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A study on refractive error in patients of Chennai city in India, using multinomial logistic regression

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Abstract
A large number of patients in Chennai city are affected by refractive error. Among the many types of refractive errors, the most common types are myopia, hyperopia, astigmatism and Presbyopia. The variables in the study are refractive error in both left and right eye, age and gender. An attempt has been made to find out the factors responsible for refractive error of patients in Chennai city using multinomial logistic regression.

Keywords: Multinomial logistic regression, refractive error

1. Introduction
Chennai is the capital of the Indian state of Tamil Nadu. Chennai is the largest commercial and industrial center of South India as well as a cultural, economic and educational center. Chennai's 2017 population is estimated at 1,04,35,000.

The eye is an organ that detects light and sends signals along the optic nerve to the brain. In humans, the eye is a valuable sense organ that gives us the ability to see. It allows for light perception and vision, including the ability to differentiate between colors and depth. Although small in size, the eye is a very complex organ. The eye is approximately 1 inch wide, 1 inch deep and 0.9 inches tall. The human eye has a 200-degree viewing angle and can see 10 million colors and shades.

Eyes are very important for the human body. The brain processes the raw data from the eyes to make sense of what one see's around him/her compared to one's knowledge of the world around him/her. The brain interprets what it receives from the eyes. Without our eyes and the complex processing of visual information by our brains, we would neither be able to make sense of writing, art or photos, nor understand as much as we do from limited visual information.

The eye allows us to see and interpret the shapes, colors, and dimensions of objects in the world by processing the light they reflect or emit. The eye is able to detect bright light or dim light, but it cannot sense an object when light is absent.

Cycloplegia inhibits the accommodative power of the eye by blocking the action of the ciliary muscle, allowing the static or objective refractive error of the eye to be measured. The best way to obtain paralysis of accommodation is to use Cycloplegic drugs like CTC, HA+T, ROP, T and T+. Cycloplegic drugs are called anticholinergic because they block the muscarinic action of acetylcholine. This action inhibits cholinergic stimulation of the iris sphincter and ciliary muscle, which results in Cycloplegia.

Sensory evaluation is a special ophthalmologic procedure that may be performed in addition to the complete eye examination. Sensory evaluation will control the eye movement of 6 extra ocular muscles. The evaluation will result in fusion, diplopia, suppressions (left, right and alternate), etc., and the methods used for sensory evaluation are Randot, Titmus fly, etc.

Keratometry is used to check the corneal curvature of the eyes. Keratometer is an instrument used to check the horizontal and vertical curvature of the cornea. Children who have cylindrical power would undergo keratometric test. Children who possess 44.00-45.00 in keratometric test are having normal corneal curvature and children who have other than normal range are said to have abnormal corneal curvature.

Raj kumar Yadav and Upendra Kumar (2018) [1] applied multiple regression models on rural area has effect of recent past prior migrants along with current migrations.

Nur Ain Abd Aziz *et al*. (2016) [2] applied multinomial logistic regression model on characteristics of smokers after the smoke-free campaign in the area of Melaka.

Courtney Coughenour *et al*. (2015) [3] observed that which infrastructure was perceived as safe and most likely to be used for transportation.

Yu-Chi Liu *et al*. (2011) [4] observed that astigmatism affects approximately three quarters of the Chinese population aged 65 years and older in Taiwan, and that with increasing age, the prevalence of astigmatism increases.

Chao-Ying Joanne Peng *et al*. (2003) [5] applied multinomial logistic regression model to predictor on Adolescent behavioral risks at drop from the school.

