Category of manuscript: Original article - clinical science

Demographic analysis of glaucoma in a defined New Zealand population.

Jeremy J Mathan, Dipika V Patel PhD MRCOphth, Charles NJ McGhee DSc FRCOphth, Hussain Y Patel MD, FRANZCO.

Department of Ophthalmology,

New Zealand National Eye Centre,

Faculty of Medical and Health Sciences,

University of Auckland, Private Bag 92019, Auckland, New Zealand

Corresponding author

Dr Hussain Patel

Department of Ophthalmology,

Faculty of Medical and Health Sciences, The University of Auckland

Level 4, 85 Park Road, Grafton, Auckland

Private Bag 92019, Auckland, 1020, New Zealand.

Tel: +649 3737599 ext. 8699

Email: hyp99@yahoo.com

Short running title

Demographics of glaucoma in New Zealand

The authors have no conflict of interest in the results presented in this article. The work herein has been supported in part by the unrestricted research grants from: the Save Sight Society, The University of Auckland Department of Ophthalmology

Word count: 2564

Abstract

Background: This study aims to determine the demographic characteristics of glaucoma in a New Zealand population.

Design: Retrospective study

Method: The clinical records of all patients presenting consecutively to the glaucoma service over a six month period were reviewed. Demographic parameters including ethnicity, age at presentation, and gender were collected along with the patients' clinical data.

Results: The records of 857 patients were reviewed. A significant difference existed in the overall ethnic distribution of the study population in comparison to the catchment population (χ^2 = 80, df=5, p<0.001). Caucasian and Indian ethnicity were over-represented whereas the Pacific Island Nations ethnicity was significantly under-represented in all groups except secondary glaucoma and Maori ethnicity under-represented in all groups except primary angle closure (PAC). The under-representation is most prominent in primary open angle glaucoma (POAG) followed by normal tension glaucoma (NTG). There were only 2 patients of Pacific origin and 1 Māori patient with POAG. To a lesser degree the Asian ethnicity was also under-represented in POAG and unexpectedly in PAC. Significant differences were identified in gender distribution including a higher preponderance of females in NTG and PAC. Significant differences in age at presentation were also identified between different glaucoma sub-types and ethnicities. Markers of glaucoma severity did not vary with respect to demographic characteristics.

Conclusion: The distribution of diagnoses within the glaucoma clinic has been outlined. For eligible cases in the glaucoma clinic, Maori, Pacific peoples and to a lesser extent Asians are underrepresented while Caucasians and Indians are overrepresented in the total population.

Key words: glaucoma, demographics, Māori, Pacific Islander, New Zealand, intraocular pressure, cup to disc ratio, visual fields.

Introduction

Estimates suggest that there are in excess of 40 million individuals clinically defined as blind worldwide.[1] According to the World Health Organization, glaucoma is the leading cause of irreversible blindness.[2]

In certain countries, it is well established that differences in glaucoma prevalence and severity exist amongst different ethnicities, age groups and between genders. For example, in the United States, persons of African or Hispanic descent have been shown to be at a greater risk of glaucoma compared to Caucasian Americans, while population based studies have shown that Asians are more susceptible to primary angle closure in comparison to Europeans and Africans. The prevalence of open angle glaucoma has been shown to increase with age and is higher in males compared to females. Females are thought to be more susceptible to normal tension glaucoma and primary angle closure compared to men.[3-8]

In 1969, a survey evaluating eye diseases including glaucoma among 333 New Zealand Māori [8] was published, reporting an absence of glaucoma in this population. However, since then there have been no other published reports regarding the demographic data for glaucoma in the New Zealand population.

The aim of this study was to determine the demographic characteristics of glaucoma in a defined New Zealand population, and to determine if glaucoma severity varies between the different demographic groups.

Methods

This was a retrospective study conducted at the Glaucoma Service, Greenlane Clinical Centre (GCC), Auckland District Health Board (ADHB). This study conformed to the Declaration of Helsinki (1995 and as revised in Edinburgh, 2000) and ethical approval was obtained from the University of Auckland Human Participants Ethics Committee and the ADHB Research Review Committee.

The medical records of all patients presenting consecutively to the glaucoma service during a 6 month period from 1st January 2014 to 1st July 2014 were reviewed. Data collected included

age at diagnosis, gender, and self-reported ethnicity. For both eyes, information regarding the diagnosis, intraocular pressure (IOP), cup to disc ratio (CDR), and automated visual field testing (VF) was collected.

Patients presenting to the glaucoma service presented either acutely, or were referred by their general practitioner, optometrist or private ophthalmologist for either a glaucoma assessment or ongoing management of their disease. The diagnosis was made by a glaucoma fellowship trained ophthalmologist.

