

# Strabismus prevalence and associated factors among pediatric patients in southern Ethiopia: a cross-sectional study

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## Abstract

**Objective:** To assess the strabismus prevalence and associated factors among children aged ≤15 years.

**Methods:** This hospital-based cross-sectional study was conducted from March 2017 to October 2017 in the Department of Ophthalmology & Optometry, Hawassa University Comprehensive Specialized Hospital. Interviewer-administered questionnaires were used to collect relevant data and clinical examinations were performed for patient diagnosis.

**Results:** Overall, 582 children participated in the study (response rate, 97%). The prevalence of childhood strabismus was 17.9% [95% confidence interval: 14.6–21.1]. Additionally, 9.6%, 16.7%, and 9.6% of the children had anisometropia, amblyopia, and dense cataract, respectively. Among the 16.7% of children with amblyopia, 56.7% had strabismus; among the 22.5% of children with clinically significant refractive error, 52.7% had strabismus. Moreover, among the 9.6% of children with anisometropia, 58.9% had strabismus. The presence of amblyopia (adjusted odds ratio [95% confidence interval]: 3.9, 1.7–8.6), age <5 years (13.5 [5.0–36.1]), age 5 to 10 years

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(6.1 [2.3–16.3]), and clinically significant refractive error (13.3 [5.8–30.6]) were significantly associated with childhood strabismus.

**Conclusions:** The prevalence of strabismus was relatively high among patients in this study. Early screening for childhood strabismus is essential. A well-controlled community-based study is needed to confirm strabismus prevalence and predictors.

### Keywords

Children, strabismus, Hawassa, southern Ethiopia, amblyopia, anisometropia, refractive error, cataract

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## Introduction

Strabismus, often called “crossed eyes,” “wall-eyes,”<sup>1</sup> or “looking obliquely”<sup>2</sup> is an eye condition in which the eyes are not properly aligned with each other. This common childhood oculomotor disorder results in manifested deviation with the absence of binocular vision.<sup>3</sup> One eye can either be constantly or intermittently turned in (esotropia), out (exotropia), upwards (hypertropia), or downwards (hypotropia); it might also be rotated inwards (incyclotropia) or outwards (excyclotropia).<sup>1,4</sup> This disorder is accompanied by abnormal motility of one or both eyes, double vision, reduced vision, ocular discomfort, headaches, and/or abnormal head posture.<sup>1</sup> Although its exact cause is unknown, strabismus is often attributable to refractive, sensory (organic), anatomical (motor), or innervational causes; it may also arise secondary to other medical conditions.<sup>1,2</sup> The global prevalence of strabismus among children ranges from 0.14% to 5.65%. It has been associated with assisted delivery (forceps or cesarean section), low birth weight and prematurity, neurodevelopmental disorders,<sup>5</sup> refractive error,<sup>6</sup> anisometropia,<sup>7</sup> cranial nerve palsy,<sup>8</sup> older maternal age at the time of childbirth,<sup>9</sup> maternal cigarette smoking during pregnancy,<sup>9</sup> and a family history of strabismus.<sup>7</sup>

In children, strabismus causes impaired depth perception and amblyopia,<sup>5,6,10,11</sup> vision loss,<sup>9</sup> poor academic performance, reduced workplace achievement, esthetic dissatisfaction,<sup>11</sup> low self-esteem, delayed developmental milestones,<sup>1</sup> poor family relationships and social stigma,<sup>1,9,11</sup> and multiple lifelong surgeries or lengthy therapies.<sup>9–11</sup> Early diagnosis and appropriate treatment of strabismus in a child can restore better visual acuity and binocular single vision, reduce the development of amblyopia and subsequent occurrence of misalignment, maximize visual potential and prevent possible visual impairment, and potentially sustain long-term visual quality.<sup>5,12</sup> Although strabismus is a common ocular condition encountered in the pediatric eye clinic and an important cause of visual impairment among children, comprehensive data concerning its prevalence and associated factors have not been collected in Ethiopia.

