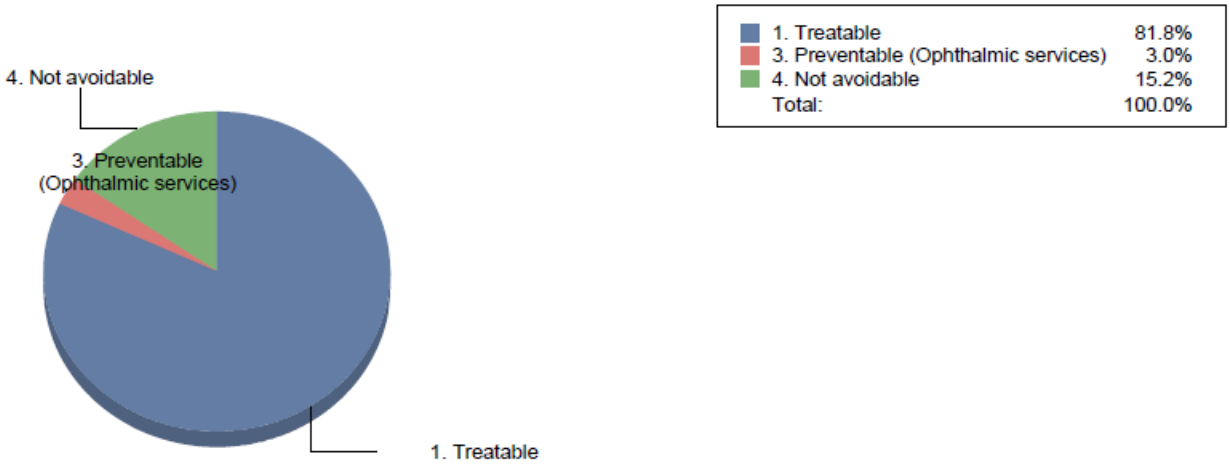
Blindness, SVI, MVI and EVI in persons by intervention category

A. Treatable (1,2,3)	27	81.8%	15	83.3%	62	84.9%	72	85.7%
B. Preventable (PHC/PEC services) (5,6,7,8)	0	0.0%	0	0.0%	0	0.0%	0	0.0%
C. Preventable (Ophthalmic services) (4,9,10)	1	3.0%	0	0.0%	1	1.4%	0	0.0%
D. Avoidable (A+B+C)	28	84.9%	15	83.3%	63	86.3%	72	85.7%
E. Posterior segment causes (8,9,10,11,12)	4	12.1%	3	16.7%	10	13.7%	12	14.3%

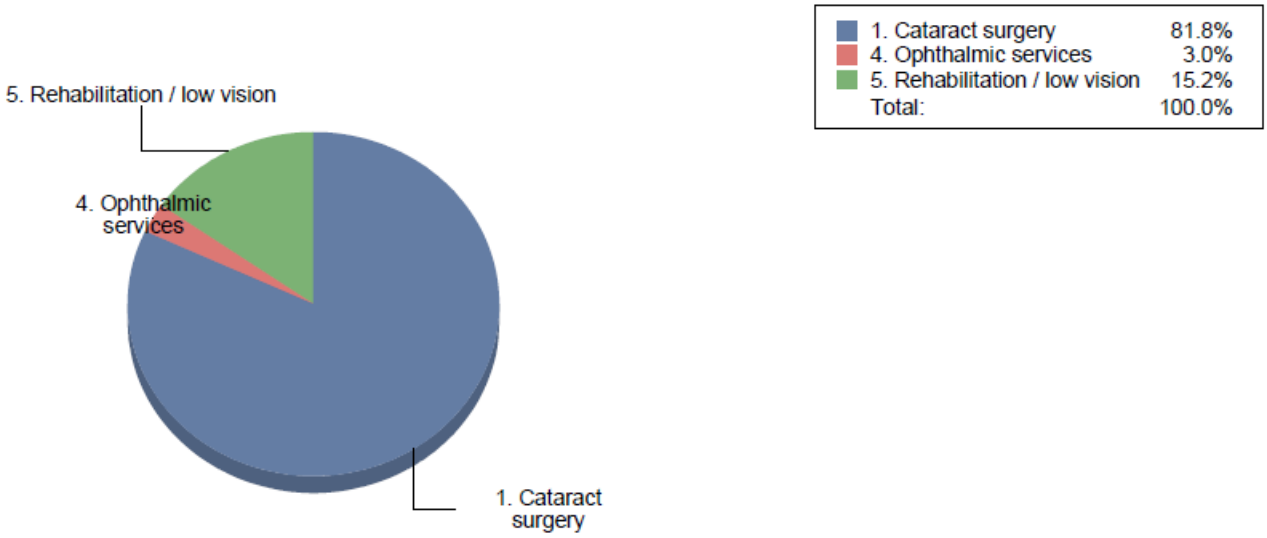
7. Graph: main cause of blindness in persons



8. Graph: main category of blindness in persons



9. Graph: action required to reduce blindness



10. Cataract surgical coverage (persons) - percentage

	Males	Females	Total
VA < 3/60	50.0	42.9	46.7
VA < 6/60	38.1	33.3	35.9
VA < 6/18	27.8	18.2	23.2

11. Barriers to cataract surgery - bilateral VA<6/60 due to cataract

	Males		Females		Total	
	n	%	n	%	n	%
Need not felt	8	44.4%	6	40.0%	**14**	**42.4%**
Fear	4	22.2%	1	6.7%	**5**	**15.2%**
Cost	3	16.7%	2	13.3%	**5**	**15.2%**
Treatment denied by provider	0	0.0%	0	0.0%	**0**	**0.0%**
Unaware treatment is possible	3	16.7%	6	40.0%	**9**	**27.3%**
Cannot access treatment	0	0.0%	0	0.0%	**0**	**0.0%**
Local reason	0	0.0%	0	0.0%	**0**	**0.0%**
Total	**18**	**100.0%**	**15**	**100.0%**	**33**	**100.0%**

12. Outcome after cataract surgery with available correction (eyes)

	Males		Females		Total	
	n	%	n	%	n	%
Very good: can see 6/12	8	33.3%	5	45.5%	13	37.1%
Good: can see 6/18	4	16.7%	0	0.0%	4	11.4%
Borderline: can see 6/60	4	16.7%	1	9.1%	5	14.3%
Poor: cannot see 6/60	8	33.3%	5	45.5%	13	37.1%
Total	**24**	**100.0%**	**11**	**100.0%**	**35**	**100.0%**

13. Outcome by type of cataract surgery with available correction (eyes)

	IOL		Total	
	n	%	n	%
Very good: can see 6/12	13	37.1%	13	37.1%
Good: can see 6/18	4	11.4%	4	11.4%
Borderline: can see 6/60	5	14.3%	5	14.3%
Poor: cannot see 6/60	13	37.1%	13	37.1%
Total	**35**	**100.0%**	**35**	**100.0%**

14. Cause of PVA<6/12 (good, borderline and poor outcome) after cataract surgery

	Selection		Surgery		Spectacles		Sequelae		Can see 6/12	
	n	%	n	%	n	%	n	%	n	%
Very good: can see 6/12	0	0.0%	0	0.0%	0	0.0%	0	0.0%	13	100.0%
Good: can see 6/18	1	50.0%	1	9.1%	2	50.0%	0	0.0%	0	0.0%
Borderline: can see 6/60	1	50.0%	1	9.1%	2	50.0%	1	20.0%	0	0.0%
Poor: cannot see 6/60	0	0.0%	9	81.8%	0	0.0%	4	80.0%	0	0.0%
Total	**2**	**100.0%**	**11**	**100.0%**	**4**	**100.0%**	**5**	**100.0%**	**13**	**100.0%**

RESULTS OF RAPID ASSESSMENT OF AVOIDABLE BLINDNESS

SUMMARY REPORT

Date and time of report:	27/06/2017	3:27:42 PM
This report is for the survey area:	Highlands	
Year and month when survey was conducted:	2017- 1 until 2017- 3	

This report shows the most important results from all the other reports. The 95% confidence interval (95% CI) is based on the sampling error in cluster sampling. More detailed information is provided in the other reports.

