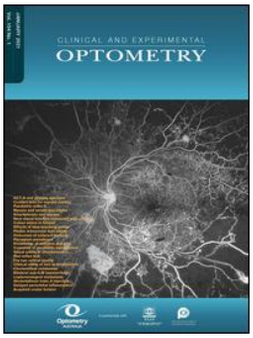

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Eye health profile of affordable eye care service users

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ABSTRACT

Clinical relevance: Knowledge of the typical eye health profile of patients experiencing social or economic disadvantage is useful for health care modelling.

Background: The aim of this work is to profile the ocular health and sociodemographic characteristics of Australian College of Optometry service users of all ages and to explore the relationships between key sociodemographic characteristics and eye health.

Methods: For 3093 eye examinations, best-corrected distance visual acuity and mean spherical equivalent refractive error were tested non-parametrically by clinic category, remoteness area, number of co-morbidities, gender and indigenous status, also correlated against age and socioeconomic advantage/disadvantage. Covariates of interest were entered into linear mixed models of visual acuity and mean spherical equivalent refractive error, controlling for age. Risk estimates are reported for visual impairment (defined as ≤6/12 best-corrected distance visual acuity in one or both eyes) and ocular diagnoses.

Results: Visual impairment is more prevalent amongst service users examined in domiciliary settings. Increasing co-morbidities were associated with poorer best-corrected distance visual acuity. Aboriginal and Torres Strait Islander service users had lower visual impairment prevalence overall but proportionally fewer aged ≥50 years attended for eye care, compared to non-indigenous.

Conclusions: Domiciliary eye examinations detect remediable visual impairment. Federal public health interventions delivered by the Australian College of Optometry for Aboriginal and Torres Strait Islander eye care appear effective but may not reach all aged ≥ 50 years; further research is required. Identification of multiple co-morbidities should prompt optometrists to tailor public health messages and signpost to low vision services earlier.

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Ageing; eye care; indigenous health; sight loss; vision impairment

Introduction

The Australian College of Optometry (ACO) provides eye care services to over 60,000 Victorians annually, through the Victorian Eyecare Service, mainly from socially or economically disadvantaged backgrounds. This government-funded service, based in Melbourne, is designed to provide affordable eye care to a variety of groups including the homeless, refugees, people living with disabilities, low-income groups receiving government assistance, and older adults in aged care. Eligibility is determined through possession of a healthcare or other concession card indicating receipt of government support, refugee/homeless status, or drawing an aged pension.

The federally funded Visiting Optometrists Scheme ensures these services are accessible to rural and regional Australians. Treatable vision impairment is more prevalent amongst the described groups[1–6] due to their increased susceptibility to health inequalities affecting overall health. There is a recognised need to tailor active health promotion interventions that address these issues, to increase reach, understanding and engagement.[7–10]

Exploring potential interactions between sociodemographic characteristics of ACO service users and their eye health could inform the tailoring of active health promotion interventions. These interventions could address particular risk factors for visual impairment or ocular diseases of identified higher incidence in ACO clinics. This could be extended to signposting or active referral to other healthcare services, e.g. smoking cessation. Such work would facilitate development and/or delivery of public health interventions, in collaboration with primary care networks and community health outreach schemes. This in turn could promote better eye health and reduce instances of preventable visual impairment.

The ACO utilises electronic patient records to document eye examinations performed as part of its clinical services, representing a unique opportunity to capture health data in this subset of the population, who can be otherwise hard to reach for routine health data collection.[10,11] This work therefore aims to profile the ocular health and sociodemographic characteristics of a large subsample of ACO service users, through electronic patient records extraction and analysis. Potential relationships between key sociodemographic characteristics and eye health can be explored and compared/contrasted to existing research. This enables recommendations to be made for targeting of public health or service initiatives, and areas for future research.

Research questions for this work were as follows: (1) What is the profile of Australian College of Optometry eye care service users?, and (2) What are the relationships between demographic characteristics, visual function and ocular health for these service users?

Methods

Data extraction from clinical records

A sample of clinical eye examination records of 3,400 individual patient visits was extracted from the electronic patient record

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Supplemental data for this article can be accessed here.

system and de-identified by a member of the direct care team. Records were from service users seen within any of the ACO clinics and services from 1st January to 31 December 2018. Data extraction and manual processing occurred between 1st April and 31st June 2019. Sample size was determined pragmatically based on project time constraints, the requirement to perform extensive manual data checking and validation, and the order in which data from clinics was extracted.

Data extraction and processing were completed for all unique visits to non-general clinics in 2018, but the sample size for the randomised subset of general clinic records was limited to 1,400 unique visits in the same calendar year, to accommodate these factors. After exclusions and data coding as detailed in the supplementary material, analysis was performed on 3093 dataset entries. For ethics details, please see supplementary material.

Statistical analysis

Fifteen ACO clinic sites were collapsed together to form four categories and increase statistical power: General – service users attending six primary clinics within inner Melbourne; Domiciliary – comprising Commonwealth Home Support, Aged Care, Visiting Disability and Supported Residential Services; Outreach – comprising homeless persons, Victorian Aboriginal Health Services and community outreach clinics; and Rural – comprising the Rural Workforce Agency of Victoria Visiting Optometrist Service and Royal Flying Doctor Service clinics.

All unique eye examinations within the Domiciliary, Outreach and Rural categories in the 2018 calendar year were included (2000 records, n = 1899 after data processing and exclusions). The general category comprised a random sample of eye examinations (1400 records, n = 1194 after data processing and exclusions) from the total pool of unique eye examinations in the 2018 calendar year in service users aged three and above (approximately 35,000 records). Age range was limited to ≥3 years to match the youngest age in the other clinic categories (2.97 years). Random sampling was achieved using a custom MATLAB script.