## Methods

### *Study design, patients, and ethical approval*

This hospital-based cross-sectional study was conducted from March 2017 to October 2017 in Hawassa University Comprehensive Specialized Hospital,

Hawassa, Ethiopia. Hawassa is located 275 km south of Addis Ababa, the capital of Ethiopia. The hospital serves more than 20 million people in the region, with services that include tertiary comprehensive eye care. During this study, three ophthalmologists (one pediatric ophthalmologist and two general ophthalmologists), 10 optometrists (seven of them are at masters of science level and three are at bachelor of science level), eight ophthalmic nurses, three registered nurses, and one ophthalmic assistant provided eye care services. All children aged  $\leq 15$  years who visited the Department of Ophthalmology & Optometry during the study period were eligible for inclusion in the study. Furthermore, the sampling technique used was a consecutive sampling method to collect the data.

The study protocol was approved by the Institutional Review Board of the College of Medicine and Health Sciences, Hawassa University in October 2016. It was also approved by the Office of the Clinical and Academic Director of the Hawassa University Comprehensive Specialized Hospital. The study was performed in accordance with the World Medical Association's Declaration of Helsinki. The study protocol was fully explained to each eligible patient and their family. Written informed assent was obtained from study participants, while written informed consent was obtained from their parents/legal guardians. The confidentiality of participant data was ensured during the study.

### Data collection

Sociodemographic data and other relevant information were collected using structured questionnaires through face-to-face interviews with children and their parents or caregivers. Visual acuity was measured using Snellen chart at 6m or light fixation behaviour depending on the age of child. External ocular examinations were

performed using a penlight, 2.5 $\times$  magnifying loupe, and slit-lamp biomicroscope. Direct and indirect ophthalmoscopes were used to examine the posterior segment of the eye in a dark room by a trained optometrist. Assessments of eye alignment at 6 m and 40 cm were performed using a unilateral cover/uncover test with a distant picture fixation target and a near figure puppet, with and/or without spectacles. Moreover, any movement of the uncovered eye after occlusion of the test eye for 3 s was considered to indicate the presence of strabismus. Infants who could not fixate a target during the cover test were assessed by corneal reflex (i.e., Hirschberg test). Normal fixation was noted as central steady and maintained behavior. Furthermore, children who were tested only at one fixation distance and who did not exhibit strabismus during the distance test were considered non-strabismic. Ocular motility was assessed using a penlight to identify the presence of any incomitance. Furthermore, refractive status was determined by means of cycloplegic refraction after 30 minutes of application of two drops of 1% cyclopentolate at 5-minute intervals. The type and amount of refractive error was recorded separately for each eye.

### Definitions used in this study

- **Strabismus:** only one eye is directed at the object of interest, as detected objectively on a cover test or near/distant Hirschberg test.<sup>9</sup>
- **Unilateral amblyopia:**  $\geq 2$ -line difference in best-corrected monocular visual acuity, together with amblyogenic factors such as past or present history of strabismus, anisohyperopia of  $\geq +1.00$  diopter sphere, anisomyopia of  $\geq -3.00$  diopter sphere, or anisoastigmatism of  $\geq 1.50$  diopter cylinder; and past or present obstruction of the visual axis.<sup>13</sup>

- **Bilateral amblyopia:** best-corrected visual acuity of  $\leq 20/40$  both eyes in the presence of amblyogenic factors such as hyperopia  $\geq 4.00$  diopter sphere, myopia  $\geq 6.00$  diopter sphere, or astigmatism  $\geq 2.50$  diopter cylinder; and past or present obstruction of the visual axis.<sup>13</sup>
- **Clinically significant refractive error:** at least one of the following three refractive abnormalities: (1) hypermetropia,  $\geq +3.00$  diopter sphere in one or both eyes; (2) myopia,  $\geq -0.50$  diopter sphere in one or both eyes; and (3) astigmatism,  $\geq 1.00$  diopter cylinder in any meridian in one or both eyes.<sup>12</sup>
- **Anisometropia:** refractive status difference of  $\geq 1.00$  diopter sphere between the two eyes.<sup>12</sup>
- **Maternal smoking:** positive if the child's mother reported cigarette smoking at any time during pregnancy.<sup>12</sup>
- **Prematurity:** birth of a child before 32 weeks (approximately 8 months gestational age).<sup>7</sup>
- **Birth weight:** weight of the child at birth, where low weight was  $< 2.5$  kg.<sup>7</sup>
- **Dense cataract:** any lens opacity involving the entire cortex from the nucleus to the capsule preventing fundus visualization and resulting in an absence of red reflex on direct ophthalmoscopic evaluation in one or both eyes.<sup>14-16</sup>
- **Family history of strabismus:** at least one first- or second-degree relative had strabismus.<sup>7</sup>