1. Eligible persons, coverage, absentees and refusals

	Examined		Not available		Refused		Not capable		Total	
	n	%	n	%	n	%	n	%	n	%
Males	717	96.4%	5	0.7%	22	3.0%	0	0.0%	744	100.0%
Females	488	96.4%	2	0.4%	15	3.0%	1	0.2%	506	100.0%
Total	**1,205**	96.4%	7	0.6%	37	3.0%	**1**	0.1%	**1,250**	100.0%

2. Age and gender distribution of people examined in the sample

	Males		Females		Total	
	n	%	n	%	n	%
50 - 59 years	364	50.8%	311	63.7%	675	56.0%
60 - 69 years	224	31.2%	141	28.9%	365	30.3%
70 - 79 years	101	14.1%	22	4.5%	123	10.2%
80+ years	28	3.9%	14	2.9%	42	3.5%
Total	**717**	**100.0%**	**488**	**100.0%**	**1,205**	**100.0%**

3. Sample prevalence of blindness, severe (SVI), moderate (MVI) and early (EVI) visual impairment - bilateral

	Males		Females		Total	
	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)
Blindness	55	7.7 (5.2 - 10.2)	49	10.0 (7.1 - 13.0)	104	8.6 (6.4 - 10.8)
Severe VI	30	4.2 (2.3 - 6.1)	16	3.3 (1.6 - 5.0)	46	3.8 (2.5 - 5.1)
Moderate VI	83	11.6 (9.6 - 13.6)	48	9.8 (6.7 - 13.0)	131	10.9 (9.0 - 12.8)
Early VI	61	8.5 (6.8 - 10.2)	28	5.7 (4.0 - 7.5)	89	7.4 (6.0 - 8.7)
Functional Low	8	1.1 (0.4 - 1.9)	3	0.6 (0.0 - 1.3)	11	0.9 (0.3 - 1.5)

4. Extrapolated magnitude of blindness, severe (SVI), moderate (MVI) and early (EVI) visual impairment - bilateral PVA

	Males		Females		Total	
	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)
Blindness	11,963	6.6 (4.1 - 9.1)	15,480	11.1 (8.1 - 14.0)	27,441	8.5 (6.4 - 10.7)
Severe VI	6,914	3.8 (1.9 - 5.7)	5,225	3.7 (2.1 - 5.4)	12,138	3.8 (2.5 - 5.1)
Moderate VI	19,450	10.7 (8.7 - 12.7)	15,021	10.7 (7.6 - 13.8)	34,467	10.7 (8.8 - 12.6)
Early VI	14,615	8.1 (6.4 - 9.7)	8,140	5.8 (4.1 - 7.6)	22,753	7.1 (5.7 - 8.4)
Functional Low	1,875	1.0 (0.3 - 1.8)	795	0.6 (0.0 - 1.2)	2,670	0.8 (0.3 - 1.4)

5. Blindness prevalence (PVA<3/60 in better eye) by age group

	Males		Females		Total	
	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)
50 - 59 years	8	2.2 (0.3 - 4.1)	10	3.2 (0.4 - 6.0)	18	2.7 (0.7 - 4.7)
60 - 69 years	15	6.7 (3.2 - 10.2)	22	15.6 (9.3 - 21.9)	37	10.1 (6.2 - 14.1)
70 - 79 years	22	21.8 (13.4 -	8	36.4 (14.0 - 58.7)	30	24.4 (17.0 - 31.8)
80+ years	10	35.7 (21.2 -	9	64.3 (44.4 - 84.2)	19	45.2 (33.0 - 57.5)
All 50+ years	55	7.7 (5.2 - 10.2)	49	10.0 (7.1 - 13.0)	104	8.6 (6.4 - 10.8)

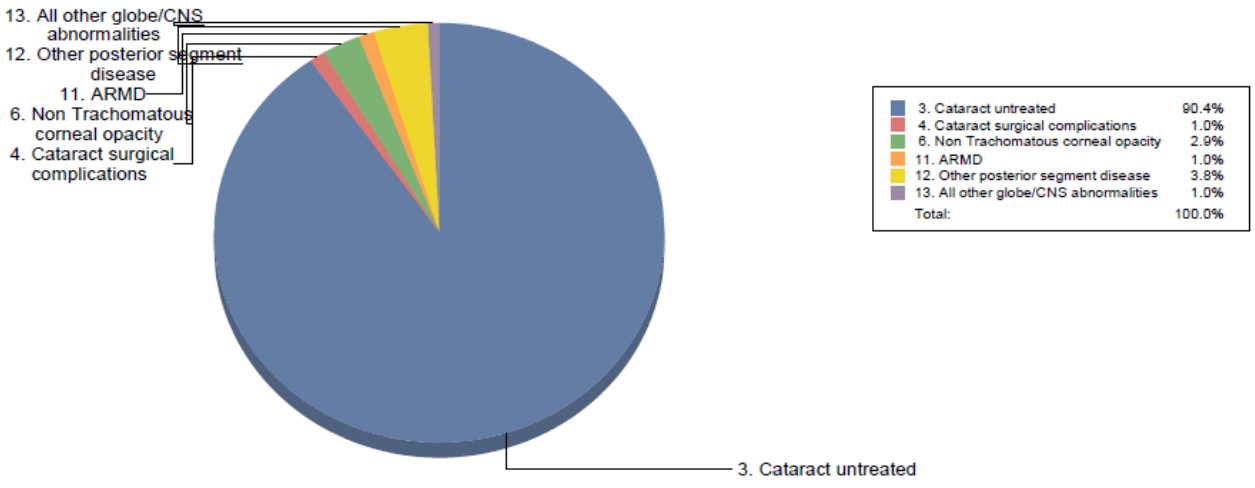
6. Principal cause of blindness, severe (SVI), moderate (MVI) and early (EVI) visual impairment in persons (PVA)