Diagnoses were categorized either individually or grouped within a disease spectra. These categories were as follows: primary open angle glaucoma (POAG), normal tension glaucoma (NTG), ocular hypertension (OHT), primary angle closure (PAC), mixed mechanism glaucoma (MM) and secondary glaucoma (SG). The PAC group included primary angle closure suspects needing peripheral iridotomy, primary angle closure, primary angle closure glaucoma, and acute angle closure crisis.

The exclusion criteria included patients classified as glaucoma suspects only, those whose initial glaucoma diagnosis could not be determined, and congenital glaucoma.

The ethnicity groups were categorised using the same classification system that ADHB uses and publishes online (http://www.adhb.govt.nz/about/population_stats.htm). The ethnic distribution of the study population was compared to the combined catchment population of the Auckland and Waitemata DHB, for which the GCC provides the glaucoma service. The Auckland regional population is also provided as a reference. Ethnicity statistics were acquired from the 2013 New Zealand Census of culture and identity (Statistics New Zealand, available at www.stats.govt.nz/). Ethnic proportions for the catchment area and Auckland region do not total 100% due to individuals identifying themselves with multiple ethnicities. The “Asian” ethnicity included patients who were recorded as South East Asian, Chinese, Other Asian and Asian not further defined. The “Indian” ethnicity included individuals who were recorded as Indian.

Data collection and statistical analysis was performed using Microsoft Excel 2010 version 14.0.7143.5000 (Microsoft Corporation, Washington, USA) and Statistical Package for the Social Sciences v21.0 (IBM, New York, USA). The Chi squared test was used to assess the difference in ethnic distribution between the study population and the catchment population. The independent samples t-test was used to analyse the inter gender variability in age, IOP and CDR. After testing for normality in data, the one way analysis of variance (ANOVA) was applied together with the Bonferroni’s post-hoc comparison test to assess the inter-ethnicity variability in age, IOP and CDR. If distributions were not normally distributed, the Kruskall-

Wallis test was applied instead. Differences between means were considered statistically significant if p values were less than 0.05.

Results

Glaucoma sub-type distribution

The medical records of 857 patients were reviewed. Glaucoma suspects (n=223), congenital/juvenile glaucoma (n=3) and those with no identified sub-type (n = 24) were excluded leaving a total of 607 patients included in the analysis. POAG was the most common diagnosis (39.0%, n=235), PAC was the next most common (24.8%, n=149), followed by NTG (17.4%, n =105), SG (11.5%, n =69), OHT (5.0%, n =30) and MM (2.3%, n =14).

There were 5 patients that had a different diagnosis in each eye and were therefore excluded from sub-type analysis. A total of 489 (80.6%) patients had bilateral disease while 118 (19.4%) had unilateral disease. The majority of the PAC group were primary angle closure suspects (108/139, 78.9%). Secondary glaucoma causes were distributed according to the following proportions: pseudoexfoliative (34%, n=15), uveitic (18%, n=8), neovascular (11%, n = 5)), pigment dispersion (11%, n=5) and other (25%, n=11).

Ethnicity distribution

The ethnicity distribution of the study population overall and for each glaucoma subtype is presented in table 1. No ethnicity was recorded in the patient notes of forty patients. There was a significant difference in the overall ethnic distribution of the study population in comparison to the catchment population (χ^2 = 80, df = 5, $p < 0.001$). Table 2 presents the glaucoma sub-type distribution for each ethnicity group. The Caucasian ethnicity was over-represented in the whole glaucoma population and in POAG, NTG and OHT when compared to the catchment population. Indian ethnicity was also over-represented in the whole glaucoma population, in POAG and PAC.

In contrast, the Pacific Island Nations ethnicity was significantly under-represented in all groups except SG. Maori ethnicity was significantly under-represented in all groups except PAC. The under-representation was most prominent in POAG followed by NTG. There were only two patients of Pacific Island Nations origin and one Māori patient with POAG. These are

10 times and 16 times less respectively when compared to the catchment population. To a lesser degree the Asian ethnicity was also under-represented in POAG and PAC.

Gender and age distribution

Table 3 presents the gender and age distribution for the whole study population and for each glaucoma sub-type. Females were predominant in NTG (63.8%female), PAC (67.1% female) and MM (78.6% female). The age at presentation was available for 441 patients. The mean age at presentation for the overall study population was 65.9 ± 13.9 years and the age range was 11-91 years. The mean age at presentation was highest for NTG (70.8 ± 12.5 years), POAG (69.1 ± 12.5 years) and PAC (64.7 ± 11.4 years) and lowest for MM (58.7 ± 11.0 years), OHT (58.1 ± 11.7 years), and SG (57.1 ± 18.9 years,).