### Statistical analysis

All questionnaires were visually checked and entered into EpiData Software, version 3.1 (The EpiData Association, Odense, Denmark), then exported to SPSS Statistics, version 20 (IBM Corp., Armonk, NY, USA) for statistical analysis. Variables are shown as frequencies (percentages) or means  $\pm$  standard deviations. In addition, bivariate and multivariate logistic

regression analyses were used to assess the statistical significance of differences in categorical variables among study groups. Variables with bivariate  $p < 0.2$  were included in multivariate analysis.  $p < 0.05$  was considered to indicate statistical significance.

### Data quality

Data quality was checked by questionnaire pre-tests in Adare General Hospital, located 5 km from the study site. The questionnaire was amended based on pretest feedback. All clinical examinations were performed by optometrists following consultation with the pediatric ophthalmologist and strict adherence to standard operating procedures.

## Results

### Sociodemographic characteristics

During the study period, 600 children were eligible for enrollment; of these, 18 refused to participate in the study. Of the 582 children included, 56.9% were boys and 43.1% were girls with a mean age of  $7.14 \pm 4.13$  years. The main religious affiliations of the children were orthodox, Protestant, and Muslim. More than half (66.7%) of the children's mothers were aged between 21 and 30 years (Table 1).

### Family and child characteristics

More than 90% of the children were born by vaginal delivery; additionally, 91.6% were delivered after full-term pregnancy. Approximately 62.5% of the children had normal birth weight, 99.7% had no prehistory of strabismus surgery, and 99.5% had no cranial nerve palsy. Finally, 22.5%, 9.6%, 16.7%, and 9.6% of the children had clinically significant refractive error, anisometropia, amblyopia, and dense cataract, respectively (Table 2).

**Table 1.** Demographic features of children who visited the Department of Ophthalmology & Optometry of Hawassa University Comprehensive Specialized Hospital.

Variable	Category	Frequency (%)
Sex	Male	331 (56.9)
	Female	251 (43.1)
Age	0–5 years	231 (39.7)
	6–10 years	193 (33.2)
	≥11 years	158 (27.1)
Religion	Orthodox	219 (37.6)
	Christian	
	Protestant	209 (35.9)
	Muslim	147 (25.3)
	Adventist	1 (0.2)
Maternal age at childbirth	Others*	6 (1.0)
	10–20 years	76 (13.1)
	21–30 years	388 (66.7)
	≥31 years	118 (20.3)

\*Hawariyat or Catholic.

### *Strabismus prevalence and associated factors*

The overall prevalence of childhood strabismus was 17.9% (95% confidence interval [CI]: 14.6–21.1). The prevalence of strabismus were 9.8% in children aged <5 years, 16.3% in full term-born children, and 3.6% among children with a family history of strabismus. Of 16.7% (97/582) children with amblyopia, 56.7% (55/97) had strabismus; of 22.5% (131/582) children with clinically significant refractive error, 52.7% (69/131) had strabismus; finally, of 9.6% (56/582) children with anisometropia, 58.9% (33/56) had strabismus.

