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Should we be worried about glaucoma? Why the prevalence of glaucoma is variably reported

Anthea Worley and **Karen Grimmer-Somers**

Centre for Allied Health Evidence, University of South Australia, City East Campus, North Tce, Adelaide, SA 5000, Australia

Aim: This paper reports on a recent review of the prevalence of glaucoma, and identifies factors that impact on its variable reporting. **Background:** Glaucoma is a recognized chronic degenerative health problem worldwide, in which approximately two-thirds of sufferers are undiagnosed. Therefore it is important to better quantify glaucoma prevalence to plan adequate resources for effective risk screening, diagnosis, management and prevention. Accurate prevalence data also assist in determining the nature of relationships between glaucoma and putative risks. **Methods:** A comprehensive search of peer-reviewed databases was conducted to identify and critically appraise secondary evidence published between 2002 and 2007. Glaucoma definitions, prevalence, incidence and risk factor data were extracted and compared in the context of their population descriptors. **Findings:** There was no standard definition of glaucoma or standard population descriptors (age, ethnicity, country) utilized by either the primary studies included in the secondary evidence or as inclusion criteria in the secondary evidence. Prevalence for glaucoma of between 1–4% was commonly reported. Despite this, the influence of age and ethnicity on glaucoma prevalence within specific populations was repeatedly highlighted. There was consistency across studies of the decreased risk of white (European) populations compared with other ethnic groups. There was an exponential increase in prevalence of glaucoma over decades of increasing age. There were limited Australian data; however, prevalence of open-angle glaucoma is comparable with international figures. There is a clear need for worldwide agreement on standard epidemiological descriptors of glaucoma, using standard population frameworks, terminology and age groups.

Key words: glaucoma; incidence; metasynthesis; prevalence; risk factors

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Introduction

Glaucoma is recognized worldwide, as a chronic degenerative health problem, expected to affect 60.5 million people by 2010 (South-East Asia Glaucoma Interest Group (SEAGIG), 2003; US Preventive Services Task Force (USPSTF), 2005). Glaucoma affects individuals through the full age span. It is estimated that up to two-thirds of people with glaucoma are undetected (USPSTF, 2005). Once established, glaucoma is progressive and usually relentless, and the damage to the eye is irreversible. The importance of good vision in maintaining good general health cannot be underestimated and therefore early detection of glaucoma is essential to global eye health.

Despite its worldwide recognition, there is no definition of glaucoma that is consistently used across the literature. Bathija (1998) cited in Rolim

Correspondence to: Karen Grimmer-Somers, Centre for Allied Health Evidence, University of South Australia, City East Campus, North Tce, Adelaide, SA 5000, Australia. Email: Karen.Grimmer-Somers@unisa.edu.au

de Moura *et al.* (2007: 2) suggests that the lack of agreement on the definition of glaucoma is one of the underlying reasons for inconsistency in glaucoma diagnosis. This lack of consistency in glaucoma diagnosis impacts on the accuracy of reported prevalence rates. There is, however, broad agreement that any form of glaucoma should be described as a progressive optic neuropathy with characteristic visual field loss, optic disc and nerve fibre degeneration. According to Burr *et al.* (2004: 2) '*Glaucoma describes a group of eye diseases in which there is progressive damage to the optic nerve characterised by specific structural abnormalities of optic nerve head and associated patterns of visual field loss*'. Accurate estimations of the prevalence of glaucoma are important to assist in planning resources for services, and to promote effective risk screening, diagnosis, management and prevention of glaucoma. Having accurate prevalence data also assist in understanding associations between glaucoma and putative risks.

This paper describes the findings of one aspect of a large metasynthesis of the literature, which distilled best evidence for the diagnosis, risk-identification and management of glaucoma. This paper reports on the prevalence of glaucoma internationally, and the factors that are associated with prevalence reports. Australian prevalence data are considered in the context of the internationally reported data.

Methodology

Objective: To report findings of a recent metasynthesis regarding international glaucoma prevalence and identify factors that impact on its variable reporting.

Justification of study design: This paper reports on aspects of findings from a wide-ranging systematic overview of the secondary literature that addressed the detection, diagnosis, prevention and management of glaucoma. Preliminary scoping of the literature for this question highlighted a large volume of secondary evidence published over the past five years. The majority (approximately 68%) of the secondary evidence identified during preliminary scoping was published between 2006 and 2007, and thus the risk of overlooking recent key primary literature within the secondary evidence was considered low. Thus, only secondary evidence was considered for this review, as it provided an efficient mechanism to synthesize the large amount of available primary literature, which had already been summarized in different forms by other reviewers. The metasynthesis included the highest level of evidence on the National Health and Medical Research Council (NHMRC) evidence hierarchy, comprising clinical guidelines, meta-analysis and systematic reviews.

Literature inclusion criteria:

- Publication date 2002–2007 (inclusive).
- English language publications only. Sensitivity testing regarding information published in languages other than English has shown that English language reviews represent a robust view of the available evidence base in health areas (Moher *et al.*, 2000; 2003; Møller and Jennions, 2001).
- Level I evidence from the NHMRC hierarchy of evidence (NHMRC, 2005) (clinical guidelines, meta-analysis and systematic reviews) that was available, unless a lack of Level I evidence in any one area of the review necessitated drawing on specific Level II or Level III evidence (recent primary studies).
- Human studies only, inclusive of all age, gender, nationality and location.

Exclusion criteria:

- Primary literature unless otherwise indicated.
- Clinical guidelines in which glaucoma was not the primary focus (for instance, glaucoma occurring as a result of suffering another health condition).
- Literature dealing exclusively with cost-based outcomes.
- Non-English language publications.
- Literature only available in abstract form or conference presentations.
- Publications not available through all available library resources.

Search strategy

A comprehensive electronic library database search was undertaken (outlined in Appendix 1). Given the wealth of current secondary evidence that appeared relevant, secondary research evidence pertaining to the detection, diagnosis, management and prevention of glaucoma was identified first.

The library database searches were supplemented by pearling and manual searching of reference lists and other resources to identify all relevant secondary evidence. Pearling (also called secondary evidence searching) occurs when the reference list of a study, which has been included in a systematic review, is checked for other references that might also be relevant to the review.