For the whole glaucoma population, the mean presenting age for Caucasians (69.4 ±12.9 years) was significantly greater than that of Asians (60.8 ±12.7 years) ($p = 0.001$), Indians (55.9 ±12.4 years; $p < 0.001$) and Pacific peoples (57.1 ± 20.4 years; $p = 0.011$). The mean age at presentation in Māori was 60.3 ±9.8 years ($p > 0.05$).

Regarding the POAG sub-group, Asians and Indians presented at a significantly younger age (62.1 ±15.0 years; $p = 0.007$ and 56.3 ±10.1 years; $p < 0.001$ respectively) in comparison to Caucasians (73.1±10.6 years). For the NTG sub-group, only Asians presented at a significantly younger age (61.1 ±11.4 years; $p = 0.001$) in comparison to Caucasians (75.3 ±10.2 years; $p = 0.001$). In PAC, Indians presented at a significantly younger age (56.3 ± 12.9 years; $p = 0.013$) compared to Caucasians (67.1 ±11.2 years; $p = 0.013$).

There was no significant difference in age of presentation between males and females for NTG, PAC, OHT, SG. However, in the POAG sub-group, males presented earlier (66.8 ± 12.7 years) than females (72.7 ± 11.1 years; $p= 0.005$).

Glaucoma Severity

Data regarding the eye with the greater CDR for each patient and its corresponding intraocular pressure at presentation were available for 260 patients. The mean CDR was 0.76 ± 0.17 (range: 0.20-1.00) and mean IOP was 23.6 ± 9.5 mmHg. For POAG, the mean CDR was 0.78 ± 0.16 and mean IOP was 24.5 ± 7.0 mmHg. For NTG, mean CDR was 0.82 ± 0.09 and mean IOP was 16.2 ± 2.5 mmHg. The distribution of IOP and CDR in the overall population did not vary significantly between ethnicities and gender. While the IOP and CDR for Maori and Pacific

peoples could not be compared with other ethnicities due to small sample sizes, IOP and CDR did not vary significantly between remaining ethnicities and gender for both POAG and NTG.

Visual field data could not be reliably analysed due to existing co-morbidities and past treatment. These included patients with cataract, early lens changes, vitreous and retinal diseases, and optic atrophy. Additionally it was decided that visual field data labelled "excessively high false positives" or "low test reliability" by the system should not be included in analysis.

Discussion

The current study showed that POAG was the most common diagnosis, PAC the second to most common at 24.8% and NTG the third to most common at 17.4%. The apparently high proportion of patients with PAC is likely due to our inclusion of all diseases that fell in the spectrum of this diagnosis which ranged from narrow angle to primary angle closure to primary angle closure glaucoma.

The Caucasian and Indian ethnic groups were shown to be over-represented overall and in many of the glaucoma sub-groups. Of particular interest is the under representation of Maori and Pacific peoples in most glaucoma subtypes and most prominently in POAG. The observed trends in ethnic distribution of the glaucoma population are likely due to a combination of three factors: genetics, access to healthcare, and population age structure.

Potter (1969) suggested that the low incidence of glaucoma among Maori and Pacific peoples may be expected given their common origin from their pre Chinese Mongoloid predecessors.[9] The current study has additionally shown that the PAC grouped diagnoses was the most common glaucoma subtype among Māori and Pacific peoples. The prevalence of PAC glaucoma is reported to be relatively higher among studies in East Asia.[10] One study in Mongolia reported a 2.8 times higher prevalence of PACG in comparison to POAG.[11] Qualitatively, the similarity observed in disease patterns between these groups and the Māori and Pacific peoples lend further credibility to the common origins explanation suggested by Potter (1969) and speculate on the existence of genes which may either protect Maori and Pacific peoples from glaucoma or predispose these ethnicities to certain types of glaucoma.

Access to the glaucoma service is commonly by way of referral from primary healthcare services. The question of access to primary eye care services for Māori and Pacific peoples is raised in order to explain their under representation in glaucoma diagnoses. These ethnic

groups are shown to have generally poor access to and utilization of primary healthcare services.[12-15] The observed under-representation in the glaucoma clinic may thus reflect the low numbers of Maori and Pacific peoples initially presenting to their optometrist or general practitioner.