2. Key terms

There are four common types of refractive errors:

- Myopia (short sightedness)
- Hypermetropia (long sightedness)
- Astigmatism
- Presbyopia

The following are the abbreviations used in the literature:

- OD is an abbreviation for Oculus Dexter, Latin for right eye from the patient's point of view. Oculus means eye.
- OS is an abbreviation for Oculus Sinister, Latin for left eye from the patient's point of view.
- OU is an abbreviation for Oculus Uterque, Latin for both eyes.
- SPH (Sphere): Amount of lens power in dioptres required to correct near-sightedness (myopia) or far-sightedness (hypermetropia). Correction is equal in all meridians of eye.
- CYL (Cylinder): Amount of lens power for astigmatism. A cylindrical correction corrects astigmatic refractive error of the eye by adding or subtracting power cylindrically in a meridian specified by the prescribed axis. If number has minus (-) sign, it is Myopic astigmatism. If number has plus (+) sign, it is Hypermetropic astigmatism.
- Axis: The lens meridian that is 90 degrees away from the meridian that contains the cylinder power. 90 degree indicates with the rule astigmatism and 180 degree indicates against the rule astigmatism.
- Presbyopia is the normal aging process of the lens of the eye. It is the loss of elasticity of the lens that occurs with aging, causing difficulty focusing at close ranges. Presbyopia usually becomes significant after the age of 40.

3. Data description

The data on 2409 patients was collected from two private hospitals in Chennai. The data relating to 1907 patients who were below 16 years of age was collected from Sankara Nethralaya hospital and the data relating to 502 patients who were above 16 years of age was collected from Appaswamy hospital. Among these private hospital patients, 54.42% were males and 45.58% were females. The data on four variables namely age, gender, refractive error in right eye and refractive error in left eye are used for the analysis in this study.

The codings for refractive error are as follows

Low Myopia: 1, Moderate Myopia: 2, High myopia: 3, Low Hyperopia: 4, Moderate Hyperopia: 5, High hyperopia: 6, Low Myopic astigmatism: 7, Moderate Myopic astigmatism: 8, High myopic astigmatism: 9, Low Hypermetropic astigmatism: 10, Moderate Hypermetropic astigmatism: 11, High hypermetropic astigmatism: 12, No refractive error: 13

4. Material and Methods

The data was entered in the MINITAB version 16.0 for evaluation. The presence of refractive error in both left and right eyes of patients was analyzed using bar chart and individual value plot. Multinomial logistic regression models were fitted to know whether the independent variables are significant and their goodness of fit were tested.

