Int J Mol Epidemiol Genet 2023;14(1):11-18
www.ijmeg.org /ISSN:1948-1756/IJMEG0148693

Original Article

The epidemiology of strabismus and cataracts within a pediatric population in Saint Vincent and the Grenadines: an analysis of 201 consecutive cases

Gracia N Luoma-Overstreet[1], Virang Kumar[1], Kevin Lam[1], Donna D Brown[2,3], Natario L Couser[4,5,6]

[1]Virginia Commonwealth University School of Medicine, Richmond, VA, USA; [2]World Pediatric Project, Richmond, VA, USA; [3]Virginia Eye Institute, Richmond, VA, USA; [4]Department of Ophthalmology, Virginia Commonwealth University School of Medicine, Richmond, VA, USA; [5]Department of Pediatrics, Virginia Commonwealth University School of Medicine, Children's Hospital of Richmond at VCU, Richmond, VA, USA; [6]Department of Human and Molecular Genetics, Virginia Commonwealth University School of Medicine, Richmond, VA, USA

Received December 22, 2022; Accepted March 28, 2023; Epub April 15, 2023; Published April 30, 2023

Abstract: Purpose: Childhood cataracts and strabismus are among the most common causes of visual impairment in children worldwide, and prompt diagnosis and correction can significantly reduce disease burden. In certain regions, including the Eastern Caribbean, access to adequate treatment can be limited and epidemiological data scarce. This study aims to analyze the epidemiological data of pediatric strabismus and cataract cases in St. Vincent and the Grenadines. Methods: The setting of the study is a clinical practice including 201 patients between the age of 0 to 19 who received care with World Pediatric Project (WPP). Factors analyzed include patient age, sex, and type of cataract or strabismus. The findings were compared to publicly available demographic information. Results: The cases were divided into cataract (n=51), strabismus (n=134), and both strabismus and cataract (n=16). Mean ages (years) were 5.96, 5.54, and 4.50, respectively. The most frequent type of cataract and strabismus were congenital (n=25) and esotropia (n=95), respectively. The highest annual cumulative incidence was 31 and 49 cases per 100,000 people for cataracts and strabismus, respectively. Conclusion: This study provides regional epidemiological data on pediatric strabismus and cataracts. Further studies can expand the patient population by increasing collaboration with local providers. Ultimately, these findings can offer a basis for which additional epidemiological studies can be performed and help guide public health efforts to prevent visual impairment in St. Vincent and the Grenadines.

Keywords: Cataract, strabismus, pediatric blindness, St. Vincent and the Grenadines, amblyopia, epidemiology, genetics

Introduction

Pediatric blindness

Cataracts and strabismus are two of the most prevalent causes of visual impairment among pediatric ophthalmologic conditions. It is difficult to assess the incidence of childhood blindness or visual impairment worldwide with precision. One study estimates 1.4 million children under the age of 18 have blindness due to any cause, about 0.06% of the pediatric population, with 75% of these children residing in Africa or Asia [1]. An estimated 95 million people of all ages worldwide are affected by cataracts, making it one of the most common ophthalmologic conditions in all age groups [2]. In pediatric populations, cataract is a leading cause of childhood blindness, accounting for 7.4%-15.3% of pediatric blindness. Pediatric cataracts are most commonly idiopathic, but known causes include hereditary, metabolic, and infectious etiologies [3]. Children may be born with cataracts (congenital), or they may acquire lens opacification from the infancy stage to the adolescence period of life due to intrinsic factors (childhood), or cataract development may arise due to external force (traumatic). With

access to appropriate screening measures, blindness related to pediatric cataracts can be identified early and treated with surgical intervention [3]. Surgical removal of the defective lens followed by long-term visual rehabilitation management with a combination of glasses, contacts lens and/or replacement with an intraocular lens is the mainstay for the treatment of visually significant cataracts. Children identified early and treated promptly may have an excellent prognosis. Unfortunately, access to appropriate screening and treatment of pediatric cataracts is largely influenced by a country's socioeconomic status (SES), and many low-income countries are disproportionately lacking in access to the necessary screening and surgical interventions [4].

