EPIDEMIOLOGY OF REFRACTIVE ERROR IN DOMINICA, WEST INDIES

By

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Dedication and Acknowledgements

This research is dedicated to the citizens of Dominica. Thank you to the following individuals who's hard work, knowledge, and participation made this project possible: Dr. Dan Wrubel and family, Dr. Bob "Kubuli Bob" Carter, the entire 2006 Michigan-VOSH Dominica team, the government and governmental officials of Dominica, and the entire Rotary Club of Dominica.

LIST OF CHARTS

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ABSTRACT

Background: This is a cross-sectional epidemiological analysis of the prevalence refractive error in the Commonwealth of Dominica, West Indies. Uncorrected refractive error is a common cause of preventable blindness around the world [7-9]. Several citizens of Dominica cannot afford or simply do not have access to the proper eye care[1,4]. Volunteer Optometric Services to Humanities (VOSH) provides eye care services in an attempt to reduced or eliminate the personal, cultural, economic affects of eye diseases and uncorrected refractive error. Cross-sectional studies and the epidemiology of refractive error across the world are also discussed in detail.

Methods: Data was gathered from a sample population of Dominicans who participated as patients on a Michigan-VOSH (Volunteer Optometric Services to Humanities) mission in January of 2006. An extensive analysis of the data was tabulated along with a thorough literature search regarding cross-sectional studies and the epidemiology of refractive error.

Results: A high prevalence of hyperopia, presbyopia, compound hyperopic astigmatism, and against-the-rule astigmatism was found.

Conclusions: More plus lenses, plus bifocal addition lenses, and against-the-rule astigmatic glasses are especially necessary on a VOSH mission to care for the needs of the Dominican patients. Not only will the information from this study facilitate in the preparation and eventual Eye Care of patients in future VOSH missions, but it can be used as a base-line for further longitudinal studies regarding refractive error in Dominica.

Introduction

The Commonwealth of Dominica, West Indies is located in the southern Caribbean between the Caribbean Sea and the North Atlantic Ocean. Spanning 754 square kilometers, the entire Island Nation is only slightly more than four times the size of Washington, D.C.[1]. Known as the "Nature Island of the Caribbean", the island of Dominica is rich in lush flora, tropical vegetation, and volcanic landscape[2]. As of July 2005, the population reached almost 70,000 people. More than half the inhabitants were between the ages of 15-64 years old. Only about 8% of the total population was found to be over the age of 65. The male-to-female ratio was at about an even 1:1 ratio[1]. Major ethnic groups living on the island were listed as; Black, European, Syrian, and Carib Amerindian. The official language of Dominica has been predominately English, (independent from Great Britain for over 25 years). Nearly 94% of the population was literate and education is valued among the Dominicans[3]. The economy has been driven mainly by agriculture and tourism[1,2]. Citrus, banana, cocoa, and herbal oils along with soap and coconut-based products are the major agricultural and manufacturing exports[1,3]. Coca-Cola and Colgate are two major manufacturing industries located on the island[4].

Unfortunately, eye care services on the island are limited to one ophthalmologist and one private practice optometrist[4]. Nearly 30% of the population is below the poverty line[1]. Michigan-Volunteer Optometric Services to Humanities (VOSH), led by Dr. Dan Wrubel, has been subsidizing the eye care needs of the Dominicans for more than 12 years, by providing basic eye examinations and dispensing new and/or previously used glasses and sunglasses. Michigan-VOSH is part of an inter-national non-profit organization in which the goal is to "facilitate in the provision of vision care worldwide where it is not affordable or accessible"[5].

VOSH provides optometric services through free or low-cost clinics, new and recycled eye glasses, basic diagnosis/detection of eye disease, along with the referral for medical eye care services including surgery[5].

Refractive error has been stated as the most common visual impairment and one of the ***leading causes of preventable blindness in the world,*** along with trachoma, onchocerciasis, and vitamin A deficiency[6-8]. Current estimates have indicated that up to ***250 million people*** are blind due to significant uncorrected refractive error[9]. The island of Dominica has shown to be no exception. Several citizens of Dominica simply cannot afford or do not have access to eye care services. Uncorrected refractive error can diminish quality of life, hinder educational and employment opportunities, and even increase the incidence of morbidity and mortality of those who suffer from this disorder[10]. Those affected by uncorrected refractive error commonly suffer from social isolation and feelings of inadequacy. On a larger scale, refractive error has also shown to have negative affects on economic development and the forward progress of several communities around the world who cannot afford or do not have access to sufficient eye care[10].