To characterise the demographics, visual function and ocular health of ACO service users, descriptive statistics were reported for the following continuous variables (mean, standard deviation):

- Mean spherical equivalent (MSE) refractive error
- Best-corrected distance logMAR visual acuity (BCVA) in each eye
- Intraocular pressure in each eye
- Australian Bureau of Statistics Index of Relative Socioeconomic Advantage/Disadvantage (IRSAD) score, determined from postcode.

And categorical variables (frequencies, percentages):

- Clinic category
- Gender
- Indigenous status
- Diagnosis
- Comorbidities
- Government pension status
- Accommodation type
- Preferred language
- Country of birth
- Need for interpreter
- Presence of visual impairment (defined as BCVA ≤6/12 in one or both eyes[3])
- Australian Statistical Geography Standard Remoteness Area (RA) codes, determined from postcode.

Government pension status, accommodation type, country of birth, preferred language and need for an interpreter are reported on a descriptive basis only, and are not included in inferential analyses due to proportion of missing data. This demographic data is not routinely collected outside the General clinics of the ACO due to limited administrative support and no direct relation to optometric clinical outcomes.

Intraocular pressure was only measured when clinically warranted, e.g. new patient, patient aged ≥ 45 years, other clinical signs of glaucoma present on examination or imaging. It was not always possible to obtain intraocular pressure measurements in some clinics involving residential visits, due to limitations in cooperation with more invasive testing that may relate to intellectual disability, cognitive impairment or complex mental health difficulties.

To explore the relationship between demographic characteristics, visual function and ocular health, inferential statistics were performed. Key outcomes BCVA and absolute MSE refractive error were not normally distributed by Shapiro-Wilk test; data were highly leptokurtic. Therefore, linear mixed modelling analysis was performed for these variables to characterise interactive factors identified as statistically significant through preliminary non-parametric analyses (per variable, Kruskal-Wallis and post hoc Bonferroni-corrected Mann-Whitney U by clinic category, RA and number of co-morbidities; Mann-Whitney U testing by gender and indigenous status; Spearman rank correlation with age and IRSAD score). Only statistically significant interactive factors were entered into the model, and for correlations, only those with a Spearman's rho of 0.200 or greater (classified as weak and above[12]) were included as covariates, due to the large sample size increasing sensitivity even to very marginal associations within the data.

In the linear mixed model, age was entered as a covariate, and clini category, indigenous status and numbers of comorbidities were entered as fixed factors, both for main effects and as interaction terms with age. The −2 log likelihood (−2LL) ratio was compared against an intercept-only model, with the covariates only, and then with each fixed factor added. No within-subjects terms were specified as this comprises a cross-sectional retrospective with no repeated measures. The model with the lowest −2LL value was selected as the preferred model.

To obtain risk estimates for visual impairment (6/12 or worse best-corrected VA in one or both eyes[5]) and different eye conditions (visually significant cataract, age-related macular degeneration [AMD], glaucoma, diabetic retinopathy, amblyopia, strabismus, binocular vision and accommodative problems), 2 × 2 contingency tables of visual impairment/diagnosis against clinic category were created to calculate Pearson chi-square and risk estimates. Clinic categories were collapsed together to form general (using the previously created general clinics category) and other (comprising domiciliary, rural and outreach).

Results

Whole sample demographic characteristics (n = 3093) are presented in Table 1. Average age was 49 years, and over half the sample had at least one comorbidity, with the

Table 1. Demographic characteristics of the sample (n = 3093).

Characteristic		Whole Sample (n = 3093)	Clinic Categories			
			General (n = 1194)	Outreach (n = 734)	Domiciliary (n = 674)	Rural (n = 491)
Age (years)Mean ± SD(Min, Max)		49.31 ± 22.24(2.97, 99.34)	49.59 ± 22.91(3.19, 98.18)	43.43 ± 19.41(4.25, 90.79)	60.95 ± 17.50(17.41, 99.34)	41.42 ± 23.59(2.97, 96.32)
Gender	Female	1556 (50.3%)	605 (50.7%)	385 (52.5%)	290 (43%)	276 (56.2%)
	Male	1537 (49.7%)	589 (49.3%)	349 (47.5%)	384 (57%)	215 (43.8%)
Aboriginal and Torres Strait Islander		462 (14.94%)	40 (3.4%)	94 (12.8%)	11 (1.6%)	317 (64.6%)
Government pension status	Aged Pension/DVA	337 (10.7%)	229 (7.4%)	13 (0.4%)	84 (2.7%)	11 (0.4%)
	Disability or Carer Support	570 (18.4%)	344 (11.1%)	43 (1.4%)	168 (5.4%)	15 (0.5%)
	Unemployed	78 (2.5%)	25 (2.1%)	19 (2.6%)	26 (3.9%)	8 (1.6%)
	Healthcare Card	381 (12.3%)	330 (27.6%)	14 (1.9%)	17 (2.5%)	20 (4.1%)
	Refugee/Overseas Pension	129 (4.2%)	101 (8.5%)	5 (0.7%)	4 (0.6%)	19 (3.9%)
	Specialist Care	33 (1.1%)	28 (2.3%)	1 (0.1%)	1 (0.1%)	3 (0.6%)
	Missing	1565 (50.6%)	129 (10.8%)	635 (86.5%)	363 (53.9%)	375 (76.4%)
Number of comorbidities	None recorded	1405 (45.4%)	527 (44.1%)	449 (61.2%)	206 (30.6%)	223 (45.4%)
	One	897 (29%)	307 (25.7%)	173 (23.6%)	269 (39.9%)	148 (30.1%)
	Two	436 (14.1%)	178 (14.9%)	66 (9%)	128 (19%)	64 (13.0%)
	Three or more	335 (11.5%)	182 (15.2%)	46 (6.3%)	71 (10.5%)	56 (11.4%)
Country of birth	Australia & New Zealand	915 (30.2%)	511 (42.8%)	67 (9.1%)	242 (35.9%)	113 (23%)
	All other countries	651 (21%)	549 (46%)	32 (4.4%)	69 (10.2%)	1 (0.2%)
	Missing	1509 (48.8%)	134 (11.2%)	635 (86.5%)	363 (53.9%)	377 (76.8%)
Preferred Language	English	1181 (38.2%)	704 (59%)	85 (11.6%)	274 (40.7%)	118 (24%)
	Not English	418 (13.5%)	362 (30.3%)	14 (1.9%)	42 (62%)	0
	Missing	1494 (48.3%)	128 (10.7%)	635 (86.5%))	358 (53.1%)	373 (76%)
Interpreter required	Yes	102 (3.3%)	67 (5.6%)	11 (1.5%)	23 (3.4%)	1 (0.2%)
	Missing	1500 (48.5%)	126 (10.6%)	634 (86.4%)	361 (53.6%)	379 (77.2%)
Living arrangements	Ownership	514 (16.6%)	465 (38.9%)	14 (1.9%)	17 (2.5%)	18 (3.2%)
	Rental	504 (16.3%)	389 (32.6%)	45 (6.1%)	32 (4.7%)	38 (7.7%)
	Temporary Housing	65 (2.1%)	5 (0.4%)	14 (1.9%)	45 (6.7%)	1 (0.2%)
	Dependent Living	218 (7%)	12 (1%)	9 (1.2%)	193 (28.6%)	4 (0.8%)
	Missing	1669 (54%)	323 (27.1%)	652 (88.8%)	387 (57.4%)	430 (87.6%)
ASGS RA Code	Major City	2441 (78.9%)	1159 (97.1%)	716 (97.5%)	519 (77%)	47 (1.9%)
	Inner Regional	288 (9.3%)	33 (2.8%)	12 (1.6%)	131 (19.4%)	112 (22.8%)
	Outer Regional and Remote	364 (11.8%)	2 (0.2%)	6 (0.8%)	24 (3.6%)	332 (67.6%)
ABS IRSAD score		991.70 ± 72.15	986.27 ± 77.86	1017.78 ± 65.96	1011.19 ± 63.60	939.14 ± 40.48

