

# A Study on Refractive Error Patients in Chennai City Using Structural Equation Modelling

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## Abstract

A lot of individuals in Chennai are suffering from refractive errors. Myopia, hyperopia, astigmatism, and presbyopia are among the majority prevalent forms of corneal abnormalities. The existence of blurred vision in both the left and right eyes in people who use contact lenses is found by 17 independent and 2 dependent variables using Structural Equation Modelling (SEM). The results are interpreted by Tests for goodness of fit in models, test for individual Parameter estimate for both independent and dependent variables and the linear relationship between the variables were performed.

**Key Words:** Refractive Error, SEM model, Path Diagram, Goodness of Fit, Estimation.

**AMS Classification:** 65D17, 65C50

## 1 Introduction

Tamil Nadu, a state in India, has Chennai as its capital. Chennai is South India's most important commercial and industrial hub as well as a major center for the economy, culture, and education. Chennai's 2019 population was estimated at 9,118,623 (9.1 million). The eye is a sensor of light that communicates with the brain by way of the optic nerve. The eye is a crucial sensory organ in humans that allows us to see. It enables vision and light perception, including the capacity to distinguish between distinct hues and varying levels of depth. The eye is a tremendously complicated organ, despite being small. The eye is roughly 0.9 inches tall, 1 inch wide, and 1 inch deep. The human eye has a 200-degree field of vision and can distinguish between 10 million different hues.

The human body's eye is a very effective organ. The cerebrum processes the raw visual data from the eyes to grasp what is going on around one in contrast to learning about one's broad surroundings. What the eyes send to the cerebrum is translated by the cerebrum. We wouldn't be able to understand writing, craftsmanship, or photography, and we wouldn't be able to understand as much from little

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visual information. The eye processes the light that objects reflect or emit to enable us to perceive and comprehend the forms, colors, and dimensions of objects in the atmosphere. The eye can distinguish between bright and dim light, but it cannot distinguish between an object in a dark environment.

By preventing the rectus muscle from contracting, cycloplegia reduces the eye's accommodating intensity, allowing for an estimation of the eye's static or goal refractive error. Utilizing cycloplegic drugs like CTC, HA+T, ROP, T, and T+ is the best way to acquire loss of motion or comfort. Because they prevent acetylcholine's muscarinic activity, cycloplegic medications are also known as anticholinergics.

The corneal bend of the eyes is evaluated using keratometry. A Keratometer is a tool used to examine the cornea's flat and vertical arch. Keratometric testing is performed on kids whose eyes are tube-shaped. Children who score between 44 and 45 on the keratometric test have normal corneal shape, whereas those who score outside of this range are said to have odd corneal arches. The following are the abbreviations used in the literature:

- **OD** or right eye from the perspective of the patient, is referred to as OD. Oculus is Latin for eye.
- **OS** stands for Oculus Sinister, which is Latin meaning the left eye from the patient's perspective.
- **OU** stands for Oculus Uterque, which is Latin for "both eyes."
- **SPH** (Sphere): The amount of lens power in dioptres needed to treat myopia or hypermetropia, which are near- or far-sightedness. All meridian lines of the eye are equally corrected.
- **CYL** (Cylinder): The number of astigmatism-friendly lens powers. By adding or removing power cylindrically in a meridian defined by the required axis, a cylindrical correction corrects the eye's astigmatic refractive error. If a number is denoted by a minus sign (-), myopia is present. Hypermetropic astigmatism is indicated by a number with a plus sign (+).
- **Axis**: the cylinder power occurs on the lens meridian, which is 90 degrees away. Rule astigmatism is undergone at 90 degrees, and rule astigmatism is indicated at 180 degrees <sup>[5]</sup>.

### Key terms

There are four common types of refractive defects.:

- Myopia (Short Sightedness)
- Hypermetropia (Long Sightedness)
- Astigmatism
- Presbyopia

**Myopia:** The person can readily see objects up close but struggles to notice stuff at a distance.

**Hyperopia:** The person is unable to clearly notice both nearby and distant items. In this situation, the retina is not in focus; rather, the retina is obscured by the light's focus. Although hypermetropia can be identified at any age, it typically manifests in older people.