For the purposes of this review, refractive error or ammetropia is defined as a <u>disorder, not a disease</u>, in which the dioptric power of the eye has changed so that parallel rays of light from infinity, with the accommodation at rest, are not properly focused on the retina. The result is visual impairment and/or asthenopic symptoms[11]. Myopia, also known as "near-sightedness" (shortsighted), is the type of ammetropia in which the eye exhibits excessive refractive power for its axial length. This occurs when either the eye has a relatively long axial length and/or increased dioptric power of one or more of its refractive components. Distance vision primarily is affected in myopia[12].

In this study, myopia is defined as more than - 0.50 diopters of spherical refractive error. Hyperopia is defined as insufficient refractive power for the eye's axial length. Also termed hypermetropia or "far-sightedness", this type of refractive error is a result of the eye exhibiting a relatively short axial length and/or reduced dioptric power of one or more of its refractive components. Near vision is primarily affected in hyperopia[12]. In this study, hyperopia was deemed present in a patient who required more than + 0.50 diopters sphere refractive correction.

Astigmatism is the condition in which light rays coming from a point source are not imaged on the retina/macula at a single point. Astigmatism results from unequal refraction of the light in different meridians by the eye's refractive components[13]. Three types of regular astigmatism will be addressed in this study. With-the-rule (WTR) astigmatism, supposedly the more common form of astigmatism, occurs when the steepest curvature, or major meridian, lies in the vertical meridian (90° +/-30°)[13,14]. Against-the-rule astigmatism is a condition in which the eye's major meridian lies in the horizontal plane (180° +/- 30°). Oblique astigmatism occurs when the steepest meridian lies between the horizontal and vertical axis (> 30° from axis 90° or 180°)[14]. In astigmatism, both distance and near vision can be affected. In this study any refractive cylinder more than – 0.50 diopters was considered astigmatism. Astigmatism can be further classified into the following categories: Simple Hyperopic Astigmatism (SHA), Simple Myopic Astigmatism (SMA), Compound Hyperopic Astigmatism (CHA), Compound Myopic Astigmatism (CMA), and Mixed Astigmatism (MA)[14].

Presbyopia is an age-related irreversible reduction in accommodative amplitude causing symptoms of blur and asthenopia at near[12,13]. The onset of presbyopia generally occurs between the ages of 40-45[12]. However, studies show that presbyopia may begin in the late 30's especially in regions along the world's equator. In this study presbyopia was determined by age and the need for additional plus lenses at near.

Methods:

Information for this cross-sectional study was gathered from a sample population of Dominicans during a 10 day VOSH expedition in January of 2006. The team providing optometric services to the Dominicans consisted of 28 volunteers; including six optometrists, four optometry students, two opticians, two occupational therapists, and 14 additional lay volunteers. Clinics were held covering the major geographical areas of the island including Grand Bay (SE), Portsmouth (NW), Marigot (NE), and Roseau (SW).

Several months before the day of the clinic, nurses and other facilitators at each location, distributed a predetermined number of tickets to those perceived to be in the most need of eye care. Those determined to be in need of care either presented with significant visual symptoms, were over 40 years old or exhibited decreased Snellen visual acuities at that time. Those who participated as patients in a VOSH mission within the last three years were not eligible and would not receive a ticket. On the day of clinic, patients presented their tickets in order to gain admission (extra's were seen if time allowed).

The eye examinations included a brief pertinent ocular and systemic health history including chief complaint and listing of medications. Other elements of the examination include blood pressure, intraocular pressure measurement, distance & near monocular acuities, auto-refraction when available, retinoscopy, external and internal ocular health assessment. Patients were pharmacologically dilated and a more thorough internal exam with indirect ophthalmoscopy was conducted when the examiner suspected an ocular pathology or was unable to adequately view the fundus. Following the examination, patients were directed to the dispensing area where they received at least one pair of the best possible spectacle correction given the limitations of the "recycled" donated glasses available.