Abbreviations: ABS = Australian Bureau of Statistics; ASGS = Australian Statistical Geography Standard; IRSAD = Index of Relative Socioeconomic Advantage/Disadvantage; RA = Remoteness Area; SD = Standard Deviation

Table 2. Breakdown of comorbidities documented within the sample (n = 3093)[a.]

Co-morbidity	Whole sample (n = 3093) (n, %)
Diabetes Mellitus (Type 1 or 2)	459 (14.8%)
Hypertension	635 (20.5%)
Dyslipidaemia	486 (15.7%)
Cardiovascular Disease	179 (5.8%)
Neuropsychiatric Condition (inc. depression, anxiety, schizophrenia, psychosis)	628 (20.3%)
Other Neurological Condition (inc. Seizures, Epilepsy and Migraine)	154 (1.8%)
Endocrine Dysfunction (Thyroid, Rheumatoid Arthritis)	86 (2.8%)
Asthma	172 (5.6%)
Cancer	70 (2.3%)
Intellectual Disability	29 (0.9%)
Communicable Disease (HIV, Hepatitis)	35 (1.1%)

Abbreviations: HIV = Human immunodeficiency virus
a. Percentages do not add up to 100% due to some individuals having more than one comorbidity.

breakdown of these comorbidities presented in Table 2. Visual function characteristics are presented in Table 3.

Frequently recorded comorbidities were hypertension (20.5%), neuropsychiatric conditions including anxiety and depression (20.3%), dyslipidaemia (15.7%) and diabetes mellitus (14.8%). The most common ocular diagnoses were correctable refractive error (54.6%) and visually significant cataract (18.1%). The proportion of the sample living with visual impairment was 14.4%. Government pension status indicated a wide distribution of pension types, with most common being receipt of a Disability or Carers' Support Pension (18.4%), a Healthcare Card (12.3%) held by many receiving government benefits, or an Aged or Department of Veteran Affairs (DVA) pension (10.7%). Regarding cultural and linguistic diversity, 21% of the sample were born overseas and 13.5% had a preferred language other than English, although only 3.3% were recorded as needing an interpreter. Only 16.6% in the sample owned their own home.

To explore the relationships between demographics of ACO service users, their visual function and ocular health, inferential statistics were performed using the most complete demographic variables. The results of this analysis will now be presented and notable findings highlighted.

Non-parametric analysis

Statistically significant Spearman's rank correlations were identified between age, IRSAD score and the majority of visual function variables, but were very weak in strength (Spearman's rho < 0.2). A slightly stronger relationship between BCVA and age was identified (Left eye [LE] rho = 0.311, $p < 0.001$; Right eye [RE] rho = 0.285, $p < 0.001$), demonstrated in Figure 1, which plots RE and LE BCVA against age. Older adults were more likely to have poorer acuity.

Findings from the correlational analysis are supported by comparison of age in those with any visual impairment to those without. Age was higher in those with any visual impairment (visual impairment age = 62.99 ± 22.71 years, no visual impairment age = 47.01 ± 21.32 years, Z = −14.1, $p < 0.001$). IRSAD score was also somewhat higher in those with visual impairment (visual impairment IRSAD score = 1002.45 ± 73.37, No visual impairment IRSAD score = 989.89 ± 71.80, Z = −3.56, $p < 0.001$), but this difference is marginal and both scores fall very close to the average IRSAD score of 1000, indicating that neither group has relative advantage or disadvantage. Practical significance may therefore be limited, especially given the lack of notable correlations between IRSAD score and BCVA in either eye. No significant gender effects were identified throughout the analysis.

