

Glaucoma among Saudi Arabian population: a scoping review

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Abstract

• Despite its high risk of leading to permanent visual dysfunction, glaucoma remains underdiagnosed in primary care settings. About 11% of glaucoma patients in Saudi Arabia end up with bilateral blindness. This scoping review investigates and presents results on the glaucoma profile, including its prevalence, knowledge, attitude, and practice of Saudi Arabians towards the disease. An online search using four databases through online software (www.rayyan.ai) was performed to extract the relevant articles. Out of 76 records, 21 articles were eligible for the analysis. All included studies were published between the years 2014 and 2022. Most studies were in Riyadh city, followed by Jeddah. All participants ($n=11\ 388$) were adults >18 years old, and male participants were generally higher than females. The findings showed poor knowledge of glaucoma among the general population, while the knowledge among glaucoma patients was acceptable. The attitude was positive, while the compliance and practice were fair. More educational programs about glaucoma, its risk to the eyes, and the overall quality of life are highly recommended.

• **KEYWORDS:** glaucoma; glaucoma prevalence; knowledge of glaucoma; Saudi Arabian

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INTRODUCTION

Glaucoma can be considered a heterogeneous group of diseases with characteristic progressive optic neuropathy, which causes the development of visual field dysfunctions and irreversible blindness^[1]. While the condition has many risk factors, the primary one is intraocular pressure (IOP). Glaucoma is the most prevalent cause of irreversible blindness worldwide^[2]. Its global prevalence among 40 to 80-year-old is about 3.5%^[3]. Glaucoma is classified based on its onset (congenital or acquired), anatomy [primary open angle glaucoma (POAG) or angle-closure glaucoma (ACG)], IOP (high IOP or normal tension), and its cause (primary or secondary). POAG is the most common (National Eye Institute, 2021). Risk factors for POAG are age, rising IOP, ethnicity, family history of the disease, and hyperopia. Old patients with hyperopia and Asian descent are at the most risk for primary close-angle glaucoma^[3]. The most common feature of all types of glaucoma is the cupping of the optic disc due to thinning of the retinal nerve fiber layers caused by degeneration of the retina's ganglion cells^[4]. Congenital glaucoma is the leading cause of childhood blindness in the Kingdom, caused by a developmental abnormality in the drainage outflow of the eye leading to high IOP shortly after birth. Primary congenital glaucoma (PCG) incidence is particularly high in Saudi Arabia at 1 in 2500^[5].

Several methods can be used to diagnose glaucoma. Some of these include visual acuity testing, pachymetry test to measure the thickness of the cornea, gonioscopy to measure the angle where the iris meets the cornea, tonometry for IOP, ophthalmoscopy to evaluate the optic disc, and perimetry to check the visual field. Also, imaging tests such as optic disc photography and optical coherence testing can be done to support clinical findings. However, its diagnosis in primary care is rare as primary health providers are not trained to conduct these tests. As a result, glaucoma is usually underdiagnosed until it progresses to its later stages^[6].

The only modifiable risk factor for glaucoma is the IOP, whose ideal level has yet to be established. Still, the American

Academy of Ophthalmology recommends decreasing it to 25% from the baseline. Different methods include topical drops, oral medication, laser therapy, laser cyclophotocoagulation, and incisional surgery. Medicine and laser therapy are recommended for initial therapy [National Institute for Health and Care Excellence (NICE), 2022]. This research paper aims to report on the prevalence, knowledge/awareness, attitude, and practice of glaucoma in Saudi Arabia.

METHODOLOGY

The present scoping review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Statement^[7] to answer the following question: What is the glaucoma prevalence and knowledge/awareness, attitude, and practice of Saudi population towards this disease? Ethical approval was exempted for this study as the collected information is publicly available and included in the review.

Search Strategy and Eligibility Criteria The search was conducted in May and updated in November 2022 using Rayyan’s online software (www.rayyan.ai). Four electronic databases, Medline/PubMed, Embase, Cochrane, and Google Scholar, were used to search for the related studies. The following relevant keywords were used in data extraction: “prevalence” OR “knowledge” OR “attitude” OR “practice” OR “profile” OR “compliance” AND “glaucoma” OR “eye disease” AND “Saudi Arabia” OR “KSA” OR “Kingdom of Saudi Arabia”. After removing the duplicates, the titles and abstracts of the remaining records were analyzed independently by two reviewers (Alamer AM and Hadadi MA). The full texts of the potentially eligible articles were screened according to the following inclusion criteria: published in English, full-length original research, and conducted in Saudi Arabia. Editorials, abstracts, posters, and review articles were excluded. Figure 1 depicts the search strategy according the PRISMA guidelines.