Results:

Approximately 1,400 patient encounters were documented during the mission. A total of 307 patients were excluded from analysis based on failure to fully document gender, age, or retinoscopy prescription findings. A small portion of patients were excluded due to large amounts of anisometropia, (more than 3.00 diopters of refractive error difference between each eye). Refractive error determination is based on the retinoscopy results retrieved from the examination forms kept on each patient.

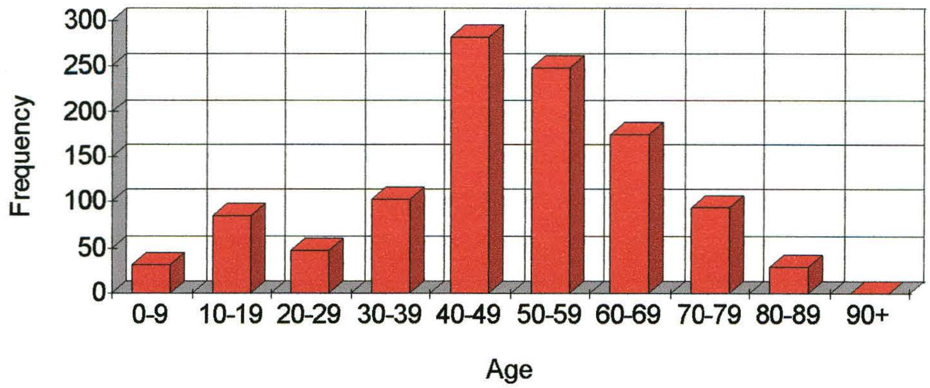
A total of 1,093 patient records were analyzed for this study. Of which, 800 members (73.2%) were female and 293 (26.8%) were male. The overall male-to-female ratio was 1: 2.73. All age groups from 1-99 were represented in this study. The mean age was 44.3 and the median age was 48. A majority of patients in the sample population, 48.4% were between the ages of 40-59 (40-49 = 25.7% & 50-59 = 22.7%). The third highest age group represented was individuals between the ages of 60-69, comprising 15.9% of the sample. Patients between the ages of 30-39 were the fourth most represented at 9.3%. All other age groups make up 26.4% of the participants in this study. Table I and Chart I both reflect the frequency distribution of the sample population based on age.

	# in Sample	Rate %	#Male/#Female Ratio
0-9	32	2.90%	14/18 (1:1.2)
10-19	85	7.80%	28/57 (1:2)
20-29	47	4.30%	13/34 (1:2.6)
30-39	102	9.30%	20/82 (1:4.1)
40-49	281	25.70%	61/220 (1:3.6)
50-59	248	22.70%	64/184 (1:2.88)
60-69	174	15.90%	52/122 (1:2.35)
70-79	95	8.70%	31/64 (1:2.06)
80-89	28	2.60%	10/18 (1:1.8)
90+	1	0.10%	0/1
Total	1093	100%	293/800 (1:2.73)

TABLE I: Frequency Distribution of Age Groups

Chart I

Aged-Based Sample Distribution



Low hyperopia between +0.50 and +1.00 ***was the most common refractive error*** demonstrated with a prevalence of 37.4%. The second most common refractive error was hyperopia between the ranges of +1.25 and +2.00 with a prevalence of 21.10%. Of the entire population at risk, 66.7% exhibited hyperopia, 19.10% were emmetropic, and 14.2% of the sample required a myopic correction (Chart II).

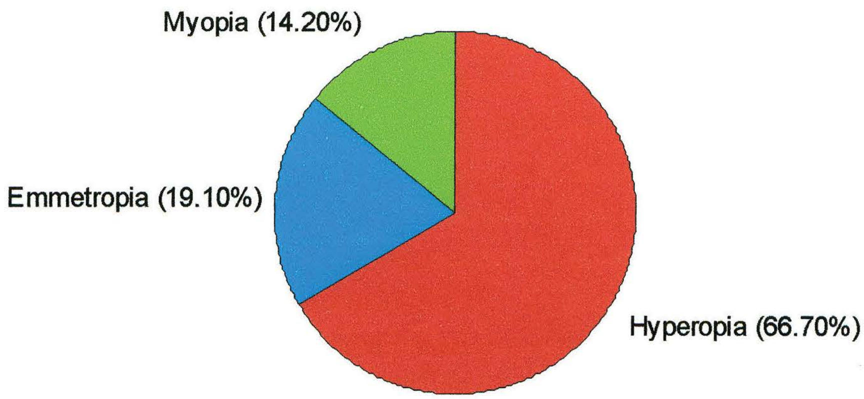
For a detailed breakdown of refractive error distribution, refer to Table II.