Both bivariate and multivariate analyses were used to assess the associations of independent variables with the prevalence of strabismus among children. Bivariate analysis showed that female sex (crude odds ratio [95% CI]: 1.7 [1.1–2.6]), age <5 years (4.4 [2.2–8.7]), age 5 to 10 years (3.1 [1.5–6.2]), delivery by cesarean section (2.1 [1.0–4.2]), premature birth (4.1 [1.5–10.9]), family history of strabismus

(19.9 [7.8–50.7]), clinically significant refractive error (14.4 [8.7–23.6]), anisometropia (9.2 [5.1–16.6]), and amblyopia (13.5 [8.1–22.5]) were significantly associated with childhood strabismus ( $p < 0.05$  for all; Table 3).

Multivariate analysis was used to adjust for possible confounders. The results showed that age <5 years, (adjusted odds ratio [95% CI]: 13.5 [5.0–36.1]), age 5 to 10 years (6.1 [2.3–16.3]), family history of strabismus (8.1 [2.4–26.7]), clinically significant refractive error (13.3 [5.8–30.6]), and amblyopia (3.9 [1.7–8.6]) remained significantly associated with childhood strabismus ( $p < 0.05$  for all; Table 3).

### **Discussion**

This study showed that clinically significant refractive error, anisometropia, amblyopia, and dense cataract were present in considerable proportions of the study population. Many of the children with strabismus had another visual defect. Notably, this study showed that age <5 years, family history of strabismus, clinically significant refractive error, and amblyopia were significantly associated with childhood strabismus.

The current study indicated that 17.9% of the children had strabismus. Previous population-based studies have reported lower prevalences of strabismus: 1.61% in Baltimore (USA),<sup>17</sup> 1.5% in a Native-American cohort,<sup>18</sup> 1.4% in Brazil,<sup>19</sup> 2.8% in Australia,<sup>20</sup> 5.65% and 3.24% in China,<sup>21,22</sup> 0.8% in Singapore,<sup>13</sup> 0.14% and 0.20% in a multiyear study in Japan,<sup>23</sup> 1.68% in Iran,<sup>24</sup> 2.1% in the United Kingdom,<sup>8</sup> and 1.36% in Denmark.<sup>25</sup> Higher prevalences of strabismus were observed among patients in a general hospital in Cameroon (22%)<sup>14</sup> and among patients with schizophrenia in South Africa (74%).<sup>26</sup> These variations might be attributable to disparities in genetic vulnerability, environmental factors, and

**Table 2.** Family and child characteristics of children who visited the Department of Ophthalmology & Optometry of Hawassa University Comprehensive Specialized Hospital.

Variable	Category	Frequency, (%)
Mode of delivery	Vaginal	529 (90.9)
	Cesarean section	40 (6.9)
	Unknown	13 (2.2)
Gestational period	Full-term	533 (91.6)
	Premature	17 (2.9)
	Unknown	32 (5.5)
Birth weight	Normal	364 (62.5)
	Low	26 (4.5)
	Unknown	192 (33)
Prior strabismus surgery	No	580 (99.7)
	Yes	2 (0.3)
Cranial nerve palsy	No	579 (99.5)
	Yes	3 (0.5)
Maternal cigarette smoking during pregnancy	No	578 (99.4)
	Yes	2 (0.3)
	Could not recall	2 (0.3)
Family history of strabismus	No	554 (95.2)
	Yes	27 (4.6)
	Could not recall	1 (0.2)
Clinically significant refractive error	No	445 (76.5)
	Yes	131 (22.5)
	Unknown	6 (1.0)
Anisometropia	No	520 (89.3)
	Yes	56 (9.6)
	Unknown	6 (1.0)
Amblyopia	No	474 (81.4)
	Yes	97 (16.7)
	Unknown	11 (1.9)
Dense cataract	No	524 (90.0)
	Yes	56 (9.6)
	Unknown	2 (0.3)

Unknown data for refractive error, anisometropia, amblyopia, and dense cataract indicate instances in which measurement instruments were unavailable.

lifestyles among the different locations. Notably, the inclusion of referral patients might have contributed to the increased prevalence of strabismus observed in the current study.