**Astigmatism:** Precisely, Clearer vision requires a single point of focused light on the retina. However, astigmatism impairs vision because two or more foci of light are focused on the retina as a result of irregularities in the refracting surface.

**Presbyopia** is the natural aging process that occurs in the eye's focal point. Growing older results in the focus point's loss of flexibility, which makes it difficult to center at close distances. After age 40, presbyopia frequently becomes noticeable.

## 2 Literature Review:

Myopia has abruptly become more common over the past few decades, and if this trend continues, by 2050, half of the world's population will be myopia. Emergent technology, together with current behavioral and lifestyle conditions, are assumed to be the causes of this growth by Dibyendu Pusti et al (2020). Most twin studies found that refractive error was highly heritable across racial groups. Myopia is highly prevalent (77%), according to the variance of refractive error in 100 twin pairs of university students in southeast Spain. A statistical investigation revealed that this group of young twins' refractive error variance was mostly influenced by their common environment and, to a lesser extent, by additive genetic factors.

Researchers may quickly make up and accurately assess fictitious links between theoretical constructs as well as those between the constructs and their observed indications using SEM when there are enough participants (N). However, it has been demonstrated that SEM studies with small N or big p are troublesome. When p is high, Lifang Deng et al (2018) discusses problems and solutions for SEM with small N. Methods for parameter estimation, test statistics for overall model evaluation, and trustworthy standard errors for assessing the importance of parameter estimations are the subjects covered.

Researcher can use SEM to build and analyze complex correlations between numerous variables in order to assess the validity of theories using empirical models. The capacity to control measurement error, which is one of the biggest constraints of most studies, is maybe its greatest benefit. Tanya N Beran (2010) found that, although it has been applied in numerous fields, epidemiology and medical research have not yet made considerable use of it.

Path/regression analysis, repeated measures analysis/latent growth curve modelling, and confirmatory factor analysis are all included in SEM. In conventional research, data analysis and result interpretation can be difficult and complicated was analyzed by Diana Suhr (1989). Traditional statistical techniques to data analysis are rigid, define default models, and presume measurement occurs without mistake. However, structural equation modelling, a multivariate technique that incorporates measured variables and latent constructs, calls for the specification of a model based on theory and research and expressly mentions measurement error.

## 3 Methodology:

### 3.1. Structural Equation Modelling (SEM):

SEM is increasingly being viewed by researchers as being more suitable for addressing a range of research problems. This is the outcome of the various software's enhanced user interfaces and the incorporation of numerous methodological strategies within the SEM techniques [8].

SEM is created by combining a measuring model and a structural model. The connections between latent (unobserved) variables [18] and observed variables are specified by the measurement model. Within the measurement model, it is hypothesized that the latent (unobserved) variables will be measured. The measurement model enables the researcher to evaluate how well the observed

variables combine to identify underlying postulated components through confirmatory factor analysis (CFA).

The latent variables must be represented by a minimum of three quantifiable variables known as indicators. Some people are against testing models that include constructs with a single indication because they feel that doing so undermines the validity of the observed indicators and the low error rate of the models. As a result, the latent variables will be better represented.

The researcher uses the observed indicators to define the latent components in the measurement model [2]. How well a latent variable is described depends on how firmly related the observable indications.

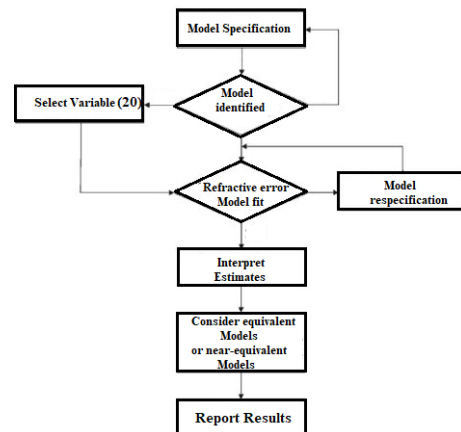


Figure 1: Process of Structural Equation Modelling.