Table 3. Visual function characteristics and ocular diagnoses (n = 3093)[a.]

Characteristic		Whole Sample (n = 3093)	Clinic Categories: General (n = 1194)	Outreach (n = 734)	Domiciliary (n = 674)	Rural (n = 491)
Best-Corrected Distance Visual Acuity (logMAR, Mean ± SD)	RE (n = 3093)	0.095 ± 0.192	0.082 ± 0.186	0.067 ± 0.156	0.188 ± 0.231	0.039 ± 0.149
	LE (n = 3093)	0.100 ± 0.191	0.085 ± 0.179	0.080 ± 0.174	0.196 ± 0.233	0.036 ± 0.123
MSE Refractive Error (DS, Mean ± SD)	RE (n = 3081)	0.008 ± 2.16	−0.176 ± 2.70	0.191 ± 1.42	−0.114 ± 2.25	0.35 ± 1.24
	LE (n = 3064)	0.036 ± 2.09	−0.129 ± 2.57	0.196 ± 1.51	−0.036 ± 2.12	0.296 ± 1.31
Intraocular pressure (mm/Hg, Mean ± SD)	RE (n = 2235)	14.20 ± 3.06	14.03 ± 3.02	14.58 ± 3.03	14.30 ± 3.15	13.86 ± 2.99
	LE (n = 2232)	14.20 ± 3.22	14.10 ± 3.12	14.38 ± 3.02	14.39 ± 3.53	13.87 ± 3.23
Type of Refractive Error	Myopia	594 (19.2%)	294 (24.6%)	96 (13.1%)	149 (22.1%)	55 (11.2%)
	Hypermetropia	825 (26.7%)	354 (29.6%)	170 (23.2%)	158 (23.4%)	143 (29.1%)
	Emmetropia	1063 (34.4%)	326 (27.3%)	326 (44.4%)	194 (28.8%)	217 (44.2%)
	Mixed	577 (18.7%)	210 (17.6%)	134 (18.3%)	159 (23.6%)	74 (15.1%)
	Missing	34 (1%)	10 (0.8%)	8 (1.1%)	14 (2.1%)	2 (0.4%)
Ocular Diagnosis	No significant ocular pathology	476 (15.4%)	114 (9.5%)	170 (23.2%)	57 (8.5%)	105 (21.4%)
	VI	444 (14.4%)	163 (13.7%)	58 (7.9%)	194 (28.8%)	29 (5.9%)
	Correctable refractive error	1996 (64.5%)	858 (71.9%)	400 (54.5%)	466 (69.1%)	272 (55.4%)
	Visually significant cataract	560 (18.1%)	193 (16.2%)	94 (12.8%)	221 (32.8%)	52 (10.6%)
	AMD	140 (4.5%)	48 (4.0%)	14 (1.9%)	60 (8.9%)	18 (3.7%)
	Glaucoma/Suspected	103 (3.3%)	47 (3.9%)	18 (2.5%)	29 (4.3%)	9 (1.8%)
	Diabetic Retinopathy	60 (1.9%)	25 (2.1%)	6 (0.8%)	14 (2.1%)	15 (3.1%)
	Amblyopia	98 (3.2%)	46 (3.9%)	16 (2.2%)	25 (3.7%)	11 (2.2%)
	Strabismus	75 (2.4%)	42 (3.5%)	5 (0.7%)	18 (2.7%)	10 (2.0%)
	Binocular vision or accommodative disorder	47 (1.5%)	23 (1.9%)	6 (0.8%)	1 (0.1%)	17 (3.5%)

Abbreviations: AMD = Age-related macular degeneration; DS = Dioptre sphere; mm/Hg = Millimetres of Mercury LE = Left eye; MAR = Minimum angle of resolution; MSE = Mean spherical equivalent; RE = Right eye; SD = Standard deviation; VI = Visual Impairment
Mixed: one type of refractive error in one eye, and another type or emmetropia in the other eye.
Visually significant cataract: 6/12 best-corrected visual acuity or worse in one or both eyes with cataract present
a. Percentages for Ocular Diagnosis do not add up to 100% due to some individuals having more than one diagnosis.