Data Extraction and Outcomes Two authors (Alamer AM and Jafar SA) extracted the parameters of interest from each study: author(s) and year of study, study area/setting, sample size, age of the participants, and male/female ratio. Furthermore, the main objective(s) of each study was/were extracted and tabulated.

RESULTS

Selection of the Eligible Studies A total of 76 records were retrieved from the search engines. Ten records were removed as duplicates. Out of 69 records, 49 records were excluded as irrelevant. The full texts of the remaining 20 articles were extracted and screened for eligibility. Out of them, 2 articles were excluded because no complete data were found. Three more studies were added by manual search. Finally, 21 studies were included in this review for qualitative analysis.

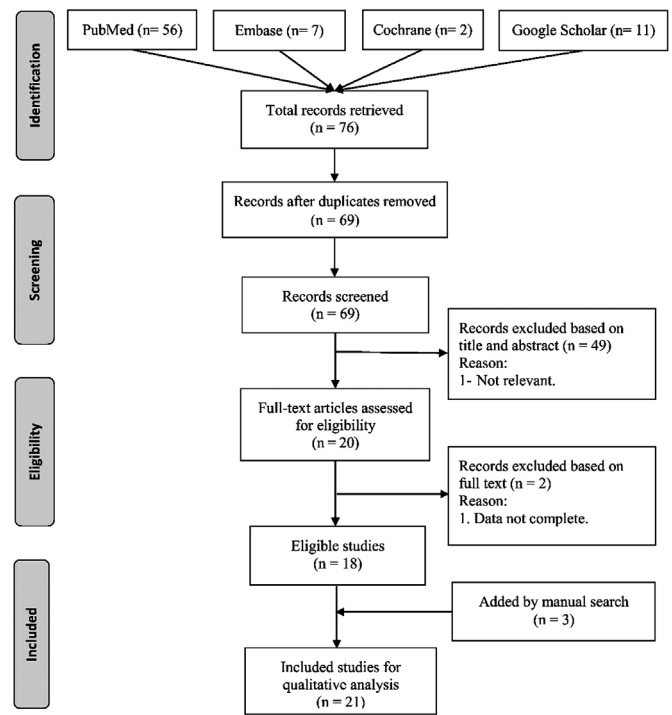


Figure 1 PRISMA flow-chart of the search strategy.

Characteristics of the Included Studies All the included studies^[1,8-27] were conducted between the years 2011 and 2022, with most of them in the few recent years. Most studies were conducted in Riyadh (n=11), followed by Jeddah (n=4). In contrast, the remaining studies were conducted in Al-Madinah Al-Munawwarah (n=1 study), Hail (n=1 study), both Al-Khobar and Dhahran (n=1 study), Dhahran (n=1 study), Makkah (n=1 study), and one study was conducted in different cities in the Kingdom. There were 11 388 participants involved in those studies, including the general population, glaucoma patients, and parents of glaucoma patients (children). All participants were adults >18 years old (one study did not report the age parameter). The male percentage ranged from 13.3% to 67.6%, with more than 50% in most studies (Table 1).

Outcome Measures and Scopes of the Included Studies

Prevalence According to Alqahtani *et al*^[1], POAG is the most common in Saudi Arabia, with 60% in the east and 30.5% in the west. On the other hand, primary ACG is the most common in the central region of Saudi Arabia, Riyadh^[1]. Similarly, AL-Anazi *et al*^[9] report that open angle glaucoma (OAG) and ACG are the most prevalent types of glaucoma in western and central Saudi Arabia. The authors also state some risk factors for glaucoma, such as diabetes, hypertension, refractive errors, high IOP, family history of the disease, and ageing. Additionally, they mention pseudo-exfoliation and hypothyroidism as factors that have not been studied extensively. According to AL-Anazi *et al*^[9], 11% of glaucoma patients in Saudi Arabia end up with bilateral blindness.