The exact underlying mechanisms for strabismus development in children is largely unknown in most cases, however, it is most likely by multifactorial means related to a combination of refractive, sensory, anatomic, and innervation abnormalities. A common sequela is amblyopia [5], which is the most common origin of monocular vision loss in children. Treatment for strabismus is aimed at reducing deficits, but many patients still have visual difficulties even after treatment [6]. Types of strabismus include esotropia, exotropia, and less commonly hypertropia and hypotropia [7]. Early interventions, which may involve patching therapy, atropine eye drops utilization, optical penalization, eyeglasses and surgical correction [8] are essential to avoid permanent visual impairment; children who are treated before age 7 often have good outcomes, but children identified and treated after this age are at significantly higher risk of having worse visual outcomes, therefore early identification is key [9]. In populations with limited access to healthcare, children are less likely to be identified and receive treatment initiation within this timeframe. Information about the global prevalence of strabismus is important to begin to reduce the burden especially in resource poor areas [10].

Objectives

Epidemiological studies related to ophthalmic conditions in St. Vincent and the Grenadines, a country with an average GDP per capita of $7,278.00 according to The World Bank (compared to $63,206.50 in the United States), are extremely limited [11]. Additionally, there is a paucity of information concerning childhood cataract and strabismus and their associated burden in low or middle-income countries. This study aims to analyze epidemiological data on strabismus and cataracts in St. Vincent and the Grenadines over an 18-year period to assess the impact of these conditions.

Materials and methods

Study population

The data was collected from 201 patients who received care through the World Pediatric Project (WPP) over an 18-year period (2002-2020) in St. Vincent and the Grenadines. Patients came from a variety of districts including St. George, Charlotte, St. Andrew, St. Patrick, and Grenadines. The project qualified for IRB exemption according to 45 CFR 46 and informed consent was waived. Research was in line with the Declaration of Helsinki as well as local and federal laws, and study design ensured compliance with HIPAA.

Data collection

Demographic data including patient age, sex, cause of cataract, and type of strabismus was documented and compared to publicly available information. Patients in the analysis were divided into cataracts (n=51, 25.4%), strabismus (n=134, 66.7%), or cataracts and strabismus together (n=16, 8.0%). Cataract cases were further divided into congenital (born with cataract), traumatic (developed after birth, before age 19 due to any type of trauma), and childhood (onset after birth, before age 19 with no identifiable source of trauma). Strabismus cases were divided into esotropia, exotropia, and other. Details regarding individual risk factors, family history, and associated conditions were unknown.

Comparison to general population

The annual cumulative incidence of cataracts and strabismus was calculated per 100,000 individuals between the age of 0 to 19 using data available from the UN World Population Prospects to calculate population size per year [12]. The cutoff of 19 years was chosen because the data provided by the UN lists population estimates in five-year ranges.

Table 1. Annual population estimates of individuals age 0-19 and number of new cases of strabismus and cataracts

Year	Population (age 0-19)	New cataract cases	New strabismus cases
2002	43000	1	0
2003	43000	2	8
2004	43000	4	15
2005	42000	2	10
2006	40000	4	5
2007	40000	1	6
2008	40000	7	13
2009	38000	1	7
2010	38000	4	7
2011	38000	3	6
2012	38000	1	6
2013	37000	3	9
2014	37000	6	6
2015	35000	1	6
2016	35000	11	17
2017	34000	9	10
2018	34000	1	4
2019	33000	3	9
2020	33000	1	6

Results

Of the 201 pediatric patients, 51 (25.4%) had cataracts only, 134 (66.7%) had strabismus only, and 16 (8.0%) had both strabismus and cataracts. The population estimates by year provided by the UN are summarized in **Table 1**, along with the cumulative incidence of cataracts and strabismus, gathered from the WPP database. There was no significant variation in average age of presentation by year for strabismus, cataracts, or both. The highest incidence of cataract and strabismus was in 2016 for both, with 31.43 and 48.57 cases per 100,000 respectively (11 and 17 total cases, respectively).

The annual cumulative incidence of cataract and strabismus per 100,000 is demonstrated in **Figure 1**. There was no significant variation by year in average age of presentation by year for strabismus, cataracts, or both. The highest incidence of cataract and strabismus was in 2016 for both, with 31.43 and 48.57 cases per 100,000 respectively (11 and 17 total cases, respectively).

