Prevalence and profile of astigmatism in individuals availing ophthalmic services at Central Regional Referral Hospital, Gelephu, Bhutan: A cross-sectional, hospital-based study

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ABSTRACT

Introduction: Astigmatism has been defined as a type of refractive error when parallel rays of light entering the eye are not focused at one point of the retina when accommodation is at rest due to irregular curvature of the cornea or lens surface. All-age data on the prevalence and types of astigmatism is not available in Bhutan. This study was carried out to determine the prevalence and determinants of astigmatism in the Central Regional Referral Hospital (CRRH) of Bhutan. **Methods:** This was a cross-sectional study done between November 2021 and August 2022 in CRRH with 302 participants. Routine visual acuity testing and refraction were done for all the individuals availing ophthalmic services and type of astigmatism was diagnosed. **Results:** The overall prevalence of astigmatism in individuals availing ophthalmic services at CRRH was found to be 4.18% and the most common types of astigmatism were compound myopic, with-the-rule (WTR) and mild astigmatism. **Conclusion:** Prevalence of astigmatism was found to be low in individuals availing ophthalmic services at CRRH. The most common types of astigmatism were compound myopic, WTR and mild astigmatism.

Keywords: *Astigmatism; Bhutan; Prevalence; Refractive error*

INTRODUCTION

Bhutan, a landlocked nation with about 800,000 people, is known for its high mountain ranges in the southern Himalayas. Gelephu, located in Sarpang District, with a population of 48,776, is home to the Central Regional Referral Hospital (CRRH)[1]. CRRH caters medical services to central Bhutan including Sarpang, Bumthang, Trongsa, Dagana, Zhemgang and Tsirang districts. The Ophthalmology Department in CRRH serves as the referral center for these areas, offering eye care to over 132,950 individuals in the region[1]. The hospital's ophthalmology department is equipped to handle a wide range of eye conditions and offers services such as routine eye examinations, cataract surgeries, and treatment for glaucoma and other ocular diseases.

Astigmatism is a type of refractive error, derived from a Greek word, which has two components; "a" means absence, and "stigma" means a point. It is a refractive error (ametropia) that occurs when parallel rays of light entering the eye, when the accommodation is at rest, are not focused at one point on the retina due to irregular curvature of the cornea or of the lens surface[2]. Astigmatism commonly occurs with other forms of refractive errors and is corrected by a cylindrical lens in a pre-

determined axis. Astigmatism can be categorized according to the positioning of focal points/median, axis orientation, and magnitude.

In 2020, approximately 2.2 billion people worldwide lived with visual impairment, amongst which at least one billion cases could have been prevented[3]. Globally, Uncorrected Refractive Error (URE) is the leading cause of moderate to severe visual impairment[4]. Evidence suggests that South Asia has the largest number of people with URE, and astigmatism is more prevalent in Asian populations than other refractive errors[5,6]. The Bhutan School Sight Survey (BSSP) conducted in 2019 found that URE was main cause of visual impairment in children, with astigmatism being the most prevalent (9.75%)[7].

Astigmatism during infancy disrupts emmetropia and is associated with an increased risk of amblyopia[8-10]. Early identification and treatment of astigmatism in children is crucial to avoid defects in their vision development and also pivotal for timely remedial interventions[11]. It is associated with headaches of unknown origin and concomitant strabismus[12-14]. If left uncorrected, this can lead to social and economic consequences for both the patients and their families[15-17]. Understanding the prevalence and determinants of astigmatism is necessary to address this major cause of visual impairment.

All-age data on the prevalence and types of astigmatism is not available in Bhutan. While Bhutan considers providing

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free spectacles to its population, there is no evidence on the types of spectacles required. This study was expected to generate data on prevalence and types of astigmatism, and its association with demographic profile. This study will help us plan for larger population-based studies on astigmatism in the country.

METHODS

This was a cross-sectional study conducted in the ophthalmology department at the CRRH in Gelephu. It received ethical approval from the Research Ethics Board of Health of Bhutan (REBH/Approval/2021/118, protocol ID: PO2021118, dated: 22/11/2021). Site and administrative clearances were also granted by CRRH and the Policy and Planning Division, respectively.

Inclusion criteria included all individuals aged ≥ 6 years availing ophthalmic services and diagnosed with astigmatism. Individuals < 6 years of age, those with a history of corneal injuries, history of any intraocular surgeries, and history of pterygium surgery were excluded from the study. Written informed consent was obtained from all the participants and for participants aged less than 18 years, verbal assent was taken from their parent or guardian.

