AN EPIDEMIOLOGICAL STUDY OF REFRACTIVE ERROR AND OCULAR PATHOLOGY IN DOMINICA, WEST INDIES

By

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REFRACTIVE ERROR
AND OCULAR PATHOLOGY
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ABSTRACT

Background: A sample of over 1,500 eye exam records from the 2014 VOSH Mission in Dominica, West Indies, have been reviewed in detail to assess and statistically compare refractive error and ocular pathology.

Methods: Of the exam forms that were evaluated, each was categorized by age, refractive error, systemic disease, blood pressure, Intra-Ocular Pressure (IOP) and presence of ocular pathology.

Results: The analysis revealed a remarkable prevalence of hyperopia (53%) versus myopia or emmetropia, with a clinically significant shift in degree of the hyperopia versus previous studies. Also noted was an increasing prevalence of myopia in the younger population. Against-the-rule toricity predominates astigmatic correction and was also found to be on the increase. An outstanding number of the population tends to be hypertensive and occurrence of diabetic comorbidity is common (35.68%).

Conclusions: As previously predicted by Drs. Dib, Green, Wrubel and Dinardo, the data pointed to a trend towards increasing prevalence of myopia and/or less amplitude of hyperopia. Presence of ocular pathology was found comparable to that predicted by like studies. Referrals were made to a local ophthalmologist for further management of dense cataracts, glaucoma, retinopathy, and in some cases severe pterygia. Continued patient education and care based on the results of this analysis are hoped to decrease the prevalence of preventable and untreated ocular manifestations and refractive error in Dominica, West Indies.

Key Words: Dominica, epidemiology, refractive error, ocular pathology, Caribbean, macular degeneration, cataract, glaucoma, diabetes, hypertension, retinopathy, pterygium, pinguecula

ACKNOWLEDGEMENTS

I would like to thank Daniel Wrubel, O.D. for his contribution, continued support, and commitment to service in Dominica, West Indies.

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CHAPTER 1 -- INTRODUCTION

Though eye care is available in Dominica, many citizens remain limited by geography and/or finances to receive even basic eye exams. Dominica, West Indies, has a robust population of nearly 73,500 living on the 290 square-mile island.[1] One general ophthalmologist, Dr. Hazel Shillingford-Ricketts, is solely responsible for medical and/or surgical eye care in Dominica. She is assisted in providing general eye care by one optometrist, Dr. Debra Williams.[2] The average income was listed around $25 U.S. per day and the average cost of an eye exam at $40. This is why Volunteer Optometric Services to Humanity (VOSH) has been invaluable in providing additional eye care for the underprivileged population. The Michigan chapter of VOSH has been traveling to Dominica, on a yearly basis, for more than two decades to provide basic exams, medical referrals, sunglasses, along with new and/or recycled prescription glasses.

The primary goals of this epidemiological study were; (1) to do a statistical comparison with two previous like studies, (2) to provide quality information in order to aid the Government (Ministry of Health) in advancing medical/eye care in Dominica and (3) to better prepare future VOSH missions to Dominica. The 2014 VOSH Team served five regions of the country, the areas surrounding the cities of Portsmouth (NW), St. Joseph (W), Grand Bay (SE), Marigot (NE) and the capital city of Roseau (SW). Given Dominica's size and population homogeneity, this study sought to test the null hypotheses that Refractive Error (RE) and Pathological Diagnoses (PDx) are consistent among the Island's five regions. Additionally, this study sought to confirm if these conditions of RE and PDx were found to be consistent or different from the three previous studies, using similar populations on Dominica.

CHAPTER 2 -- METHODS

The data reviewed for this study was collected across Dominica by VOSH members as they provided eye care throughout the 20th VOSH Dominica Mission in January of 2014. A population of 1,528 patients was included in this study divided among five geographical regions. All personal and identifying information has been extracted from the data and does not impact the results. All data has been analyzed and strategically differentiated according to region in respect to refractive error and/or pathological diagnoses.

Appropriate categorization of refractive error and pathological diagnoses was indicated by the examining optometrists. The evaluation of refractive error is based on retinoscopy results rather than the dispensed prescription, as prescriptions were skewed at the VOSH doctors' discretion in order to most appropriately suit the patient needs, adaptations and the available stock. Hyperopic and myopic refractive errors refer to greater than or equal to +0.50 diopters sphere or -0.50 diopters sphere, respectively. Emmetropia represents the range of refractive errors between +0.50 D and -0.50 D. Astigmatic correction was broken down into categories: With-the-Rule (WTR) accounting for minus cylinder axis of 180° (+/- 30°), Against-the-Rule (ATR) accounting for minus cylinder axis of 90° (+/- 30°), and Oblique Astigmatism (OA) accounting for any outlying minus cylinder axis ranging from 30° to 60° and/or 120° to 150°. Classification of presbyopia was based on the necessity of additional plus powered correction at near.

Systemic disease prevalence used in this paper, related to a previously identified diagnoses of diabetes or hypertension by other medical professionals as reported at the time of examination and/or in accordance with other medical information that was gathered by

members of the VOSH team. Diagnosis of ocular pathology at the time of exam was determined based on presence versus absence of said pathology.

Retinopathy was defined in this study as a presence of one or more of the following: significant macular edema, retinal microaneurysm, dot/blot hemorrhage, flame hemorrhage, cotton wool spot or neovascularization. Hypertension was based on the patient history provided in combination with measurements obtained at the time of exam. All forms of cataracts were identified in this study, including nuclear sclerotic, cortical, and posterior subcapsular. Indication of glaucoma was determined by patient history, measured intra-ocular pressure (IOP) at the time of the exam, basic assessment of confrontation visual fields, and/or evaluation of the anatomy of the optic nerve head (disc) with or without dilation. Both forms of macular degeneration (AMD), exudative and non-exudative, are represented by these statistics.

