

ASSESSING THE IMPACT OF D65 TUBE LIGHT ON VISUAL ACUITY AND COLOR VISION IN INDUSTRIAL SETTINGS

Syed Ahmad Hassan*

*Department of Allied Health Sciences, Superior University Lahore, Pakistan

*samibukhari79@gmail.com

Maira Sharafat

Department of Allied Health Sciences, Superior University Lahore, Pakistan

Khazeema Afzal

Department of Allied Health Sciences, Superior University Lahore, Pakistan

Ayesha Sharif

Department of Allied Health Sciences, University of Faisalabad, Pakistan

Author Details

Keywords:

Colour vision, Visual acuity, Retina, Cornea

Received on 12 Dec, 2025

Accepted on 26 Jan, 2026

Published on 11 Feb, 2026

Corresponding E-mails & Authors*:

Syed Ahmad Hassan
samibukhari79@gmail.com

Abstract

Aim: This study will evaluate the effect of D65 white tube light used in colour-matching machines on visual acuity and colour vision.

Background: When light rays disperse before reaching the retina it causes many visual function defects. Light enters through the cornea, and lens, and makes a sharp image on the photosensitive layer i.e., the retina.

Methodology: A retrospective study was carried out at Kalash Textile Mills in Faisalabad. A total of 40 subjects were selected for this study. One group of 40 people who were working under the

D65 tube light were selected for visual acuity by using Log MAR. The same group of 40 people who were working under the D65 white tube light took colour vision testing using D15. Informed consent was obtained from them. The procedure started with the taking of the history of the participants and then the visual acuity with the Log MAR chart. The colour vision was measured by D15. Then compared it with the initial data of visual acuity and colour vision. All the subjects that were taken had the work experience of more than one year in the quality assurance department, and

were work under D65 white tube light. The paired t-test was used for statistical analysis through the statistical package for social science (SPSS) software.

Result: After applying the paired t-test the result of visual acuity was significant $p < 0.05(0.000)$ and the result of colour vision was also significant $p < 0.05(0.000)$.

Conclusion: It was concluded that D65 tube light causes disturbing visual acuity and color vision.

INTRODUCTION

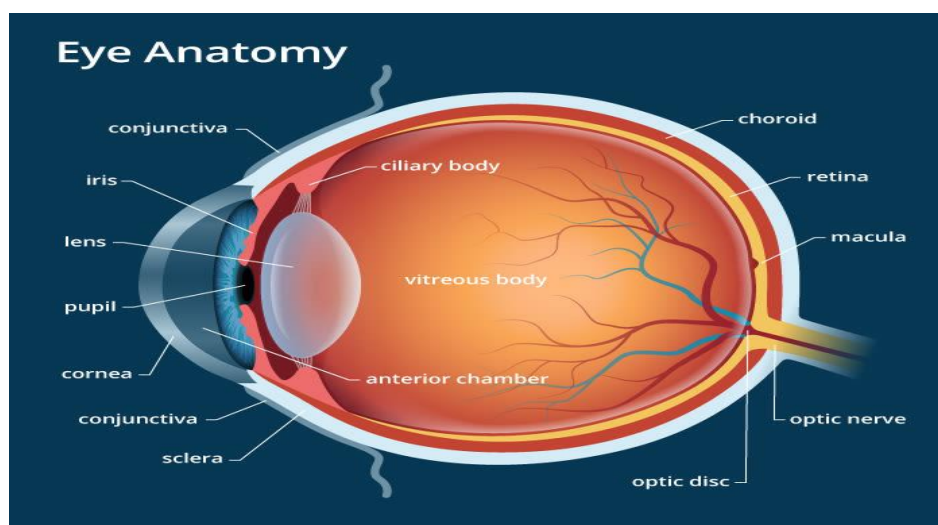
One of the body's most intricate organs is the eye. There are three layers of the human eye that are discriminable with the naked eye. The outer layer of human eye consists of cornea and sclera (1). The cornea is a structure which makes up anterior portion of the eye's outer layer and it extremely transparent along with the outer part of the outer coat, the opaque sclera is continues. The limbus or corneo-scleral junction is the transitional region where the cornea meets sclera. The average thickness of the human cornea is 535nm is the central and 100nm thicker towards the edge and is similar to that of the negative meniscus ophthalmic lens. The cornea protects the eye from any infection and structural damage to the deep layer of the eye; it also plays a major role in transmitting and refracting the light to the natural crystalline lens and retina (2).