Table 1 Characteristics, objectives, and main outcomes of the included studies

Study, y	Sample size, gender, age	Setting population	Objective(s) and main outcomes
Surrati <i>et al</i> , 2022	n=555 13.3% M >20y	Al-Madinah Al-Munawwarah Saudi adults (parents with children aged under 15y)	Awareness and perception of children's eye diseases: an acceptable knowledge level (19.2%) among parents regarding childhood glaucoma. Knowledge level was higher among participants with higher family income, parents aged 51 or older, a child with an eye disease, and of Saudi origin. About 85.4% of parents accepted the idea of ophthalmologic surgery for their children if needed.
Alqahatani <i>et al</i> , 2021	n=383 61.9% M 38.5±12.94y	Jeddah Attendees of a local eye care hospital	Awareness and knowledge: the most frequently reported source of information about glaucoma was another person with glaucoma. The study revealed low awareness and knowledge levels about glaucoma among the attendees of a local eye care hospital, where several misconceptions about disease risk factors, clinical features, and management are identified.
Alammar <i>et al</i> , 2021	n=953 41.1% M 31.99y	Different cities Saudi adults (general population)	Levels of knowledge regarding cataract and glaucoma: glaucoma was correctly defined by 42.5% of the participants, and cataract was correctly defined by 55.8% of the participants. Regarding glaucoma definition, 48.4% of the participants with previous eye disease answered correctly compared with 40.1% without previous eye disease who answered correctly. The study also highlighted that although there are higher levels of knowledge regarding cataract than glaucoma in terms of definition, the higher levels of knowledge regarding the latter are necessary because of its irreversible effects.
Alshammari <i>et al</i> , 2021	n=400 53.8% >18y	Hail Saudi adults (general population)	Public awareness of common eye diseases: in the Hail Region of Saudi Arabia, there is an overall moderate comprehension of common eye disorders among the general population. The most known eye infections were dry eyes (66%), diabetic retinopathy (44%), glaucoma (43%), 31% and cataracts (31%). Only 46% of the respondents knew about the eye disease. The primary sources of information about the common eye diseases were pharmacists.
Helayel <i>et al</i> , 2021	n=999 52.9% M 58.8±17.4y	Al-Khobar and Dhahran glaucoma patients	Profile of glaucoma: the three most common types of glaucoma were POAG 27.7%, secondary glaucoma 26.8%, and ACG 15.5%. However, congenital glaucoma (2.2%) and juvenile glaucoma (1.8%) expressed a small proportion of the studied population.
Al Mazrou <i>et al</i> , 2021	n=1070 48.3% M 38±9y	Riyadh Saudi adults (parents)	Awareness of pediatric eye diseases: most of the participants' knowledge test score about the eye health and care was poor (91.9%). Only 10.6% of the participants had acceptable knowledge level regarding glaucoma.
Almarzouki, 2020	n=608 59.2% M 28.3±11.4y	Jeddah Saudi adults (general population)	Awareness of glaucoma: about 66.3% of the participants had good knowledge about glaucoma, while 33.7% had no previous knowledge about glaucoma.
Shadid <i>et al</i> , 2020	n=263 57.8% M 61.6±14.2y	Riyadh glaucoma patients	Compliance with medical treatment among adult Saudi glaucoma patients: about 43% had less than a one-year duration of glaucoma. Among them, 72% complied with topical medications, while 87% complied with the follow-up appointments.
Khandekar <i>et al</i> , 2019	n=890 56% M >40y	Riyadh Saudi adults (general population)	Prevalence and determinants of glaucoma: the community-based prevalence of glaucoma was 5.6%. Males were more likely to develop glaucoma than females, and people aged 60 years and older also had substantially higher rates of glaucoma.
Al Owaifeer <i>et al</i> , 2018	n=196 54.8% M 58.7±16.0y	Riyadh glaucoma patients	Effect of a short animated educational video on knowledge among glaucoma patients: mean pre-intervention knowledge score was 6 out of 17, and the post-intervention score was 11.1.
Al Rashed <i>et al</i> , 2017	n=711 49.2% M 35.32±12.2y	Riyadh Saudi adults (general population)	Public awareness regarding common eye diseases: the majority of respondents in the knowledge exam had good knowledge (68.2%), some had outstanding knowledge (17.3%), and only a small number had inadequate knowledge (14.4%) on eye health and care. For glaucoma, only 14.8% had acceptable knowledge and 85.2% had poor knowledge.
Almulhim <i>et al</i> , 2017	n=210 31.7% M 41–60y	Dhahran glaucoma patients	Knowledge and practice of glaucoma: fifty-six participants had excellent knowledge of glaucoma, 119 participants had good knowledge, and 35 had poor knowledge. The knowledge of glaucoma among urban Saudi adults is less than desired.
Osman <i>et al</i> , 2016	n=93 54.8% M 58.7±16.0y	Riyadh glaucoma patients	Compliance of glaucoma patients: chronic ACG was the most common diagnosed disease (45.2%) while, POAG accounted for 29%. About 46.2% of the respondents knew that glaucoma is a chronic disease, and 29% believe that it can be cured, while 44.1% were aware of glaucoma complications.
Badeeb <i>et al</i> , 2014	n=34 62% M NR	Jeddah patients with PCG	CYP1B1 mutations in patients with PCG: the most common cause of PCG in the population of Saudi Arabia is CYP1B1 mutations, and the most pathogenic variant is p.Gly61Glu.
AL-Anazi <i>et al</i> , 2018	n=469 53.3% M 38.6±14.5y	Riyadh Saudi adults (general population)	Awareness of glaucoma: the majority had good knowledge of glaucoma with only a few having excellent knowledge. However, only 0.6% of the respondents needed to gain better knowledge of glaucoma.
Al Obeidan <i>et al</i> , 2011	n=1236 41.0% M 53.9±22.9y	Riyadh glaucoma patients	Profile of glaucoma: the most common glaucoma types were PACG (46.6%) followed by secondary glaucoma (SG; 13%) and POAG (12.8%). Normal tension glaucoma (NTG) accounted for 5.9%, followed by childhood and juvenile glaucoma, 2.6% and 1.9%, respectively.
Shibrayn <i>et al</i> , 2018	n=1021 63.0% M <20 – >51y	Riyadh Saudi adults (general population)	General awareness and knowledge about glaucoma: about 52% of samples were aware of visual problems and a minimum of 1.2% samples had knowledge about glaucoma, followed by 19.9% about diabetic retinopathy and 2% about cataract. The sample in the age group of above 50 years of age had significant higher proportion of awareness regarding all diseases.
Al Rashed <i>et al</i> , 2021	n=263 57.8% M 61.6±14.2y	Riyadh glaucoma patients	Knowledge, attitude, and practice toward glaucoma: 24% of patients had excellent knowledge about glaucoma and its management, 36.1% of patients needed better knowledge about glaucoma and its management. The attitude toward glaucoma and its management was positive among 33.8% of patients. The practice for managing glaucoma was excellent among 3.8% of patients and good score among 73% of patients. There were 17.9% of patients with an excellent overall grade of KAP.
Abdujawad <i>et al</i> , 2018	n=575 57.6% M 40–59y	Jeddah glaucoma patients	Compliance of glaucoma patients: approximately half of the respondents (53%) thought that the patient could not know that they are experiencing glaucoma from the symptoms and nearly the same percentage (55.1%) correctly perceived that the physician would perform the tests of eye pressure, visual field, and optic nerve examination to reach a definite diagnosis.
Subhan <i>et al</i> , 2022	n=134 50.0% M >18y	Makkah glaucoma patients	Compliance to anti-glaucoma medications after a structured interventional program: non-compliance was detected in 15.7% of all recruited patients (n=134). However, the non-compliance percentage dropped significantly to 10 (7.5%) after the structured program.
Alwazae <i>et al</i> , 2022	n=145 67.6% M 56.82±7.66y	Riyadh glaucoma patients	Effect of encounter GDA: after GDA use, the overall knowledge improved by 80%, there was a statistically significant increase in adherence, and all five decision conflict subscales were significantly decreased.