	Blindness		Severe VI		Moderate VI		Early VI	
	n	%	n	%	n	%	n	%
1. Refractive error	0	0.0%	0	0.0%	11	8.4%	33	37.1%
2. Aphakia uncorrected	0	0.0%	0	0.0%	0	0.0%	0	0.0%
3. Cataract untreated	94	90.4%	44	95.7%	109	83.2%	46	51.7%
4. Cataract surgical complications	1	1.0%	0	0.0%	2	1.5%	3	3.4%
5. Trachomatous corneal opacity	0	0.0%	0	0.0%	0	0.0%	0	0.0%
6. Non Trachomatous corneal opacity	3	2.9%	1	2.2%	0	0.0%	0	0.0%
7. Phthisis	0	0.0%	1	2.2%	0	0.0%	0	0.0%
8. Onchocerciasis	0	0.0%	0	0.0%	0	0.0%	0	0.0%
9. Glaucoma	0	0.0%	0	0.0%	0	0.0%	0	0.0%
10. Diabetic retinopathy	0	0.0%	0	0.0%	0	0.0%	0	0.0%
11. ARMD	1	1.0%	0	0.0%	2	1.5%	0	0.0%
12. Other posterior segment disease	4	3.8%	0	0.0%	7	5.3%	7	7.9%
13. All other globe/CNS abnormalities	1	1.0%	0	0.0%	0	0.0%	0	0.0%
Total	**104**	**100.0%**	**46**	**100.0%**	**131**	**100.0%**	**89**	**100.0%**

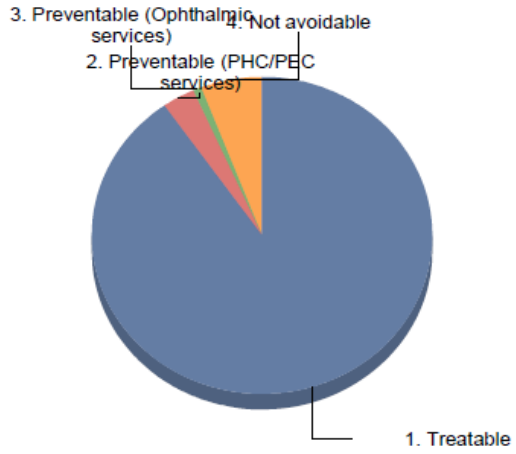
Blindness, SVI, MVI and EVI in persons by intervention category

A. Treatable (1,2,3)	94	90.4%	44	95.7%	120	91.6%	79	88.8%
B. Preventable (PHC/PEC services) (5,6,7,8)	3	2.9%	2	4.4%	0	0.0%	0	0.0%
C. Preventable (Ophthalmic services) (4,9,10)	1	1.0%	0	0.0%	2	1.5%	3	3.4%
D. Avoidable (A+B+C)	98	94.2%	46	100.0%	122	93.1%	82	92.1%
E. Posterior segment causes (8,9,10,11,12)	5	4.8%	0	0.0%	9	6.9%	7	7.9%

7. Graph: main cause of blindness in persons

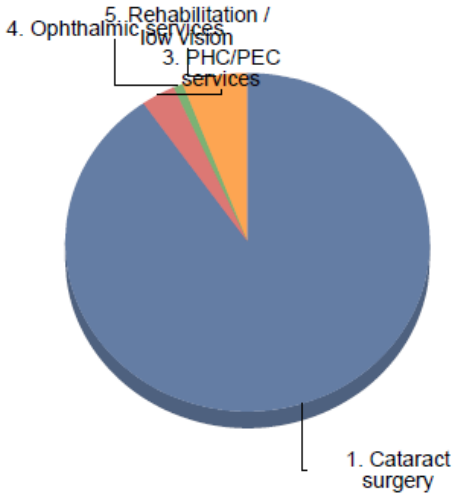


8. Graph: main category of blindness in persons



1. Treatable	90.4%
2. Preventable (PHC/PEC services)	2.9%
3. Preventable (Ophthalmic services)	1.0%
4. Not avoidable	5.8%
Total:	100.0%

9. Graph: action required to reduce blindness



1. Cataract surgery	90.4%
3. PHC/PEC services	2.9%
4. Ophthalmic services	1.0%
5. Rehabilitation / low vision	5.8%
Total:	100.0%

10. Cataract surgical coverage (persons) - percentage

	Males	Females	Total
VA < 3/60	30.5	11.5	21.6
VA < 6/60	25.0	9.2	18.1
VA < 6/18	18.5	6.5	13.6

11. Barriers to cataract surgery - bilateral VA<6/60 due to cataract

	Males		Females		Total	
	n	%	n	%	n	%
Need not felt	42	33.3%	51	43.2%	93	38.1%
Fear	0	0.0%	0	0.0%	0	0.0%
Cost	12	9.5%	3	2.5%	15	6.1%
Treatment denied by provider	0	0.0%	0	0.0%	0	0.0%
Unaware treatment is possible	49	38.9%	55	46.6%	104	42.6%
Cannot access treatment	23	18.3%	9	7.6%	32	13.1%
Local reason	0	0.0%	0	0.0%	0	0.0%
Total	**126**	**100.0%**	**118**	**100.0%**	**244**	**100.0%**

12. Outcome after cataract surgery with available correction (eyes)

	Males		Females		Total	
	n	%	n	%	n	%
Very good: can see 6/12	10	26.3%	2	18.2%	12	24.5%
Good: can see 6/18	3	7.9%	4	36.4%	7	14.3%
Borderline: can see 6/60	10	26.3%	2	18.2%	12	24.5%
Poor: cannot see 6/60	15	39.5%	3	27.3%	18	36.7%
Total	**38**	**100.0%**	**11**	**100.0%**	**49**	**100.0%**

13. Outcome by type of cataract surgery with available correction (eyes)

	Non-IOL		IOL		Total	
	n	%	n	%	n	%
Very good: can see 6/12	0	0.0%	12	26.7%	**12**	**24.5%**
Good: can see 6/18	1	25.0%	6	13.3%	**7**	**14.3%**
Borderline: can see 6/60	1	25.0%	11	24.4%	**12**	**24.5%**
Poor: cannot see 6/60	2	50.0%	16	35.6%	**18**	**36.7%**
Total	**4**	**100.0%**	**45**	**100.0%**	**49**	**100.0%**

14. Cause of PVA<6/12 (good, borderline and poor outcome) after cataract surgery

	Selection		Surgery		Sequelae		Can see 6/12	
	n	%	n	%	n	%	n	%
Very good: can see 6/12	0	0.0%	0	0.0%	0	0.0%	12	100.0%
Good: can see 6/18	0	0.0%	0	0.0%	7	33.3%	0	0.0%
Borderline: can see 6/60	0	0.0%	4	44.4%	8	38.1%	0	0.0%
Poor: cannot see 6/60	7	100.0%	5	55.6%	6	28.6%	0	0.0%
Total	**7**	**100.0%**	**9**	**100.0%**	**21**	**100.0%**	**12**	**100.0%**

RESULTS OF RAPID ASSESSMENT OF AVOIDABLE BLINDNESS

SUMMARY REPORT

Date and time of report: 27/06/2017 3:08:40 PM

This report is for the survey area: Coastal

Year and month when survey was conducted: 2017- 2 until 2017- 4

This report shows the most important results from all the other reports. The 95% confidence interval (95% CI) is based on the sampling error in cluster sampling. More detailed information is provided in the other reports.