A third possible explanation may be related the differences in age structure of the Maori and Pacific population in comparison to the Caucasian population. Maori [16] and Pacific peoples [17] in New Zealand have been reported to have a lower life expectancy in comparison to Caucasians. These populations are thus comparatively younger populations. According to statistics New Zealand, 17.1% of the Caucasian population are over 65 years while only 5.4% and 4.7% of the Maori and Pacific population respectively are over 65. Since glaucoma is a disease of the elderly, the under representation of Maori and Pacific peoples in the glaucoma clinic may be due to the lower life expectancy of the Maori and Pacific peoples. The older Caucasian population may explain their relative over-representation in our study.

An unexpected observation is the under-representation of Asians with glaucoma in the total population and surprisingly in the PAC sub-group. Since the prevalence of open angle glaucoma among Asians is thought to be similar to Indians but higher than Caucasians and the prevalence of angle closure glaucoma is thought to be much higher in comparison to other studied ethnicities, Asians were expected to be over-represented or at least equally represented in the PAC population.[1,10] The authors hypothesized that the reason for this under-representation was due to possible underutilization of primary eye care services, in particular optometrists for regular check-ups, or the public system as a whole. Upon closer scrutiny of the data by removing the angle closure suspects, Asians were in fact over-represented, as they formed 22.5% of patients with primary angle closure, narrow angle glaucoma and primary angle closure glaucoma which are conditions at the more symptomatic end of the spectrum. More exploration is needed in characterizing the demographics of patients presenting to optometrists as well as the private sector.

One limitation of the study is the grouping of the Asian and Indian ethnicity as this does not consider the differences in glaucoma susceptibility within these diverse ethnic groups. The absolute and relative prevalence of glaucoma subtypes have been shown to vary between different groups of what we have classified as “Asians”.[10] Moreover some who identified themselves in the Asian group were Sri Lankans, who are likely, more similar to Indians. Furthermore, while the Fijian ethnicity was not further defined in the data collection, it was

reasonable to assume by name that most Fijians were in fact Fijian Indians. This group may be considered to be genetically and culturally more similar to the Indian ethnicity rather than the Pacific Island Nations group.

Conclusion

To the best of our knowledge, this is the first time a glaucoma population in New Zealand has been studied t. We have described the distribution of diagnoses, ethnicities, as well as trends in gender and age. Of particular interest is the clear under representation of Māori and Pacific peoples with glaucoma. The results from this study may aid in risk prediction for patients presenting to the glaucoma service.

Acknowledgements

The work herein has been supported in part by an unrestricted research grant from the Save Sight Society.

References

(1) Quigley H, Broman AT. The number of people with glaucoma worldwide in 2010 and 2020. Br J Ophthalmol 2006;90(3):262-267.

(2) Resnikoff S, Pascolini D, Etya'ale D, Kocur I, Pararajasegaram R, Pokharel GP, et al. Global data on visual impairment in the year 2002. Bull World Health Organ 2004;82(11):844-851.

(3) Tielsch JM, Sommer A, Katz J, Royall RM, Quigley HA, Javitt J. Racial variations in the prevalence of primary open-angle glaucoma: The Baltimore eye survey. J Am Med Assoc 1991;266(3):369-374.

(4) Murakami Y, Lee BW, Duncan M, Kao A, Huang J-, Singh K, et al. Racial and ethnic disparities in adherence to glaucoma follow-up visits in a county hospital population. Arch Ophthalmol 2011;129(7):872-878.

(5) Quigley HA, West SK, Rodriguez J, Munoz B, Klein R, Snyder R. The prevalence of glaucoma in a population-based study of Hispanic subjects: Proyecto VER. Arch Ophthalmol 2001;119(12):1819-1826.

(6) He M, Foster PJ, Johnson GJ, Khaw PT. Angle-closure glaucoma in East Asian and European people. Different diseases? Eye 2006;20(1):3-12.

(7) Levene RZ. Low tension glaucoma: A critical review and new material. Surv Ophthalmol 1980 0;24(6):621-664.

(8) Shiose Y, Kitazawa Y, Tsukahara S, Akamatsu T, Mizokami K, Futa R, et al. Epidemiology of glaucoma in Japan. A nationwide glaucoma survey. Jpn J Ophthalmol 1991;35(2):133-155.

(9) Potter D. A preliminary field survey of Maori eyes. Trans Ophthalmol Soc N Z 1969;21:54-64.

(10) Cho H-, Kee C. Population-based glaucoma prevalence studies in Asians. Surv Ophthalmol 2014;59(4):434-447.

(11) Foster PJ, Baasanhu J, Alsbirk PH, Munkhbayar D, Uranchimeg D, Johnson GJ. Glaucoma in Mongolia: A population-based survey in Hövsgöl Province, Northern Mongolia. Community Eye Health Journal 1997;10(22):30.