	Refractive Errors	# in Sample	Prevalence	% Rate Total
	+.50<x<+1.00	409	37.40%	
	+1.25<x<+2.00	231	21.10%	
Hyperopia	+2.25<x<+3.00	66	6%	66.70%
	+3.25<x<+4	20	1.80%	
	+4.25<x<+5.00	2	0.18%	
	+5.25<x<+6	1	0.10%	
Emmetropia	+.25<x<-.25	209	19.10%	19.10%
	-.50<x<-1.00	77	7.04%	
	-1.25<x<-2.00	45	4.12%	
	-2.25<x<3.00	10	0.90%	
	-3.25<x<-4.00	7	0.64%	
Myopia	-4.25<x<-5.00	6	0.55%	14.20%
	-5.25<x<-6.00	3	0.27%	
	-6.25<x<-7.00	3	0.27%	
	-7.25<x<-8.00	1	0.10%	
	>-8.25	3	0.27%	
Total		1093	100%	100%

Table II: Frequency Distribution of Refractive Errors

CHART II

Refrative Error Distribution



An analysis of refractive error based on gender reveals that ***49.3% of the patients were female and hyperopic.*** Male hyperopia was the second most prevalent patient at 17.4%. Female emmetropes were third most prevalent at 13.3%. Hyperopia was the most common refractive error for both genders followed by emmetropia and then myopia. Further analysis demonstrates that females are 1.2% more likely than males to be myopic and 2.6% more likely to be hyperopic than males. The prevalence of emmetropia is 3.8% higher in males than females.

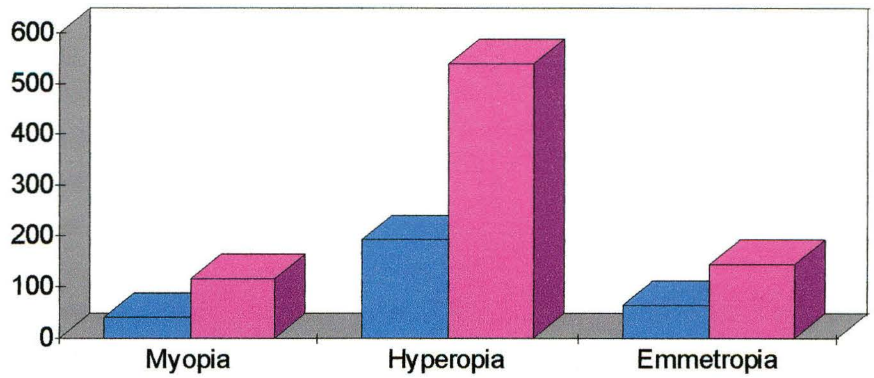
For detailed data, see Table III and Chart III.

	Myopia	Hyperopia	Emmetropia	Total
Male	39 (3.6%)	190 (17.4%)	64 (5.8%)	293
Female	116 (10.6%)	539 (49.3%)	145 (13.3%)	800
Total	155	729	209	1093

Table III: Frequency Distribution of Refractive Error by Gender

Chart III

Refractive Error by Gender



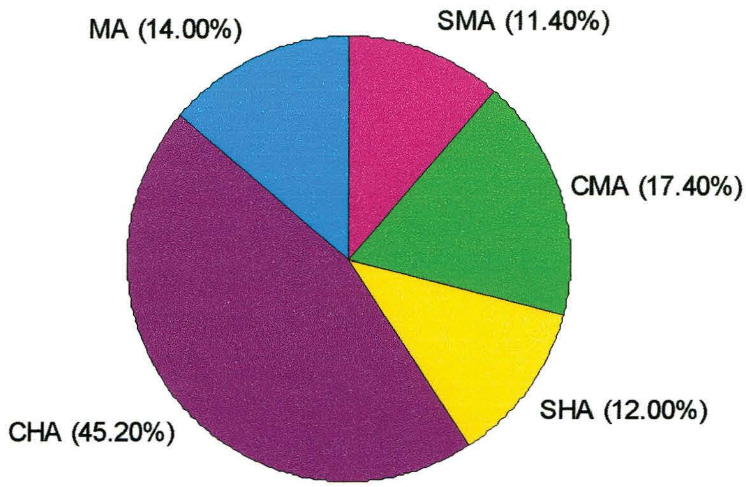
Astigmatism in one or both eyes was found in 47.5% of the population, the highest prevalence being compound hyperopic astigmatism (CHA) at 21.3%. Continually, compound hyperopic astigmatism was the most common out of all the astigmatic patients with 233 patients or 45.2% exhibiting this type of refractive error. See Table IV and Chart IV for further analysis.