1. Eligible persons, coverage, absentees and refusals

	Examined		Not available		Refused		Not capable		Total	
	n	%	n	%	n	%	n	%	n	%
Males	627	99.4%	1	0.2%	3	0.5%	0	0.0%	631	100.0%
Females	615	99.4%	1	0.2%	2	0.3%	1	0.2%	619	100.0%
Total	**1,242**	99.4%	**2**	0.2%	**5**	0.4%	**1**	0.1%	**1,250**	100.0%

2. Age and gender distribution of people examined in the sample

	Males		Females		Total	
	n	%	n	%	n	%
50 - 59 years	308	49.1%	287	46.7%	595	47.9%
60 - 69 years	180	28.7%	188	30.6%	368	29.6%
70 - 79 years	104	16.6%	96	15.6%	200	16.1%
80+ years	35	5.6%	44	7.2%	79	6.4%
Total	**627**	**100.0%**	**615**	**100.0%**	**1,242**	**100.0%**

3. Sample prevalence of blindness, severe (SVI), moderate (MVI) and early (EVI) visual impairment -

	Males		Females		Total	
	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)
Blindness	26	4.2 (2.7 - 5.6)	41	6.7 (4.6 - 8.7)	67	5.4 (4.2 - 6.6)
Severe VI	20	3.2 (1.7 - 4.6)	23	3.7 (1.6 - 5.8)	43	3.5 (2.1 - 4.8)
Moderate VI	90	14.4 (10.8 - 17.9)	111	18.1 (13.6 - 22.5)	201	16.2 (13.1 - 19.3)
Early VI	56	8.9 (6.1 - 11.8)	51	8.3 (5.4 - 11.2)	107	8.6 (6.4 - 10.9)
Functional Low	8	1.3 (0.3 - 2.3)	5	0.8 (0.2 - 1.5)	13	1.1 (0.5 - 1.6)

4. Extrapolated magnitude of blindness, severe (SVI), moderate (MVI) and early (EVI) visual impairment - bilateral PVA

	Males		Females		Total	
	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)
Blindness	4,439	3.4 (2.0 - 4.8)	6,045	5.1 (3.1 - 7.2)	10,484	4.2 (3.0 - 5.5)
Severe VI	3,818	2.9 (1.5 - 4.4)	3,577	3.0 (0.9 - 5.1)	7,395	3.0 (1.7 - 4.3)
Moderate VI	16,233	12.5 (8.9 - 16.0)	18,576	15.7 (11.3 - 20.2)	34,807	14.0 (10.9 - 17.1)
Early VI	10,800	8.3 (5.5 - 11.1)	8,922	7.6 (4.7 - 10.4)	19,721	7.9 (5.7 - 10.2)
Functional Low	1,615	1.2 (0.3 - 2.2)	961	0.8 (0.2 - 1.5)	2,576	1.0 (0.5 - 1.6)

5. Blindness prevalence (PVA<3/60 in better eye) by age group

	Males		Females		Total	
	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)
50 - 59 years	3	1.0 (0.0 - 2.0)	5	1.7 (0.0 - 3.4)	8	1.3 (0.5 - 2.2)
60 - 69 years	8	4.4 (1.2 - 7.7)	10	5.3 (2.8 - 7.8)	18	4.9 (2.8 - 7.0)
70 - 79 years	8	7.7 (2.6 - 12.8)	15	15.6 (7.4 - 23.8)	23	11.5 (7.0 - 16.0)
80+ years	7	20.0 (8.5 - 31.5)	11	25.0 (14.8 - 35.2)	18	22.8 (15.7 - 29.9)
All 50+ years	26	4.2 (2.7 - 5.6)	41	6.7 (4.6 - 8.7)	67	5.4 (4.2 - 6.6)

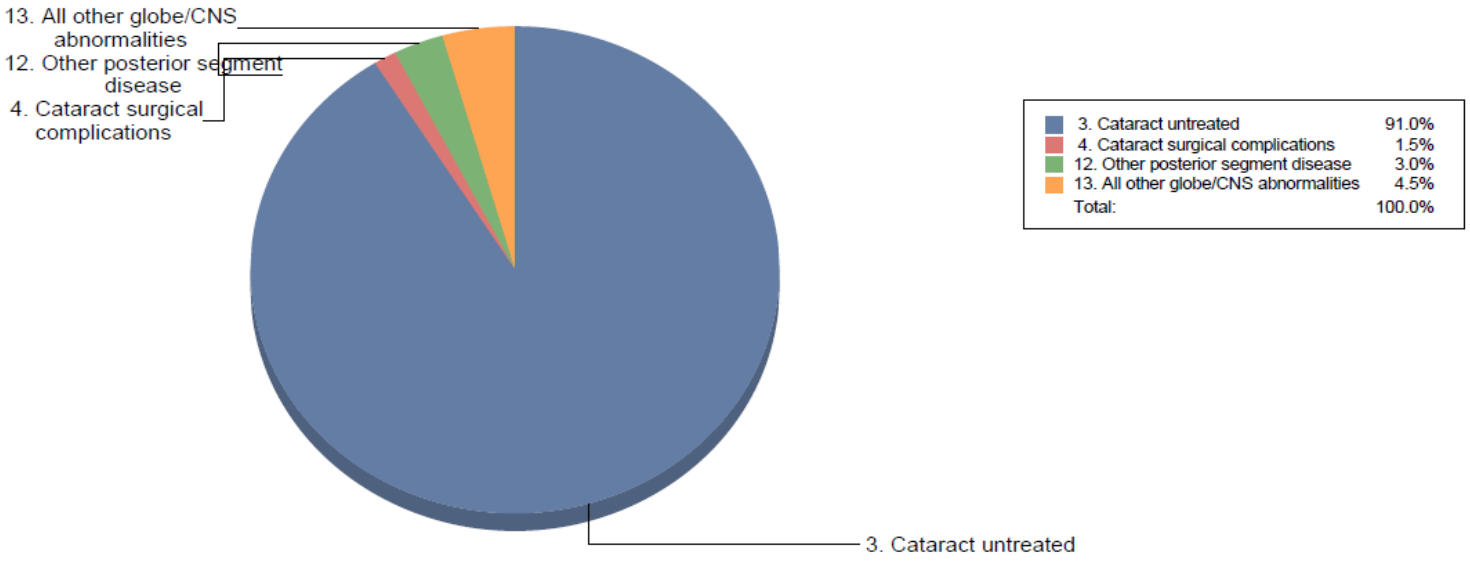
6. Principal cause of blindness, severe (SVI), moderate (MVI) and early (EVI) visual impairment in persons (PVA)