All patients underwent ocular examination which included uncorrected distance visual acuity assessment using a Snellen chart (Tumbling E), refraction with a streak retinoscopy (Welch Allen) performed by an optometrist to evaluate the amount of astigmatism, and fundus examination performed by an ophthalmologist. Jackson's cross-cylinder was used to determine the final astigmatic error. Cycloplegic refraction using cyclopentolate/tropicamide eye drops was done for children. All patients diagnosed with astigmatism after this assessment were potential participants for the study and were enrolled after informed written consent. Once enrolled, further data regarding their demographics were gathered using structured pro-forma. All data from the examination were noted on this pro-forma.

For the purpose of uniformity, astigmatism was defined as cylindrical refractive error measured after refraction or cycloplegic refraction expressed in correcting plus or minus cylinder form. It was further classified into different types based on meridians, axis and magnitude as described in Box 1.

The data from the structured pro-forma was extracted, double-entered to ensure the accuracy and quality of data, and validated using Epidata Version 4.6. Data analysis was done using STATA/SE, version 14.1. The correlation of different types of astigmatism between the two eyes were tested using the Pearson correlation coefficient and categorical data were analyzed with Chi-Squared test with Cramer's V (types of astigmatism against age group, gender, region, occupation, and education level) with the confidence level kept at 95%. A p-value of less than 0.05 indicated a statistically significant association.

RESULTS
Characteristics of study participants
Of the 302 participants with astigmatism, 175 (57.9%) were females. The mean age was 30.59 ± 18.9 years (range 6-94 years).

Box 1. Diagnostic criteria for astigmatism

A] Based on positions of focal points/meridional[2]

- *Simple myopic astigmatism:* If one focal point lies in front of the retina and the other on the retina e.g. Plano/-0.75x160.

- *Compound myopic astigmatism:* If both focal points lie in front of the retina e.g. -1.00/-1.00x150.

- *Simple hyperopic astigmatism:* If one focal point lies behind the retina and the other on the retina e.g. Plano/+1.00x70.

- *Compound hyperopic astigmatism:* If both focal points lie behind the retina e.g. +1.25/+1.50x80.

- *Mixed astigmatism:* If one focal point lies in front of the retina and the other behind the retina e.g. -0.50/+1.50x120.

B] Based on axis[11,25]

- *With the rule astigmatism (WTR):* If the axis of the cylinder falls within 180°±15°

- *Against the rule astigmatism (ATR):* If the axis of the cylinder falls within 90°±15°.

- *Oblique astigmatism:* If the axis of the cylinder falls other than 180°±15° and 90°±15°.

C] Based on magnitude[23]

- *Mild astigmatism:* If the cylinder falls <1.50D(0.25-1.25)

- *Moderate astigmatism:* If cylinder falls between 1.50D-2.50D

- *High / significant astigmatism:* If cylinder is more than 2.50D

Table 1 shows that those in the age group of 16-25 years had the highest proportion (28.8%) of astigmatism followed by those in the age group of 6-15 years (22.5%). The majority of participants were students (41.9%) followed by those with elementary occupations (15.3%), which included manual workers, labourers, and cleaners.

Prevalence and types of astigmatism
The overall prevalence of astigmatism in the individuals availing ophthalmic services at CRRH was found to be 4.18%. The total number of ophthalmic patients who availed the service during that period was used as the denominator to find the prevalence. Table 2 shows the breakdown of different types of astigmatism amongst males and females. Compound myopic astigmatism (146 in the right eye and 139 in the left eye) was most common followed by simple myopic astigmatism (91 in the right eye and 96 in the left eye) with regards to meridional astigmatism. The most prevalent axis astigmatism was with-the-rule astigmatism (161

Table 1. Demographic profile of individuals availing ophthalmic services at CRRH, Sarpang (N=302)