(12) Ellison-Loschmann L, Pearce N. Improving access to health care among New Zealand's Maori population. Am J Public Health 2006;96(4):612-617.

(13) Malcolm L. Inequities in access to and utilisation of primary medical care services for Maori and low income New Zealanders. N Z Med J 1996;109(1030):356-358.

(14) Teevale T, Denny S, Percival T, Fleming T. Pacific secondary school students' access to primary health care in New Zealand. N Z Med J 2013;126(1375).

(15) Crampton P, Dowell A, Woodward A, Salmond C. Utilisation rates in capitated primary care centres serving low income populations. N Z Med J 2000;113(1120):436-438.

(16) Harris R, Tobias M, Jeffreys M, Waldegrave K, Karlsen S, Nazroo J. Effects of self-reported racial discrimination and deprivation on Māori health and inequalities in New Zealand: cross-sectional study. The Lancet 2006 6/17–23;367(9527):2005-2009.

(17) Tobias MI, Cheung J. Monitoring health inequalities: Life expectancy and small area deprivation in New Zealand. Population Health Metrics 2003;1.

(18) Vijaya L, George R, Baskaran M, Arvind H, Raju P, Ramesh SV, et al. Prevalence of Primary Open-angle Glaucoma in an Urban South Indian Population and Comparison with a Rural Population. The Chennai Glaucoma Study. Ophthalmology 2008;115(4):648-654.e1.

(19) Liang YB, Friedman DS, Zhou Q, Yang X, Sun LP, Guo LX, et al. Prevalence of primary open angle glaucoma in a rural adult chinese population: The Handan eye study. Invest Ophthalmol Visual Sci 2011;52(11):8250-8257.

Tables

Table 1 Distribution of reported ethnicity in all patients within total study population and in subpopulations of glaucoma diagnoses compared to the population of the catchment area and the Auckland regional population.

Ethnicity	Percentage by population (%)								
	Total population n= 567	POAG n= 217	NTG n= 100	OHT n= 28	PAC n= 138	MM n= 13	SG n= 60	Catchment area population	Auckland population
Caucasians	71.3	76.0	72.0	82.1	61.6	84.6	63.3	62.0	55.8
Asians	11.5	10.1	17.0	17.9	10.9	0.0	10.0	15.8	14.8
Indians	9.7	10.1	6.0	0.0	13.0	15.4	10.0	5.6	6.9
Pacific peoples	3.2	0.9	2.0	0.0	5.1	0.0	11.7	8.9	13.8
Māori	2.5	0.5	2.0	0.0	6.5	0.0	3.3	8.0	10.1
Other†	1.9	2.3	1.0	0.0	2.9	0.0	1.7	3.2	2.9

POAG, primary open angle glaucoma; NTG, normal tension glaucoma; OHT ocular hypertension; PAC, primary angle closure, MM, mixed mechanism; SG, secondary glaucoma

Table 2 Distribution of diagnoses within the study population and within each ethnic group.

Diagnoses	Percentage by ethnicity (%)						
	Study population n = 602	Caucasians n= 400	Asians n= 65	Indians n= 54	Pacific peoples n= 18	Māori n= 14	Other n= 11
POAG	39.0	41.3	33.8	40.7	11.1	7.1	45.5
NTG	17.4	18.0	26.2	11.1	11.1	14.3	9.1
OHT	5.0	5.8	7.7	0.0	0.0	0.0	0.0
PAC	24.8	21.3	23.1	33.3	38.9	64.3	36.4
MM	2.3	2.8	0.0	3.7	0.0	0.0	0.0
SG	11.5	11.0	9.2	11.1	38.9	14.3	9.1

POAG, primary open angle glaucoma; NTG, normal tension glaucoma; OHT ocular hypertension; PAC, primary angle closure group; MM, mixed mechanism; SG, secondary glaucoma

Table 3 Gender and mean presenting age (where available) distribution within the study population and in subpopulations of glaucoma diagnoses.

	% Male (%Female)	Mean presenting age (years) ±SD (n)
Total population	46.0 (54.0)	65.9 ±13.9 (441)
POAG	58.3 (41.7)	69.1 ±12.5 (146)
NTG	36.2 (63.8)	70.8 ±12.5 (74)
OHT 1^0	43.3 (56.7)	58.1 ±11.7 (25)
PAC	32.9 (67.1)	64.7 ±11.4 (133)
MM	21.4 (78.6)	58.7 ±11.0 (3)
SG	52.2 (47.8)	57.1 ±18.9 (55)

POAG, primary open angle glaucoma; NTG, normal tension glaucoma; OHT, ocular hypertension; PAC, primary angle closure group; MM, mixed mechanism; SG, secondary glaucoma