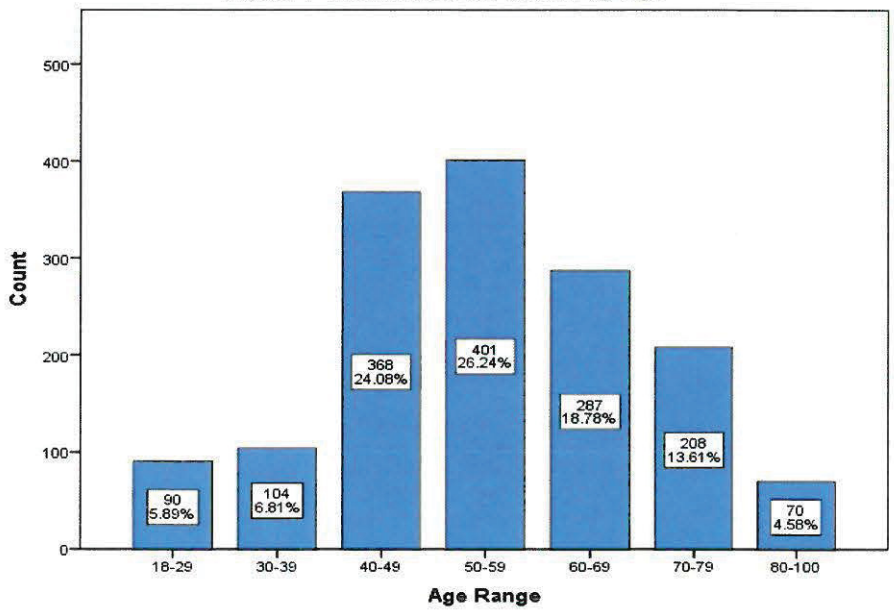
Distinguishing factors (dry vs. wet AMD) were not indicated and not assessed by this study.

CHAPTER 3 -- RESULTS

The data from the 2014 VOSH exams represented about 2% of the entire population of Dominica. The five geographical regions (Portsmouth, St. Joseph, Grand Bay, Marigot, and Roseau) were not equally represented, as the population of the island is skewed. Roseau is the capital city and represents nearly half of the data and over 25% of the population. As to not diminish representation from the other regions, a focus is placed on regional data. However, for cross comparison, it is assumed the data is a valid representation of the country as a whole.

The age range of patients extends from 18 to 100 years of age. Of the 1,528 patients, the most represented age range is 50-59 (401 patient records), closely followed by those aged 40-49 years (368). See Figure 1 for a detailed view of the age distribution of the population. Reference Appendix A for details on disease prevalence throughout the five regions in Dominica.

Figure 1- Distribution of Patients by Age



REFRACTIVE ERROR

Over half (53%) of the entire sample population showed a hyperopic refractive error, followed by 33% emmetropia and 14% myopia (see Figure 2). This number is down significantly from the last study (67%) in 2006 (see Figure 3). Special note about the significant shift towards less overall prevalence and amplitude of hyperopia 2014 vs 1997 and 2006. Myopia percentages in the overall sample remained the same from the 2006 data.

Figure 2:Refractive Error Distribution of Total Patient Population

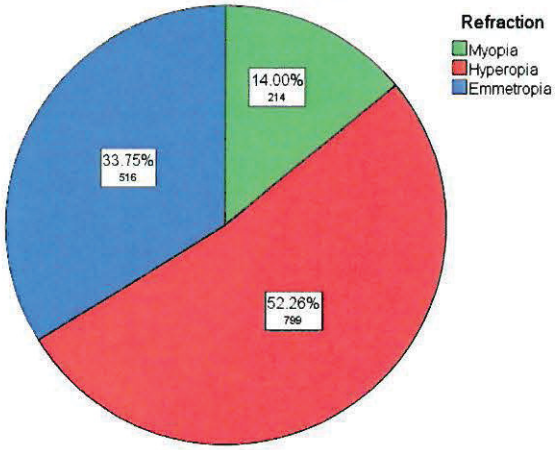
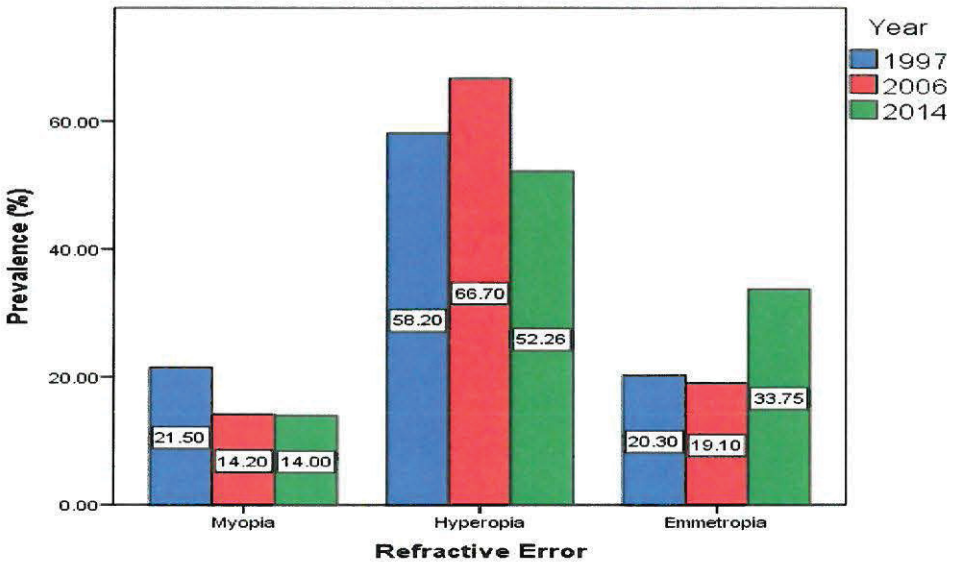
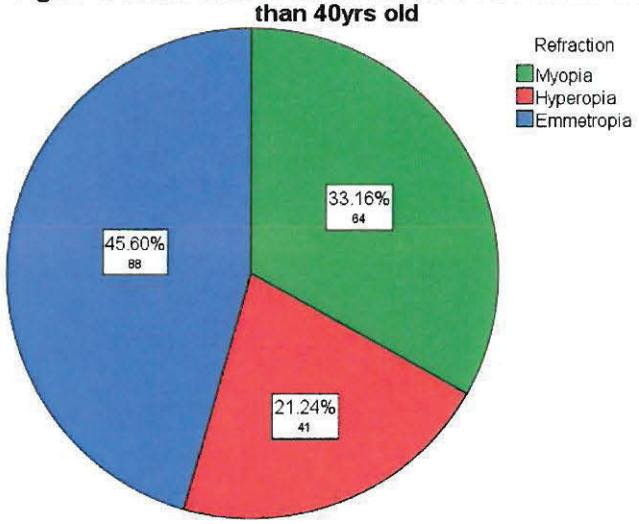