Age distribution

The mean age of the patients with pediatric cataracts was 5.96, with a standard deviation of 4.07. The mean age of presentation of strabismus was 5.94, with a standard deviation of 4.47. For both presenting together the mean age was 4.50, with a standard deviation of 4.57 over the 18-year period. The most common age of presentation was 6 years for cataract and 1 year for strabismus. The distribution of the age at first presentation for each condition is represented in **Figure 2**.

Causes of cataract and subtypes of strabismus

The most common cause of cataracts among patients in the only cataract group were congenital (n=25, 49%), childhood (n=14, 27%) and traumatic (n=12, 23%) (**Figure 3**). The most common type of strabismus in patients with only strabismus was isolated esotropia (n=87, 65%; n=95 total including combined) followed by isolated exotropia (n=36, 27%). The other cases included: esotropia that progressed to exotropia after surgical correction, Brown's syndrome, hypotropia, and hypertropia (**Figure 3**).

Gender distribution

Cataract was more common in male than in female patients, with 38 males (32 cataracts alone, 6 both) and 27 females (17 cataracts alone, 10 both). Strabismus had a slight female predominance, with 67 males (61 strabismus alone, 6 both) and 79 females (69 strabismus alone, 10 both). Data on gender identification was not provided by six patients. The distribution can be seen in **Table 2**.

Discussion

Our analysis included 201 patients in Saint Vincent and the Grenadines treated by the WPP from 2002-2020. To most accurately report the information obtained by this analysis, we identified and analyzed patients with only cataract findings, only strabismus findings, and both cataract and strabismus findings.

Age at presentation

Mean age at presentation with cataracts and strabismus together was 1.5 years earlier than either condition independently. This may be

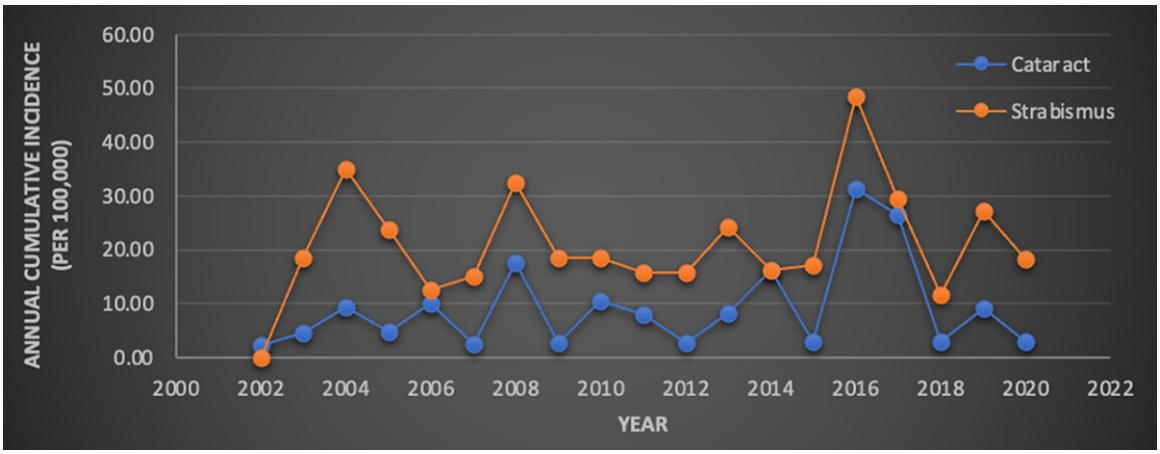

Figure 1. Annual incidence of cataract and strabismus per 100,000 individuals age 0-19 in St. Vincent and the Grenadines.