When examination of the cornea is through the slit lamp bio-microscope the cornea seems to be some somewhat oval in form (3). The eye is protected from internal and external pressure by the sclera, a layer of connective tissue that also helps to maintain the shape of the eye. Iris is the membrane that allows light to pass through and regulate the amount of that light reaches the pupil of the eye (4). Size and diameter of the pupil also maintain by the iris. By limiting the light quantity that entering the pupil, improving depth of focus and minimize excessive glare, It also aids in improving good vision by reducing aberrations from the lens and cornea (5). Central layer of the eye constitute the ciliary body and choroid. Oxygen and nutrients to the outer retinal layer is supplied by the choroid and is vascular in nature (1).

The major function of natural crystalline lens is accommodation; it is the capability of the natural lens to change the focal length of lens by alternating the curvature of the natural lens. In

accommodation the refractive power of natural lens changes (6). In order to shield the retina from UV light, the lens also absorbs it. Light must pass through a clear lens in order to reach the retina. Lens clarity plays an important role for the light rays that produce a sharp focus at the retina. Lens clarity is maintained due to an absence of blood vessels and by the arrangement of the lens fibers (7).

Between the lens and retina lies a space called the vitreous humour. A connective tissues in the eye called vitreous humour that plays an important in the number of physiological and pathological processes. The lens and ora-serrata, where the retina finishes anteriorly, are both connected by the vitreous humour (8). The retina receives visual information from the surroundings, focuses it, and converts it into neural signals that the retina can interpret before delivering to the brain via the optic nerve. As a result, the retina is essential for gathering and evaluating finally detailed visual information including visual acuity, color and motion detection, which is subsequently processed by brain (9). The need for further research into this component of the visual system is confirmed by the retina's easy accessibility, crucial function in creating visual pictures and interacting with the environment, and the fact that the majority of sensory input is of a visual character (10).



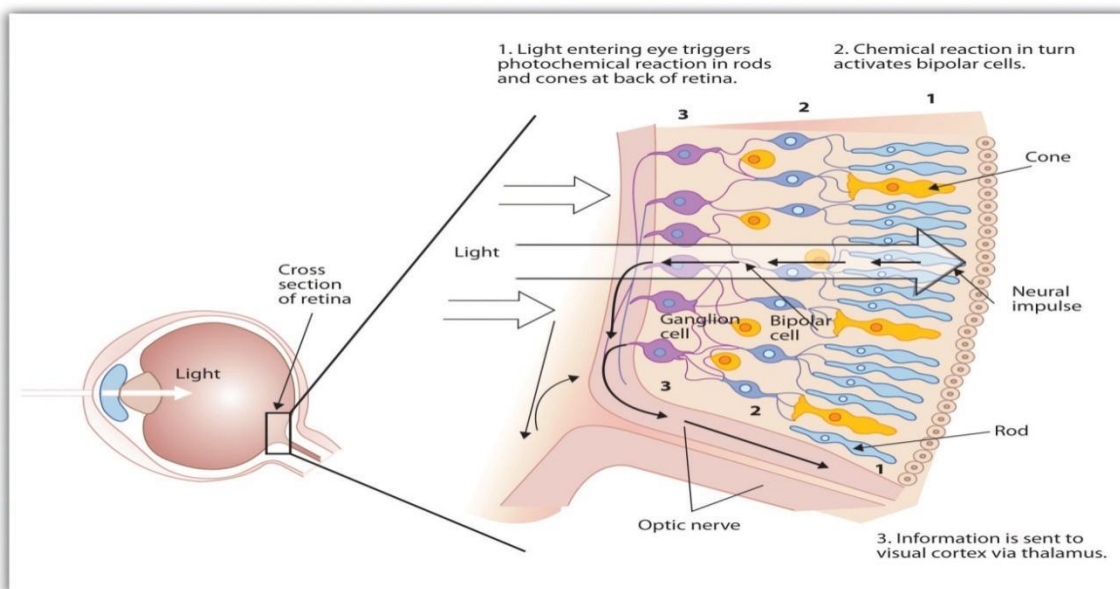
The human retina as like of many other species work as a duplex. It holds the two functions both a scotopic system which works in low light that provides by the straight as well as moonlight and

photopic system that works at the high level of illumination that is considered during the daylight. There is an intermediate system in which both the system carry out function called as mesopic. The scotopic system is occupied with rod receptor and photopic system with cones. The wide range of adaptation seen in human eye is achieved only by the alternation from one system to other system, along with the adjustment of sensitivity within the each system.