POAG: Primary open angle glaucoma; ACG: Angle-closure glaucoma; PCG: Primary congenital glaucoma; PACG: Primary angle-closure glaucoma; GDA: Glaucoma decision aid; KAP: Knowledge, attitude, and practice; NR: Not reported.

Helayel *et al*^[21] conducted a retrospective analysis on 999 patients from Dhahran Eye Specialist Hospital and King Fahd Hospital of Al Khobar University. The authors established that the three most common types of glaucoma were POAG (27.7%), secondary glaucoma (26.7%), and primary ACG (18.2%). PCG (2.2%) and juvenile OAG (1.8%) accounted for the smallest portion of the studied population^[21]. The study also observed bilateral occurrence in most patients (83.3%). Furthermore, the mean age of the studied patients was 58.8y, indicating a high prevalence of glaucoma among the elderly^[21]. Al Obeidan *et al*^[11] had slightly different results when they measured the prevalence of glaucoma subtypes among King Abdul Aziz University Hospital (KAUH) patients. Primary ACG was the most prevalent, accounting for 46.6% of cases. However, primary angle closure (PAC), secondary glaucoma, and POAG were second, third, and fourth, respectively, at 17.2%, 13%, and 12.8%. The least dominant types were normal tension glaucoma, PCG, and juvenile glaucoma at 5.9%, 2.6%, and 1.9%, respectively^[11]. The slight differences can be attributed to the small sample size used in the latter study. However, they still report on global prevalence studies that predict an increase of glaucoma cases from 2.65% in 2010 to 2.86% by the end of 2020 among the demographic of over 40-year-olds^[11]. They estimate a different result for Saudi Arabia, which is already high, with a 5.1% prevalence rate of congenital eye anomalies brought about by high consanguinity rates in the region^[11]. Also, according to Al Obeidan *et al*^[11], the prevalence of glaucoma types in Middle and Far East countries differ from those of Western nations as the former have POAG as the most dominant type while the latter have primary ACG as the most prevalent type.