Management of selection bias: Independent reviewers undertook investigation of all data sources to ensure a comprehensive scope of the search, and to reduce errors/bias in accessing or identifying the evidence.

Assessment of the methodological quality

A standard process was followed to critically appraise the included secondary literature for methodological quality.

Clinical guidelines were critically appraised using the Appraisal of Guidelines Research and Evaluation (AGREE) instrument (AGREE Collaboration, 2001). Two reviewers undertook independent appraisal and the scores were standardized into a single percentage score as detailed in the instrument guide (AGREE Collaboration, 2003). A high quality guideline should have high percentage scores across all domains of the AGREE tool. This assures readers that the guideline processes were well constructed and that the recommendations are believable and free of bias/external interference.

Systematic reviews and meta-analyses were critically appraised using the Critical Appraisal Skills Programme (CASP) tool for systematic reviews (CASP Tool; http://www.phru.nhs.uk/Doc_Links/S.Reviews%20Appraisal%20Tool.pdf). Two experienced reviewers independently critically appraised a random selection of 10% of the secondary evidence. They then shared their appraisal scores and discussed reasons for differences in scores. They agreed on a protocol for score assignment and interpretation of reporting, which underpinned assurances of reliability of scoring. The reviewers then independently reviewed the remainder of the secondary evidence, on an assumption that had both reviewers critically appraised each article, the same score would have been reached. Scores were reported numerically for critical appraisal items that attracted Yes/No answers (1. Clearly focused question? 2. Include the right type of study? 3. Identify all relevant studies? 4. Quality of study assessed? 5. If results have been combined, was it reasonable? 8. Results applicable to local situation? 9. All important outcomes considered? 10. Policy or practice change?). The remaining questions required qualitative text answers and were not readily summarized for statistical reporting. The questions with Yes answers were scored as 1, and each paper was given a score out of 8. The average score for each of the eight questions, and for each of the systematic reviews (and standard deviations), was calculated.

Data extraction, validation and reporting

Data were extracted using a purpose-built data extraction form that incorporated information on year and nature of publication, country of publication, sample descriptors (age, gender and ethnicity), population numbers, type of glaucoma, risk factors, prevalence and incidence data. A reference committee of Australian content experts (ophthalmologists, optometrists, GP, pharmacist, practice nurse) assisted the systematic review team by validating whether all relevant literature had been identified, and interpreted correctly. For this paper, all reports of glaucoma prevalence and incidence were highlighted, the data were summarized, and reasons for differences in reporting were considered.

Results

Search findings

The overall secondary literature search identified 65 systematic reviews and 14 clinical guidelines. Of these, 20 systematic reviews (reporting on over 230 primary studies) and six clinical guidelines reported on prevalence in glaucoma, and hence the findings from these studies are included in this aspect of the metasynthesis. To validate our decision to include secondary evidence that reported on prevalence and incidence of glaucoma, we checked the included primary references in these secondary evidence sources for their methodological design. Epidemiological studies are the appropriate research approach to report on incidence and prevalence of disease, and all the included primary studies reported epidemiologically appropriate designs.

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Table 1 Appraisal of Guidelines Research and Evaluation critical appraisal scores

	Scope and purpose (%)	Stakeholder involvement (%)	Rigour of development (%)	Clarity and presentation (%)	Applicability (%)	Editorial independence (%)	Average domain score (%)
American Academy of Ophthalmology (AAO) (2005)	56	38	40	75	17	0	38
American Optometric Association (AOA) (2002)	67	38	26	58	17	0	34
Japan Glaucoma Society (JGS) (2004)	44	33	17	50	11	0	26
Royal College of Ophthalmologists (RCO) (2004)	50	38	21	67	0	0	29
South-East Asia Glaucoma Interest Group (SEAGIG) (2003)	83	29	24	75	17	25	42
US Preventive Services Task Force (USPSTF) (2005)	89	58	86	100	39	100	79

Guidelines: The scores for each AGREE domain, as well as the average domain score for each included guideline for this paper, are provided in Table 1. The scores were not uniformly high across all domains for all guidelines, highlighting the variable quality of guideline construction.

Systematic reviews: The overall average quality score for the 20 systematic reviews for the eight quantitative questions in the CASP tool was 5.3 (SD 1.9), which indicated the moderate quality overall of the reviews. Variable-sized average scores but similar standard deviations were found for each question (Q1 0.9 (SD 0.4), Q2 0.7 (SD 0.5), Q3 0.8 (SD 0.4), Q4 0.4 (SD 0.5), Q5 0.7 (SD 0.5), Q8 0.8 (SD 0.4), Q9 0.9 (SD 0.4), and Q10 0.5 (SD 0.5). The individual scores for each included paper are reported in Table 2.

Table 2 Relevant Critical Appraisal Skills Programme scores (Q 1–5, 8–10) (total 8)

Alexander *et al.* (2002)	3
Burr *et al.* (2007)	6
Denis *et al.* (2007)	6
Einarson *et al.* (2006)	5
Fleming *et al.* (2005)	5
Friedman and Vedula (2006)	6
Fung *et al.* (2007)	8
Hatt *et al.* (2006)	4
Holmstrom *et al.* (2005)	7
Law and Li (2007)	6
Madden *et al.* (2002)	3
Maier *et al.* (2005)	8
Moore and Nischal (2007)	1
Obstbaum *et al.* (2004)	4
Plosker and Keam (2006)	2
Rolim de Moura *et al.* (2007)	8
Rowe *et al.* (2004)	6
Saw *et al.* (2003)	6
Schmier *et al.* (2007)	5
Sycha *et al.* (2003)	6

Overview

Types of glaucoma

Reports of prevalence and incidence were found mostly for primary open-angle glaucoma (POAG), and primary angle-closure glaucoma (PACG). Prevalence data were largely missing for childhood and secondary glaucomas.