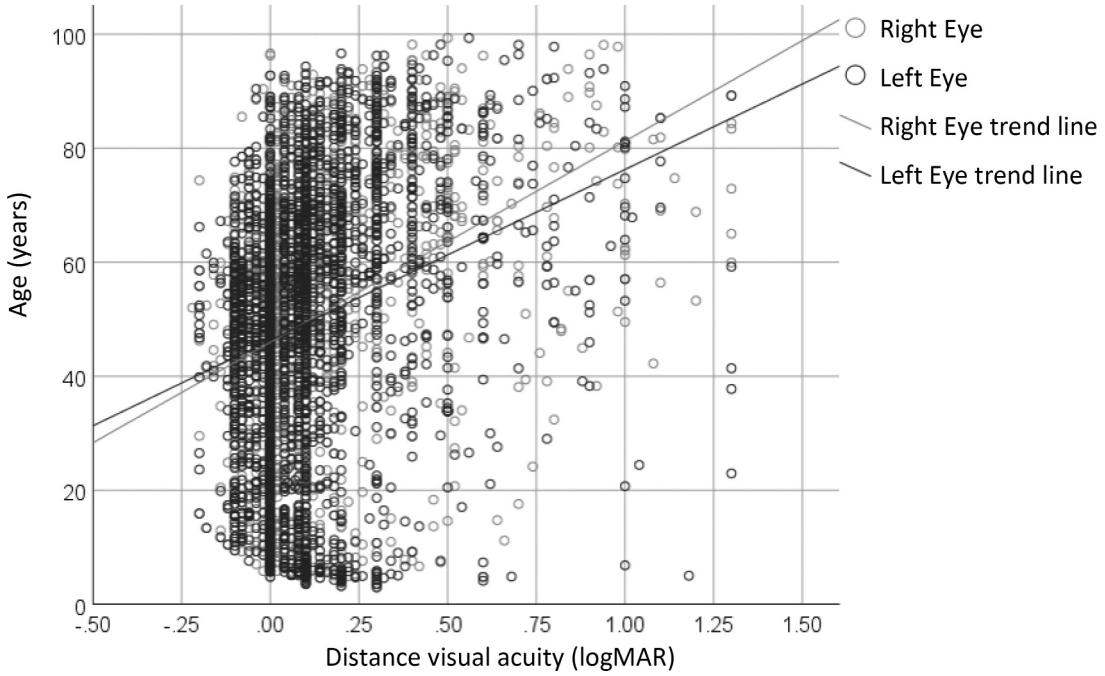

Figure 1. Distance visual acuity by age (n:= 3093).

Table 1 demonstrates that service users within the Domiciliary clinics category, which includes aged care services, are older by at least a decade on average (vs General Z = −9.618, p < 0.001; vs Outreach Z = −15.46, p < 0.001; vs Rural Z = −13.33, p < 0.001). To a lesser extent, general clinic users were older than those attending Outreach and Rural clinics (vs Outreach Z = −6.65, p < 0.001; vs Rural Z = −6.35, p < 0.001). Service users attending Rural clinics had the lowest IRSAD scores compared to all other sites (vs. Outreach Z = −21.18, p < 0.001; vs. Domiciliary Z = −18.98, p < 0.001; vs General Z = −14.31, p < 0.001), but also had better average visual acuities (vs General Z = −5.77 (RE) & −5.89 (LE), p < 0.001 (both); vs Outreach Z = −5.00 (RE) & −5.53 (LE), p < 0.001 (both); vs Domiciliary Z = −14.51 (RE) & −14.59 (LE), p < 0.001 (both)).

The Domiciliary clinic group had a higher than expected proportion of service users with visual impairment (observed 194 vs. expected 97, Chi-Square = 167.98, df = 3, p < 0.001), reflecting the poorer average BCVA recorded for this group. More service users than expected had one or two comorbidities in this group (one comorbidity observed 269 vs expected 196; two comorbidities observed 128 vs expected 95, Chi-Square = 171.69, p < 0.001). Increasing number of comorbidities was significantly associated with greater age (Kruskal Wallis H = 575.52, p < 0.001) and poorer BCVA (Kruskal Wallis H = 69.56 (RE) & 47.43 (LE), p < 0.001 (both)).

The above associations are demonstrated in Figure 2, which represents visual impairment status by age based on the number of co-morbidities they have. This corroborates findings for the domiciliary group. In support, Chi-Squared testing indicated lower than expected observations of visual impairment for individuals without comorbidities (151 observed vs 202 expected, Chi-Square = 27.85, df = 3, p < 0.001).

Aboriginal and Torres Strait Islander Peoples comprise 65% of the rural clinic category, therefore analysis of this subgroup provided further insights. Compared to non-indigenous, Mann-Whitney U testing identified this group as significantly younger (mean difference = 13.36, Z = −11.37, p < 0.001), with better BCVA (mean difference = 0.065 (RE) & 0.079 (LE), Z = −8.31 (RE) & −9.14 (LE), p < 0.001 (both)) and more hypermetropic MSE refractive error (mean difference = 0.33 (RE) & 0.27 (LE), Z = −3.65 (RE) & −3.51 (LE), p < 0.001 (both)), as well as a lower IRSAD score (mean difference = 50.08, Z = −16.33, p < 0.001). Although the overall proportion of Aboriginal and Torres Strait Islander service users was relatively low (n = 462, Table 1), Chi-square testing indicated a lower than expected number of this group had visual impairment (observed 21 vs expected 66, Chi-square = 42.51, p < 0.001).

Figure 3 shows the proportion of visually impaired individuals by their Aboriginal and Torres Strait Islander status (16% non-indigenous with visual impairment, compared to 5% Aboriginal and Torres Strait Islander Peoples with visual impairment). Aboriginal and Torres Strait Islander Peoples were relatively under-represented in the older age group of 50 years and above (observed 168 vs expected 246, Chi-Square = 62.45, p < 0.001), and were twice as likely to be aged < 50 years. This is demonstrated in Figure 4, showing a bimodal age distribution for Aboriginal and Torres Strait Islander Peoples within the group, but few aged ≥ 50 years, who are eligible for funded Aged Care services.[13] Remoteness area code analysis mirrors findings for IRSAD score and indigenous status presented here, therefore this analysis is presented in the supplementary material.

In Table 4, 2 × 2 risk estimates for different ocular diagnoses are shown against examination site (collapsed into general and other clinic categories). Correctable refractive error was slightly more likely to be diagnosed in the General clinic (risk ratio = 1.11, Chi-Square = 31.51, p < 0.001) compared to clinics in the clinic category termed 'Other', which include Rural and Outreach clinic categories with greater percentage of emmetropes (Table 1). Visually significant cataract diagnosis was more likely in the Other clinic category, represented as a lower risk estimate for General clinic attendance (risk ratio = 0.81, Chi-Square = 6.828, p = 0.009). Of note, 60% of the cataract diagnoses in the Other clinic category are attributed to Domiciliary clinics (Table 1). Lastly,