	Blindness		Severe VI		Moderate VI		Early VI	
	n	%	n	%	n	%	n	%
1. Refractive error	0	0.0%	0	0.0%	38	18.9%	48	44.9%
2. Aphakia uncorrected	0	0.0%	0	0.0%	0	0.0%	0	0.0%
3. Cataract untreated	61	91.0%	39	90.7%	154	76.6%	52	48.6%
4. Cataract surgical complications	1	1.5%	0	0.0%	3	1.5%	0	0.0%
5. Trachomatous corneal opacity	0	0.0%	0	0.0%	0	0.0%	0	0.0%
6. Non Trachomatous corneal opacity	0	0.0%	1	2.3%	0	0.0%	0	0.0%
7. Phthisis	0	0.0%	0	0.0%	0	0.0%	0	0.0%
8. Onchocerciasis	0	0.0%	0	0.0%	0	0.0%	0	0.0%
9. Glaucoma	0	0.0%	0	0.0%	0	0.0%	0	0.0%
10. Diabetic retinopathy	0	0.0%	0	0.0%	0	0.0%	0	0.0%
11. ARMD	0	0.0%	0	0.0%	1	0.5%	1	0.9%
12. Other posterior segment disease	2	3.0%	1	2.3%	5	2.5%	6	5.6%
13. All other globe/CNS abnormalities	3	4.5%	2	4.7%	0	0.0%	0	0.0%
Total	**67**	**100.0%**	**43**	**100.0%**	**201**	**100.0%**	**107**	**100.0%**

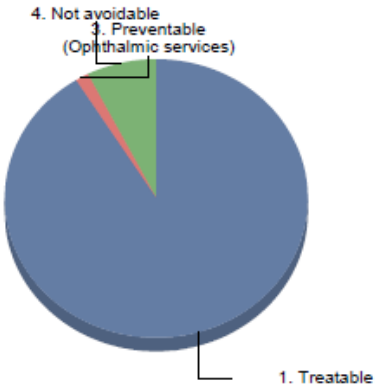
Blindness, SVI, MVI and EVI in persons by intervention category

A. Treatable (1,2,3)	61	91.0%	39	90.7%	192	95.5%	100	93.5%
B. Preventable (PHC/PEC services) (5,6,7,8)	0	0.0%	1	2.3%	0	0.0%	0	0.0%
C. Preventable (Ophthalmic services) (4,9,10)	1	1.5%	0	0.0%	3	1.5%	0	0.0%
D. Avoidable (A+B+C)	62	92.5%	40	93.0%	195	97.0%	100	93.5%
E. Posterior segment causes (8,9,10,11,12)	2	3.0%	1	2.3%	6	3.0%	7	6.5%

7. Graph: main cause of blindness in persons

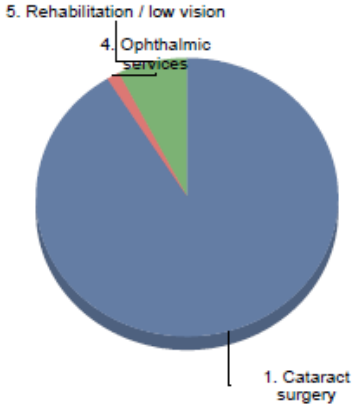


8. Graph: main category of blindness in persons



1. Treatable	91.0%
3. Preventable (Ophthalmic services)	1.5%
4. Not avoidable	7.5%
Total:	100.0%

9. Graph: action required to reduce blindness



1. Cataract surgery	91.0%
4. Ophthalmic services	1.5%
5. Rehabilitation / low vision	7.5%
Total:	100.0%

10. Cataract surgical coverage (persons) - percentage

	Males	Females	Total
VA < 3/60	42.4	34.0	37.5
VA < 6/60	38.5	28.6	32.6
VA < 6/18	23.5	14.8	18.8

11. Barriers to cataract surgery - bilateral VA<6/60 due to cataract

	Males		Females		Total	
	n	%	n	%	n	%
Need not felt	3	10.0%	10	20.0%	13	16.3%
Fear	0	0.0%	1	2.0%	1	1.3%
Cost	13	43.3%	15	30.0%	28	35.0%
Treatment denied by provider	0	0.0%	0	0.0%	0	0.0%
Unaware treatment is possible	3	10.0%	8	16.0%	11	13.8%
Cannot access treatment	11	36.7%	16	32.0%	27	33.8%
Local reason	0	0.0%	0	0.0%	0	0.0%
Total	**30**	**100.0%**	**50**	**100.0%**	**80**	**100.0%**

12. Outcome after cataract surgery with available correction (eyes)

	Males		Females		Total	
	n	%	n	%	n	%
Very good: can see 6/12	18	42.9%	15	45.5%	33	44.0%
Good: can see 6/18	7	16.7%	4	12.1%	11	14.7%
Borderline: can see 6/60	8	19.0%	8	24.2%	16	21.3%
Poor: cannot see 6/60	9	21.4%	6	18.2%	15	20.0%
Total	**42**	**100.0%**	**33**	**100.0%**	**75**	**100.0%**

13. Outcome by type of cataract surgery with available correction (eyes)

	Non-IOL		IOL		Total	
	n	%	n	%	n	%
Very good: can see 6/12	0	0.0%	33	44.6%	**33**	**44.0%**
Good: can see 6/18	0	0.0%	11	14.9%	**11**	**14.7%**
Borderline: can see 6/60	0	0.0%	16	21.6%	**16**	**21.3%**
Poor: cannot see 6/60	1	100.0%	14	18.9%	**15**	**20.0%**
Total	**1**	**100.0%**	**74**	**100.0%**	75	100.0%

14. Cause of PVA<6/12 (good, borderline and poor outcome) after cataract surgery

	Selection		Surgery		Spectacles		Sequelae		Can see 6/12	
	n	%	n	%	n	%	n	%	n	%
Very good: can see 6/12	0	0.0%	0	0.0%	0	0.0%	0	0.0%	33	100.0%
Good: can see 6/18	1	50.0%	0	0.0%	4	66.7%	6	21.4%	0	0.0%
Borderline: can see 6/60	1	50.0%	4	66.7%	2	33.3%	9	32.1%	0	0.0%
Poor: cannot see 6/60	0	0.0%	2	33.3%	0	0.0%	13	46.4%	0	0.0%
Total	**2**	**100.0%**	**6**	**100.0%**	**6**	**100.0%**	**28**	**100.0%**	**33**	**100.0%**

RESULTS OF RAPID ASSESSMENT OF AVOIDABLE BLINDNESS

SUMMARY REPORT

Date and time of report:	27/06/2017 3:54:40 PM
This report is for the survey area:	Islands
Year and month when survey was conducted:	2017- 1 until 2017- 4

This report shows the most important results from all the other reports. The 95% confidence interval (95% CI) is based on the sampling error in cluster sampling. More detailed information is provided in the other reports.