There was no standard definition of glaucoma, with examples of definitions from systematic reviews being:

1. Glaucoma is an eye affliction characterized by an increase in intraocular pressure (Amar, 2006: 17).

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2. Glaucoma is an optic nerve neuropathy that leads to progressive visual field loss (Fleming *et al*., 2005: 167).
3. Glaucoma describes a group of eye diseases, in which there is progressive damage to the optic nerve leading to impaired vision and blindness if untreated. The primary glaucomas (those that are not a consequence of other eye or systemic disease) can be classified as OAG or angle-closure glaucoma. These two types are distinguished by the anatomy of the anterior segment of the eye (Burr *et al*., 2007: 3).
4. Glaucoma is a group of related conditions characterised by optic nerve damage, nerve layer fibre defects and visual field loss and is generally associated with high intraocular pressure (Schmier *et al*., 2007: 288).
5. Glaucoma refers to a multifactorial disease characterized by a progressive optic neuropathy followed by gradual visual field loss. Elevated intraocular pressure (IOP), which previously was part of the definition of glaucoma, is now recognized as the major risk factor for the development of the disease (Costa *et al*., 2003: 770).

Whilst many systematic reviews and clinical guidelines report on, or predict, actual numbers of people who may suffer glaucoma, these numbers are generally meaningless without a standard comparator. For example, 'an estimated 2.5 million Americans have open angle glaucoma', (American Optometric Association, 2002: 7) and glaucoma 'affects >2 million people in the US, and the incidence is expected to exceed 3 million by 2020' (Schmier *et al*., 2007: 287). Without a comparator, the true nature of the severity of glaucoma is not able to be determined.

Internationalization

Of the secondary evidence included in this metasynthesis, the majority was internationally focused, with only one systematic review (Madden *et al*., 2002) reporting specifically on Australian data. Another systematic review (Burr *et al*., 2007) included Australian data from two studies (Mitchell *et al*., 1996; Weih *et al*., 2001); however, the data were reported as population-based prevalence, and not stratified by age, gender or other descriptor. The expert reference committee recommended the inclusion of Australian primary evidence: the Blue Mountains Eye Study (BMES) (Mitchell *et al*., 1996), the Visual Impairment Project (VIP) (Weih *et al*., 2001) and data from the Australian Institute of Health and Welfare (AIHW) (2005) and the Australian Bureau of Statistics (ABS) (2004), in order to provide more comprehensive Australian glaucoma prevalence/incidence findings.

We summarized the metasynthesis findings into categories of ethnicity, age, specific populations and glaucoma subtypes, in order to make sense of the ways in which glaucoma prevalence and incidence of glaucoma was reported.

Terminology differed regarding calculation of prevalence and incidence. In most instances, it was unstated. The most useful definition was from Burr *et al*. (2007: 26): Methods of calculation of prevalence 'as the number of participants diagnosed with glaucoma divided by the number of participants screened'. These researchers reported calculating incidence for each age category 'as the mean and range for cases per 100 000 years at risk…… As an example, incidence estimates for the UK were determined by dividing the number of cases newly diagnosed by the number of people at risk (population data were obtained from the 2001 UK Census)'.

Ethnicity was reported in both very general terms such as black and white, and in very specific ethnic terms such as East Greenlandic Inuit or Chinese. Data were either country-specific or for a group of countries (such as western, worldwide, industrialized).

Table 3 compares data between ethnic groups with respect to risks of different types of glaucoma. This table highlights the variability of reports of prevalence with respect to ethnicity. Schmier *et al*. (2007: 288) reported that the prevalence of POAG is higher among African Americans and Hispanics/Latinos than among other ethnic groups. Conversely prevalence of PACG is reported to be highest among those of Asian or Inuit heritage, with rates in these populations reported to be three- to ten-fold higher than in other ethnic groups (Friedman and Vedula, 2006; Schmier *et al*., 2007).

Table 4 reports on the incidence of glaucoma with respect to different populations. This table highlights the consistency across studies in the decreased risk of white (European) populations compared with other ethnic groups.

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Table 3 Differential ethnic risks of glaucoma subtypes

		Eskimos (Canada and Greenland) versus white Europeans	Asians versus whites	Asian and Eskimos versus other ethnic groups	African versus Europeans or Asians	Black versus white
Friedman and Vedula (2006)	PACG	↑	↑			
Hatt *et al.* (2006)	OAG				↑ × 4–5 times	
Fleming *et al.* (2005)	POAG					↑ × 4 times
Burr *et al.* (2007)	OAG					RR 3.8 (95% CI 2.56–5.64)
Schmier *et al.* (2007)	PACG			↑ × 3–10 times		

PACG = primary-angle closure glaucoma; OAG = open-angle glaucoma; POAG = primary OAG; RR = relative risk; CI = confidence interval.

Table 4 Incidence within specific populations for glaucoma subtypes

Author	Country	Age	Ethnicity	Type	Incidence
Law and Li (2007)	US	Adults	Black	OAG	3.9 per 100 000
Law and Li (2007)	US	Adults	White	OAG	1.1 per 100 000
Moore and Nischal (2007)	Western	Infants	Any	PCG	1 per 10 000–20 000 live births
American Optometric Association (AOA) (2002)	US	55	Caucasians	OAG	40–60 per 100 000
AOA (2002)	US	75	Caucasians	OAG	200–220 per 100 00
AOA (2002)	US	55	Black	OAG	263 per 100 000
AOA (2002)	US	75	Black	OAG	541 per 100 000

OAG = open-angle glaucoma; PCG = primary closed glaucoma.

Age was variably classified into five- or ten-year ranges, as well as undefined descriptors such as 'adult' or 'infant'. There was a large volume of secondary evidence reporting on the influence of age on open-angle glaucoma (OAG) and POAG (see Table 5). Plosker and Keam (2006) indicated that overall, there was four times the risk of glaucoma for people aged 80 or more compared with people younger than 50 years. In the Australian VIP study, this difference was substantially bigger being 17 times more likely that, participants aged 80 years and older were likely to have glaucoma than participants less than 50 years of age (Weih *et al.*, 2001: 1969).

Table 6 reports on the contributing influence that both age and ethnicity have on the prevalence of glaucoma within specific populations. For instance, the Burr *et al.* (2007) data show the prevalence of glaucoma in the American black population aged 70–79 years as 9.15%. This is four times greater than the American white population aged 80 or more. This is further supported by Schmier *et al.* (2007) who report age-adjusted prevalence rates for POAG were four to five times higher in blacks as compared with whites.