Figure 3: Changes in Refractive Error Prevalence Over Time for Total Population



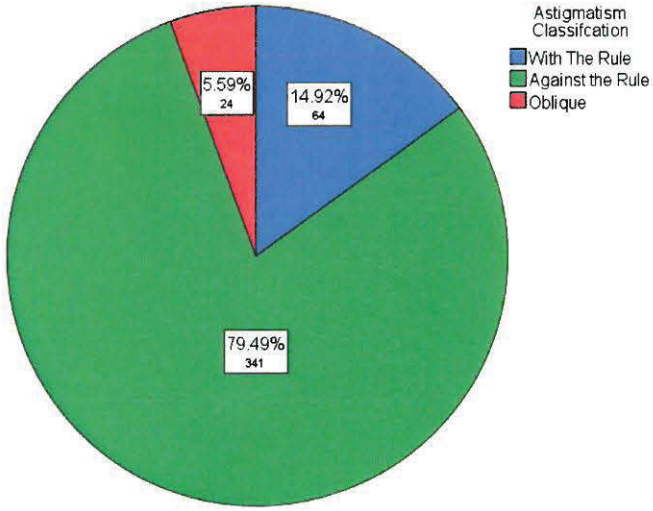
Also interesting to note, is the shift towards more myopia in the less than 40 year age group, 24% (2006) to 33% (2014), see Figure 4.

Figure 4: Distribution of Refractive Error for Patients less than 40yrs old



Nearly 80% of those with astigmatism were classified as ATR. The remaining 20% were split between WTR and OA, 14.92% and 5.59% respectively. No overt difference was observed between regions. Note that this was found to have shifted (increased) since the 2006 Mission, 70% versus 80% (see Figure 5).

Figure 5: Distribution of Astigmatism Type



RETINOPATHY

Retinopathy was simply recorded by the VOSH doctors as either positive/presence or negative/absence. A description of type and/or significance is not included in this data set. St. Joseph, Portsmouth, and Roseau are in close proximity for having the lowest prevalence of retinopathy, ranging from 2.0% to 2.7%. Grand Bay and Marigot were seen to have a higher, though not clinically significant ($p = .147$), prevalence at 4.5% and 5.3%, respectively (see Figure 6 and 7).

Figure 6: Retinopathy Age Distribution

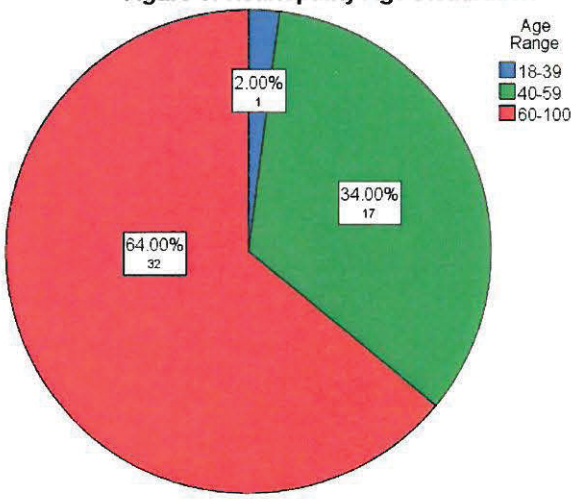
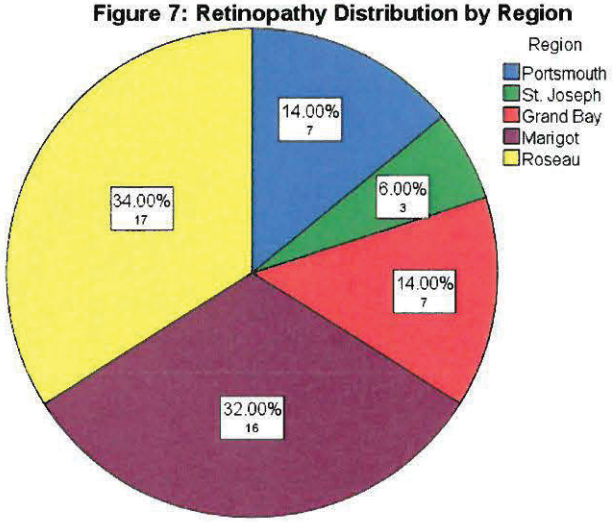
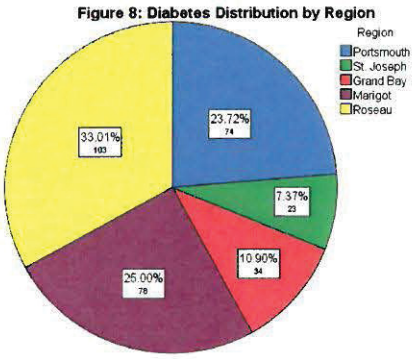


Figure 7: Retinopathy Distribution by Region



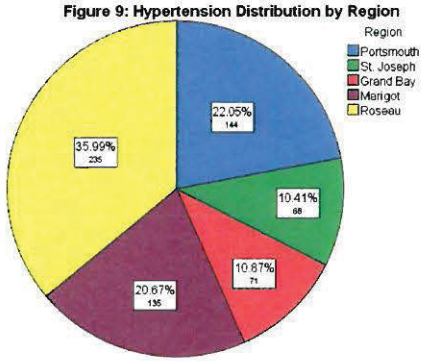
DIABETES

St. Joseph and Roseau showed the lowest prevalence at 15.3% and 16.4%, respectively; while Marigot had nearly 26% of their site population with Diabetes (see Appendix A). The difference between regions was significant ($p < .001$). Figure 8 below, shows the prevalence per region based upon the total sample population. Recall, as noted previously, Marigot also had the highest frequency of retinopathy of any of the five regions tested in 2014.



HYPERTENSION

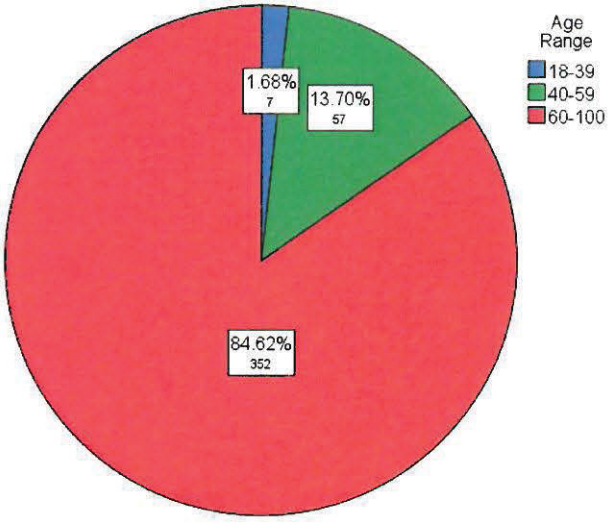
Approximately 43% of our overall sample site population were labeled as hypertensive. The range of frequency within the regions was 37.4% to 49.3% in Roseau and Portsmouth, respectively (see Appendix A). This discrepancy by region was found to be clinically significant ($p = .007$). Again, below, Figure 9 shows the distribution of hypertension by region relative to the total sample.