PCG, denoting the occurrence of glaucoma in an infant, is highly common in Saudi Arabia, with an incidence in about 1 of every 2500 live births^[20]. Badeeb *et al*^[20] correlate high occurrences of PCG in Saudi Arabia with a high prevalence of consanguinity in Saudi families. They also report prevalence rates of PCG in various regions using records from King Khaled Eye Specialist Hospital. The southern area recorded the highest prevalence at 27.8%, followed by the western province at 23.6% and the central area at 22.2%, while the eastern and the northern regions represented 11.1% and 9%, respectively^[20].

Khandekar *et al*^[22] conducted a community-based survey of Riyadh Governorate, excluding the capital, to establish prevalence rates of glaucoma among residents older than 40. Among the 940 residents used as a cluster sample for the study, the prevalence rate of glaucoma was 5.6%, considered high^[22]. Males outdid females in the prevalence group, with OAG occurring in 78% of the cases^[22]. The 67% of the patients had also experienced mild visual impairment^[22]. Eid *et al*^[28]

also conducted a retrospective hospital-based study at Jeddah Magrabi Eye and Ear Center in western Saudi Arabia. They focused on the prevalence of legal blindness and glaucoma subtypes recorded by patients during their first visit to the center. The mean age of the patients was 56.4, primarily male, with 17.7% being glaucomatous, while 3.8% were suspected of having glaucoma because of signs like ocular hypertension and glaucoma-like discs^[28]. While unilateral glaucoma had the least prevalence at 20%, it also had the highest rate of legal blindness at 38.8%^[28]. Bilateral glaucoma was the most prevalent at 73.9% but had a legal blindness rate of 11.3%^[28]. The study also recorded POAG as the most prevalent type at 38.1%, followed by primary ACG at 24.7%. Secondary ACG and secondary OAG had prevalence rates of 18.2% and 12.2%, respectively, while PAC had 2.9% and pediatric glaucoma had 2.8%^[28].

Knowledge Alqahtani *et al*^[1] present results on patients' awareness of glaucoma after screening at Jeddah Eye Hospital. Most of them were males (61.9%) with an educational level of a university degree or higher (61.6%)^[1]. Nevertheless, 30% reported they did not know about glaucoma^[1]. The other 33.4% could report on different glaucoma types with sources of information ranging from other glaucoma patients (28.2%), health personnel (24.8%), television (19.6%), acquaintances (16.7%), and print media (12.2%)^[1]. Therefore, media, health personnel, and acquaintances were the most dominant sources of information concerning glaucoma. The most known forms of glaucoma were ACG, OAG, and congenital glaucoma at 26%, 16.2%, and 11.2%, respectively^[1]. Still, 17.5% of those aware of glaucoma could not differentiate it from cataracts^[1]. According to Alqahtani *et al*^[1], personal and family history of the disease, diabetes history, and high educational levels were the most significant factors in determining the patients' awareness of glaucoma.

Al Rashed *et al*^[14] also conducted a cross-sectional study at a Riyadh tertiary eye care facility to determine levels of knowledge regarding glaucoma causes and management among patients. The average age of the participants was 61.6y, with 36.1% recording poor levels of knowledge and 24% recording excellent levels of knowledge^[14]. Similarly, AL-Anazi *et al*^[9] assessed glaucoma awareness among patients at King Abdul-Aziz University Hospital in Riyadh. The study revealed that 67% of the patients knew about glaucoma from health personnel, the community, and the media. The majority had good knowledge, with only a few displaying insufficient knowledge^[9]. Also, Almulhim *et al*^[17] assessed the knowledge levels of Dhahran residents regarding glaucoma. Among the 210 interviewed adults, 26.7% had excellent knowledge levels, 56.6% had acceptable levels, and 16.7% had poor levels^[17]. However, age groupings and educational levels did not impact

the study's findings. The most dominant sources of information were health personnel, friends/family, and mass media^[17].