Table 7 reports on the Australian-specific age-related glaucoma data. The population prevalence of glaucoma from these studies ranges from 1.7% to 2.5%.

Location: Madden *et al.* (2002) conducted a systematic review of eye health in rural Australia, finding little relevant published information. These authors used but did not define the terms 'possible glaucoma' and 'probable glaucoma'. They reported the prevalence of various eye conditions from the VIP, and found a significantly elevated risk of possible glaucoma in rural areas (rural prevalence 1.8%, urban prevalence 1.2%), odds ratio of 1.6 (95% CI (confidence interval) 1.1, 2.2). Probable glaucoma had a rural prevalence of 1.02% (urban prevalence of 0.49%) again demonstrating a significantly elevated odds with rural living (odds ratio 1.6 (95% CI 1.1, 2.5)).

Australian Aboriginal and Torres Strait Islanders: The ABS (2004) *National Aboriginal and Torres Strait Islander Health Survey 2004–05*

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Table 5 Prevalence of age-based glaucoma within the general population

Author	Country	Age	Type	Prevalence (%)
Einarson *et al.* (2006)	Worldwide	Age adjusted	POAG	1.5–2
Maier *et al.* (2005)	Industrialized nations	Adult	Glaucoma	1–3
Burr *et al.* (2007)	UK	Adult	OAG	2.10
Burr *et al.* (2007)	Congo	Adult	OAG	13
Burr *et al.* (2007)	Barbados	Adult	OAG	16
Burr *et al.* (2007)	Western	Adult	OAG	2.10
Burr *et al.* (2007)	Western	40	OAG	0.30
Burr *et al.* (2007)	UK	40	OAG	0.30
Denis *et al.* (2007)	US	40+	Glaucoma	1–2
Obstbaum *et al.* (2004)	US	40+	POAG	1.86
Japan Glaucoma Society (JGS) (2004)	Japan	40+	NTG	3.60
Sycha *et al.* (2003)	US	43–54	NTG	0.20
American Optometric Association (AOA) (2002)	US	52–85	NTG	0.05–0.79
Einarson *et al.* (2006)	Worldwide	>60	POAG	6–8
Burr *et al.* (2007)	UK	70	OAG	3.30
Burr *et al.* (2007)	Western	70	OAG	3.30
Schmier *et al.* (2007)	US	>75	POAG	5
Sycha *et al.* (2003)	US	75+	NTG	1.60

OAG = open-angle glaucoma; POAG = primary OAG; Glaucoma = subtype not specified; NTG = normal tension glaucoma.

Table 6 Prevalence of open-angle glaucoma (OAG) and primary OAG (POAG) within different ethnic and age populations

Author	Country	Ethnicity	Age	Type	Prevalence (%)
Law and Li (2007)	US	Black	10–49	OAG	1.23
Rowe *et al.* (2004)	US	Black	40+	POAG	1.2–11.3
American Optometric Association (AOA) (2002)	US	African-Americans	40+	POAG	5.6
AOA (2002)	US	Caucasians	40+	POAG	1.7
Japan Glaucoma Society (JGS) (2004)	Japan	Japanese	40+	POAG	0.32
Royal College of Ophthalmologists (RCO) (2004)	Worldwide	White	40+	POAG	1–2
Schmier *et al.* (2007)	US	Black	40–49	POAG	1.23
Burr *et al.* (2007)	US	Black	40–49	OAG	1.23
Burr *et al.* (2007)	US	Black	70–79	OAG	9.15
Schmier *et al.* (2007)	US	Black	80+	POAG	11.26
Rowe *et al.* (2004)	US	White	>40	POAG	0.9–2.1
Schmier *et al.* (2007)	US	White	40–49	POAG	0.92
Schmier *et al.* (2007)	US	White	80+	POAG	2.16
RCO (2004)	Worldwide	White	80+	POAG	4+
Rolim de Moura *et al.* (2007)	Worldwide	White	Adults	POAG	0.8–3

provided data on long-term eye/sight problems. Eye/sight problems were reported in 30% of the population, compared with a report, three years earlier (2001), of 29%. Consistent with results from the 2001 survey, eye/sight problems were the most commonly reported long-term health condition among Aboriginal and Torres Strait Islander people in 2004–2005. Diseases of the eye were broken into the following conditions: cataract, short sighted/myopia, long sighted/hyperopia, blindness (complete/partial) and other diseases of the eye and adnexa. Glaucoma is not a condition specified in the breakdown; however, it is likely to fall within the 'other diseases of the eye and adnexa' category. In 2001, 7% of the population reported 'other diseases of the eye and adnexa', while in 2004 this had declined to 6%.

Open-angle glaucoma: Table 8 reports on the per-age group per 100 000 incidence of open-angle glaucoma. The reported incidence rates

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Table 7 Prevalence of glaucoma in Australian studies (clinical and self-reported) (Australian Institute of Health and Welfare (AIHW), 2005)

BMES 1992–1994		VIP 1992–1996		NHS 1995		NHS 2001	
Age	Rate (%)	Age	Rate (%)	Age	Rate (%)	Age	Rate (%)
		40–49	0.1	45–49	0.5	45–49	0.4
50–59	0.2	50–59	0.6	50–54	1.0	50–54	1.0
				55–59	1.2	55–59	2.2
60–69	1.1	60–69	1.9	60–64	1.7	60–64	1.9
				65–69	3.7	65–69	3.4
70–79	4.3	70–79	5.2	70–74	3.9	70–74	4.7
				75–79	5.4	75–79	5.5
80+	8.2	80–89	5.5	80+	4.2	80+	6.6
		90+	11.8				
Total	2.4		1.7		2.2		2.5

BMES = Blue Mountains Eye Study; VIP = Visual Impairment Project; NHS = National Health Service.