Categories	n (%)
Age group, years	
6-15	68 (22.5)
16-25	87 (28.8)
26-35	43 (14.3)
36-45	39 (12.9)
46-55	23 (7.6)
56-65	25 (8.3)
66+	17 (5.6)
Sex	
Male	127(42.1)
Female	175(57.9)
Occupation	
Managers	2(0.7)
Professionals	20(6.6)
Associate professionals & technicians	6(2.0)
Clerical support workers	3(1.0)
Services & sales workers	11(3.7)
Skilled agricultural, forestry & fishery workers	36(11.6)
Craft related trade workers	4(1.3)
Plant & machine operators and machine workers	4(1.3)
Elementary occupation	46(15.3)
Armed forces	9(3.0)
Students	126(41.9)
Religious (Monk/nun)	6(2.0)
Unemployed	29(9.6)
Region	
West	5(1.7)
Central	289(95.7)
East	8(2.6)
Education	
No education	80 (26.5)
*Primary school	42 (13.9)
†Lower-Middle secondary school	86 (28.5)
$Higher secondary school	51 (16.9)
Diploma/certificate	9 (3.0)
Bachelor's degree & above	34 (11.2)

Primary school – includes Pre-Primary-Class VI; †Lower-Middle secondary school – includes Class VII-X; $Higher secondary school – includes Class XI-XII

in the right eye and 153 in the left eye) while the least common axis astigmatism was oblique (12 in the right eye and 15 in the left eye). Amongst both children and adults, mild astigmatism was the most prevalent in both right and left eyes, as depicted in Table 3.

Monocular visual acuity characteristics
The majority of participants (90.73%) had uncorrected visual acuity between 6/12 and 6/60, as shown in Figure 1. However, 95.37% of them had their visual acuity corrected by just having a refraction and being prescribed glasses. Mean cylindrical powers for right and left eye were -1.16 ± 1.08 D and -1.13 ± 1.04 D respectively.
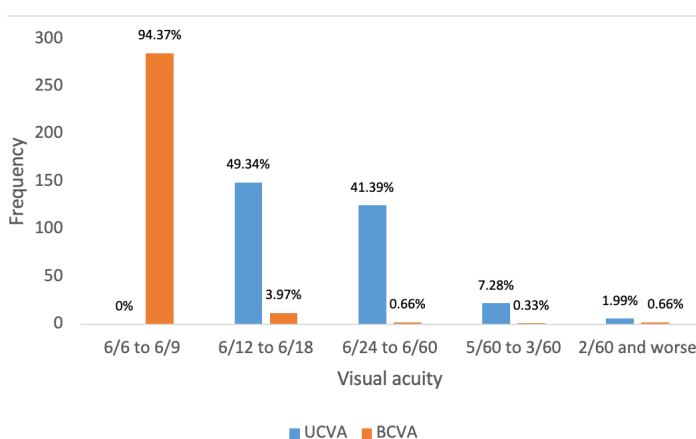

Figure 1. Uncorrected and best corrected visual acuity of the individuals availing ophthalmic services at CRRH; UCVA-uncorrected visual acuity, BCVA-best corrected visual acuity

Association between types of astigmatism with demographic profile
A Pearson's Chi-squared test with Cramér's V was conducted to evaluate the association between various types of astigmatism and demographic variables, including gender, age group, region, education level, and occupation. No significant associations were found between the types of astigmatism (classified by meridional orientation, axis, and magnitude for both the right and left eyes) and either gender or region. However, an association was observed between different types of astigmatism with both age group and education level ($p < 0.05$), with the exception of magnitude astigmatism, where no socio-demographic characteristics were significantly associated. Axis astigmatism exhibited an association with occupation ($p < 0.05$), while other forms of astigmatism did not show any significant relationship with occupation (Tables 4 and 5).

Table 2. Distribution of gender and types of astigmatism in individuals availing ophthalmic services at CRRH, Sarpang (N=302)

Types of astigmatism		Right eye optics		Left eye optics	
		Male	Female	Male	Female
		n (%)	n (%)	n (%)	n (%)
Based on positions of focal points	Simple myopic astigmatism	38 (41.8)	53 (58.2)	39 (40.6)	57 (59.4)
	Simple hyperopic astigmatism	3 (75.0)	1 (25.0)	3 (60.0)	2 (40.0)
	Compound myopic astigmatism	57 (39.0)	89 (61.0)	54 (38.8)	85 (61.2)
	Compound hyperopic astigmatism	1 (100)	0 (0.0)	1 (100)	0 (0.0)
	Mixed astigmatism	24 (50.0)	24 (50.0)	22 (48.9)	23 (51.1)
	$Not applicable	4 (33.3)	8 (66.7)	8 (50.0)	8 (50.0)
Based on axis	*WTR	71 (44.1)	90 (55.5)	64 (41.8)	89 (58.2)
	†ATR	50 (42.7)	67 (57.3)	50 (42.4)	68 (57.6)
	Oblique	2 (16.7)	10 (83.3)	5 (33.3)	10 (66.7)
	$Not applicable	4 (33.3)	8 (66.7)	8 (50.0)	8 (50.0)
Based on magnitude	Mild	81 (39.3)	125 (60.7)	82 (40.4)	121 (59.6)
	Moderate	33 (52.4)	30 (47.6)	28 (47.5)	31 (52.5)
	High	9 (42.9)	12 (57.1)	9 (37.5)	15 (62.5)
	$Not applicable	4 (33.3)	8 (66.7)	8 (50.0)	8 (50.0)