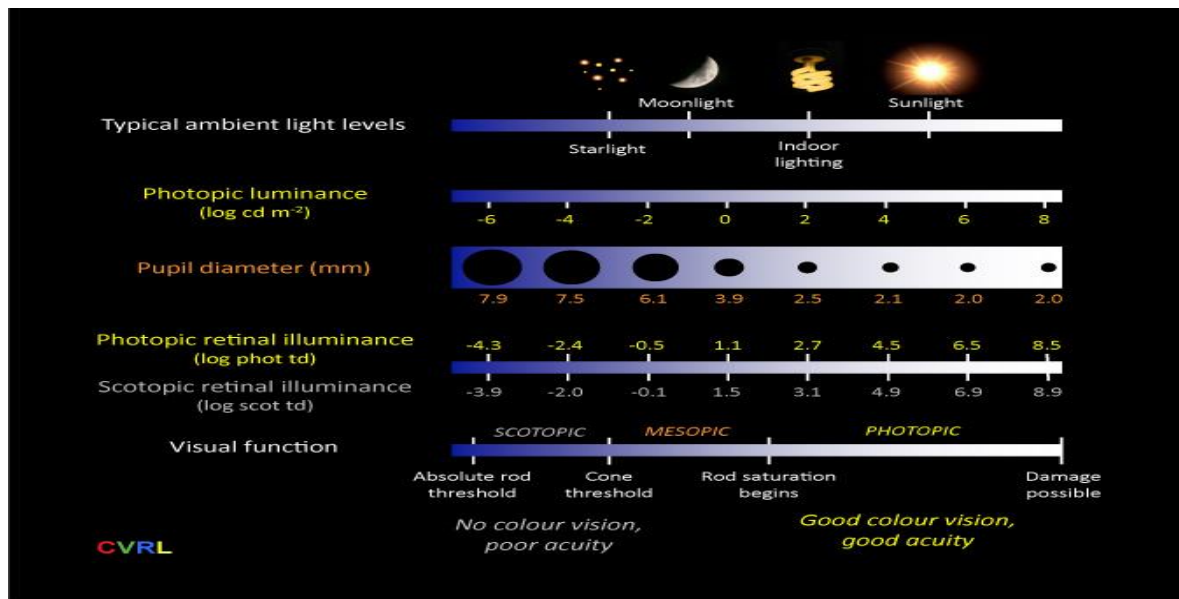
The retinal receptors consisting of rods and cones contain photo pigments. When the light is absorbed, the pigment breakdown and resultantly generates signals which are sent to brain and is interrupted as light. After then, the pigment is regenerated and is once more exposed to light. The amount of unbleached pigments determines how much the eye is sensitive to the light. Under the condition of steady brightness concentration of photo-pigment is in equilibrium, when there is variation in brightness, pigment can either be bleached or regenerated to again establish the equilibrium. The cones system adapt more rapidly than the rod system, even after exposure to the high level of brightness. Exposure to direct bright light entirely depletes the photo-pigments in rods. It is thought that this depletion makes rods incapable of functioning in the photopic region (11).

The visual system of the human eye is sensitive to brightness levels of around 10^{14} cd/m². Within in this range cones perform their function at higher end consisting of the luminance range 10 to 10^3 cd/m² and it is typically defined as photopic vision. Day light scenes cover photopic range in which colors are visible. It is clarified that there is no highest operating limit of cone cells, but the illumination range of 10^8 cd/m² is considered as a safe upper limit (greater luminance values are considered while looking directly at brighter lights. However this is covered by its own cells documented worse impact on photoreceptors). Cones are less sensitive but more susceptible to changes in the light levels. Rod cells are saturated in the photopic vision. A condition referred as mesopic vision in white both the rods and cones are active works within luminance range between 10^{-1} to 10^{-3} cd/m². Towards the lower range of the luminance level 10^{-3} to 10^{-6} cd/m². Only rods perform the functions and the consisting of the wavelength that is more than the normal eye can tolerate and when the light striking the retina the physiology occur as; within the cones the reactions

of photochemical occur and electrical impulses are produce that are then sent to brain along the nerves (12).