1. Eligible persons, coverage, absentees and refusals

	Examined		Not available		Refused		Not capable		Total	
	n	%	n	%	n	%	n	%	n	%
Males	599	93.4%	27	4.2%	12	1.9%	3	0.5%	**641**	**100.0%**
Females	580	95.2%	20	3.3%	7	1.1%	2	0.3%	**609**	**100.0%**
Total	**1,179**	94.3%	**47**	3.8%	**19**	1.5%	5	0.4%	**1,250**	**100.0%**

2. Age and gender distribution of people examined in the sample

	Males		Females		Total	
	n	%	n	%	n	%
50 - 59 years	293	48.9%	321	55.3%	**614**	**52.1%**
60 - 69 years	181	30.2%	148	25.5%	**329**	**27.9%**
70 - 79 years	86	14.4%	72	12.4%	**158**	**13.4%**
80+ years	39	6.5%	39	6.7%	**78**	**6.6%**
Total	**599**	**100.0%**	**580**	**100.0%**	**1,179**	**100.0%**

3. Sample prevalence of blindness, severe (SVI), moderate (MVI) and early (EVI) visual impairment - bilateral PVA

	Males		Females		Total	
	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)
Blindness	6	1.0 (0.0 - 2.0)	15	2.6 (1.4 - 3.8)	21	1.8 (1.1 - 2.5)
Severe VI	7	1.2 (0.4 - 1.9)	8	1.4 (0.5 - 2.3)	15	1.3 (0.6 - 1.9)
Moderate VI	41	6.8 (4.5 - 9.2)	46	7.9 (5.3 - 10.6)	87	7.4 (5.6 - 9.1)
Early VI	46	7.7 (5.3 - 10.1)	39	6.7 (4.4 - 9.0)	85	7.2 (5.2 - 9.2)
Functional Low Vision	6	1.0 (0.0 - 2.1)	6	1.0 (0.2 - 1.9)	12	1.0 (0.2 - 1.8)

4. Extrapolated magnitude of blindness, severe (SVI), moderate (MVI) and early (EVI) visual impairment - bilateral PVA

	Males		Females		Total	
	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)
Blindness	487	0.7 (0.0 - 1.7)	1,352	2.2 (1.0 - 3.4)	1,839	1.4 (0.7 - 2.1)
Severe VI	721	1.0 (0.3 - 1.8)	769	1.3 (0.3 - 2.2)	1,489	1.1 (0.5 - 1.8)
Moderate VI	3,908	5.6 (3.3 - 8.0)	4,185	6.9 (4.3 - 9.5)	8,092	6.2 (4.5 - 8.0)
Early VI	4,555	6.6 (4.2 - 8.9)	3,744	6.2 (3.9 - 8.5)	8,299	6.4 (4.4 - 8.4)
Functional Low Vision	640	0.9 (0.0 - 2.0)	534	0.9 (0.0 - 1.8)	1,175	0.9 (0.1 - 1.7)

5. Blindness prevalence (PVA<3/60 in better eye) by age group

	Males		Females		Total	
	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)
50 - 59 years	0	0.0 (0.0 - 0.0)	1	0.3 (0.0 - 0.9)	1	0.2 (0.0 - 0.5)
60 - 69 years	1	0.6 (0.0 - 1.7)	3	2.0 (0.0 - 4.3)	4	1.2 (0.0 - 2.4)
70 - 79 years	2	2.3 (0.0 - 5.3)	7	9.7 (3.1 - 16.3)	9	5.7 (1.8 - 9.6)
80+ years	3	7.7 (0.0 - 18.9)	4	10.3 (1.4 - 19.2)	7	9.0 (2.0 - 15.9)
All 50+ years	6	1.0 (0.0 - 2.0)	15	2.6 (1.4 - 3.8)	21	1.8 (1.1 - 2.5)

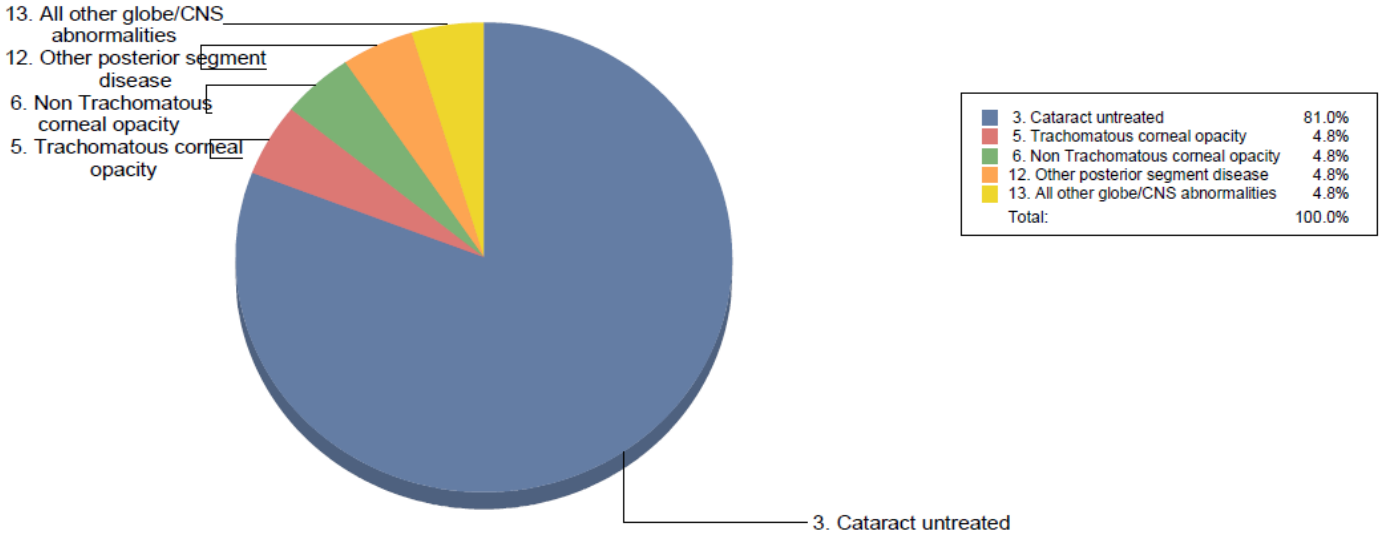
6. Principal cause of blindness, severe (SVI), moderate (MVI) and early (EVI) visual impairment in persons (PVA)

	Blindness		Severe VI		Moderate VI		Early VI	
	n	%	n	%	n	%	n	%
1. Refractive error	0	0.0%	1	6.7%	24	27.6%	60	70.6%
2. Aphakia uncorrected	0	0.0%	0	0.0%	0	0.0%	0	0.0%
3. Cataract untreated	17	81.0%	11	73.3%	54	62.1%	9	10.6%
4. Cataract surgical complications	0	0.0%	1	6.7%	1	1.1%	0	0.0%
5. Trachomatous corneal opacity	1	4.8%	0	0.0%	0	0.0%	0	0.0%
6. Non Trachomatous corneal opacity	1	4.8%	0	0.0%	0	0.0%	0	0.0%
7. Phthisis	0	0.0%	0	0.0%	0	0.0%	0	0.0%
8. Onchocerciasis	0	0.0%	0	0.0%	0	0.0%	0	0.0%
9. Glaucoma	0	0.0%	0	0.0%	0	0.0%	0	0.0%
10. Diabetic retinopathy	0	0.0%	1	6.7%	0	0.0%	1	1.2%
11. ARMD	0	0.0%	1	6.7%	3	3.4%	8	9.4%
12. Other posterior segment disease	1	4.8%	0	0.0%	5	5.7%	7	8.2%
13. All other globe/CNS abnormalities	1	4.8%	0	0.0%	0	0.0%	0	0.0%
Total	**21**	**100.0%**	**15**	**100.0%**	**87**	**100.0%**	**85**	**100.0%**