Alammar *et al*^[15] undertook a cross-sectional study of Saudi Arabia's general public's knowledge concerning definitions of glaucoma and cataract. Participants who had already experienced eye illnesses (48.4% for glaucoma and 71.44% for cataracts) provided accurate descriptions^[15]. Nevertheless, it was hard for the respondents to differentiate between the two, as only 7.3% of those with prior experience with eye diseases provided correct definitions for both^[15]. The study showed cataracts were more known than glaucoma, and patients could hardly tell them apart. Recognizing the importance of knowledge in disease prevention. Alshammari *et al*^[18] surveyed 400 people to assess their awareness of various eye diseases. The most known eye infections were dry eyes (66%), diabetic retinopathy (44%), and glaucoma (43%)^[18]. Only 31% of the participants knew of cataracts. With only 46% of the respondents learning about eye diseases, the researchers concluded that massive knowledge gaps had to be overcome^[18]. They identified health personnel, the internet, and acquaintances as the most viable sources of information for overcoming the knowledge gaps.

Surrati *et al*^[27] surveyed parents in Madinah, Saudi Arabia, to assess their knowledge of children's eye diseases. The 78.2% of the 555 parents who were assessed displayed poor levels of knowledge, while 18.2% had acceptable levels and only 3.6% had high levels^[27]. The parents' low records of knowledge regarding potential eye infections for their children were alarming to the researchers and presented as a risk factor. They observed that the family's financial level, parents' ages, prior exposure to children's eye disorders, and Saudi background were mediating factors in the knowledge gaps^[27]. They could be improved by connecting the parents to more doctors and the internet^[27]. Similar findings were recorded by Al Mazrou *et al*^[29] when they also assessed parents' awareness in Riyadh concerning pediatric eye diseases. While most participants were well aware of general eye health and emergencies, most were unaware of common diseases such as tumours, glaucoma, visual deprivation, and strabismus^[10]. Some factors that led to improved knowledge included educational levels (university or higher) and experience in the medical field^[10]. Still, community members were reported as the most viable source of information regarding pediatric eye diseases^[10].

To assess whether a short educational video could improve glaucoma awareness among patients at King Khaled Eye Specialist, Al Owaifeer *et al*^[12] used 196 patients with a mean age of 55.7 years old. Even though poor predictors for knowledge, such as unemployment (41.8%), low income (62.8%), and illiteracy (29.6%), were present, the researchers were able to increase the patients' knowledge about glaucoma

in the short term^[12]. Similarly, Alwazae *et al*^[19] explored the effect of encounter glaucoma decision aid (GDA) on the overall knowledge of glaucoma patients after three months of intervention. The authors of that study found significant improvement in the overall knowledge of the patients from poor to good.

Attitude Using interview questions to assess the attitudes of Saudi patients towards glaucoma knowledge and management, Al Rashed *et al*^[14] found that 33.8% of 263 patients displayed positive attitudes. They recognized the score as very low, requiring strategies for improvement. Surrati *et al*^[27] also assessed parents' attitudes toward pediatric eye diseases. They found that most parents had no problem letting their children undergo ophthalmic surgery (84.5%) and wear spectacles (76.9%)^[27]. Beliefs and attitudes toward disease management highly affect patients' compliance rates. Therefore, Shadid *et al*'s study^[24] on adherence rates among adult patients at a tertiary eye center in Riyadh helps assess their attitude toward glaucoma and its management. Among the 263 glaucoma patients interviewed by the researchers, 72% complied with topical medications, while 87% complied with the follow-up appointments^[24]. The researchers concluded that adherence rates were high, indicating that the patients at the center had positive attitudes and beliefs toward glaucoma management.

Osman *et al*^[23] also provide insight into Riyadh patients' attitudes toward glaucoma management by assessing the compliance rates of patients at King Abdulaziz University Hospital. Non-compliance was recorded among only 19.4% of the interviewed patients^[23]. Age was the leading risk factor for non-compliance, with older adults comprising most of the non-compliance group^[23]. Osman *et al*^[23] identified treatment personalization, good physician-patient relationships, and awareness campaigns as viable means for improving attitudes toward glaucoma medication and compliance.