	# in sample	Percentage (x/516)	Prevalence
SMA	59	11.40%	5.40%
CMA	90	17.40%	8.20%
SHA	62	12%	5.70%
CHA	233	45.20%	21.30%
MA	72	14%	6.60%
Total	516	100%	47.20%

Table IV: Frequency distribution and prevalence of astigmatism

Chart IV

Frequency Distribution of Astigmatism



Analysis of astigmatism by axis shows that ***against-the-rule astigmatism*** was by far ***the most common*** at 70.2%. With-the-rule astigmatism was found in only 17.2% of all astigmats and oblique astigmatism was the least frequent at 12.6%.

See Table V and Chart V for further information.

	# in Sample	Percentage (x/516)
WTR	89	17.20%
ATR	362	70.20%
Oblique	65	12.60%
Total	516	100%

Table V: Astigmatism by axis

Chart V

Astigmatism by Axis

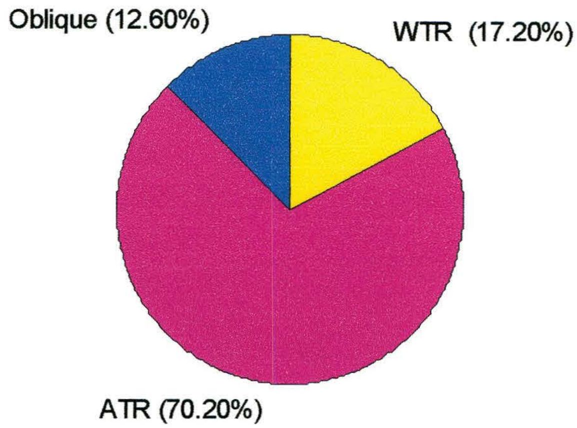


Table VI provides a break down of the middle age related presbyopia by age group. Our data showed that 94% of all patients over the age of 40 were presbyopic. The prevalence of presbyopia measured at 71.1%.

	# Presby	Total # in age group	% Presbyopic
40-49	251	281	89.30%
50-59	238	248	96%
60-69	167	174	96%
70-79	95	95	100%
80-89	28	28	100%
90+	1	1	100%
Total	777	827	94%

TABLE VI: Presbyopia

Discussion:

The 2006 Michigan VOSH Eye Care Mission only serviced just over 2% of the entire population of Dominica. A large majority, 73.2% of patients cared for were female. The overall male to female ratio being 1: 2.73 compared to 1:1 on the island as a whole. The median age of a patient presenting to the clinic for optometric services was 48 years old. According to the most recent census, the median age of inhabitants on Dominica was actually 30. About 7.9% of the total population of Dominica is over the age of 65. Whereas, in this study/review, individuals over 65 made up over 11.4% of the sample population examined.

In fact, 64.3% of participants were between the ages of 40-69. It appears that the sample population in this study does not reflect the entire population of the island but is skewed towards data based on older patients, particularly females. This reflects the fact that older, presbyopic patients are more likely to seek optometric services than a young healthy emmetrope or the low hyperope. Many more females presented to the clinics than males. This fact may reflect the social stigma related to decreased virility or unattractiveness associated with dependence on glasses, mainly in the adult males. Continually, eye clinics were held during working hours on weekdays. Males simply may not have been able to attend due to employment responsibilities.

Hyperopia showed to be the most common refractive error, with a majority of patients presenting with low to moderate levels. Over 8% of all patients and 12.2% of all hyperopes exhibited hyperopia over +2.25 diopters. Emmetropia was the second most common state 19.1%, yet this figure does not exclude emmetropic presbyopes. Of all emmetropes, 141 individuals or 67.5% of all emmetropes were also presbyopic.