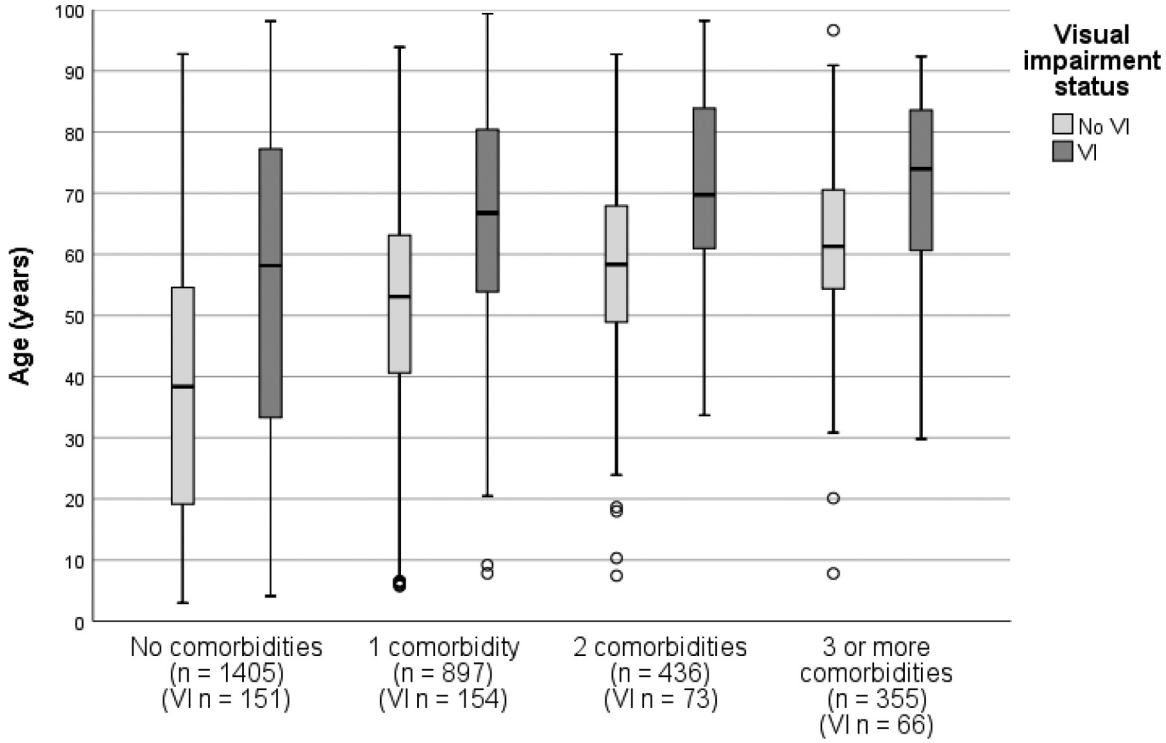

Figure 2. Presence/absence of visual impairment by age and number of comorbidities N:= 3093). Box represents interquartile range with median dividing the upper and lower quartiles. Error bars represent data falling 1.5 × IQR above and below the 25th and 75th percentiles. Circles indicate outliers within 1.5 to 3 × IQR range.

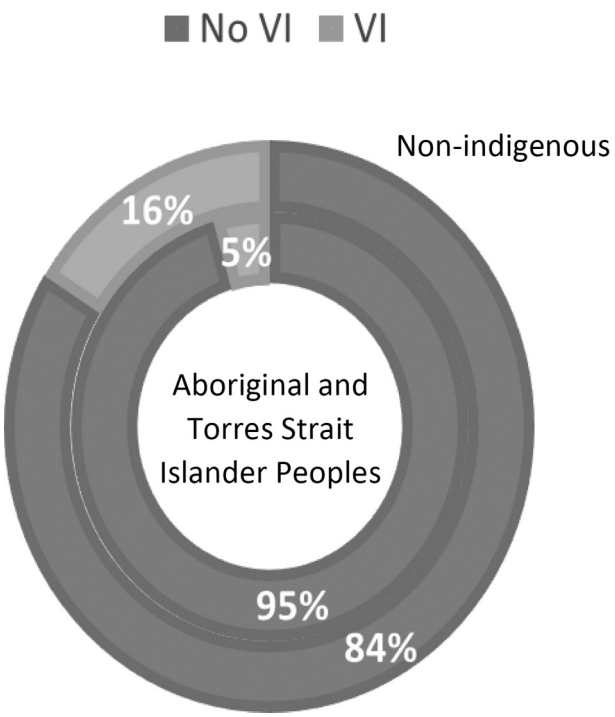

Figure 3. Proportion of visual impairment by aboriginal and Torres strait islander status N:= 3093) inner ring: aboriginal and Torres strait islander peoples n = 462. outer ring: non-indigenous n = 2631.

strabismus was twice as likely to be diagnosed in those attending the General clinics as Other clinics (risk ratio = 2.02, Chi-Square = 9.82, p = 0.002).

Linear mixed modelling analysis

Based on the non-parametric analyses, age, clinic category, Aboriginal and Torres Strait Islander status and number of comorbidities and RA were determined as key variables of interest for linear mixed modelling.

To summarise findings from the linear mixed modelling analysis (presented with parameter estimates in the supplementary material), poorer BCVA was associated with increasing age, the domiciliary clinic category (or outreach, to a much lesser extent) or more comorbidities. This echoes the non-parametric analyses. Parameter estimates indicated such factors were associated with BCVA approximately a logMAR line poorer in someone aged 70 years versus someone aged 40 years. Parameter estimates for MSE refractive error in either eye were fractional, limiting clinical significance.

Discussion

Eligibility for affordable eye care delivered by the ACO is largely determined by socioeconomic disadvantage, or recognised need for targeted public health support. Although eligibility does not necessarily translate to uptake, these criteria have served to homogenise our sample. This is corroborated by IRSAD score clustering between clinic groups around the 1000 average (indicating no particular relative advantage/disadvantage), and a very weak relationship between IRSAD score and BCVA. Gender distribution was similar to that identified at state level in the 2016 Census.[14] Key findings and recommendations are now discussed in more detail, and are summarised in Table 4 of the Supplementary Material.