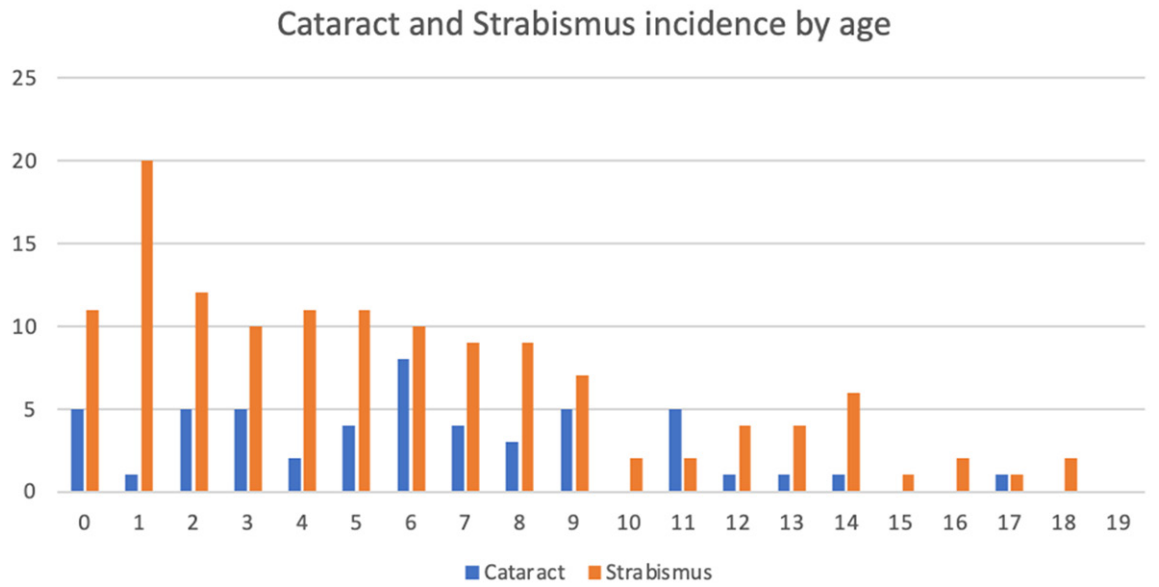

Figure 2. Distribution of age at first presentation for patients with cataract and strabismus.

attributable to an increased urgency in seeking treatment when both conditions are present. A retrospective review in Nigeria reported a median age of presentation of childhood cataract as 4 years, with the median age of initial detection at 13.5 months [13]. The age of presentation of strabismus is highly variable, though incidence peaks around three years of age [14]. A retrospective review in Minnesota reported the median age of diagnosis of all types of strabismus as 4.6, with earlier diagnosis of esotropia (3.1 years) and later diagnosis of exotropia (7.2 years) [15]. The age of presentation of these conditions varies significantly by region, and a later age of presentation may indicate that children in St. Vincent and the Grenadines may potentially suffer from visual impairments secondary to cataracts and strabismus for longer durations before a diagnosis is made and treatment may begin, when compared to pediatric populations from other studies.

Types of cataract and strabismus

Patients treated by the WPP in the St. Vincent and Grenadines were more likely to have congenital cataracts (49%) than childhood (27%) or traumatic (24%) cataracts. In patients treated

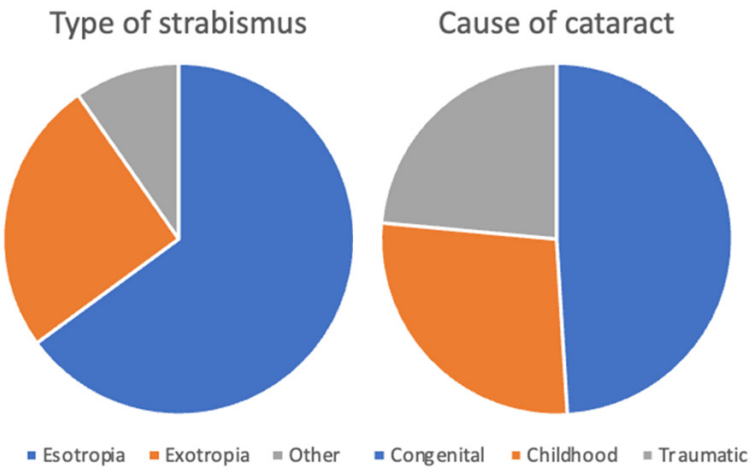

Figure 3. Proportion of different types of strabismus and different causes of cataract.

Table 2. Gender distribution of strabismus and cataract

	Strabismus	Cataract	Both
Male	61	32	6
Female	69	17	10
Unknown	4	2	0
Total	134	51	16

for strabismus, there was more than a two-fold difference in the number treated for isolated esotropia (65%) compared to isolated exotropia (27%). The frequency of esotropia and exotropia appears to vary by region, with evidence suggesting that esotropia may be more common in Western populations [15], while exotropia may be more common in Asian populations [16] across all ages.