4.1 Bar char of Refractive errors

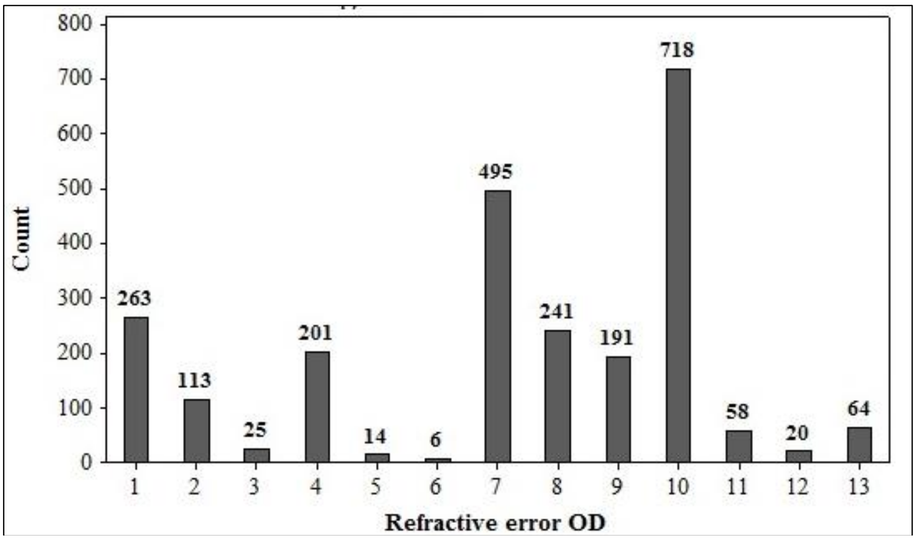

Fig 4.1.1: Bar Chart of Refractive Error OD

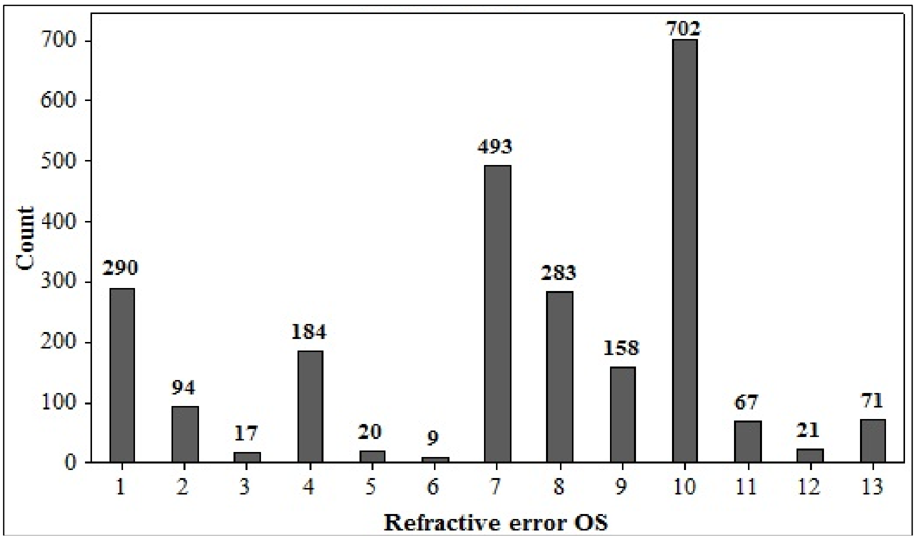

Fig 4.1.2: Bar Chart of Refractive Error OD

From Figure 4.1.1, we observe that a maximum number (718) of patients are affected by Low Hypermetropic astigmatism and minimum number (6) of patients are affected by high hyperopia in the right eye.

From Figure 4.1.2, we observe that a maximum number (702) of patients are affected by Low Hypermetropic astigmatism and minimum number (9) of patients are affected by high hyperopia in left eye.