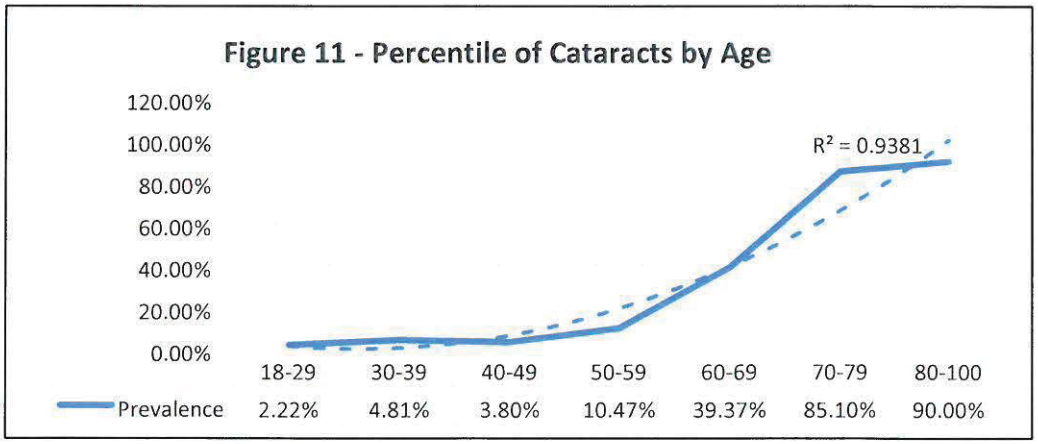


CATARACT

Cataracts were commonplace among the elder patients and also including a small percentage of patients under the age of 40 (see Figure 10). Nearly 85% of the population with cataracts were at least age 60. Figure 11 depicts the progression in the prevalence of cataracts with age. Included is a second-order polynomial trend line, calculating the expected prevalence with age progression and an R^2 value of 0.9381. Again, the regional distribution was significantly different ($p < .001$).

Figure 10: Cataract Distribution by Age





GLAUCOMA

This particular study lumps all types of glaucoma into one category. Roughly 4% of the sample population was determined as having glaucoma. Some patients received donated, sample-sized bottles of topical IOP reducing medications. A portion of the patients were also referred to the local ophthalmologist for further management and care: treatment, maintenance, possible surgical intervention, and/or further testing. A wide spread of diagnosis was present with Marigot being 5.6% versus only 2% in St. Joseph. However, the difference between regions was not significant ($p = .352$). See Figures 12 and 13.

Figure 12: Glaucoma Distribution by Age

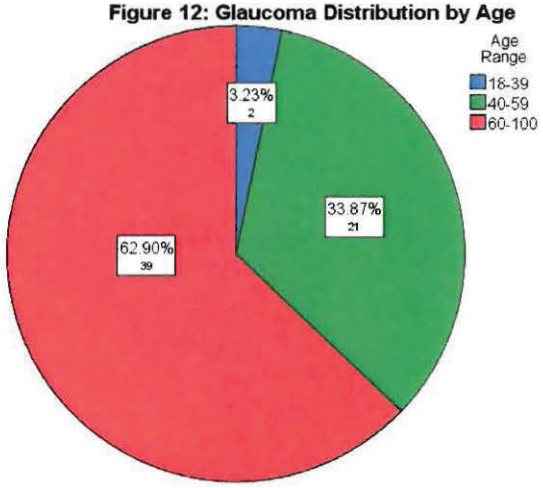
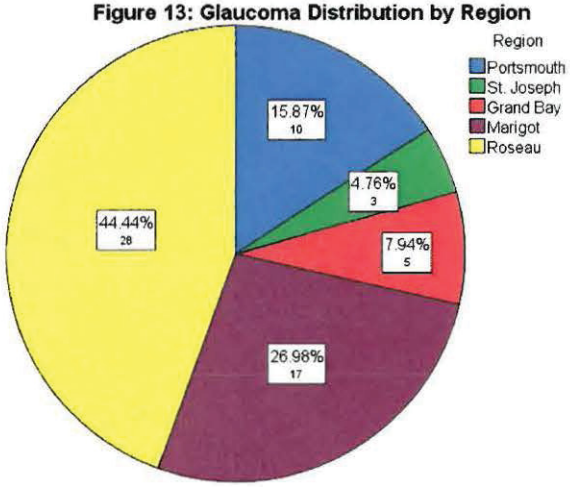


Figure 13: Glaucoma Distribution by Region



MACULAR DEGENERATION

A relatively low percentage of the sample population was shown to be affected by Macular Degeneration; as seen below, less than 5% of the entire sample population. As expected, the region was not a significant predictor of prevalence (p = .581).

See Figures 14 and 15.

Figure 14: Macular Degeneration Distribution by Age

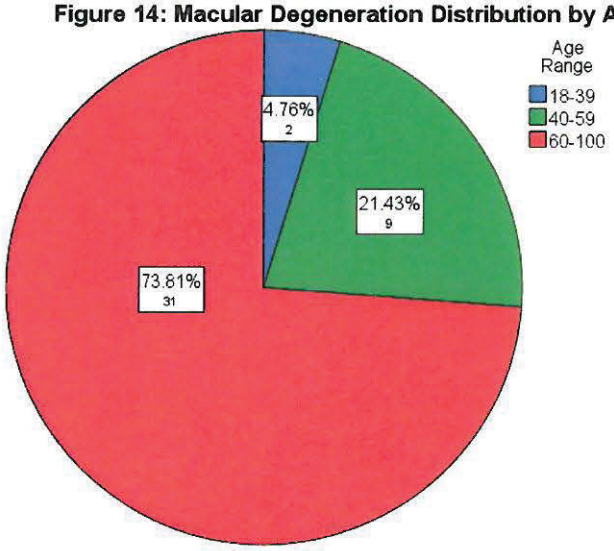
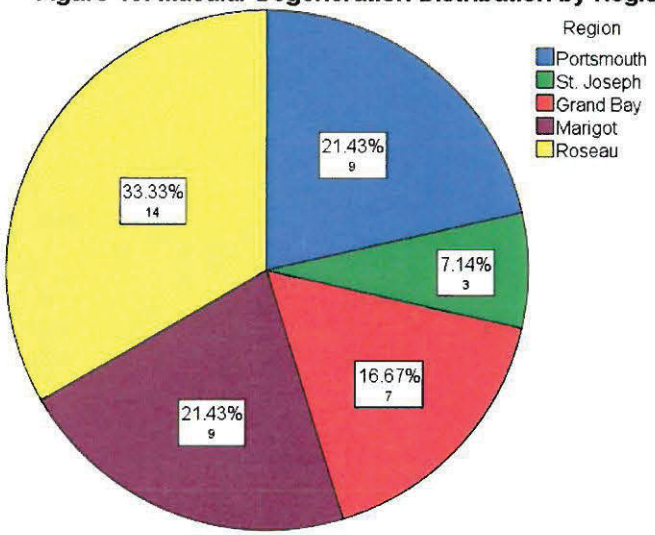