Table 8 Incidence of open-angle glaucoma within the general population

Author	Country	Age	Incidence
Burr *et al.* (2007)	UK	50	30 per 100 000
Burr *et al.* (2007)	UK	70	181 per 100 000
Burr *et al.* (2007)	US, Netherlands, Australia	40	30 per 100 000
Burr *et al.* (2007)	US, Netherlands, Australia	70	181 per 100 000
Burr citation	General	40	0 per 100 000
Burr citation	General	50	20 per 100 000
Burr citation	General	50	40 per 100 000
Burr citation	General	60	120 per 100 000
Burr citation	General	60	60 per 100 000
Burr citation	General	70	280 per 100 000
Burr citation	General	70	140 per 100 000
Burr citation	General	71	124 per 100 000

vary widely even between the same age groups across the 'general' population. For example, the general incidence rate in 60 year old population is reported as 60 and also 120 per 100 000. This variance could possibly be due to the use of different definitions of glaucoma, which could affect whether a diagnosis of glaucoma is made.

Angle-closure glaucoma: Table 9 reports on the prevalence of angle-closure glaucoma, within specific populations. The table illustrates the association between ethnicity and risk of angle-closure glaucoma. Inuit adults have a higher prevalence compared to other ethnic groups including Asian, European and African groups (American Academy of Ophthalmology (AAO), 2005). The SEAGIG (2003) reports the incidence of acute angle-closure glaucoma, within different ethnic groups in Finland and Singapore. It was found that Chinese have a higher incidence of acute angle-closure glaucoma (15.5 per 100 000) than other ethnic groups (4.7–6.7 per 100 000) (SEAGIG, 2003).

Discussion

Overview

Our metasynthesis approach to summarizing the literature for the question regarding glaucoma prevalence highlighted the efficiencies of using existing secondary evidence, which had already summarized a large number of recent primary studies. Metasynthesis of secondary evidence is becoming an increasingly common technical

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Table 9 Prevalence of angle closure glaucoma within specific populations

Author	Country	Ethnicity and age	Prevalence (%)
American Academy of Ophthalmology (AAO) (2005)	Alaska	Inuit adults >40 years	2.65–3.8
	Greenland	East Greenlandic Inuit adults ⩾40 years	2.5
	Taiwan	Adults ⩾40 years	3.0
	Mongolia	Asian adults aged ⩾40 years	1.4
	Singapore	Chinese adults aged ⩾60 years	1.25
	Southern India	Asian adults aged ⩾40 years	1.08
	Japan	Asian adults aged ⩾40 years	0.34
	Arizona, USA	Hispanic adults aged >40 years	0.10
	Baltimore, USA	African and African-derived adults aged ⩾40 years	0.9
	Tanzania, East Africa	African and African-derived adults aged ⩾40 years	0.58
	South Africa	Zulus adults aged ⩾40 years	0.5
	Italy	European and European-derived adults aged >40 years	0.6
	Baltimore, USA	European and European-derived adults aged ⩾40 years	0.4
	Bedford, UK	European and European-derived adults aged ⩾40 years	0.17
	Sweden	European and European-derived adults aged 55–69 years	0.10
	UK	European and European-derived adults aged ⩾40 years	0.09
	Beaver Dam, USA	European and European-derived adults aged >50 years	0.04
	Ireland	Not specified	0.009

approach, which efficiently capitalizes on existing secondary evidence research. In this case, despite identifying 20 systematic reviews and six clinical guidelines (providing access to at least 230 primary studies published in the past five years), the heterogeneity of the included reviews precluded meta-analysis. This metasynthesis found a wealth of international publication interest in glaucoma; however, there was little consistency in definitions of glaucoma or risk factors, methods of reporting or prevalence estimates. None of the included systematic reviews dealt only with the topic of prevalence of glaucoma. This information was often reported as a precursor to other information related to glaucoma diagnosis or risk identification.

Glaucoma definitions

There is no one definitive definition of glaucoma that is consistently used in the papers included in this review. This appears largely due to the number of subtypes and separate classifications of glaucoma involved. For example, the Japan Glaucoma Society (JGS) (2004) classifies glaucoma into: primary glaucoma, in which no other cause of elevated intraocular pressure (IOP) is present; secondary glaucoma, in which the elevation in IOP results from other ocular diseases, ocular trauma, systemic diseases or drug use; and developmental glaucoma, in which the elevation in IOP results from developmental anomalies in the anterior chamber angle. This can cause glaucomatous damage to the optic nerve head and prevents visual development. Alternatively, in Henness *et al*. (2007) systematic review, glaucoma is classified into three broad categories: congenital glaucoma; open-angle glaucoma; and angle-closure glaucoma, with primary and secondary types within each category.

Not all prevalence studies of glaucoma separate primary and secondary glaucoma in a consistent fashion, if they have done so at all. Debate remains over inclusion of subtypes such as ocular hypertension and normal tension glaucoma under the broader term of POAG.

Foster *et al*. (2002) highlight the effect that the selection of glaucoma definition and the population

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from which the data is derived, can have on the accuracy of reporting prevalence and incidence. Different definitions of glaucoma can result in under-estimation or over-estimation of the prevalence and incidence of glaucoma and its subtypes. It can also result in non-diagnosis of glaucoma. Given the estimated percentage of the population with undiagnosed glaucoma, this would seem to be of concern. The lack of clear information on prevalence and incidence, will impact on policymakers' ability to estimate resource use to appropriately diagnose and manage glaucoma in future populations.

Different population descriptors

There were no standard population descriptors (age, ethnicity, country) utilized by the primary studies included in the published systematic reviews, or in the guidelines identified in this search. As a consequence, it was difficult to make comparisons between studies, or to propose consistent figures with respect to glaucoma prevalence, incidence or risk in specific populations.

Age classification

In general, in white populations around the world, the prevalence and incidence of glaucoma increases significantly with adult ages (Mitchell *et al*., 1996; Weih *et al*., 2001; Burr *et al*., 2007). Burr *et al*. (2007) and Plosker and Keam (2006) both report that people aged 70+ years have approximately three times greater risk of developing glaucoma than people aged 40 years. However, in the VIP, an Australian study, this difference was substantially bigger. Weih *et al*. (2001: 1969) reported participants aged 80 years and older were 17 times more likely to have glaucoma than participants less than 50 years of age.