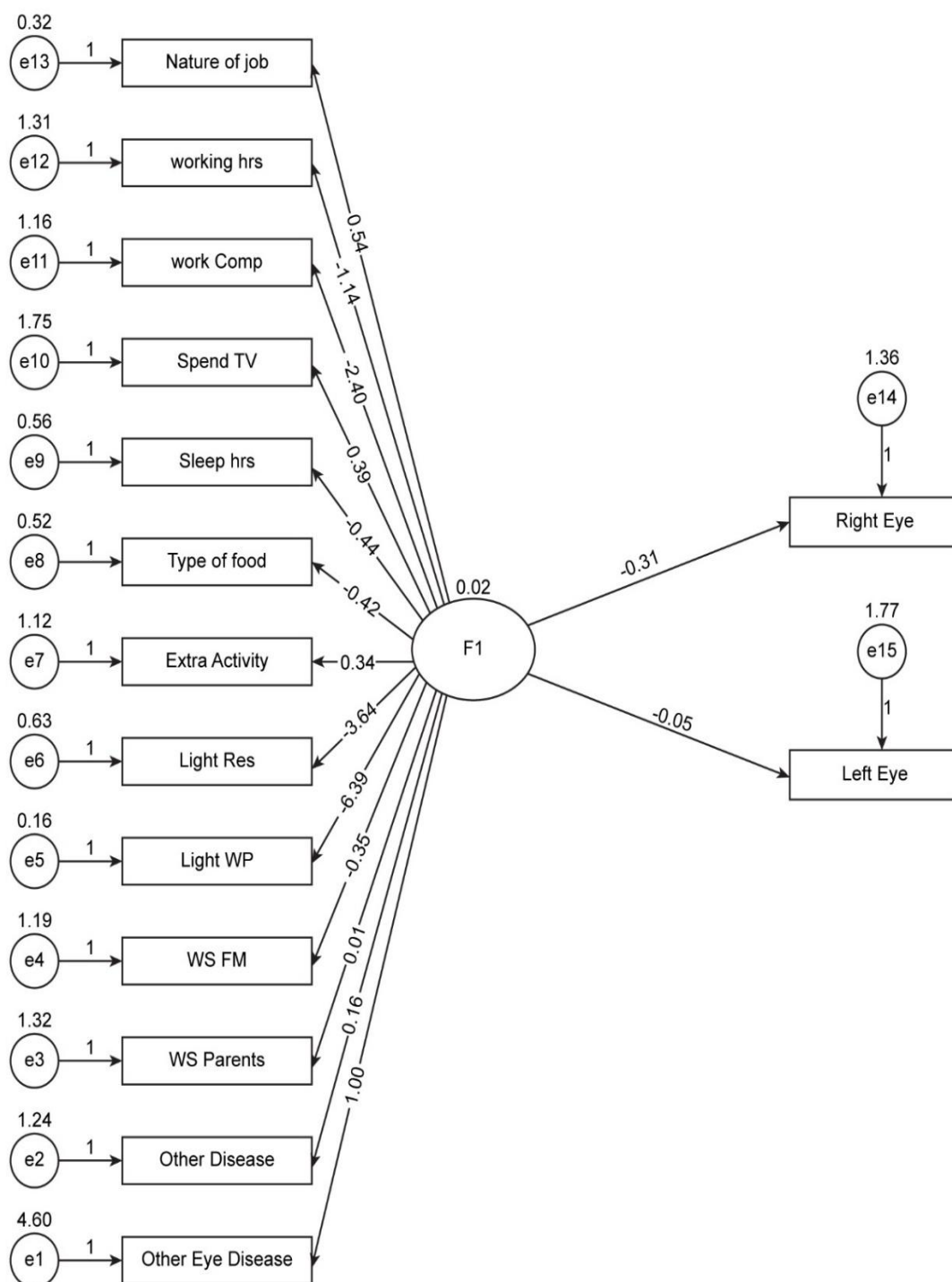
### 3.2 Data description

The KK eye hospitals in Chennai provided the data on 3042 patients. These patients at the private hospital were split 50.09 percent male and 49.91 percent female. The information on 19 variables, including age, gender, educational attainment, employment status, type of work, working hours, computer use, television viewing, sleeping hours, type of food, additional activity, light in the home and light at work, Parents wearing glasses, family members wearing glasses, other diseases, and other eye diseases, Refractive Error in both left and right eye are used for the analysis in this study.

For analysis, the data was entered into SPSS AMOS version 28.0. Structural equation modeling was used to examine if patients' left and right eyes have refractive error. To test the goodness of fit in models, individual Parameter estimate for both independent and dependent variables is done.