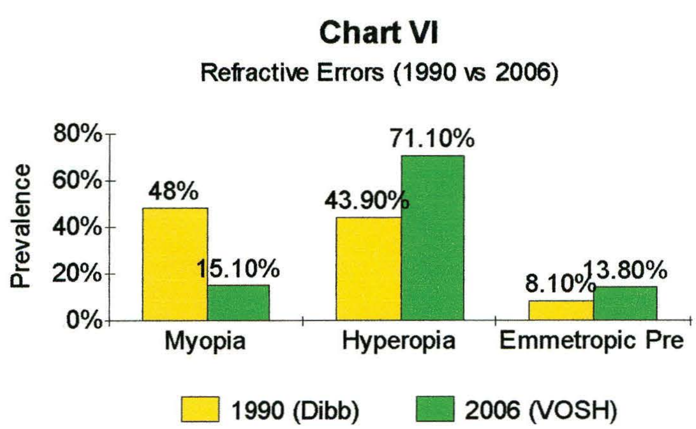
Following statistics from this review, myopia was the least encountered refractive error at 14.2%. Most were low myopes between - 0.50 and -1.00 diopters.

Almost half of the sample population exhibited some type of astigmatic error. By far the most prevalent form of astigmatism was compound hyperopic astigmatism, at 45.2%. Against-the-rule was extremely common, making up over 70% of all astigmats. With-the-rule and oblique astigmatism made up the remaining astigmatic errors at 29.8% combined.

Statistics showed that 827 or 75.6% of the patients were over the age of 40. Of those patients 777 or 94%, were found to be presbyopic and in the need of additional optical correction at near. Almost 90% of patients between 40-49 years old required bifocals, giving further support to the theory that Dominicans and other communities near the equator develop presbyopia at an earlier age. Continually, 72.1% of all presbyopes were also hyperopic. It is well known that hyperopes tend to develop presbyopia at and earlier age than myopes and emmetropes[12].

Two other epidemiological studies have been accomplished in regards to refractive error in Dominica, West Indies[4,15]. In 1990, Alfred Dib, O.D. analyzed the retinoscopy and subjective refraction findings of 779 consecutive office/clinic patients. The goal of his study was to determine refractive error categorization based on age, sex, and occupation. Emmetropes were not included in the study. Dr. Dibb found a significant relationship between gender, age, and occupation and refractive error. Males were more likely to be myopic and females were more likely to be hyperopic. He attributed gender differences in refractive error to higher education levels and near-work occupations in males versus females.

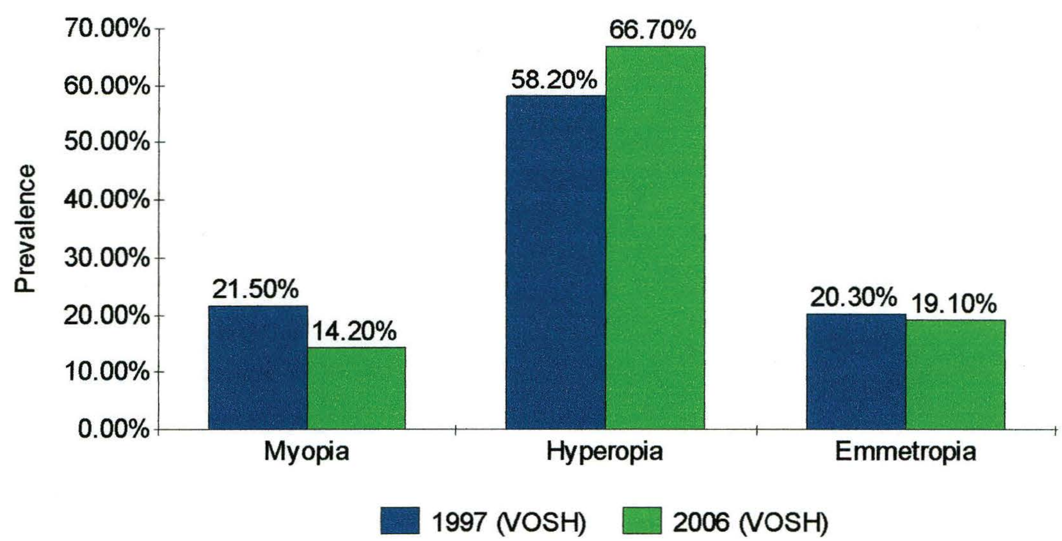
It was also found that younger patients were more likely to be students and professionals, and thus a higher rate of myopia among these individuals. He notes a peak in the rate of myopia occurred at about age 23. Continually, Dr. Dibb found a strong association between occupations with high near-work demands and myopia. Out of 302 patients with near-work oriented professions such as teachers, students, and lawyers, 56% were myopes and the remaining 44% were hyperopic[15]. Chart VI, demonstrates refractive error prevalence in Dr. Dibb's study from 1990 compared to the results of this study. It seems clear that Dr. Dibb's patients exhibited a higher prevalence of myopia. The patients who participated in the clinics on the VOSH mission exhibited a higher prevalence of hyperopia. Disparities between the results of the two studies could be attributed to different backgrounds, occupations, and socio-economic status between the patients in each group. Also, hyperopes and presbyopes are less likely to pay for an office visit to receive a spectacle prescription due to the fact that they can find and purchase plus lenses/readers rather inexpensively over-the-counter. Whereas, minus lenses for myopes are difficult to find and a prescription would be almost always necessary.