Prevalence and incidence rates were often reported by age classifications, however, without a consistent reference classification. For example, some studies used five-year ranges, whilst others used 10-year ranges, that is, 45–49, 40–49 and 80+ or 90+. Glaucoma was also reported with variable prevalence, usually related to different age groups (for instance, under 40 years, or 50 years, for younger age glaucoma, and 60 years, or 70 years, for older glaucoma). Thus it was not possible to accurately compare the prevalence rates between age groups. Some studies used the descriptors 'adult' and 'infant', without defining what age brackets these terms encompassed. Two systematic reviews reported age-adjusted prevalence data. Einarson *et al*. (2006; citing Coleman (1999), Leske *et al*. (1994)) and Schmier *et al*. (2007) systematic reviews both reported specific age-adjusted prevalence rates for POAG. Age-adjusted prevalence data have limited application in the clinical sense, as it is a mechanism for providing comparisons across the population as a whole. It is more often used in the research environment. A clinician is more interested in understanding what the actual risk is, for (say) a 70-year-old patient, with whom they are consulting. This lack of consistency in classifying age makes it difficult to compare results, as well as constraining translation of research evidence into clinical practice.

Country classification

Prevalence and incidence rates were reported using countries as population descriptors. This was either as individual country/countries or as a grouping of countries. Often it was not clear which countries were included in a group. For example under 'worldwide', there was no explanation as to how many and which countries data had been collected from. It was also not clear whether the data collected were proportional (ie, had data been collected from each continent). It also seems unlikely that data were collected from all 195 countries; therefore, the appropriateness of 'worldwide' as a descriptor is questioned. Similarly, there is no internationally agreed standard terminology for some of the descriptors used (industrialized, Western) and thus different people could interpret the generalizability and applicability of the data differently.

Ethnicity classification

There was no clarity on ethnic classifications. Some classifications were general (black, white or Asian), without any details on ethnic inclusions, whilst others were very specific to a small population, such as the East Greenlandic Inuit. Given the diversity of the included population under generic ethnic terms, these data are unlikely to be as generalizable or applicable as data that are collected with specified ethnicity.

Despite concerns regarding definition and diagnosis, the prevalence of glaucoma for black

and Asian (unspecified country of origin) populations is elevated compared with white populations, with most reports suggesting approximately a three-fold increase. The same differential is reported for incidence in black populations compared with white. The exact racial and ethnic components included within the umbrella terms 'black' and 'white' were not uniformly specified within the secondary evidence. In the majority of cases where some specification was made, black referred to those of African American origin and white to those of Caucasian origin. There was nothing to imply that black populations included indigenous populations as relevant to the Australian context.

Open-angle glaucoma

Overall prevalence for glaucoma of between 1–4% is commonly reported worldwide, although the prevalence and incidence of POAG and general OAG were variably reported. Prevalence is closely linked to age and ethnicity of the population. Open-angle glaucoma is the most common form of glaucoma and accounts for 75% to 95% of primary glaucomas, except in people of Eastern Asian (Mongoloid) descent (Burr *et al*., 2007). There appears to be consistency for the prevalence reported within the subgroups and general population, across most of the literature. However, reporting the incidence of OAG in the general population varied considerably (see Table 8).

Angle-closure glaucoma

There is little information on the incidence and prevalence of angle-closure glaucoma. This lack of data should not undermine the importance of angle-closure glaucoma, as in China, PACG is reported to be responsible for >90% of bilateral glaucoma blindness (Saw *et al*., 2003). Foster *et al*. (2002) emphasize that current PACG classification is largely based on clinical observations in European derived people, among whom the condition is rare. While the acute, symptomatic phase is dramatic, it occurs in only a minority of those with PACG diagnosed in population-based surveys in African and Asian settings.

Childhood and secondary glaucomas

There was only one systematic review (Moore and Nischal, 2007) that considered the incidence data on childhood primary congenital glaucoma. However, this review did not discuss prevalence data. Prevalence and incidence data for secondary glaucoma was not reported in the included systematic reviews for this review. This highlights that there is a possible gap in available evidence for this classification of glaucoma. It is also probable that the varying definitions of glaucoma have affected the diagnosis of secondary glaucoma, thereby impacting on available prevalence and incidence data.

Specifically for Australia

There was only one systematic review that focused specifically on Australia (Madden *et al*., 2002), which for glaucoma prevalence was only reported from the VIP study. Burr *et al*. (2007) included non-age stratified prevalence data from the VIP and BMES studies. These two primary Australian studies were also included in our review, as well as an ABS (2004) survey and AIHW (2005) report in order to collate current Australian prevalence information.

The two landmark population studies performed in Australia (BMES, VIP) provide useful data on the prevalence of eye diseases and visual impairment. However, they were conducted predominantly on white people and prevalence data from other ethnic groups were not provided. No people with an Aboriginal or Torres Strait Islander ancestry were involved in either study (Mitchell *et al*., 1996; Weih *et al*., 2001). Weih *et al*. (2001: 1969) in the 'VIP study found an overall prevalence of definite (1.8%) or probable or definite (2.5%) glaucoma which is comparable with prevalence reported for other white populations'. Mitchell *et al*. (1996: 1665) note that an 'exponential increase in prevalence for glaucoma was found for increasing 10-year age groups'.

A key failing of these two studies in providing useful estimates of prevalence was the inclusion of 'white' people without further ethnic breakdown. Given the multicultural population of Australia, the generalizability of these findings across the entire Australian population should be questioned. Data regarding the prevalence and incidence of glaucoma within the indigenous population of Australia are limited. However, POAG does not appear to be an important cause of visual impairment in indigenous Australians

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(refer to ABS (2004)). Overall, Australian data on the prevalence of glaucoma appear to be comparable with the international prevalence rates for OAG in white populations (refer to Tables 5–7).

Comparison measures

Prevalence was always reported as percentages. However, the differing population descriptors made a synthesis of these estimates difficult. The risk of glaucoma was often reported using quantified (ie, four-fold higher) or unquantified (ie, increased) comparisons or risk ratios between different ethnic groups (refer to Table 3).