Additionally, the present study showed that 16.7% of the children had amblyopia. This finding is comparable with the results of a study conducted in a tertiary hospital in southern Nigeria (16%)<sup>27</sup> and a study conducted in an ophthalmology clinic in a large hospital in Brazil (18.6%).<sup>28</sup> However, lower prevalences were observed in other studies: 0.82% in schoolchildren in rural southwest China,<sup>29</sup> 2.3% in a population-based cross-sectional study in Iran,<sup>30</sup> and 0.8% (in an urban area) and 0.2% (in a rural area) in schoolchildren in India.<sup>31</sup> Furthermore, of the children with amblyopia in this study, 56.7% had strabismus. In previous studies, 15% and 51.7% of Singaporean children in China<sup>13</sup> and preschool children in southern Ethiopia<sup>32</sup> had strabismic amblyopia, respectively. The variations among studies might be due to differences in parental knowledge of amblyopia, age of the participants, public education regarding the condition, and/or referral challenges encountered by the patients.

In this study, the prevalence of anisometropia was 9.6%. However, a lower prevalence of anisometropia was reported by several studies, such as 3.9% in a population-based cross-sectional study in Iran,<sup>30</sup> 2.2% in schoolchildren in Iran,<sup>33</sup> 3% among preschool children in Australia,<sup>34</sup> and 3.8% in another study of schoolchildren in Iran.<sup>35</sup> The variation might be attributable to the application of different criteria and methods for assessment of anisometropia among studies.

The present study revealed that 22.5% of the children had clinically significant refractive error. However, this prevalence was higher than the rates observed in a study of schoolchildren in India<sup>31</sup> (5.46% in an urban area and 2.63% in a rural area) and in another study of schoolchildren in India<sup>36</sup> (17.5% in an urban area and 12% in a rural area). Differences in the refractive error threshold might have led to the

**Table 3.** Factors associated with strabismus among children who visited the Department of Ophthalmology & Optometry of Hawassa University Comprehensive Specialized Hospital.

Variable	Category	Total	Strabismus		
			Yes (n [%])	COR (95% CI)	AOR (95% CI)
Age	<5 years	231	57 (9.8)	4.4 (2.2–8.7)*	13.5 (5.0–36.1)*
	5–10 years	193	36 (6.2)	3.1 (1.5–6.2)*	6.1 (2.3–16.3)*
	≥11 years	158	11 (1.9)	1.00	1.00
Sex	Male	331	48 (8.2)	1.00	1.00
	Female	151	56 (9.6)	1.7 (1.1–2.6)*	1.4 (0.76–2.5)
Mode of delivery	Vaginal	529	91 (15.6)	1.00	1.00
	Cesarean section	40	12 (2.1)	2.1 (1.0–4.2)*	0.84 (0.28–2.5)
	Unknown	13	1 (0.2)	0.40 (0.52–3.1)	2.8 (0.26–29.8)
Birth weight	Normal	364	75 (12.9)	1.00	1.00
	Low birth weight	26	11 (1.9)	0.35 (0.16–0.08)	3.3 (0.9–12.7)
	Unknown	192	18 (3.1)	0.14 (0.05–0.35)	0.8 (0.36–1.18)
Gestational period	Full term	533	95 (16.3)	1.00	1.00
	Preterm	17	8 (1.4)	4.1 (1.5–10.9)*	0.33 (0.07–1.6)
	Unknown	32	1 (0.2)	0.15 (0.02–1.1)	0.35 (0.03–4.0)
Family history of strabismus	No	555	83 (14.3)	1.00	1.00
	Yes	27	21 (3.6)	19.9 (7.8–50.7)*	8.1 (2.4–26.7)*
Clinically significant refractive error	No	445	32 (5.5)	1.00	1.00
	Yes	131	69 (11.9)	14.4 (8.7–23.6)*	13.3 (5.8–30.6)*
	Unknown	6	3 (0.5)	12.9 (2.5–66.5)*	3.1 (0.95–10.2)
Anisometropia	No	520	70 (12)	1.00	1.00
	Yes	56	33 (5.7)	9.2 (5.1–16.6)*	1.1 (0.42–2.9)
	Unknown	6	1 (0.2)	1.3 (0.15–11.2)	0.88 (0.1–6.3)
Amblyopia	No	474	42 (7.2)	1.00	1.00
	Yes	97	55 (9.5)	13.5 (8.1–22.5)*	3.9 (1.7–8.6)*
	Unknown	11	7 (1.2)	18 (5.1–64)*	18.5 (3.9–88.9)*