Figure 15: Macular Degeneration Distribution by Region



PTERYGIA AND PINGUECULAE

The Figures (16 & 17) below show the frequency by age for both ocular surface diseases pterygium and pinguecula. The data suggested that both pterygia ($p < .001$) and pinguecula ($p = .021$) were nearly the same percentage over the five clinic sites or geographical regions examined.

Figure 16: Pterygium Distribution by Age

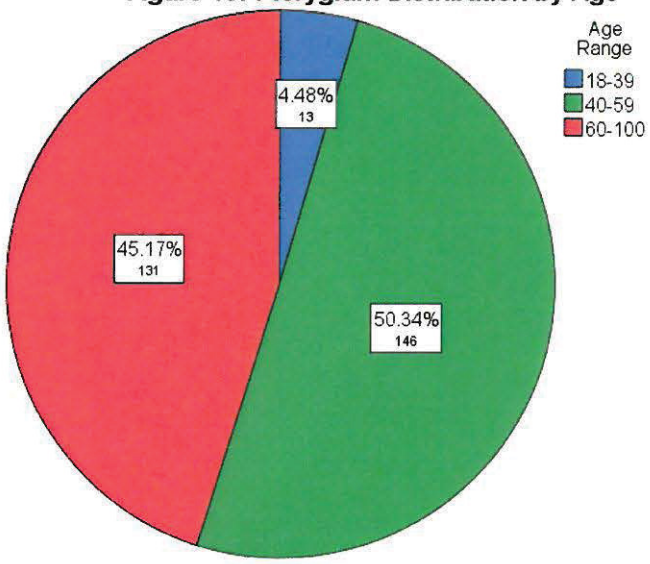
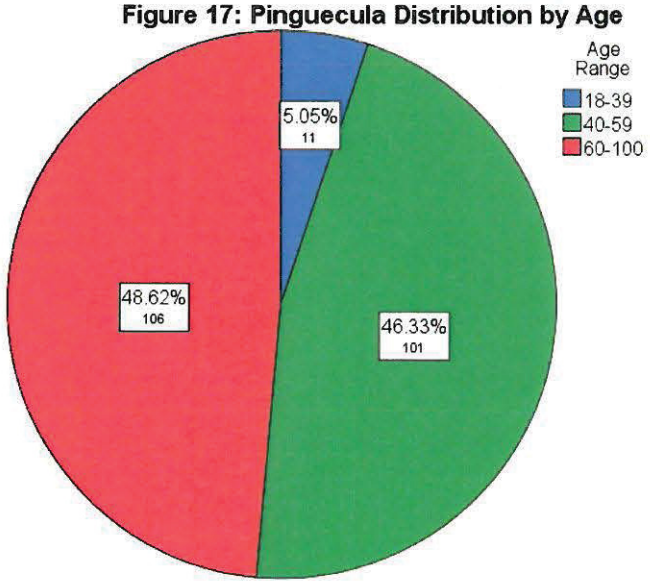


Figure 17: Pinguecula Distribution by Age

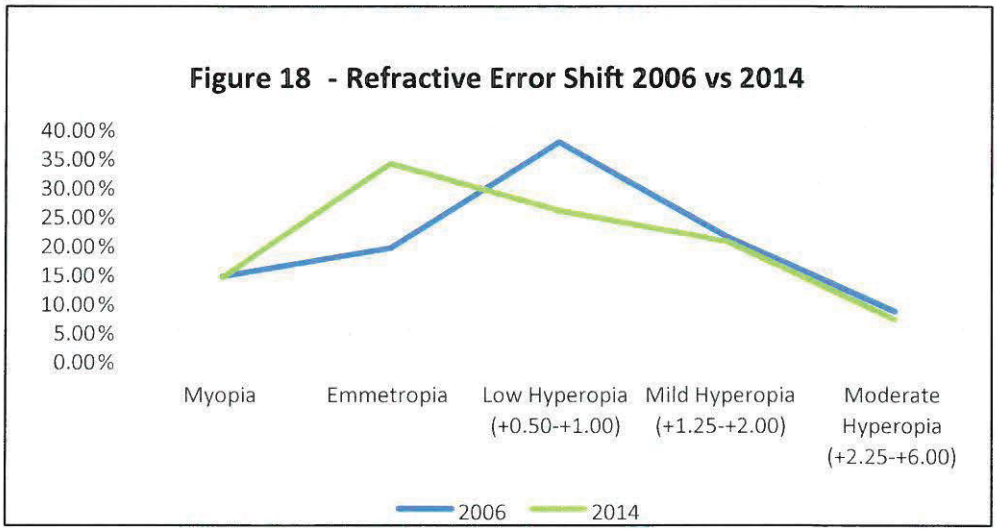


CHAPTER 4 -- DISCUSSION

Based on the data analyzed, the most common refractive error for all regions was hyperopia. Slightly over 50% of the sample population have a hyperopic refractive error. This was a dramatic reduction compared to the last two studies (58-67% vs 53%). The remaining population is split with about two-thirds emmetropia and one-third myopia. This represents 33% and 14% of the population as a whole, respectively. As Dr. Dib hypothesized in his analysis in 1990, it is evident that a shift toward emmetropia and even myopia is apparent. There is a likely correlation with age, education, and profession.[3] Unfortunately, we were unable to adequately assess education and profession in this particular study. However, it is fair to conclude that the population examined in Roseau is more likely to have reached a higher level of education than the other locations based on the presence of opportunity and surrounding job opportunity. Based on this assumption alone, it is therefore no surprise that Roseau tops the chart with 16.2% myopia and just about twice that, 32%, emmetropic. A study completed in 2006 by Drs. Dinardo and Wrubel concluded roughly two-thirds of the population was hyperopic. In 2006, an almost identical portion of the population was myopic, at 14.2%.[4] The data from 2006 also showed minimal fluctuation from that ten years previous in 1997.[5]