Gender distribution

There was no significant difference in genders in either condition; there was a slight male predominance in the patients treated for cataracts (38 males:27 females) and a slight female predominance in those treated for strabismus (67 males:79 females). A study in Ethiopia suggested a statistically significant female predominance in strabismus [5]; however, previous research has indicated little or no significant difference in prevalence of childhood cataracts [13, 17] or strabismus [10, 18] between males and females. It is not possible to draw conclusions about the gender distribution of these conditions in St. Vincent and the Grenadines given the relatively small sample size.

Global incidence

In our analysis, the incidence of patients treated for cataracts ranged from 2.3 to 31.4/100,000 per year. This number excludes any children who did not present to WPP to receive treatment for their cataracts. This is higher than the results of a report on the global incidence of childhood and congenital cataracts, which estimated 1.8 to 3.6/10,000 (0.2-0.4/100,000) cases per year globally [17]. The incidence of children treated for strabismus in our analysis ranged from 0.0 to 48.6/100,000 per year. The global prevalence of strabismus has been estimated to be between 1.8% and 3.6% among pediatric patients [10, 19] though there is limited data available on the global incidence of strabismus annually, which is likely lower than the reported prevalence. Additionally, the data from WPP may underestimate the incidence of strabismus due to a lower number of patients seeking surgical/medical treatment because of its more benign symptoms and decreased need for surgical correction compared to cataracts.

Resource dependence

The density of ophthalmologists correlates closely with GDP worldwide, as demonstrated by an international group of researchers. They estimate that there are on average 3.7 ophthalmologists per million in low-income countries compared to 76.2 ophthalmologists per million in high income countries [20]. In addition to providers, availability of ophthalmic resources also varies greatly by socioeconomic status (SES), with a much greater supply of resources available in regions with higher SES [21]. This means that people living in regions with lower GDP may not have access to routine screening and may not receive prompt care for treatable ocular conditions, including cataracts and strabismus.

In addition to higher rates of undiagnosed and untreated cataracts and strabismus, many resource-limited countries have higher rates of

other pediatric conditions leading to visual impairment including vitamin A deficiency, infectious agents, and premature birth [22]. Nationally, reports indicate that the prevalence of childhood cataracts is higher in lower income countries (0.63-13.6/10,000) compared to higher income countries (0.42-2.05/10,000) [3]. There is a significantly higher incidence of vision impairment due to all causes in low-resource settings, with less access to appropriate treatment [4]. Early identification and treatment is effective in preventing or improving outcomes for many ophthalmologic conditions, and lack of primary eye care or optical services leads to unnecessary vision loss that disproportionately affects countries with lower resources [23, 24]. Cataract and strabismus can significantly impact an individual's disability-adjusted life-years (DALY) and areas with lower SES subsequently have a higher DALY caused by these conditions [25].

Genetics

Congenital cataracts, when present bilaterally, are often caused by genetic mutation, and there have been several hundred specific pathogenic variants reported to date. These variants are categorized in various databases, for example, summarized in real time on CatMap [26], a helpful tool for tracking the discovered pathogenic variants. Many of the known genetic causes are associated with an autosomal dominant inheritance, though some are autosomal recessive or X-linked. Cataracts can manifest solely due to a genetic mutation or may also be compounded by an environmental insult [27]. Additionally, cataracts can be an isolated finding or may occur as part of a syndrome, including conditions related to DNA repair defects. Systemic disease associations include: Fabry disease, Lowe syndrome, galactosemia, Nance-Horan cataract-dental syndrome, and aniridia. Finally, diseases with impaired chromosomal or DNA synthesis may cause cataract and these include: WAGRO syndrome, Cockayne Syndrome, Prader-Willi syndrome, for example [28].

The specific genetic cause of strabismus in the absence of a structural abnormality of the brain is not yet well understood. In 2002, congenital cranial dysinnervation disorders (CCDDs) were introduced, a group of syndromes related to problems in the normal development and connectivity of ocular motoneurons [29]. The associated genes implicated in CCDD include *PHOX2A, SALL1, SALL4, KIF21A, CHN1, ROBO3, TUBB3, HOXB1,* and *HOXA1*. The improper innervation of the muscles involved in extraocular movement leads to fibrosis of the target muscle and presentation of strabismus [30].