In 1997, Dan Wrubel O.D. and Melissa Green O.D. conducted an epidemiological study of refractive error amongst a sample population of Dominicans receiving services from an earlier VOSH mission[4]. Refractive errors were determined by retinoscopy in a similar fashion to the current study. All other methods were very similar to those described in this paper. As reflected in Chart VI below, prevalence of emmetropia remained about the same. There appears to be a shift towards less myopia and a higher prevalence of hyperopia in 2006 compared to 1997. However, this shift does not appear to be clinically or statistically significant.

Chart VI

Refractve Errors (1997 vs 2006)



A cross-sectional survey is a type of observational study. An observational study takes place in a way such that the examiner does not interfere with natural forces but simply observes them. In other words, observational studies simply allow "nature to take its course" without intervention[16]. Cross-sectional surveys, also called prevalence surveys, utilize data from a sample population at a *single point in time* to make the estimation for the entire population[17].

The primary goal of cross-sectional studies is to estimate the prevalence of a particular disease or dysfunction in order to take measures to improve health care services in the future. With the knowledge gained from a cross-sectional study, healthcare services can be designed more efficiently and the needs of the population can be assessed and met[16]. With regards to this study, it is our hopes that the refractive error profiles established can be used to determine the needs of the Dominicans presenting to clinics for future VOSH services. Using this study, Michigan-VOSH can seek out and acquire spectacles that match the refractive error profiles and minimize the number of spectacles that would not reflect the refractive needs of the patients. By doing so, not only will more patients go home with more accurate/appropriate glasses they need, but also the provisional clinics will be more efficient.

Data from cross-sectional studies can be used to draw further hypotheses, provide justification for further statistical studies, and can be used as baseline data for longitudinal studies[17]. Cross-sectional studies are economical and relatively quick to perform. This type of study cannot determine etiology and does not separate cause from effect[17].

Three pieces of information are gained from a cross-sectional study: prevalence, prevalence ratio, and odds ratio[16]. Prevalence is typically referred to as the number of cases in a distinct population at a specific point in time. Prevalence ratio then is the measure of cumulative incidence or risk based on prevalence[17]. The odds ratio quantifies the relationship between exposure and the disease. A logistic regression analysis can be applied to the odds ratio in a cross-sectional study in an attempt to describe an association between one or more dependent or independent variables[16,17,18].

The effectiveness of prevalence ratios versus odds ratios for analysis in a cross-sectional study tends to be controversial[17,18].