The findings of this work suggest that visual impairment (BCVA ≤6/12 in one or both eyes) is more prevalent amongst adults receiving eye care through the ACO's domiciliary services. As well as being older and more likely to have poorer BCVA and additional co-morbidities, the highest percentages of visually significant cataract and AMD were diagnosed

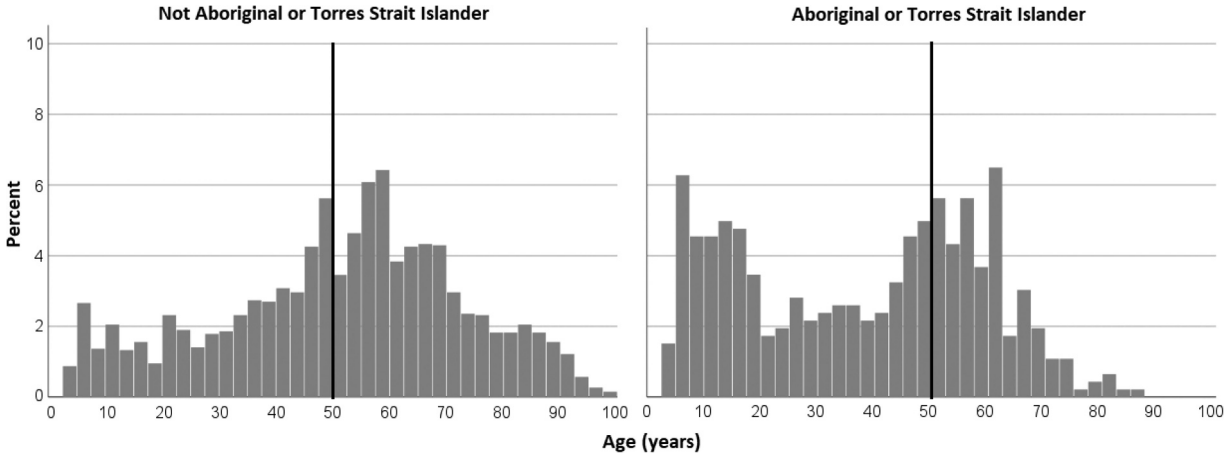

Figure 4. Histograms detailing the distribution of age for aboriginal and Torres strait islanders N:= 462) in comparison to non-indigenous N:= 2631). Reference line shows age 50 years, at which aboriginal and Torres strait islander peoples qualify for government-funded aged care services.

Table 4. Risk estimates for each type of ocular diagnosis[a.]

Ocular Diagnosis		General (n = 1194)	Other(n = 1899)	Chi-square	p-value	Risk ratio (General vs Other)
VI	Present	163 (13.7%)	281 (14.8%)	0.783	0.376	0.92
	Absent	1031 (86.3%)	1618 (85.2%)			
Correctable Refractive Error	Present	858 (71.9%)	1138 (59.9%)	31.51	**< 0.001**	**1.11**
	Absent	336 (28.1%)	761 (40.1%)			
Visually significant cataract	Present	186 (15.6%)	366 (19.3%)	6.828	**0.009**	**0.81**
	Absent	1008 (84.4%)	1533 (80.7%)			
AMD	Present	48 (4%)	92 (4.8%)	1.15	0.283	0.83
	Absent	1146 (96%)	1807 (95.2%)			
Glaucoma/Suspected	Present	47 (3.9%)	56 (2.9%)	2.220	0.136	1.35
	Absent	1147 (96.1%)	1843 (97.1%)			
Diabetic Retinopathy	Present	25 (2.1%)	35 (1.8%)	0.242	0.623	1.14
	Absent	1169 (97.9%)	1864 (98.2%)			
Amblyopia	Present	46 (3.9%)	52 (2.7%)	2.967	0.085	1.41
	Absent	1148 (96.1%)	1847 (97.3%)			
Strabismus	Present	42 (3.5%)	33 (1.7%))	9.82	**0.002**	**2.02**
	Absent	1152 (96.5%)	1866 (98.3%)			
Binocular vision/ accommodative disorders	Present	23 (1.9%)	24 (1.3%)	2.15	0.143	1.52
	Absent	1171 (98.1%)	1875.7%)			

Abbreviations: AMD = Age-related macular degeneration; VI = Visual impairment
Visually significant cataract: 6/12 best-corrected visual acuity or worse in one or both eyes with cataract present.
a. Percentages for Ocular Diagnosis do not add up to 100% due to some individuals having more than one diagnosis.

within this group, both remediable forms of sight loss with timely treatment. A smaller estimated BCVA decrement (~1 line) with 30 year age increase was identified, compared to the Blue Mountains Eye Study[15] (~2 line decrement for 25 year increase), or the Melbourne visual impairment project[16] (~5.5 line decrement for 50 year increase).

Both of the above studies are nearly 25 years old and the differing findings in the present study may reflect practice changes yielding earlier detection and treatment of age-related eye disease, as older adults in our study had better average visual acuities. Younger adults had comparatively poorer average visual acuities, potentially influenced by the younger adults in our sample who may be homeless, refugees or claiming government benefits – these groups may experience poorer best-corrected acuities due to later diagnosis of sight-threatening pathologies. Further comparison of prevalence of visual impairment and ocular conditions to existing Australian research is made within the supplementary material.

In the present risk analysis, visual impairment risk estimates did not significantly differ between categories, likely due to the other category combining the domiciliary clinic type with high visual impairment prevalence with other clinics such as rural, with low visual impairment prevalence. Although greater risk of strabismus in the general clinic category is identified in this work, general clinic sites run dedicated binocular vision clinics not on offer within other clinic categories, and this finding may be an artefact of specialist referrals.