Strengths and limitations

Though the WPP was able to provide care for many patients in St. Vincent and the Grenadines, the data is limited by lack of data on patients treated outside of WPP or patients not receiving treatment, thereby affecting the generalizability of our findings. The true incidence is therefore predicted to be higher than that reported in this manuscript. Further studies can expand the database by inviting collaboration and data sharing between local providers to curate a more detailed representation of ocular findings in the region. Regardless, this analysis provides unique data on the incidence and demographics of childhood strabismus and cataracts in St. Vincent and the Grenadines.

Conclusion

There is a significantly higher incidence of visual impairment in children within regions with lower SES [4], with less access to the screening and prevention tools or to the appropriate treatment. This is especially important considering the treatability of these conditions if provided with the appropriate resources. This report provides regional epidemiological data on pediatric strabismus and cataracts, including cumulative incidence and common disease presentations.

Public health efforts aimed at reducing this disparity will help minimize the unequal burden faced by low- and middle-income countries. Understanding the rates of strabismus and cataracts in St. Vincent and the Grenadines provides a starting point for improving access to care in this country. Ultimately, these findings along with other analyses will heighten awareness and help guide public health efforts to combat preventable permanent visual impairment from strabismus and cataracts among children in St. Vincent and the Grenadines.

Disclosure of conflict of interest

None.

Address correspondence to: Dr. Natario L Couser, Department of Ophthalmology, Virginia Commonwealth University School of Medicine, Children's Hospital of Richmond at VCU, 1000 E. Broad Street, Children's Pavilion, 6th FL, Suite K, Richmond, VA 23298, USA. Tel: 804-828-9315; ORCID: 0000-0001-8713-2097; Fax: 804-628-9544; E-mail: natario.couser@vcuhealth.org

References

[1] Beare NAV and Bastawrous A. 67 - ophthalmology in the tropics and sub-tropics. In: Farrar J, Hotez PJ, Junghanss T, Kang G, Lalloo D, White NJ, editors. Manson's Tropical Infectious Diseases (Twenty-third Edition) [Internet]. London: W.B. Saunders; 2014 [cited 2022 Jun 19]. pp. 952-994, e1. Available from: https://www.sciencedirect.com/science/article/pii/B9780702051012000686.

[2] Liu YC, Wilkins M, Kim T, Malyugin B and Mehta JS. Cataracts. Lancet Lond Engl 2017; 390: 600-12.

[3] Khokhar SK, Pillay G, Dhull C, Agarwal E, Mahabir M and Aggarwal P. Pediatric cataract. Indian J Ophthalmol 2017; 65: 1340-9.

[4] Yan W, Wang W, van Wijngaarden P, Mueller A and He M. Longitudinal changes in global cataract surgery rate inequality and associations with socioeconomic indices. Clin Exp Ophthalmol 2019; 47: 453-60.

[5] Agaje BG, Delelegne D, Abera E, Desta K, Girum M, Mossie M, Eshetu D and Tadewos Hirigo A. Strabismus prevalence and associated factors among pediatric patients in southern Ethiopia: a cross-sectional study. J Int Med Res 2020; 48: 0300060520964339.

[6] Birch EE. Amblyopia and binocular vision. Prog Retin Eye Res 2013; 33: 67-84.

[7] Gunton KB, Wasserman BN and DeBenedictis C. Strabismus. Prim Care Clin Off Pract 2015; 42: 393-407.

[8] Clarke WN. Common types of strabismus. Paediatr Child Health 1999; 4: 533-5.

[9] Holmes JM, Lazar EL, Melia BM, Astle WF, Dagi LR, Donahue SP, Frazier MG, Hertle RW, Repka MX, Quinn GE and Weise KK; Pediatric Eye Disease Investigator Group. Effect of age on response to amblyopia treatment in children. Arch Ophthalmol 2011; 129: 1451-7.