WTR-with-the-rule astigmatism; †ATR-against-the-rule astigmatism; $ Not applicable-the participant had astigmatism in only one eye

Table 3. Proportion of magnitude of astigmatism in children and adults availing ophthalmic services at CRRH, Sarpang (N=302)

Magnitude	Right eye optics		Left eye optics	
	Male	Female	Male	Female
	n (%)	n (%)	n (%)	n (%)
Mild				
Children (6 -17 years)	27 (45.8)	32 (54.2)	29 (47.5)	32 (52.5)
Adults (18+ years)	54 (36.7)	93 (63.3)	53 (37.3)	89 (62.7)
Moderate				
Children (6-17 years)	13 (68.4)	6 (31.6)	10 (66.7)	5 (33.3)
Adults (18+ years)	20 (45.5)	24 (54.5)	18 (40.9)	26 (59.1)
High				
Children (6-17 years)	6 (50.0)	6 (50.0)	5 (45.5)	6 (54.5)
Adults (18+ years)	3 (33.3)	6 (66.7)	4 (30.8)	9 (69.2)
*Not applicable				
Children (6-17 years)	1 (33.3)	2 (66.7)	3 (50.0)	3 (50.0)
Adults (18+ years)	3 (33.3)	6 (66.7)	5 (50.0)	5 (50.0)

Not applicable because these participants had astigmatism in only one eye

Table 4: Chi-square test of association between socio-demographic characteristics and types of astigmatism (based on positions of focal points) for right and left eye optics