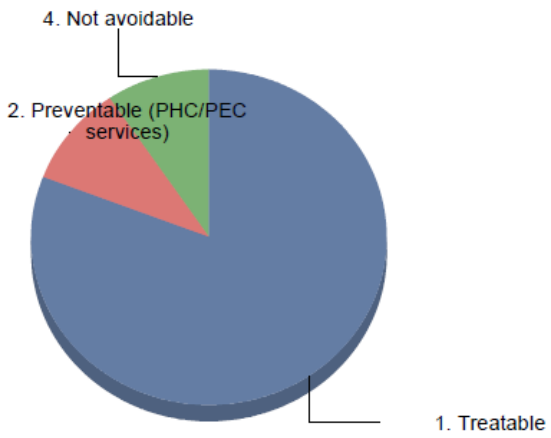
Blindness, SVI, MVI and EVI in persons by intervention category

A. Treatable (1,2,3)	17	81.0%	12	80.0%	78	89.7%	69	81.2%
B. Preventable (PHC/PEC services) (5,6,7,8)	2	9.5%	0	0.0%	0	0.0%	0	0.0%
C. Preventable (Ophthalmic services) (4,9,10)	0	0.0%	2	13.3%	1	1.2%	1	1.2%
D. Avoidable (A+B+C)	19	90.5%	14	93.3%	79	90.8%	70	82.4%
E. Posterior segment causes (8,9,10,11,12)	1	4.8%	2	13.3%	8	9.2%	16	18.8%

7. Graph: main cause of blindness in persons

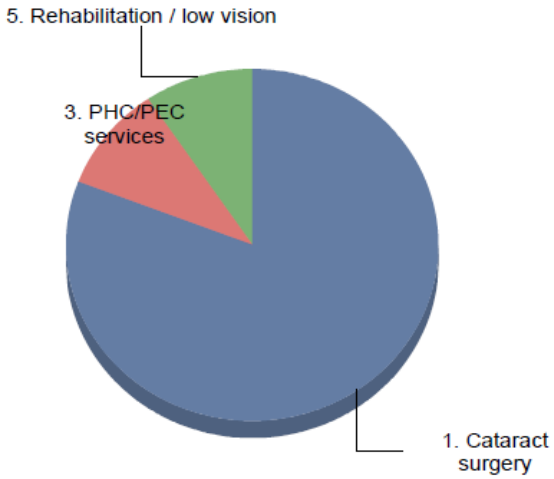


8. Graph: main category of blindness in persons



1. Treatable	81.0%
2. Preventable (PHC/PEC services)	9.5%
4. Not avoidable	9.5%
Total:	100.0%

9. Graph: action required to reduce blindness



1. Cataract surgery	81.0%
3. PHC/PEC services	9.5%
5. Rehabilitation / low vision	9.5%
Total:	100.0%

10. Cataract surgical coverage (persons) - percentage

	Males	Females	Total
VA < 3/60	81.0	60.0	74.2
VA < 6/60	78.3	46.7	65.8
VA < 6/18	59.5	37.0	50.0

11. Barriers to cataract surgery - bilateral VA<6/60 due to cataract

	Males		Females		Total	
	n	%	n	%	n	%
Need not felt	3	42.9%	3	27.3%	6	33.3%
Fear	0	0.0%	1	9.1%	1	5.6%
Cost	0	0.0%	1	9.1%	1	5.6%
Treatment denied by provider	0	0.0%	0	0.0%	0	0.0%
Unaware treatment is possible	2	28.6%	4	36.4%	6	33.3%
Cannot access treatment	2	28.6%	2	18.2%	4	22.2%
Local reason	0	0.0%	0	0.0%	0	0.0%
Total	**7**	**100.0%**	**11**	**100.0%**	**18**	**100.0%**

12. Outcome after cataract surgery with available correction (eyes)

	Males		Females		Total	
	n	%	n	%	n	%
Very good: can see 6/12	27	56.3%	8	42.1%	35	52.2%
Good: can see 6/18	7	14.6%	0	0.0%	7	10.4%
Borderline: can see 6/60	7	14.6%	4	21.1%	11	16.4%
Poor: cannot see 6/60	7	14.6%	7	36.8%	14	20.9%
Total	**48**	**100.0%**	**19**	**100.0%**	**67**	**100.0%**

13. Outcome by type of cataract surgery with available correction (eyes)

	Non-IOL		IOL		Total	
	n	%	n	%	n	%
Very good: can see 6/12	2	22.2%	33	57.9%	35	53.0%
Good: can see 6/18	1	11.1%	6	10.5%	7	10.6%
Borderline: can see 6/60	0	0.0%	11	19.3%	11	16.7%
Poor: cannot see 6/60	6	66.7%	7	12.3%	13	19.7%
Total	**9**	**100.0%**	**57**	**100.0%**	**66**	**100.0%**

14. Cause of PVA<6/12 (good, borderline and poor outcome) after cataract surgery

	Selection		Surgery		Spectacles		Sequelae		Can see 6/12	
	n	%	n	%	n	%	n	%	n	%
Very good: can see 6/12	0	0.0%	0	0.0%	0	0.0%	0	0.0%	35	100.0%
Good: can see 6/18	0	0.0%	1	12.5%	2	66.7%	4	23.5%	0	0.0%
Borderline: can see 6/60	0	0.0%	6	75.0%	1	33.3%	4	23.5%	0	0.0%
Poor: cannot see 6/60	4	100.0%	1	12.5%	0	0.0%	9	52.9%	0	0.0%
Total	**4**	**100.0%**	**8**	**100.0%**	**3**	**100.0%**	**17**	**100.0%**	**35**	**100.0%**

RESULTS OF RAPID ASSESSMENT OF AVOIDABLE BLINDNESS

FINDINGS ON DIABETES AND DIABETIC RETINOPATHY

Date and time of report: 12/07/2017 22:06:02

This report is for the survey area: NCD

Year and month when survey was conducted: 2017- 2 until 2017- 2

The diagnosis of diabetes is based on either a history of known diabetes, or, in case the person is not known with diabetes, on a random blood sugar of 200 mg/dl or higher.