Practice Besides knowledge and attitude, Al Rashed *et al*^[14] also assessed practice levels of glaucoma management among Saudi adults. They found excellent practice levels among 3.8% of its participants and good practice levels among 73%^[14]. Some factors they associated with good practice in their study were young age, longer duration with glaucoma, and history of glaucoma surgery^[14]. They indicated that practice, attitude, and knowledge must be improved among Saudi adults. Surrati *et al*^[27] also assessed management practice for pediatric eye diseases among parents in Madinah, Saudi Arabia. They found that 58.6% of the parents assessed had already taken their children to an ophthalmic clinic for screening^[27]. Also, most were optimistic about letting their children undergo ophthalmic surgery and wear spectacles. Abdujawad *et al*^[8] investigated the compliance of glaucoma patients in Jeddah. The authors found that nearly half of the participants thought

the patients could not be aware of their glaucoma from the symptoms. In comparison, Subhan *et al*^[26] explored the effects of a structured interventional program on the compliance of glaucoma patients to anti-glaucoma medications. The authors noticed a significant improvement in the patient's compliance from 84.3% to 92.5%. In the same study by Alwazae *et al*^[19], the authors also explored the effects of the encounter GDA on the adherence of glaucoma patients. They found a significant increase in adherence to medication, from 41.4% to 65.5%.

Adherence rates for glaucoma management also provide insight into its practice. Shadid *et al*^[24] provide evidence for 72% compliance with topical medications and 87% compliance with follow-up appointments among 263 glaucoma patients in a tertiary eye center in Riyadh. The researchers concluded that adherence rates were high, indicating that the patients at the center had positive attitudes and beliefs toward glaucoma management. Osman *et al*^[23] also assessed the compliance rates of patients at King Abdulaziz University Hospital and reported 19.4% non-compliance among the interviewed patients^[23]. Age was the leading risk factor for non-compliance, with older adults comprising most of the non-compliance group^[23]. Eid *et al*^[28] provide different results as almost half of the patients who were analyzed during the study maintained regular follow-up visits after glaucoma diagnosis, 28.3% did not show up for the follow-up visits, and 22.5% presented inconsistently for them. Osman *et al*^[23] identified treatment personalization, good physician-patient relationships, and awareness campaigns as viable means for improving glaucoma management practice among patients.

According to Al Rashed *et al*^[13], eye health management can be improved by increasing knowledge and understanding of common eye diseases and their management. The improved practice also leads to reduced eye care costs and reduced cases of visual impairment. Also, according to Almulhim *et al*^[17], good practices for glaucoma entail regular screening and timely management, which can be achieved through public health education strategies.

DISCUSSION

The results show that the knowledge and attitude of Saudi Arabians towards glaucoma are poor and present as high-risk factors for adverse outcomes among glaucoma patients^[30]. Alqahtani *et al*^[1] reported that 30% of patients visiting Jeddah Eye Hospital for screening with an educational level of a university degree or higher did not know about glaucoma. Al Rashed *et al*^[14] also recorded poor levels of knowledge regarding glaucoma among 36.1% of patients at a Riyadh tertiary eye care facility. Parents are also revealed to be largely unaware of pediatric eye diseases, as Surrati *et al*^[27] surveyed parents in Madinah, Saudi Arabia, and found that 78.2% displayed poor levels of knowledge. Concerning attitude,

Al Rashed *et al*^[14] found that only 33.8% of patients showed positive attitudes and recognized the score as very low, requiring strategies for improvement. Comparison with other countries reveals low awareness levels in developing countries such as Ethiopia (2.4%), Nepal (2.4%), and India (0.27%) and high awareness levels in developed nations like the United States of America (72%) and Malaysia (71.5%)^[31]. These results indicate gaps in knowledge concerning glaucoma in Saudi Arabia that should be addressed by enhancing common communication channels, including health personnel, the media, and the community.

The results also reveal relatively high prevalence rates of glaucoma in Saudi Arabia compared with other countries, which indicates it is a risk factor for adverse outcomes among patients. Al Obeidan *et al*^[11] reported on global prevalence rates of 2.65% in 2010 that they predicted would increase to 2.86% in 2020 but estimated a different result for Saudi Arabia, which is already high, with a 5.1% prevalence rate of congenital eye anomalies brought about by high rates of consanguinity in the region, which can be addressed by further genetic studies among Saudi families. Badeeb *et al*^[20] also report on the high prevalence of PCG in Saudi Arabia, with an incidence in about 1 of every 2500 live births correlating with high occurrences of consanguinity in Saudi families. The disparity in the prevalence of glaucoma might be attributed to the regional/racial variations among the Kingdom or might be due to genetic and possible environmental differences. Comparison with other countries reveals that the prevalence of POAG in Western Europe and North America^[32] is so low that it is difficult to conduct large-scale epidemiological studies. PCG occurs in almost 1 out of 10 000–68 000 live births, with one diagnosis approximately every five years^[33]. The comparison shows that PCG contributes to the prevalence rates of glaucoma in Saudi Arabia and can be addressed by discouraging consanguinity among Saudi families. More detail in comparison with other countries is presented in Table 2.