Socio-demographic characteristics (n=290)+	Right eye optics					Left eye optics					Statistical values		
	Simple Myopic	Simple Hyperopic	Compound Myopic	Compound Hyperopic	Mixed	Simple Myopic	Simple Hyperopic	Compound Myopic	Compound Hyperopic	Mixed	χ^2	Cramér's V	p-value
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	1st row statistical values for right eye & 2nd row for left eye		
Sex													
Male	38 (41.8)	3 (75.0)	57 (39.0)	1 (100)	24 (50.0)	39 (40.6)	3 (60.0)	54 (38.8)	1 (100)	22 (48.9)	4.924	0.13	0.295
Female	53 (58.2)	1 (25.0)	89 (61.0)	0 (0.0)	24 (50.0)	57 (59.4)	2 (40.0)	85 (61.2)	0 (0.0)	23 (51.1)	3.555	0.112	0.47
Age-group													
6-15	24 (26.4)	1 (25.0)	26 (17.8)	0 (0.0)	14 (29.2)	25 (26.0)	2 (40.0)	24 (17.3)	0 (0.0)	13 (28.9)			
16-25	24 (26.4)	0 (0.0)	52 (35.6)	0 (0.0)	9 (18.8)	24 (25.0)	0 (0.0)	52 (37.4)	0 (0.0)	8 (17.8)	73.726	0.252	p<0.001
26-35	11 (12.1)	0 (0.0)	29 (19.9)	0 (0.0)	3 (6.2)	10 (10.4)	0 (0.0)	27 (19.4)	0 (0.0)	3 (6.7)			
36-45	17(18.6)	0 (0.0)	20 (13.7)	0 (0.0)	1 (2.1)	20 (20.8)	0 (0.0)	19 (13.7)	0 (0.0)	0 (0.0)	74.493	0.256	p<0.001
46-55	6 (6.6)	0 (0.0)	10 (6.8)	0 (0.0)	6 (12.5)	7 (7.3)	0 (0.0)	9 (6.5)	0 (0.0)	6 (13.3)			
56-65	6 (6.6)	2 (50.0)	2 (1.4)	1 (100)	12 (25.0)	7 (7.3)	2 (40.0)	2 (1.4)	1 (100)	10 (22.2)			
66+	3 (3.3)	1 (25.0)	7 (4.8)	0 (0.0)	3 (6.2)	3 (3.1)	1 (20.0)	6 (4.3)	0 (0.0)	5 (11.1)			
Education													
No education	29 (31.8)	3 (75.0)	28 (19.2)	1 (100)	15 (31.3)	30 (31.2)	3 (60.0)	26 (18.7)	1 (100)	16 (35.6)			
Primary	16 (17.6)	0 (0.0)	15 (10.3)	0 (0.0)	11 (22.9)	18 (18.8)	0 (0.0)	14 (10.1)	0 (0.0)	8 (17.8)	47.654	0.203	p<0.001
Lower-Middle secondary	25 (27.5)	0 (0.0)	39 (26.7)	0 (0.0)	17 (35.4)	26 (27.1)	1 (20.0)	38 (27.3)	0 (0.0)	15 (33.3)			
Higher secondary	13 (14.3)	0 (0.0)	32 (21.9)	0 (0.0)	5 (10.4)	14 (14.6)	0 (0.0)	32 (23.0)	0 (0.0)	5 (11.1)			
Diploma/certificate	3 (3.3)	1 (25.0)	4 (2.7)	0 (0.0)	0 (0.0)	3 (3.1)	1 (20.0)	4 (2.9)	0 (0.0)	0 (0.0)	39.392	0.186	p<0.01
Bachelor's degree & above	5 (5.5)	0 (0.0)	28 (19.2)	0 (0.0)	0 (0.0)	5 (5.2)	0 (0.0)	25 (18.0)	0 (0.0)	1 (2.2)			
Occupation													
Managers	0 (0.0)	0 (0.0)	1 (0.7)	0 (0.0)	0 (0.0)	1 (1.0)	0 (0.0)	1 (0.7)	0 (0.0)	0 (0.0)	50.822	0.210	0.363
Professionals	4 (4.4)	0 (0.0)	15 (10.3)	0 (0.0)	1 (2.1)	4 (4.2)	0 (0.0)	14 (10.1)	0 (0.0)	1 (2.2)			
Ass. Prof. & technicians	2 (2.2)	0 (0.0)	3 (2.1)	0 (0.0)	0 (0.0)	3 (3.1)	0 (0.0)	3 (2.2)	0 (0.0)	0 (0.0)			
Clerical support workers	1 (1.1)	0 (0.0)	1 (0.7)	0 (0.0)	1 (2.1)	1 (1.0)	0 (0.0)	1 (0.7)	0 (0.0)	1 (2.2)			
Services & sales workers	1 (1.1)	0 (0.0)	7 (4.8)	0 (0.0)	3 (6.3)	1 (1.0)	0 (0.0)	7 (5.2)	0 (0.0)	2 (4.4)			
Skilled agri., forestry & fishery	10 (11.0)	1 (25.0)	11 (7.6)	1 (100)	10 (20.8)	12 (12.5)	1 (20.0)	9 (6.5)	1 (100)	10 (22.2)			

Craft related trade workers	1 (1.1)	0 (0.0)	2 (1.4)	0 (0.0)	1 (2.1)	2 (2.1)	0 (0.0)	1 (0.7)	0 (0.0)	1 (2.2)		
Plant & machine operators	2 (2.2)	0 (0.0)	1 (0.7)	0 (0.0)	1 (2.1)	2 (2.1)	0 (0.0)	1 (0.7)	0 (0.0)	1 (2.2)		
Elementary occupation	15 (16.5)	1 (25.0)	23 (15.9)	0 (0.0)	5 (10.4)	14 (14.6)	1 (20.0)	23 (16.7)	0 (0.0)	5 (11.1)	44.877	0.198	0.602
Armed forces	1 (1.1)	0 (0.0)	8 (5.5)	0 (0.0)	0 (0.0)	1 (1.0)	0 (0.0)	7 (5.1)	0 (0.0)	0 (0.0)		
Students	45 (49.4)	0 (0.0)	56 (38.6)	0 (0.0)	21 (43.7)	45 (46.9)	1 (20.0)	54 (39.1)	0 (0.0)	20 (44.4)		
Monks/ Nuns	3 (3.3)	1 (25.0)	1 (0.7)	0 (0.0)	1 (2.1)	2 (2.1)	1 (20.0)	2 (1.4)	0 (0.0)	1 (2.2)		
Unemployed	6 (6.6)	1 (25.0)	16 (11.0)	0 (0.0)	4 (8.3)	8 (8.4)	1 (20.0)	15 (10.9)	0 (0.0)	3 (6.7)		

[+]12 cases of 'Not applicable' observations were omitted from the test.