### 4 Results:

The relationships between exogenous and endogenous variables, as well as latent and observable variables, are shown using arrows in a path diagram, which is similar to a flow chart. The model's path diagram is created, and the model's fitness is assessed. If the fitness is beyond the allowed range, the model is changed, and a check is conducted.



**Figure 2.** Path diagram for structural equation modelling

#### 4.1 Regression Weights:

			Estimate	S.E.	C.R.	P
Other_ED	<---	F1	1.000			
Other_Disease	<---	F1	.158	.181	.874	.382
WS_Parents	<---	F1	.013	.178	.073	.941
WS_FM	<---	F1	-.345	.205	-1.686	.092
Light_WP	<---	F1	-6.387	2.178	-2.932	.003
Light_Res	<---	F1	-3.642	1.219	-2.987	.003
Extra_Activity	<---	F1	.340	.199	1.705	.088
Type_Food	<---	F1	-.420	.179	-2.343	.019
Sleep_hrs	<---	F1	-.436	.186	-2.348	.019
Spend_TV	<---	F1	.394	.244	1.617	.106
Work_Comp	<---	F1	-2.397	.816	-2.939	.003
Working_hrs	<---	F1	-1.413	.503	-2.810	.005
Nature_job	<---	F1	.541	.200	2.699	.007
Right_Eye	<---	F1	-.313	.209	-1.498	.134
Left_Eye	<---	F1	-.051	.207	-.245	.806

**Table 1. Regression Weights for Path diagram 1**

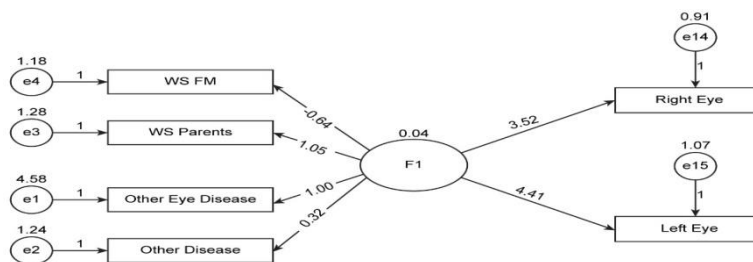
From the regression weights tables, 2 dependent variables and 13 independent variables are tested in structural equation model. other disease, WS Parents, WS\_FM, Extra Activity, Spent TV, Right Eye and Left Eye factors are not significant. when compare to  $p < 0.05$ . The interpretations on the parameter estimates are straight forward. Therefore, the highest estimation value of the variable Other Diseases is 1.000 and lowest value of the variable Light in Working Place is -6.387. In this model, Chi-square value is 2302.788, degrees of freedom are 90 and probability is 0.000.

The fitness of the model is tested based on the following criteria i.e.,			
Name of category	Name of index	Adequate fit	Index Value
Absolute fit measure	CMIN/Df	Less than 5	25.57
	GFI	Greater than 0.90	0.905
	AGFI	Greater than 0.90	0.873
	RMSEA	Less than 0.10	0.090
Incremental fit measure	NFI	Greater than 0.90	0.315
	CFI	Greater than 0.90	0.320
	TLI	Greater than 0.90	0.207
	IFI	Greater than 0.90	0.323
Parsimonious fit measure	PGFI	Greater than 0.50	0.857
	PCFI	Greater than 0.50	0.270
	PNFI	Greater than 0.50	0.274

**Table 2.** Test on Fitness of Model 1

As the adequate fit criteria for the above model are not getting satisfied for many indices like CMIN/Df, AGFI, NFI, CFI, TLI, IFI, PCFI and PNFI. The path needs to reframe and the analysis must be carried out to fit.