Data collection

The method of data collection can impact on the accuracy of the glaucoma diagnosis. Some of the Australian data were self-reported. In one survey, 'vision loss was defined by self-report as blindness and other vision disturbances which cannot be corrected by spectacles, and is a long-term sight problem which has lasted or is expected to last for 6 months or more' (AIHW, 2005: 30), whereas in another survey, 'vision loss was defined by self-report as total or partial loss of sight, which cannot be corrected by spectacles' (AIHW, 2005: 30). Self-reported data can be questionable depending on whether definitions are provided to or determined by participants and on the type, number and complexity of the questions asked. Foster *et al*. (2002) state the accuracy of prevalence and incidence data derived from 'self-reported' cases of glaucoma needs to be considered, given the likelihood of differing definitions of glaucoma held by clinicians as well as the population.

Also of note was that many of the systematic reviews were based on the epidemiology data from papers often published up to 10 years earlier. Thus, even from recent reviews it was difficult to obtain a current and consistent view of prevalence. For example, in the Moore and Nischal (2007) review, the incidence data on childhood primary congenital glaucoma came from a study published in 1980, whilst in the Rolim de Moura *et al*. (2007) review, the prevalence data for POAG were based on studies reported in 1983, 1991, 1994, 1997, 1998 and 2000.

Conclusion

There is a lack of consistent summary evidence on the prevalence and incidence of glaucoma internationally, although the available secondary evidence suggests that it is of the magnitude 1–4%. Variability in reporting glaucoma epidemiology appears to reflect international differences in disease and population definitions, disease prevalence measures and data capture methods. There is a clear need for worldwide agreement on standard epidemiological descriptors of glaucoma, using standard population frameworks, standard terminology and standard age groups. Ethnic and age differences are reported as consistent risk factors related to glaucoma type and prevalence, although these are variably defined. The key clinical and methodological issues that need to be considered in future research include clearly defined population descriptors and the use of standard glaucoma definitions and classifications to enable meaningful comparisons to be made, increasing the believability of the data reported.

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References

AGREE Collaboration. 2001: Appraisal of guidelines for research and evaluation (AGREE) instrument. Retrieved 18 February 2008 from http://www.agreecollaboration.com

AGREE Collaboration. 2003: Development and validation of an international appraisal instrument for assessing the quality of clinical practice guidelines: the AGREE project. *Quality and Safety in Health Care* 12, 8–23.

Alexander, C.L., Miller, S.J. and **Abel, S.R.** 2002: Prostaglandin analog treatment of glaucoma and ocular hypertension. *Annals of Pharmacotherapy* 36, 504–11.

Amar, M.B. 2006: Cannabinoids in medicine: a review of their therapeutic potential. *Journal of Ethnopharmacology* 105, 1–25.

American Academy of Ophthalmology (AAO). 2005: *Primary angle closure preferred practice pattern*. San Franciso, CA: American Academy of Ophthalmology.

American Optometric Association (AOA). 2002: *Optometric clinical practice guideline: care of the patient with open*

angle glaucoma, second edition. St Louis, MO: American Optometric Association.

Australian Institute of Health and Welfare (AIHW). 2005: Vision problems among older Australians. AIHW Bulletin-27. Retrieved 8 August 2008 from http://www.aihw.gov.au/publications/index.cfm

Australian Bureau of Statistics (ABS). 2004: National Aboriginal and Torres Strait Islander Health Survey 2004–05. Retrieved 28 May 2008 from http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/4715.0Main+Features12004-05?OpenDocument

Burr, J., Azuara-Blanco, A. and **Avenell, A.** 2004: Medical versus surgical interventions for open angle glaucoma. *Cochrane Database of Systematic Reviews* 8CD004399, 10.1002/14651858.CD004399.pub2.

Burr, J.M., Mowatt, G., Hernández, R., Siddiqui, M., Cook, J., Lourenco, T., Ramsay, C., Vale, L., Fraser, C., Azuara-Blanco, A., Deeks, J., Cairns, J., Wormald, R., McPherson, S., Rabindranath, K. and **Grant, A.** 2007: The clinical effectiveness and cost-effectiveness of screening for open angle glaucoma: a systematic review and economic evaluation. *Health Technology Assessments* 11, 1–206.

Costa, V.P., Harris, A., Stefansson, E., Flammer, J., Krieglstein, G.K., Orzalesi, N., Heijl, A., Renard, J.P. and **Serra, L.M.** 2003: The effects of antiglaucoma and systemic medications on ocular blood flow. *Progress in Retinal and Eye Research* 22, 769–805.

Denis, P., Lafuma, A., Khoshnood, B., Mimaud, V. and **Berdeaux, G.** 2007: A meta-analysis of topical prostaglandin analogues intraocular pressure lowering in glaucoma therapy. *Current Medical Research and Opinion* 23, 601–608.

Einarson, T.R., Vicente, C., Machado, M., Covert, D., Trope, G.E. and **Iskedjian, M.** 2006: Screening for glaucoma in Canada: a systematic review of the literature. *Canadian Journal of Ophthalmology* 41, 709–21.

Fleming, C., Whitlock, E.P., Beil, T., Smit, B. and **Harris, R.P.** 2005: Screening for primary open-angle glaucoma in the primary care setting: an update for the US preventive services task force. *Annals of Family Medicine* 3, 167–70.

Foster, P.J., Buhrmann, R., Quigley, H.A. and **Johnson, G.J.** 2002: The definition and classification of glaucoma in prevalence surveys. *British Journal of Ophthalmology* 86, 238–42.

Friedman, D.S. and **Vedula, S.S.** 2006: Lens extraction for chronic angle-closure glaucoma. *Cochrane Database of Systematic Reviews*. Issue 13 Art. No. CD005555.

Fung, A.T., Reid, S.E., Jones, M.P., Healey, P.R., McCluskey, P.J. and **Craig, J.C.** 2007: Meta-analysis of randomised controlled trials comparing latanoprost with brimonidine in the treatment of open-angle glaucoma, ocular hypertension or normal-tension glaucoma. *British Journal of Ophthalmology* 91, 62–68.

Hatt, S., Wormald, R. and **Burr, J.** 2006: Screening for prevention of optic nerve damage due to chronic open angle glaucoma. *Cochrane Database of Systematic Reviews*. Issue 4 Art. No. CD006129.