4.2 Individual value plot of Refractive errors

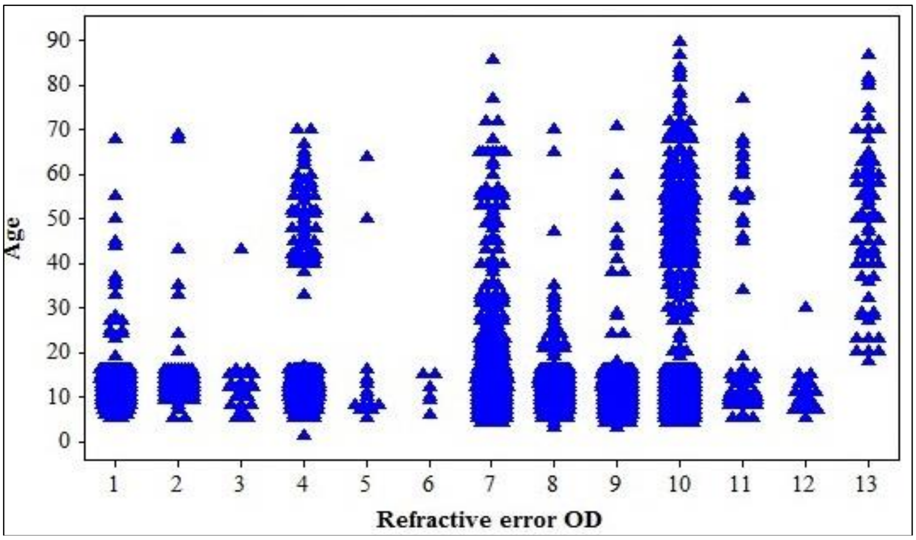

Fig 4.2.1: Individual Value Plot of Age

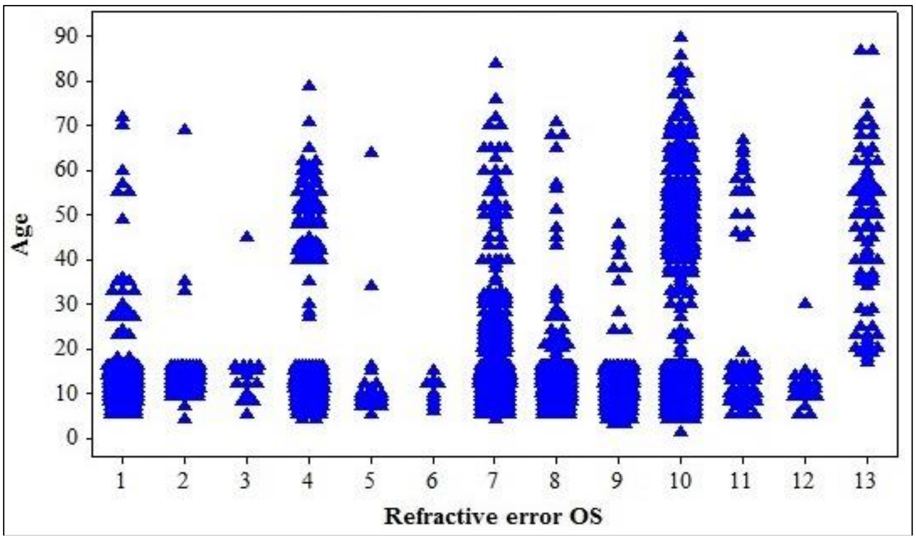

Fig 4.2.2: Individual Value Plot of Age

From Figure 4.2.1, we observe that a maximum number of patients in the age group 5 to 90 are affected by Low Hypermetropic astigmatism and a minimum number of patients in the age group 5 to 15 are affected by high hyperopia in right eye.
From Figure 4.2.2, we observe that a maximum number of patients in the age group 5 to 90 are affected by Low Hypermetropic astigmatism and a minimum number of patients in the age group 5 to 15 are affected by high hyperopia in left eye.
From Figure 4.2.1 and Figure 4.2.2, the individual value plot of refractive error for codes 1 to 13 except 4 and 9 are similar for both left and right eyes.

4.3 Multinomial Logistic Regression model

Incorporating the variables under consideration, the multinomial logistic regression model can be written in the form

$$Y_{i,k} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 \quad ,$$

where $Y_{i,k}$ denotes refractive error with codes i = 1,2,…,13 ; k = 1 denotes left eye (OS) and k=2 denotes right eye(OD); X_1 denotes age and X_2 denotes gender.

Table 4.3.1: Logistic regression table for refractive error OD

Logit \ Predictor	Constant		Age		Gender	
	Coefficient	p-value	Coefficient	p-value	Coefficient	p-value
1 (High hypermetropic astigmatism)	2.04327	0.002	-0.148738	0.001*	0.070561	0.895**
2 (Moderate hypermetropic astigmatism)	1.40952	0.001*	-0.047177	0.000*	0.455507	0.223**
3 (Low hypermetropic astigmatism)	4.31637	0.000*	-0.057118	0.000*	0.121035	0.081**
4 (High myopic astigmatism)	3.55978	0.000*	-0.104807	0.000*	0.54039	0.081**
5 (Moderate myopic astigmatism)	3.88849	0.000*	-0.096834	0.000*	0.109983	0.717**
6 (Low myopic astigmatism)	4.14791	0.000*	-0.072609	0.000*	0.316119	0.268**
7 (High hyperopia)	0.646423	0.557**	-0.147774	0.065**	0.47562	0.581**
8 (Moderate hyperopia)	0.839512	0.135**	-0.07536	0.000*	-0.188592	0.762**
9 (Low hyperopia)	3.02079	0.000*	-0.054242	0.000*	0.030335	0.920**
10 (High myopia)	1.9849	0.000*	-0.108477	0.000*	-0.494569	0.345**
11 (Moderate myopia)	2.97635	0.000*	-0.093207	0.000*	0.34293	0.302**
12 (Low myopia)	3.88818	0.000*	-0.094673	0.000*	0.242878	0.418**