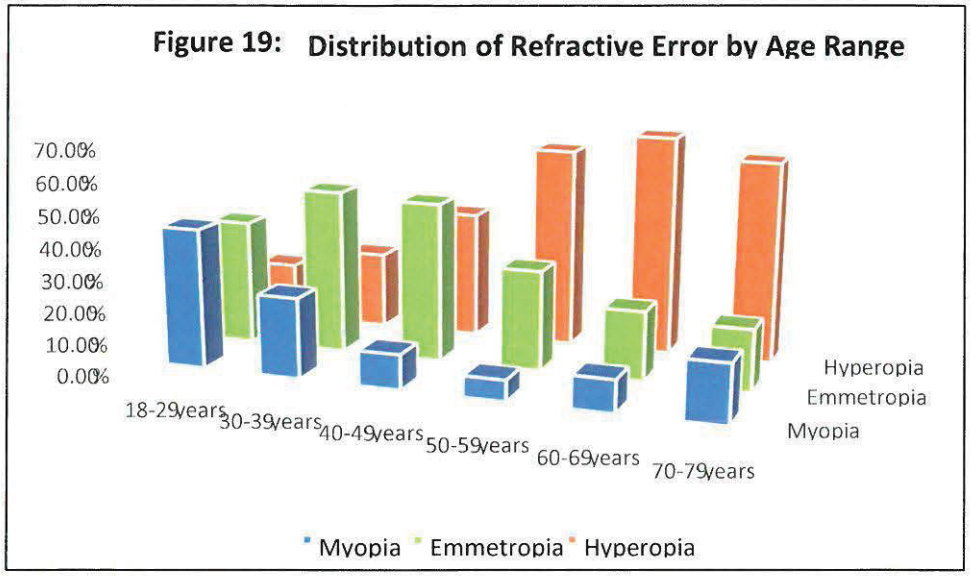
The refractive shift is likely to have affected those with low-hyperopic refractive errors.[4] This would suggest a continual shift away from hyperopia toward emmetropia and myopia (Figure 18). Over 85% of all hyperopic refractive error lie under +2.00 diopters. As compared to data from the study in 2006, there was a shift from low hyperopia to emmetropia in 2014. There is no dioptric-specific data for the two previous studies, but both Drs. Dib and

Green also discussed a shift away from hyperopia. They suggested that it may be due to an increased emphasis on education. We tend to agree with the relationship in the more business related capital city area. But these trends may also be associated with employment and/or more recently the increased use of technology, mainly computers and cell phones.[7, 8]

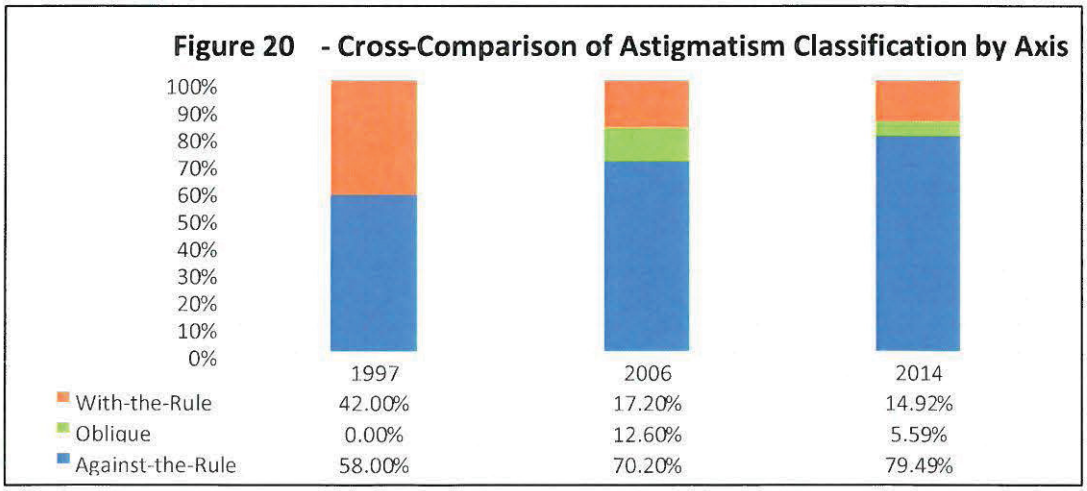


Age may also be a contributing factor to the shift in refractive error. Patients between the ages of 18 and 29 years had a surprising prevalence of 43.3% myopia. Compared to the 14.0% prevalence of myopia in the population as a whole and in contrast to those between the ages of 60 and 79 years showing a prevalence of 11.86%.

Similarly, the prevalence is split in the opposite direction for hyperopia. Results show a 17.8% prevalence for hyperopia between the ages of 18 and 29 years, while there is a shocking 65.86% prevalence of hyperopia between the ages of 60 and 79 years (Figure 19).