### 4.3. Re-Structured the Path Diagram of Structural Equation Modelling



### 4.4. Model Fit Summary

#### 4.4 a) Regression Weights:

			Estimate	S.E.	C.R.	P
Other_ED	<---	F1	1.000			
WS_FM	<---	F1	-.638	.225	-2.832	.005
WS_Parents	<---	F1	1.053	.326	3.229	.001
Other_Disease	<---	F1	.316	.168	1.881	.060
Right_Eye	<---	F1	3.523	1.007	3.499	***
Left_Eye	<---	F1	4.411	1.281	3.443	***

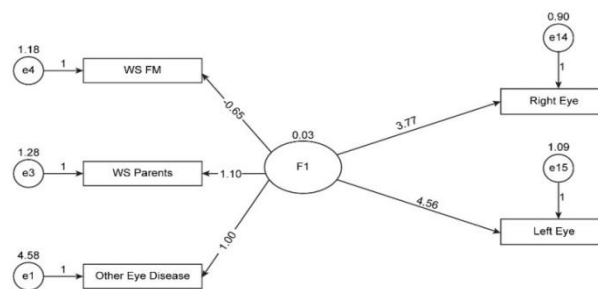
**Table 3.** Regression Weights for model test 1

From the recreated path diagram, 2 dependent variables and 4 independent variables are tested in structural equation model. Therefore, the highest estimation value of the variable, Left Eye is 4.41 and lowest value of the variable Wearing specs for Family Members is -0.638. Other disease factor is not significant, Chi-square value is 107.599, degrees of freedom are 9 and probability is 0.000.

The fitness of the model is tested based on the following criteria i.e.,		
Name of category	Name of index	Index Value
Absolute fit measure	CMIN/Df	11.955
	GFI	0.988
	AGFI	0.973
	RMSEA	0.060
Incremental fit measure	NFI	0.828
	CFI	0.823
	TLI	0.730
	IFI	0.840
Parsimonious fit measure	PGFI	0.600
	PCFI	0.503
	PNFI	0.497

**Table 4. Fitness of model test 2**

As the adequate fit criteria for the above model are not getting satisfied for many indices like CMIN/Df, NFI, CFI, TLI, IFI and PNFI. Thus, the modification needs to be done in the model. The path diagram is rebuilt in such a way that, it should satisfy the following criteria for Absolute fit measure, Incremental fit measure, and Parsimonious fit measures.



**Figure 4. Final Path diagram for structural equation modelling**

## 4.6 Model Fit Summary

### 4.6 a) Regression Weights:

			Estimate	S.E.	C.R.	P
Other_ED	<---	F1	1			
WS_FM	<---	F1	-0.653	0.24	-2.717	0.007
Right_Eye	<---	F1	3.766	1.132	3.325	***
Left_Eye	<---	F1	4.557	1.385	3.291	***
WS_Parents	<---	F1	1.098	0.354	3.098	0.002

**Table 5. Regression weight table for fitness model 2**

From the analysis, we infer that all factors are significant, when compared to  $p < 0.05$ . Thus, the data on 5 variables namely, Other Eye Disease, Wearing Specs with Family members, Wearing Specs with Parents shows considerable Refractive error in Right Eye and Refractive error in Left Eye. Therefore, the highest estimation value of the variable Left Eye is 4.557 and lowest value of the variable Wearing specs for Family Members is -0.653. Chi-square value is **67.813**, degrees of freedom are 5 and probability is 0.000.

The fitness of the model is tested based on the following criteria i.e.,		
Name of category	Name of index	Index Value
Absolute fit measure	CMIN/Df	13.563
	GFI	0.991
	AGFI	0.974
	RMSEA	0.064
Incremental fit measure	NFI	0.883
	CFI	0.89
	TLI	0.78
	IFI	0.891
Parsimonious fit measure	PGFI	0.5
	PCFI	0.442
	PNFI	0.445

**Table 6. Fitness of model test 3**

The goodness of fit of a statistical model describes how well it fits a set of observations. In this modified path diagram, the adequate fit criteria for the above model are satisfied for many indices like GFI, AGFI, RMSEA, NFI, CFI, IFI and PGFI. Therefore, five factors are satisfied in the path diagram of structural equation modelling.

## 5 Conclusion

A group of statistical methods known as structural equation modelling (SEM) is used to quantify and examine the latent and observable variables. Structural equation modeling is used in this study to build a model that examines the link between independent and dependent variables. If the variables do not fit the model, it gets recreated. From the analysis, we can interpret the factors for refractive error in left and right eye by examining Goodness of Fit for each variable. It is suggested that a moderate lifestyle would aid to reduce refractive error based on the interpretation. Wearing Specs family members, Wearing Specs Parents and Other Eye Diseases factors are highly interacted with RE in both left eye and Right eye.

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