1. Prevalence of known and newly diagnosed diabetes by age group and by gender

	Males		Females		Total	
	n	p (95% CI)	n	p (95% CI)	n	p (95% CI)
50 - 59	24	7.0% (3.9-10.0)	36	7.3% (4.3-10.2)	60	7.1% (4.9-9.4)
60 - 69	13	9.7% (4.5-14.9)	14	10.4% (4.5-16.4)	27	10.1% (5.8-14.3)
70 - 79	2	4.3% (0.0-9.4)	1	4.5% (0.0-12.8)	3	4.4% (0.2-8.7)
80+	2	20.0% (0.0-43.3)	1	20.0% (0.0-55.8)	3	20.0% (1.9-38.1)
All ages	41	7.7% (5.1-10.3)	52	7.9% (5.0-10.8)	93	7.8% (5.5-10.1)

2. Acceptance of random blood sugar test and DR examination

		Males		Females		Total	
		n	%	n	%	n	%
Full sample	Examined	535	92.6%	657	97.8%	1,192	95.4%
	Non-responders	43	7.4%	15	2.2%	58	4.6%
	Total	**578**	**100.0%**	**672**	**100.0%**	**1,250**	**100.0%**
Examined	RBG taken	532	99.4%	654	99.5%	1,186	99.5%
	RBG refused	3	0.6%	3	0.5%	6	0.5%
	Total	**535**	**100.0%**	**657**	**100.0%**	**1,192**	**100.0%**
All diabetics	Known diabetes	14	34.1%	21	40.4%	35	37.6%
	Newly diagnosed diabetes	27	65.9%	31	59.6%	58	62.4%
	Total	**41**	**100.0%**	**52**	**100.0%**	**93**	**100.0%**
Known diabetes	RBG taken	14	100.0%	21	100.0%	35	100.0%
	Total	**14**	**100.0%**	**21**	**100.0%**	**35**	**100.0%**
Known diabetes	Bloodsugar <200 mg/dl	4	28.6%	6	28.6%	10	28.6%
	Bloodsugar >200 mg/dl	10	71.4%	15	71.4%	25	71.4%
	Total	**14**	**100.0%**	**21**	**100.0%**	**35**	**100.0%**
Known diabetes	DR examination done	12	85.7%	17	81.0%	29	82.9%
	DR examination refused	2	14.3%	4	19.0%	6	17.1%
	Total	**14**	**100.0%**	**21**	**100.0%**	**35**	**100.0%**
Newly diagnosed diabetes	DR examination done	26	96.3%	29	93.5%	55	94.8%
	DR examination refused	1	3.7%	2	6.5%	3	5.2%
	Total	**27**	**100.0%**	**31**	**100.0%**	**58**	**100.0%**

3. Treatment in people with known diabetes

	Males		Females		Total	
	n	%	n	%	n	%
No treatment	4	28.6%	5	23.8%	**9**	**25.7%**
Diet only	3	21.4%	4	19.0%	**7**	**20.0%**
Tablets	7	50.0%	12	57.1%	**19**	**54.3%**
Insulin	0	0.0%	0	0.0%	**0**	**0.0%**
Tablets + Insulin	0	0.0%	0	0.0%	**0**	**0.0%**
Other	0	0.0%	0	0.0%	**0**	**0.0%**
Total	**14**	**100.0%**	**21**	**100.0%**	**35**	**100.0%**

4. Last eye examination for DR among known diabetics

	Males		Females		Total	
	n	%	n	%	n	%
Never had eye examination for DR	12	85.7%	17	81.0%	**29**	**82.9%**
0-12 months ago	1	7.1%	3	14.3%	**4**	**11.4%**
13-24 months ago	0	0.0%	0	0.0%	**0**	**0.0%**
>24 months ago	1	7.1%	1	4.8%	**2**	**5.7%**
Total	**14**	**100.0%**	**21**	**100.0%**	**35**	**100.0%**

5. Prevalence of DR in diabetics and in entire sample

	N	Among diabetics p (95% CI)	Full sample p (95% CI)
Retinopathy grade			
No retinopathy (R0)	47	56.0% (45.1-66.8)	3.9% (2.5-5.4)
Background DR - mild (R1)	10	11.9% (5.7-18.1)	0.8% (0.3-1.4)
Background DR - observable (R2)	7	8.3% (3.4-13.3)	0.6% (0.1-1.0)
Background DR - referable (R3)	6	7.1% (2.1-12.2)	0.5% (0.1-0.9)
Proliferative DR (R4)	3	3.6% (0.0-7.7)	0.3% (0.0-0.5)
Ungradable DR (R6)	11	13.1% (5.0-21.2)	0.9% (0.3-1.6)
Any retinopathy	37	44.0% (33.2-54.9)	3.1% (1.8-4.5)
Maculopathy grade			
No maculopathy (M0)	55	65.5% (54.8-76.1)	4.6% (3.0-6.2)
Maculopathy - observable (M1)	12	14.3% (6.6-22.0)	1.0% (0.3-1.7)
Maculopathy - referable (M2)	1	1.2% (0.0-3.5)	0.1% (0.0-0.2)
Ungradable Maculopathy (M6)	16	19.0% (9.0-29.1)	1.3% (0.5-2.2)
Any maculopathy	29	34.5% (23.9-45.2)	2.4% (1.3-3.6)
Any retinopathy and/or maculopathy	39	46.4% (36.1-56.8)	3.3% (1.9-4.7)
Sight threatening DR (R4 and/or M2)	4	4.8% (0.2-9.3)	0.3% (0.0-0.6)
Any laser scars	16	19.0% (9.0-29.1)	1.3% (0.5-2.2)

6. Prevalence of any retinopathy and/or maculopathy by age and gender

	Males		Females		Total	
	n	p (95% CI)	n	p (95% CI)	n	p (95% CI)
50 - 59	4	16.7% (0.0-33.4)	17	47.2% (33.0-	21	35.0% (24.0-46.0)
60 - 69	9	69.2% (43.8-	7	50.0% (21.4-	16	59.3% (39.9-78.6)
70 - 79	1	50.0% (0.0-	0	0.0% (0.0-0.0)	1	33.3% (0.0-87.8)
80+	1	50.0% (0.0-	0	0.0% (0.0-0.0)	1	33.3% (0.0-87.8)
All ages	15	36.6% (23.3-	24	46.2% (32.3-	39	41.9% (31.8-52.1)

7. Prevalence of MVI, SVI and blindness among people with and without diabetes

	Persons with diabetes		Persons without diabetes	
	n	p (95% CI)	n	p (95% CI)
Normal vision	80	86.0% (79.9-	904	82.3% (79.4-
Early VI	3	3.2% (0.0-6.8)	81	7.4% (5.4-9.3)
Moderate VI	4	4.3% (1.1-7.5)	69	6.3% (4.6-8.0)
Severe VI	2	2.2% (0.0-4.7)	16	1.5% (0.7-2.2)
Blindness	4	4.3% (0.0-9.2)	29	2.6% (1.7-3.6)

8. Causes of visual impairment among people with and without diabetes

	Blindness				Severe VI				Moderate VI				Early VI			
	DM		Non-DM		DM		Non-DM		DM		Non-DM		DM		Non-DM	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Refr. error	0	0%	0	0%	1	50%	0	0%	0	0%	19	27%	3	100%	46	56%
Cataract	4	100%	23	79%	1	50%	13	81%	4	100%	39	56%	0	0%	23	28%
Other PSD	0	0%	4	13%	0	0%	3	18%	0	0%	10	14%	0	0%	12	14%
Other	0	0%	2	6%	0	0%	0	0%	0	0%	1	1%	0	0%	0	0%
Total	**4**	**100%**	**29**	**100%**	**2**	**100%**	**16**	**100%**	**4**	**100%**	**69**	**100%**	**3**	**100%**	**81**	**100%**

PNG EYE CARE

UNIVERSITY OF PAPUA NEW GUINEA

DEPARTMENT OF HEALTH

Brien Holden VISION INSTITUTE

The Fred Hollows Foundation

IAPB

National Prevention of Blindness Committee
PNG's Voice for Vision

UNSW School of Optometry & Vision Science

Australian Government