[10] Hashemi H, Pakzad R, Heydarian S, Yekta A, Aghamirsalim M, Shokrollahzadeh F, Khoshhal F, Pakbin M, Ramin S and Khabazkhoob M. Global and regional prevalence of strabismus: a comprehensive systematic review and meta-analysis. Strabismus 2019; 27: 54-65.

[11] GDP per capita (current US$) - St. Vincent and the Grenadines|Data [Internet]. [cited 2022 Jun 7]. Available from: https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?locations=VC&most_recent_value_desc=false.

[12] World Population Prospects - Population Division - United Nations [Internet]. [cited 2022 Jun 18]. Available from: https://population.un.org/wpp/Download/Standard/Population/.

[13] Olusanya BA, Ugalahi MO, Adeyemo AO and Baiyeroju AM. Age at detection and age at presentation of childhood cataract at a tertiary facility in Ibadan, Southwest Nigeria. BMC Ophthalmol 2020; 20: 38.

[14] Kanukollu VM and Sood G. Strabismus. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2022 [cited 2022 Sep 13]. Available from: http://www.ncbi.nlm.nih.gov/books/NBK560782/.

[15] Mohney BG, Greenberg AE and Diehl NN. Age at strabismus diagnosis in an incidence cohort of children. Am J Ophthalmol 2007; 144: 467-9.

[16] Greenberg AE, Mohney BG, Diehl NN and Burke JP. Incidence and types of childhood esotropia: a population-based study. Ophthalmology 2007; 114: 170-4.

[17] Sheeladevi S, Lawrenson JG, Fielder AR and Suttle CM. Global prevalence of childhood cataract: a systematic review. Eye (Lond) 2016; 30: 1160-9.

[18] Qanat AS, Alsuheili A, Alzahrani AM, Faydhi AA, Albadri A and Alhibshi N. Assessment of different types of strabismus among pediatric patients in a tertiary hospital in Jeddah. Cureus 2020; 12: e11978.

[19] Ryu WY and Lambert SR. Incidence of strabismus and amblyopia among children initially diagnosed with pseudostrabismus using the optum data set. Am J Ophthalmol 2020; 211: 98-104.

[20] Resnikoff S, Lansingh VC, Washburn L, Felch W, Gauthier TM, Taylor HR, Eckert K, Parke D and Wiedemann P. Estimated number of ophthalmologists worldwide (International council of ophthalmology update): will we meet the needs? Br J Ophthalmol 2020; 104: 588-92.

[21] Yusufu M, Bukhari J, Yu X, Lin TPH, Lam DSC and Wang N. Challenges in eye care in the Asia-Pacific region. Asia Pac J Ophthalmol (Phila) 2021; 10: 423-9.

[22] Gilbert C and Foster A. Childhood blindness in the context of vision 2020--the right to sight. Bull World Health Organ 2001; 79: 227-32.

[23] Mafwiri MM, Kisenge R and Gilbert CE. A pilot study to evaluate incorporating eye care for children into reproductive and child health services in Dar-es-Salaam, Tanzania: a historical comparison study. BMC Nurs 2014; 13: 15.

[24] Rahi JS, Sripathi S, Gilbert CE and Foster A. Childhood blindness in India: causes in 1318 blind school students in nine states. Eye (Lond) 1995; 9: 545-50.

[25] Lou L, Wang J, Xu P, Ye X and Ye J. Socioeconomic disparity in global burden of cataract: an analysis for 2013 with time trends since 1990. Am J Ophthalmol 2017; 180: 91-6.
[26] Cat-Map Variant File |Cat-Map| Washington University in St. Louis [Internet]. [cited 2022 Dec 19]. Available from: https://cat-map.wustl.edu/home/cat-map-variant-file/.
[27] Shiels A and Hejtmancik JF. Mutations and mechanisms in congenital and age-related cataracts. Exp Eye Res 2017; 156: 95-102.
[28] Li J, Chen X, Yan Y and Yao K. Molecular genetics of congenital cataracts. Exp Eye Res 2020; 191: 107872.
[29] Engle EC. The genetic basis of complex strabismus. Pediatr Res 2006; 59: 343-8.
[30] Graeber CP, Hunter DG and Engle EC. The genetic basis of incomitant strabismus: consolidation of the current knowledge of the genetic foundations of disease. Semin Ophthalmol 2013; 28: 427-37.