Unlike knowledge, attitude, and prevalence, the scoping review results show that glaucoma management is highly effective in Saudi Arabia. Al Rashed *et al*^[14] found excellent practice levels among 3.8% and good practices among 73% of the Saudi adults they assessed. Surrati *et al*^[27] also evaluated management practice for pediatric eye diseases among parents in Madinah. They found that 58.6% of the parents had already taken their children to an ophthalmic clinic for screening; most were positive about letting their children undergo ophthalmic surgery and wear spectacles. The study also utilizes adherence rates for glaucoma management to provide insight into its practice. According to Shadid *et al*^[24], glaucoma patients in a tertiary eye center in Riyadh recorded high adherence rates, as 72% complied with topical medications and 87% complied

Table 2 Comparison of the Saudi Arabia studies and some studies among other countries

Saudi Arabia	Other countries
POAG is the most dominant type of glaucoma, followed by primary ACG in the Middle East and Far East countries such as Saudi Arabia, India and China (Al Obeidan <i>et al</i> , 2011).	Globally, primary OAG is the most dominant type of glaucoma followed by primary ACG (Zeleznik <i>et al</i> , 2023).
PCG, denoting the occurrence of glaucoma in an infant, is highly common in Saudi Arabia, with an incidence in about 1 of every 2500 live births (Badeeb <i>et al</i> , 2014). Badeeb <i>et al</i> (2014) correlate high occurrences of PCG in Saudi Arabia with a high prevalence of consanguinity in Saudi families.	According to Moore <i>et al</i> (2013), infants with glaucoma most commonly experience PCG. However, its prevalence in Western Europe and North America is so low that it is difficult to conduct large-scale epidemiological studies. PCG occurs in almost 1 out of 10 000–68 000 live births in these regions, and diagnosis may occur approximately every five years.
Alqahtani <i>et al</i> (2021) reported that 30 percent of participants with an educational level of a university degree or higher need to learn about glaucoma. The other 33.4 per cent could report on different glaucoma types with sources of information ranging from other glaucoma patients, health personnel, media, and acquaintances (Alqahtani <i>et al</i> , 2021).	Al-Naggar <i>et al</i> (2020) reported on a study conducted in Malaysia that identified awareness of glaucoma among 71.5 percent of participants who had a university degree or higher educational level. The study compares the Malaysian study's results to developing countries where awareness levels are low [Ethiopia (2.4%), Nepal (2.4%), and India (0.27%)] and developed nations like the United States of America, where awareness levels are quite high (72%).
Shadid <i>et al</i> (2020) provided evidence for 72 percent compliance with topical medications and 87 percent compliance with follow-up appointments among 263 glaucoma patients in a tertiary eye center in Riyadh. The researchers concluded that adherence rates were high, indicating that the patients at the center had positive attitudes and beliefs toward glaucoma management.	Newman-Casey <i>et al</i> (2015) examined adherence trends in glaucoma patients enrolled in a US-managed care plan. They recorded persistently moderate compliance among the most significant portion of the group (37 percent for four-year follow-up and 48.1 percent for one-year follow-up).

POAG: Primary open angle glaucoma; ACG: Angle-closure glaucoma; PCG: Primary congenital glaucoma; PACG: Primary angle closure glaucoma; GDA: Glaucoma decision aid.

with follow-up appointments. Therefore, the results reveal that glaucoma management is effectively practiced in Saudi Arabia, and concern should be placed more on knowledge and attitude concerning the disease and its prevalence rate in the country, particularly high rates of PCG^[34].

Some of the study's limitations include the need for epidemiological studies showcasing prevalence patterns of different glaucoma subtypes across Saudi Arabia, as most studies only provide evidence for prevalence in distinct regions. However, Al Obeidan *et al*^[11] provide a general account of POAG being the most dominant type of glaucoma, followed by primary ACG in the Middle East and Far East countries, such as Saudi Arabia, India, and China, while primary ACG is the most dominant type followed by POAG in Western countries, including Europe and North America. Another limitation is the need for comprehensive studies investigating the attitudes of Saudi Arabians toward glaucoma. This review compensates for the gap by examining how beliefs and attitudes toward a disease affect patients' compliance rates during management. Therefore, future studies should focus on better measurements of attitude towards disease as it also plays a crucial role in determining patient outcomes.

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