As in any study, cross-sectional studies are not without potential sources of error. The first source of bias originates from the initial selection of the sample population. Sampling error occurs when the participants do not reflect the status of the entire population. Selection bias played a role in this study because on many occasions, patients chose to participate in the study based on a need for optical correction or a particular concern about their ocular health. Our data/sample more reflected that of a clinical population versus a geographical one. The best way to avoid selection bias is to choose the subjects completely at random using a probability-sampling scheme where all members have an equal probability of being selected[17]. Measurement bias is a result of inadequate or improper classifications of the disease and its variables[16]. For example, measurement bias may have been a factor in this study because of improper lighting conditions during retinoscopy leading to inaccurate refractive error predictions. Other sources of measurement bias in this particular study are inaccurate retinoscopy due to miotic pupils and/or lens opacities, latent hyperopia not detected due to lack of cycloplegia, using retinoscopy bars only capable of detecting refractive error to the nearest +/- 0.50 diopters, retinoscopist/auto-refractor error, inaccurate trial lens refraction, or lack of patient cooperation and understanding.

While this study is not designed to determine the cause of refractive error in Dominica, inferences can and have been made concerning the origin of refractive error not only in Dominica but around the world. Researchers have pinpointed several theoretical yet very possible factors influencing the type and degree of refractive error including age, gender, ethnicity, diet, educational level, working demands, and more. Age has been the topic of several epidemiological studies as it pertains to refractive error. According to Borish, age is the single most important determinant of the distribution of refractive error in a given group. Several studies report a high incidence of low to moderate hyperopia (standard deviations on the order of +1.00 -+2.00 diopters) and more than 1 diopter cylinder of astigmatism in infants less than one year of age [12]. However, as the child ages and emmetropization begins there is a steep decline in astigmatism and hyperopia. As children reach school-age, an increase in the incidence of juvenile-onset myopia is evident[12]. The Beaver Dam Eye Study reports a decrease in myopia and a higher prevalence of hyperopia in the older age groups above age 43. This was partially attributed to changes in the density of the physiological lens and loss of tonic influences by the ciliary muscle[19].

A study by Sperduto et. al. analyzing differences refractive error between ethnic groups in the United States determined no difference in prevalence for races other than between Caucasian and African-American subsets. Between the ages of 12-54 years old, myopia is twice as common in whites as African-Americans with a difference of 26% in whites and 13% in African-Americans[20]. Studies of school-aged children in California, Hawaii, and Hong Kong indicate a general pattern in which myopia is highest in Asian school aged children, intermediate in white children, and least prevalent in black children[21-23].

Presbyopia and its rate of development have been linked to both geographical latitude and temperature. Several studies have implied earlier onset of presbyopia in regions near the equator.

Wharton and Yolton studied rural populations in Central America noting 50% of their sample population requiring "adds" in their early 30's[24]. A study comparing populations in India and Europe suggested that patients in the equatorial climate of India lost accommodative amplitude a much sooner than patients living in the temperate region of Europe[25]. Jain et al notes a positive correlation between early onset presbyopia and individuals living in hot climates with a probability value of less than 0.001[26]. Continually, regions near the equator are naturally exposed to a higher level of ultra-violet radiation. This cannot be excluded as a contributing factor to early presbyopia[27].

Dietary intake has been has been associated with ammetropia, particularly myopia. A nonrandomized clinical trial by Gardiner showed that individuals with the highest levels of animal protein in their diets were less likely to develop myopia[28]. A study by Lane suggests calcium depletion is related to an increase in myopia[29]. An examination of 102 seven year old children in Hong Kong demonstrated a higher prevalence of myopia in children with lower intake of dietary protein, fat, vitamins B and C, and other nutrients[30].

Genetics and heredity have been shown to play a significant role in the presence of refractive error. Studies show there is positive correlation between the refractive errors of parent and child, siblings, monozygotic twins, and dizygotic twins[12]. In fact, several genetic markers for myopia, hyperopia, and astigmatism have been identified on the human chromosome[31].

Environmental factors and the level of near work demand upon an individual resulting in increased tonic accommodation has long been a proposed cause of increased myopia. Several studies link level of education, amount of study, increased reading activity and other near work with increased axial length and myopia[12]. The Beaver Eye Dam Study found a higher frequency of myopia and lower frequency of hyperopia in patients who had completed the most years of schooling[19]. As previously mentioned, Dr. Alfred Dibb performed a refractive error analysis of 779 patients in Dominica and found a strong relationship between myopia and near-work related professions such as students, teachers, office clerks, and lawyers. Farmers and other professions exhibited a higher incidence of hyperopia[15]. Continually, higher intelligence and scholastic achievement has been linked with myopic individuals whereas hyperopes demonstrate poorer reading skills and other perceptual anomalies[32-36].

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