Table 5: Chi-square test of association between socio-demographic characteristics and types of astigmatism (based on Axis) for right and left eye optics

Socio-demographic characteristics (n=290)+	Right eye axis			Left eye axis			Statistical values		
	With the rule astigmatism	Against the rule astigmatism	Oblique astigmatism	With the rule astigmatism	Against the rule astigmatism	Oblique astigmatism	χ^2	Cramér's V	p-value
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	1st row statistical values for (Right Eye) & 2nd row for (Left Eye)		
Sex									
Male	71 (44.1)	50 (42.7)	2 (16.7)	64 (41.8)	50 (42.4)	5 (33.3)	3.449	0.109	0.178
Female	90 (55.9)	67 (57.3)	10 (83.3)	89 (58.2)	68 (57.6)	10 (66.7)	0.454	0.039	0.797
Age-group									
6-15	50 (31.1)	13 (11.1)	2 (16.7)	48 (31.4)	14 (11.8)	2 (13.3)			
16-25	60 (37.3)	20 (17.1)	5 (41.8)	60 (39.2)	20 (16.9)	4 (26.7)	50.071	0.294	p<0.001
26-35	21 (13.0)	21 (17.9)	1 (8.3)	20 (13.1)	18 (15.3)	2 (13.3)			
36-45	13 (8.1)	24 (20.5)	1 (8.3)	13 (8.5)	23 (19.5)	3 (20.0)			
46-55	6 (3.7)	15 (12.8)	1 (8.3)	5 (3.3)	16 (13.6)	1 (6.7)			
56-65	6 (3.7)	16 (13.7)	1 (8.3)	4 (2.6)	16 (13.6)	2 (13.3)	56.969	0.316	p<0.001
66+	5 (3.1)	8 (6.9)	1 (8.3)	3 (1.9)	11 (9.3)	1 (6.7)			
Education									
No education	21 (13.0)	51 (43.6)	4 (33.3)	19 (12.4)	51 (43.2)	6 (40.0)			
Primary	30 (18.6)	11 (9.4)	1 (8.3)	27 (17.7)	11 (9.3)	2 (13.3)			
Lower-Middle secondary	55 (34.2)	22 (18.8)	4 (33.3)	53 (34.6)	24 (20.3)	3 (20.0)	43.001	0.272	p<0.001
Higher secondary	36 (22.4)	12 (10.3)	2 (16.7)	36 (23.5)	12 (10.2)	3 (20.0)			
Diploma/certificate	3 (1.9)	5 (4.3)	0 (0.0)	3 (2.0)	5 (4.2)	0 (0.0)			
Bachelor's degree & above	16 (9.9)	16 (13.7)	1 (8.3)	15 (9.8)	15 (12.7)	1 (6.7)	42.558	0.273	p<0.001
Occupation									
Managers	0 (0.0)	1 (0.9)	0 (0.0)	1 (0.7)	1 (0.9)	0 (0.0)			
Professionals	11 (6.9)	9 (7.7)	0 (0.0)	11 (7.2)	8 (6.8)	0 (0.0)			
Ass. Prof. & technicians	1 (0.6)	4 (3.4)	0 (0.0)	1 (0.7)	5 (4.2)	0 (0.0)			