Henness, S., Harrison, T.S. and **Keating, G.M.** 2007: Ocular carteolol – a review of its use in the management of glaucoma and ocular hypertension. *Drugs & Aging* 24, 509–28.

Holmstrom, S., Buchholz, P., Walt, J., Wickstrom, J. and **Aagren, M.** 2005: Analytic review of bimatoprost, latanoprost and travoprost in primary open angle glaucoma. *Current Medical Research and Opinion* 21, 1875–83.

Japan Glaucoma Society (JGS). 2004: *Guidelines for glaucoma*. Tokyo: Japan Glaucoma Society.

Law, S.K. and **Li, T.** 2007: Acupuncture for glaucoma. *Cochrane Database of Systematic Reviews*. Issue 4 Art. No. CD006030.

Madden, A.C., Simmons, D., McCarty, C.A., Khan, M.A. and **Taylor, H.R.** 2002: Eye health in rural Australia. *Clinical and Experimental Ophthalmology* 30, 316–21.

Maier, P.C., Funk, J., Schwarzer, G., Antes, G. and **Falck-Ytter, Y.T.** 2005: Treatment of ocular hypertension and open angle glaucoma: meta-analysis of randomised controlled trials. *British Medical Journal* 331, 134–39.

Mitchell, P., Smith, W., Attebo, K. and **Healey, P.** 1996: Prevalence of open-angle glaucoma in Australia: the Blue Mountains eye study. *Ophthalmology* 103, 1661–69.

Moore, W. and **Nischal, K.K.** 2007: Pharmacologic management of glaucoma in childhood. *Pediatric Drugs* 9, 71–79.

Moher, D., Klassen, T.P., Schulz, K.F. and **Berlin, J.A.** 2000: What contributions do languages other than English make on the results of meta-analyses? *Journal of Clinical Epidemiology* 53, 964–72.

Moher, D., Pham, B., Lawson, M.L. and **Klassen, T.P.** 2003: The inclusion of reports of randomised trials published in languages other than English in systematic reviews. *Health Technology Assessment* 7, 1–90.

Møller, A.P. and **Jennions, M.D.** 2001: Testing and adjusting for publication bias. *Trends in Ecology & Evolution* 16, 580–86.

National Health and Medical Research Council (NHMRC). 2005: NHMRC additional levels of evidence and grades for recommendations for developers of guidelines: stage 2 consultation. Retrieved 8 August 2008 from http://www.nhmrc.gov.au/guidelines/_files/Stage%202%20Consultation%20Levels%20and%20Grades.pdf, www.nhmrc.gov.au

Obstbaum, S.A., Cioffi, G.A., Krieglstein, G.K., Fennerty, M.B., Alm, A., Araie, M., Carassa, R.G., Greve, E.L., Hitchings, R.A., Kaufman, P.L., Kitazawa, Y., Pongpun, P.R., Susanna, R., Jr Wax, M.B. and **Zimmerman, T.J.** 2004: Gold standard medical therapy for glaucoma: defining the criteria identifying measures for an evidence-based analysis. *Clinical Therapeutics* 26, 2102–20.

Plosker, G.L. and **Keam, S.J.** 2006: Bimatoprost – a pharmaco-economic review of its use in open-angle glaucoma and ocular hypertension. *PharmacoEconomics* 24, 297–314.

Rolim de Moura, C., Paranhos, A., Jr and **Wormald, R.** 2007: Laser trabeculoplasty for open angle glaucoma (review). *Cochrane Database of Systematic Reviews*. Issue 4 Art. No. CD003919.

Rowe, S., MacLean, C.H. and **Shekelle, P.G.** 2004: Preventing visual loss from chronic eye disease in primary care: scientific review. *Journal of the American Medical Association* 291, 1487–95.

Royal College of Ophthalmologists (RCO). 2004: *Guidelines for the management of open angle glaucoma and ocular hypertension*. London: Royal College of Ophthalmologists.

Saw, S.M., Gazzard, G. and **Friedman, D.S.** 2003: Interventions for angle-closure glaucoma: an evidence-based update. *Ophthalmology* 110, 1869–78.

Schmier, J.K., Halpern, M.T. and **Jones, M.L.** 2007: The economic implications of glaucoma – a literature review. *PharmacoEconomics* 25, 287–308.

South-East Asia Glaucoma Interest Group (SEAGIG). 2003: *Asia Pacific glaucoma guidelines*. Sydney: South-East Asia Glaucoma Interest Group.

Sycha, T., Vass, C., Findl, O., Bauer, P., Groke, I., Schmetterer, L. and **Eichler, H.** 2003: Interventions for normal tension glaucoma. *Cochrane Database of Systematic Reviews*. Issue 1 Art. No. CD002222.

US Preventive Services Task Force (USPSTF). 2005: *Screening for glaucoma: recommendation statement*. Rockville, MD: Agency for Healthcare Research and Quality, 1–16.

Weih, L., Nanjan, M., McCrty, C. and **Taylor, H.** 2001: Prevalence and predictors of open-angle glaucoma: results from the visual impairment project. *Ophthalmology* 108, 1966–72.

Appendix 1

Identified keywords

'Glaucoma' AND

Primary	Secondary	Treatment
Open	Closed	Manag$
Congenital	Guideline	Pharma$
Visual loss	Definition	Therap$
Prevalence	Incidence	Alternative
Prognosis	Progression	Co-morbid$
Outcome	Diagnos$	Causal
Detection	Screening	Intervene$
Monitoring	Surveillance	Medicat$
Prevent$	Risk	Surg$
Pregnan$	Effect$	Laser

Databases searched

Peer reviewed databases	AMED Cinahl MEDLINE Cochrane Database of Systematic Reviews ACP Journal Club DARE (Database of Abstracts of Reviews of Effects) Embase Australian Public Affairs Full Text Meditext Family & Society Plus AUSThealth PsycInfo Academic Search Premier
Non-peer reviewed databases	Google (Google Scholar) Meta-crawler Digital Dissertations (ProQuest) Australian Digital Dissertations National Guideline Clearinghouse

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