Remediable visual impairment was detected in a variety of vulnerable groups through domiciliary services, including those with intellectual disability, neuropsychiatric conditions, or ≥85 years of age. These findings demonstrate the importance of domiciliary eye care provision to maximise level of vision and evidence eligibility for low vision rehabilitation services, to improve vision-related quality of life.

While it is not possible to identify the number of individuals in domiciliary settings across Australia and estimate level of need for domiciliary eye care services, domiciliary eye care provision makes up a very low percentage of Medicare Benefit Schedule (MBS) claims in Australia: 20,809 domiciliary MBS add-ons (codes 10931, 10932, 10933) were claimed for the 2018 calendar year for all ages nationally, equating to domiciliary tests for 54,977 individual patients and comprising just 0.4% of all claims under Group A10: Optometrical Consultations. Of these claims, 10.11%

(n = 2,103) of services were provided by the ACO, comprising 11.33% (n = 6,229) of individual patients.

Annual domiciliary add-on claims nationally are substantially less than the number of individuals in residential aged care in 2017-2018 (n = 272,500), without considering other groups shown to benefit from domiciliary eye care, such as people living with dementia in their own home. Given that early detection and treatment of sight loss carries a number of quality of life benefits,[17–20] more provisioning for domiciliary eye examinations would improve coverage and access for those unable to attend a conventional clinic site.

Multiple co-morbidities were prominently associated with poorer BCVA, and eye care professionals should be aware of this relationship. Identification of multiple co-morbidities during history-taking should prompt the clinician to emphasise the importance of regular eye examinations in reducing instances of treatable sight loss.[21] Documenting co-morbidities as part of a detailed clinical history can create opportunities to deliver additional public health messages, or for earlier signposting to support services, including low vision rehabilitation.

Common co-morbidities documented within the sample carry ocular complications, such as hypertension and diabetes, but neuropsychiatric conditions such as depression and anxiety were also common and can worsen with increasing visual impairment.[22–24] Other healthcare professionals working with people living with these co-morbidities, such as primary care workers, allied health professionals or specialist nurses, could also have a role in emphasising the importance of regular eye examinations, if they were made aware of this through initiatives such as shared or integrated care pathways, or interprofessional learning opportunities. This information could be delivered as a brief educational intervention during a routine care appointment, shown to be helpful in examples such as smoking cessation[25] or weight management.[26]

Our findings suggest that 95% of Aboriginal and Torres Strait Islander Peoples accessing ACO services enjoy a good level of vision after correction of refractive error. This is slightly higher than the Indigenous Eye Health Survey (93%), but it should be noted that this survey is population-based. The Aboriginal and Torres Strait Islander Peoples surveyed in this work comprised a larger proportion in the sample (14.9%) compared to 2016 Census data for Victoria (0.8%)[14] due to the sampling used in this study of encompassing all outreach and regional optometry services, limiting comparability.

The above caveats considered, the findings are an important indicator of the value and need for ongoing funding of regional public health initiatives delivered by the ACO, including the Victorian Aboriginal Spectacle Subsidy Scheme and eye examinations delivered within the Victorian Aboriginal Health Service.[27] However, this percentage prevalence of visual impairment may be because Aboriginal and Torres Strait Islander Peoples within the present sample were younger on average – 36.4% were aged ≥ 50 years, compared to non-indigenous (56.3%). They were also low in representation within the Domiciliary clinic grouping (n = 11 of 462, 2.4% of all Aboriginal and Torres Strait Islander Peoples in the sample), which encompasses both aged care facilities and supported home care schemes.

Other research and official government figures suggest under-representation of indigenous Australians within aged care facilities,[28] limited places within culturally sensitive Flexible Aged Care models,[13] and low uptake of community care programmes such as the Commonwealth Home Support Program. Such under-representation can be partially attributed to the lower percentage of older Aboriginal and Torres Strait Islander Peoples residing within Victoria (who comprise 0.9% of Victoria's target aged care population,[13]) and cultural differences in aged care for elders in this group, where care priorities centre around remaining 'on country',[29] with high emphasis on family support.

As the population of older indigenous Australians is set to treble in the next six years,[30] future research, in full collaboration with Victorian Aboriginal Community Controlled Health Organisations, could explore how and where this age group of Aboriginal and Torres Strait Islander Peoples access routine eye care, to ensure their needs are met.

The strengths of this work can be summarised as follows:

- The eye health of a diverse population eligible for affordable eye care has been captured and characterised, including those living with disabilities, the homeless, rural locales and aged residential or community care.
- Aboriginal and Torres Strait Islander status and gender recording are complete, enabling appropriate consideration of these demographic variables within analyses.
- The section of the dataset with complete BCVA, refractive error and diagnostic data are large enough to warrant meaningful analysis for these parameters.
- General health recording within the dataset has made it possible to explore the impact of multi-morbidity as an interactive factor in analysis.

The limitations of this work can be summarised as follows:

- Data completeness for non-general clinics is more limited, thus it was not appropriate to perform inferential analysis for living arrangements, government pension status, country of birth, preferred language and interpreter usage, as well as the ocular health variable of intraocular pressure. This also limits ability to compare our sample against state-wide Census data for demographic variables, so reported proportions for these variables should be interpreted with caution.
- Missing General Health data cannot be differentiated from total absence of co-morbidities, therefore the true number of individuals within the dataset with no co-morbidities may be lower than reported.
- Only country of birth and preferred language are recorded, rather than ethnicity, excepting Aboriginal and Torres Strait Islander status. Further profiling of service users who are culturally and linguistically diverse (CALD) was not possible.
- Very young children (below the age of 2.97 years) were not included in the dataset, therefore the present findings are not generalisable to this group

The ACO as an organisation has taken steps to promote collection of demographic data by optometrists outwith general clinics, to ensure data extracted in future years will be more complete, enabling deeper analysis and addressing some of the limitations highlighted.

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