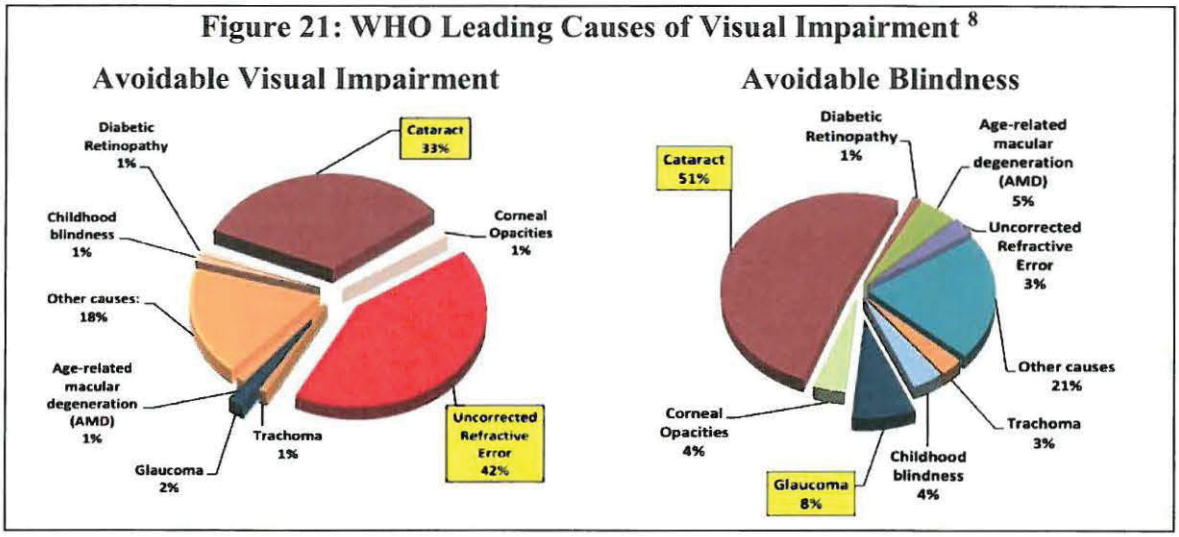


As anticipated, the most highly represented classification of astigmatic correction is against-the-rule (Figure 20). Drs. Dinardo and Green concluded much the same result in the previous two studies.[4, 5] However, there has been a consistent progression toward against-the-rule correction over the last 17 years. It should also be noted that population age may be contributing to this remarkable prevalence of against-the-rule astigmatism. It is a widely accepted phenomenon that against-the-rule astigmatism increases with age.[6] Therefore, perhaps the data is skewed slightly based on the representation of an elder population.



Visually significant eye disease is still a major problem worldwide. According to the World Health Organization (WHO), uncorrected Refractive Error remains the main factor in avoidable visual impairment, while Cataracts continue to lead in the percentage for avoidable blindness when left un-operated. Glaucoma, diabetic retinopathy, and macular degeneration are the other main contributors to avoidable visual impairment and eventual blindness (Figure 21).[9]

Figure 21: WHO Leading Causes of Visual Impairment [8]



Availability of medical care and especially eye care in Dominica is limited, with eye care more inaccessible. With only two eye care providers serving the entire population of Dominica, it's no wonder patients can go without receiving proper care. According to the CIA World Factbook, the United States allots 17.9% of GDP on healthcare versus only 5.9% in Dominica. Geographically and economically comparable countries such as St. Lucia and Guyana allot 7.2% and 5.9%, respectively.[10]

The point of this comparison was to note the great contribution that the VOSH team has made in voluntarily providing improved access to eye health care in Dominica. The three main goals or objectives listed and followed by VOSH International are:

#1 Provide basic eye care/vision exams and dispense glasses to those in the most need, either because of lack of funds or geographic access to said care.

#2 Triage medical/eye disease and provide appropriate referrals for management of said disease to "local" health care providers.

#3 Work and grow with the Government Health System (Ministry of Health) to advance and/or enhance the health and wellbeing of the individuals of said country.

Retinopathy can be visually threatening and an alarming portion of patients can be categorized as having retinopathy that may progress to a point of blindness. According to a nine-year study in Barbados, the prevalence of diabetic retinopathy (DR) was nearly 30%. Of that 30%, 7% had progressed to a level of proliferative retinopathy after a four-year follow-up interval.[11] These numbers are shocking, and thankfully not entirely representative of the Dominican population. We do not have contrasting data to represent such an in-depth study, however, a closer look at the presence of retinopathy in the population with concurrent hypertension and diabetes is presented below (Figure 22 & 23).

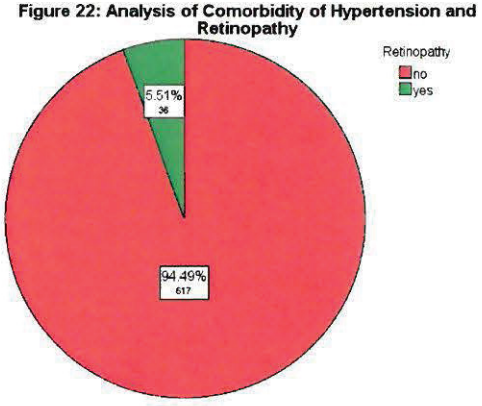


Figure 22: Analysis of Comorbidity of Hypertension and Retinopathy

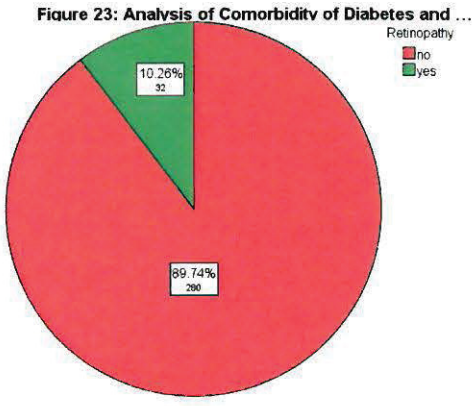


Figure 23: Analysis of Comorbidity of Diabetes and ...

Cataracts are a problem worldwide and, as previously stated, the leading cause of preventable or avoidable blindness. In the black population in the United States, there is an overall prevalence of 12.99% in those over the age of 40 years. Compared to a 26.75% (over double) prevalence in the Dominican population of the same age. When compared to a study in Maharashtra, India, which is in similar proximity to the equator, patients aged 60-80 years showed a 55% prevalence compared to 58.47% in Dominica.[12] Known risk factors for development of cataracts include exposure to ultraviolet radiation. It is likely that this is a major contributing factor to the development of cataracts in the Dominican population. The VOSH team contributes to awareness, prevention and earlier detection by providing access to eye health exams, prescription and nonprescription sunglasses, and ultimately providing patient education regarding preventative measures.

Though the diagnosis of what constitutes age-related macular degeneration (AMD) may be controversial, this study has focused simply on the presence versus absence of macular pathology paramacular, not Retinopathy.

The VOSH doctors used changes associated with the typical presentation of age-related macular degeneration (pigmentary changes), ignoring severity. With that in mind, we can compare a multi-nation study which found an overall prevalence of 1.63% across all age groups. The prevalence in Dominica being somewhat higher at 2.7%.[13] When compared to the results of the Barbados Eye Study (12.6% early, 0.7% late), Dominica showed a much lower prevalence of age-related macular degeneration. This may be due to the fact that the results from the study in Dominica are not separated into categories of early versus late, which could result in early cases being excluded from the results altogether. What we can take from the results of the Barbados Eye Study is the likelihood for progression of 2% of

early cases later resulting in late macular degeneration, including atrophic and neovascular changes.[14] That is, it is likely fair to anticipate a 2% progression to late macular degeneration in those previously identified with macular changes over a period of about a decade.