***** Significant,
**Not Significant

From Logit 1 of Table 4.3.1, we get the model,

$$Y_{12,2} = 2.04327 - 0.148738X_1 + 0.0705606X_2 \qquad \ldots 4.3.1$$

From the equation (4.3.1), we see that as age X_1 increases by one unit, high hyperopia astigmatism in right eye $Y_{12,\ 2}$ decreases by 0.148738 units. Further, the p-value for age (0.001) is less than the significance level of 0.05 and p-value for gender (0.895) is not less than the significance level of 0.05. This indicates that the age has significant effect and gender has no significant effect on high hyperopia astigmatism in right eye.
In a similar way we observe the following for logit 2 to logit 12 of Table 4.3.1:
Age has significant effect on all types of refractive error except high hyperopia in right eye. Gender has no significant effect on all types of refractive errors in right eye.

Table 4.3.2: Logistic regression table for refractive error OS

Logit \ Predictor	Constant		Age		Gender	
	Coefficient	p-value	Coefficient	p-value	Coefficient	p-value
1 (High hypermetropic astigmatism)	1.52411	0.010*	-0.126998	0.001*	-0.01233	0.981**
2 (Moderate hypermetropic astigmatism)	1.5343	0.001*	-0.047751	0.000*	-0.053176	0.879**
3 (Low hypermetropic astigmatism)	3.90455	0.000*	-0.048366	0.000*	-0.07054	0.786**
4 (High myopic astigmatism)	3.11849	0.000*	-0.10544	0.000*	0.336683	0.264**
5 (Moderate myopic astigmatism)	3.54456	0.000*	-0.083518	0.000*	0.058634	0.835**
6 (Low myopic astigmatism)	3.82232	0.000*	-0.068437	0.000*	0.156491	0.560**
7 (High hyperopia)	1.61861	0.113**	-0.186399	0.036*	-0.95719	0.256**
8 (Moderate hyperopia)	1.08103	0.035*	-0.090158	0.000*	-0.1607	0.759**
9 (Low hyperopia)	2.46125	0.000*	-0.044065	0.000*	-0.051	0.860**
10 (High myopia)	0.46974	0.408**	-0.084713	0.000*	0.594176	0.285**
11 (Moderate myopia)	2.62238	0.000*	-0.088877	0.000*	-0.18899	0.568**
12 (Low myopia)	3.62577	0.000*	-0.083093	0.000*	-0.0848	0.763*

***** Significant,
**Not Significant

From Logit 1 of Table 4.3.2, we get the model,

$$Y_{12,1} = 1.52411 - 0.126998X_1 - 0.0123252X_2 \qquad \ldots 4.3.2$$

From the equation (4.3.2.1), we see that as age X_1 increases one unit, high hyperopia astigmatism in left eye $Y_{12,1}$ decreases by 0.126998 units. Further, the p-value for age (0.001) is less than the significance level of 0.05 and p-value for gender (0.981) is not less than the significance level of 0.05. This indicates that the age has significant effect and gender has no significant effect on high hyperopia astigmatism in left eye.
In a similar way we observe the following for logit 2 to logit 12 of Table 4.3.2:
Age has significant effect on all types of refractive error except high hyperopia in left eye. Gender has no significant effect on all types of refractive errors in left eye.

5. Conclusion
From this study, we observe that a maximum number of patients are affected by Low Hypermetropic astigmatism and minimum numbers of patients are affected by high hyperopia in both the left and right eyes. We also observe that age has significant effect on the refractive error in both right and left eyes. Also we see that gender has no significant effect on the refractive error in both right and left eyes.

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