Unknown data for refractive error, anisometropia, and amblyopia indicate instances in which measurement instruments were unavailable. \* indicates  $p < 0.05$ .

AOR, adjusted odds ratio; CI, confidence interval; COR, Crude odds ratio.

variability in refractive error prevalence among studies.

In this study, children with clinically significant refractive errors were 13.3-fold more likely to have strabismus. This finding is consistent with the results of studies conducted in Nigeria,<sup>7</sup> Saudi Arabia,<sup>9</sup> Australia,<sup>20</sup> and Germany.<sup>37</sup> Furthermore, we found that children with amblyopia were 3.9-fold more likely to have strabismus. The finding was similar to the results of studies conducted in Australia,<sup>20</sup> Cameroon,<sup>26</sup> Korea,<sup>38</sup> and Denmark.<sup>39</sup> In addition, strabismus severity was greater

among children with amblyopia than among children without amblyopia. Although the association between amblyopia and strabismus is unclear, a child with amblyopia is presumed to use his/her non-amblyopic eye for clear vision, while the amblyopic eye is permitted to deviate and become strabismic.

In the present study, children with a family history of strabismus were 8.1-fold more likely to have strabismus, compared with children in families without a history of strabismus. Similar findings were reported in studies from southwestern

Nigeria,<sup>7</sup> southern Nigeria,<sup>27</sup> Saudi Arabia,<sup>9</sup> and Baltimore (USA),<sup>11</sup> as well as in a twin study conducted by Sanfilippo et al.<sup>40</sup> These findings imply that strabismus can be inherited from a child's parents.

Notably, a cross-sectional study conducted by Hashemi et al.<sup>41</sup> indicated no association between age and strabismus. Conversely, the current study indicated a significant association between age and strabismus, especially among children aged  $\leq 10$  years. The discrepancy may be due to the different number of patients (sample size) between the studies; specifically,  $>6$ -fold more children participated in the study by Hashemi et al.

This study had some limitations. First, the study population comprised children who visited the Department of Ophthalmology & Optometry for ophthalmic care; this might have led to greater prevalence of strabismus, compared with previous community-based studies. Second, our study was cross-sectional in nature and thus could not conclusively demonstrate a relationship between strabismus and potential causative factors. Third, this study used a non-probability sampling method (i.e., a consecutive sampling approach) for the enrollment of study participants; therefore, it might have been influenced by the presence of outliers. Despite these limitations, this study provided important evidence regarding childhood strabismus in Ethiopia.

## Conclusion

The findings of this study indicated a relatively high prevalence of strabismus among children who visited the Department of Ophthalmology & Optometry for ophthalmic care. The presence of amblyopia, clinically significant refractive error, age and family history of strabismus were factors significantly associated with childhood strabismus. Therefore, early screening for

childhood strabismus is essential. A well-controlled community-based study is needed to confirm strabismus prevalence and predictors.

## Availability of data and materials

The dataset of this article is not openly available. However, it can be accessed upon reasonable request to the corresponding author and subsequent authorization from the Office of the Clinical and Academic Director of the Hawassa University Comprehensive Specialized Hospital.

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## Authors' contributions

BG and DD conceived the project and designed the study, BG, DD, EA, KD, MG, MM, and DE performed the experiments and analyzed the data. BG and ATH wrote the paper. ATH critically reviewed the manuscript. All authors read and approved the manuscript.

## Declaration of conflicting interest

The authors declare that there is no conflict of interest.

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