Glaucoma can be a visually devastating disease, especially when left untreated. Because of the rurally located Dominican population, diagnosis and treatment of glaucoma can be difficult. Glaucoma accounts for the second leading cause of avoidable blindness worldwide, and the third most common cause of avoidable visual impairment.[8] The Barbados Eye Study revealed a 7.0% prevalence of open angle glaucoma in the general black population, while that number grew to 12.0% by age 60.[15] In Dominica, the national prevalence of all types of glaucoma was found to be 4.1%. Though slightly lower than that in the comparable population in Barbados, a much larger separation is seen when examining the statistics by age. The prevalence only rises to 6.9% at age 60 years or older, nearly half that observed in Barbados. A more precise evaluation of the type and severity of glaucoma would be more appropriate for comparison with the Barbados Eye Study. However, when compared to prevalence within the black population of the United States, it is fairly similar at 3.42%. Looking at age 40-49 years with 1.15% in the US, compared to 1.4% in Dominica. Similarly in the population over the age of 80, the US statistic rises to 11.42% and Dominican to 14.3%.[16] The increased prevalence in the older population in Dominica may be contributed to the fact that if an older patient is aware of a history of glaucoma, they may preferentially seek examination by the VOSH team. Regardless, we may conclude that both age (> 60 years) and region within Dominica, especially those near Marigot, may be contributing factors to the development of glaucoma.

Pterygia and pingueculae are both ocular surface pathologies. Dr. Green reported that increased exposure to UV light (therefore proximity to the equator) and increasing age are contributing factors to the formation of pterygia.[5] A study completed in 2009 as a portion of the Tehran Eye Study reported that sun exposure does, in fact, play an important role in the development of both pterygia and pingueculae, indicating a higher prevalence in tropical areas of the world, such as Dominica.[17]

CONCLUSIONS

From this study, we can conclude that: (1) there was a significant decrease in overall amount of hyperopia (> 60% vs. 52%) and/or more emmetropia, (2) there was an increasing prevalence of myopic refractive error in the younger aged population, less than age 40 (14% to 21%) and (3) as for astigmatism, we found that a profound percentage and an increased number of patients demonstrated the need for against-the-rule correction (70% vs. 80%). One could project that these changes could be related to the increase in technology over the past 20 years. Cell phone and computer use in Dominica over the past twenty years has astronomically increased.[8] This could prove to be beneficial in the preparation of the annual VOSH missions in providing guidelines for appropriate prescription eyewear preparation.

The prevalence of all eye diseases discussed in this study only varied slightly from that expected in the United States. This could be viewed as positive for the Dominican medical care team in light of less access to medical care and less technology in diagnosis and treatment. One could speculate that less processed foods (natural home grown), more basic transportation (walking) and more outdoor activities could make for a more healthy population. This will provide more realistic expectations for those providing health care and/or eye-care services in Dominica.

Limitations in this study were; (1) clinical population versus geographic population used, (2) modified/advanced eye screening (VOSH) versus full comprehensive examinations and (3) limited children involved in the VOSH program the last two years. Also of note was

the lack of documentation associated with either sex (male vs. female) or occupation collected on the VOSH exam forms.

As for the betterment of the care provided by the VOSH team on their annual missions, it is my/our hope that the future teams welcome the opportunity to aid Dominica's Ministry of Health in providing eye care for the underprivileged population. The diagnostic assistance provided by the VOSH team is invaluable, however, does not provide the needed long-term management. The goal should be to educate both patients and healthcare providers regarding the necessity of consistent diagnoses and more timely treatment, along with regular follow-up care. Then with time, that the patient may become more proactive in seeking care as well as preparing the healthcare systems for this undertaking.

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APPENDIX A

DISTRIBUTION OF REFRACTIVE ERROR AND

OCULAR PATHOLOGY BY REGION

Table 1 - Distribution of Refractive Error and Ocular Pathology by Region

	Portsmouth	St. Joseph	Grand Bay	Marigot	Roseau	Total
Myopia	9.90%	11.30%	12.70%	15.30%	16.20%	14.00%
Emmetropia	33.60%	38.70%	34.40%	33.90%	32.40%	33.00%
Hyperopia	56.50%	50.00%	52.90%	50.80%	51.40%	53.00%
Astigmatism	25.70%	20.70%	31.80%	29.20%	28.30%	27.60%
Against-the-Rule	80.25%	73.33%	90.20%	80.68%	76.54%	79.49%
Oblique	8.64%	6.67%	3.92%	7.95%	3.35%	5.59%
With-the-Rule	11.11%	20.00%	5.88%	11.36%	20.11%	14.92%
Retinopathy	2.40%	2.00%	4.50%	5.30%	2.70%	3.30%
Diabetes	25.30%	15.30%	21.70%	25.90%	16.40%	20.40%
Hypertension	49.30%	45.30%	45.20%	44.90%	37.40%	42.70%
Cataracts	24.30%	24.70%	31.20%	38.20%	23.10%	27.30%
Glaucoma	3.40%	2.00%	3.20%	5.60%	4.50%	4.10%
Macular Degeneration	3.10%	2.00%	4.50%	3.00%	2.20%	2.70%
Pterygia	23.30%	14.70%	22.90%	25.60%	14.00%	19.00%
Pingueculae	12.30%	10.70%	21.00%	17.30%	12.90%	14.30%

APPENDIX B

IRB APPROVAL FORM

Ferris State University

Institutional Review Board (FSU - IRB)
Office of Academic Research
Ferris State University
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Big Rapids, MI 49307
(231) 591-2553
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To: Dr. Daniel Wrubel and Anna Baumgartner
From: Dr. Stephanie Thomson, IRB Chair
Re: IRB Application #140409 (Title: *An Epidemiological Study of Refractive Error and Ocular Pathology in Dominica, West Indies*)
Date: July 9, 2014

The Ferris State University Institutional Review Board (IRB) has reviewed your application for using human subjects in the study, *"An Epidemiological Study of Refractive Error and Ocular Pathology in Dominica, West Indies"* (#140409) and determined that it meets Federal Regulations ***Exempt-1E.*** This approval has an expiration date of three years from the date of this letter. **As such, you may collect data according to the procedures outlined in your application until July 9, 2017.** It is your obligation to inform the IRB of any changes in your research protocol that would substantially alter the methods and procedures reviewed and approved by the IRB in this application. Your protocol has been assigned a project number (#140409), which you should refer to in future correspondence involving this same research procedure.

We also wish to inform researchers that the IRB requires annual follow-up reports for all research protocols as mandated by Title 45 Code of Federal Regulations, Part 46 (45 CFR 46) for using human subjects in research. We will send a one-year reminder to note the continuation of this project or to complete the final report. The final-report form is available on the IRB homepage. Thank you for your compliance with these guidelines and best wishes for a successful research endeavor. Please let us know if the IRB can be of any future assistance.

Regards,

Ferris State University Institutional Review Board
Office of Academic Research, Academic Affairs