Clerical support workers	1 (0.6)	2 (1.7)	0 (0.0)	1 (0.7)	2 (1.7)	0 (0.0)	72.755	0.355	p<0.001
Services & sales workers	7 (4.4)	3 (2.6)	1 (8.3)	5 (3.3)	3 (2.5)	2 (13.3)			
Skilled agri., forestry & fishery	10 (6.3)	19 (16.2)	4 (33.3)	11 (7.2)	18 (15.3)	4 (26.7)			
Craft related trade workers	2 (1.2)	2 (1.7)	0 (0.0)	2 (1.3)	2 (1.7)	0 (0.0)	74.596	0.362	p<0.001
Plant & machine operators	0 (0.0)	4 (3.4)	0 (0.0)	0 (0.0)	4 (3.4)	0 (0.0)			
Elementary occupation	20 (12.5)	24 (20.5)	0 (0.0)	18 (11.8)	23 (19.5)	2 (13.3)			
Armed forces	5 (3.1)	4 (3.4)	0 (0.0)	3 (2.0)	4 (3.4)	1 (6.7)			
Students	95 (59.4)	21 (17.9)	6 (50.0)	92 (60.5)	22 (18.6)	6 (40.0)			
Monks/Nuns	1 (0.6)	5 (4.3)	0 (0.0)	1 (0.7)	5 (4.2)	0 (0.0)			
Unemployed	7 (4.4)	19 (16.3)	1 (8.3)	6 (3.9)	21 (17.8)	0 (0.0)			

[+]12 cases of 'Not applicable' observations were omitted from the test.

DISCUSSION

Refractive errors are the most common ocular problem affecting all age groups. Globally, among the types of refractive errors, astigmatism was the most common refractive error both in children and adults[15]. This is the first study to evaluate the prevalence and types of astigmatism and its association with the demographic profiles of individuals availing ophthalmic services at CRRH, Gelephu, Bhutan. Most of the astigmatic errors were within -1.50D. It was more common in adults which correlates with a meta-analysis done in 2017[15]. The study found that the overall prevalence of astigmatism was 4.18% which is lower than the prevalence of astigmatism (9.75%) in Bhutan projected by the BSSS 2019 study[7]. The lower prevalence in this study may be due to the fact that the study period coincided with the period soon after the national lockdown due to the COVID-19 pandemic. In this period, the number of patients visiting the hospital was lower than usual times.

The global estimated pool prevalence (EPP) of astigmatism in children and adults in Southeast Asia is 9.8% and 44.8% as of 2017[15]. Contrary to these findings, our study revealed a prevalence rate of 7.56% for children and 3.49% for adults. A potential reason for this difference could be due to the variation in sample size, genetic differences between the study populations and differences in examination techniques, wherein cycloplegics were not used for refraction[11]. The higher rate among children is concerning because uncorrected astigmatism during childhood can impact normal visual development and result in amblyopia. Moreover, astigmatism in children has been linked to abnormal binocular vision, such as strabismus, and the earlier onset of myopia[13]. These children may also experience headaches and symptoms of eye strain (asthenopia).

There is mixed data on the gender involvement of astigmatism based on age. Studies amongst children, like one conducted in Tunisia, have reported girls being affected more than boys[18]. Amongst adults, studies in Singapore and North India have reported that males are affected more than females[6,19]. Our study found that astigmatism was more prevalent in women than in men. This may be because we included participants of a wide age range [6 – 94 years]. A potential reason why females tend to have more axis astigmatism than males may be because of the larger degrees of upward palpebral fissure slant[20].

Our study did not note significant associations between the types of astigmatism (classified by the position of focal points, axis, and magnitude for both the right and left eyes) and gender. A significant association (p<0.001) was noted between astigmatism and age groups, wherein children were affected more. This is likely because children have steeper corneas, which flatten as they grow older[21]. A significant association was also noted between astigmatism and higher education levels. This is likely due to the requirement of more frequent close reading and greater use of electronics amongst those with higher educational qualifications. Similarly, a significant association (p<0.001) was also noted between astigmatism (defined via axis) and students, who would require more frequent close reading.

Limitations

This study was a single hospital-based study. Thus, the prevalence findings cannot be generalized to the Bhutanese population. The study period coincided with the period soon after the COVID lockdown lifting, resulting in a smaller sample size.

CONCLUSION

The prevalence of astigmatism in individuals availing ophthalmic services at CRRH was 4.18%. The majority of astigmatism was WTR, compound myopic and mild astigmatism. Further studies are needed to investigate the national prevalence of astigmatism, its types and its association with demographic profile in children as well as adults.

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AUTHORS CONTRIBUTION

SC formulated the concept, collected data, wrote up, edited and reviewed the manuscript.

TJ formulated the concept, wrote up, edited and reviewed the manuscript.

IPS formulated the concept, wrote up, edited and reviewed the manuscript.

Authors agree to be accountable for all respects of the work in ensuring that questions related to the accuracy and integrity of any part of the work are appropriately investigated and resolved.