In normal physiology of light striking the retina is that the light entering the eye triggers photochemical reactions in rods and cones at back of retina where the chemical reaction in turn activates bipolar cells and then information send is sent to visual cortex via thalamus and retina senses the light. In 1991, it was documented that rod cells are more sensitive as compared to the cones because their ability to respond even a single photons but the scotopic vision has less chromatic discrimination. At the mesopic level, the cones become to activate through color perception is still poor due to the photochromic range where only grey tone is captured while at the photopic level color become visible.



The usual time constants for flickers and time detection threshold recovery in dark following considerable light adaptation is with the order of 15s in blue-yellow opponent pathway whereas 16s-20s in white-blue opponent pathway respectively. Visual acuity (VA) is a crucial test for assessing the eye's ability to detect objects at specific distances, requiring consistent evaluation to detect any visual changes. The cornea refracts light to provide two thirds of its optical power, with the internal lens supplying the remaining one third. When focusing on close objects, the internal lens of the eye can change shape to increase its focusing strength. When the lens accommodates normally, an eye is considered to be emmetropic if it generates a sharply focused retinal image of distant targets (13). The ability of a retina to distinguish between an object and its background depends on its contrast sensitivity. The ganglion cells in the retina, which send visual information towards the brain, control contrast sensitivity. Particularly horizontal cells block adjacent cells, emphasizing the borders between light and dark to increase contrast. In order to process contrast information, the brain's visual cortex reacts to particular orientations and spatial frequencies (14).

The ability to distinguish variations in light waves of various wavelengths and correlate them with various colors is known as color vision. Cones in the eye are stimulated by light, which sends messages to the brain. Individuals are able to sense a large variety of hues because the brain interprets these

signals as colors. Cones and the brain interact in a sophisticated way to produce a wide range of hues. Visual tiredness can be brought on by either too little or too much D65 white lighting. Glare can lower visual acuity and make it harder to see properly. Glare is caused when there is a substantial disparity in luminance between various portions of the visual field (21).

All of the visible spectrum hues are present in D65 white tube light. The colors in the surroundings may change as a result of changing illumination, which might impact how well things contrast with their background. For example, some color contrasts may be less noticeable in warm, yellowish light than in colder, bluish light. UV is an excellent D65 simulator, having marginally less UV content than that of illuminant D65. Without the additional UV, however, the values of the resulting total spectral radiance factor fall far below that of D65 in the 400–550 nm range (22).

The actual image on the retina is formed by the cornea and lens of an eye. The cornea is where light enters the eye from the outside. The cornea starts to focus on the light beams because of its curved surface, which functions as a convex lens. After that, the light travels through the pupil and strikes the eye's lens. The light is further focused by the same convex lens so that it strikes the retina at the rear of the eyeball and forms the image. The retina forms an actual, flipped image. Rod and cone cells are specific types of light-sensitive cells found in the retina (4). Visibility may become blurry when exposed to the intense light of a D65 white tube light as it has UV radiation range from 400-500nm (22).

The wavelength of the beam affects how much UV light is absorbed by various structures in the eye. The tear film is the first structure that absorbs UV light. Major UV filters such as the cornea and lens cortex mostly absorb wavelengths in the shorter, more active UVB band. All UV radiation below 280 nm is absorbed by the human cornea. Transmission increases quickly to 320 nm above this threshold, after which it increases steadily to a maximum in the visible spectrum. Longer UVR wavelengths are more able to penetrate the anterior segment of the eye and reach the lens and retina. Below 400 nm, the lens absorbs wavelengths (23).

The colors that make up D65 white light are all mixed together and have distinct wavelengths. White light enters our eyes through the lens and strikes the retina, which is located at the rear of

the eye. Cones are specialized cells found in the retina that are responsive to various light wavelengths. Color perception is made possible by these cones. D65 white tube light has usually a colour temperature ranging from 6400 Kelvin therefore it is proposed to symbolize usual daylight. As D65 is representative daylight that is why all colorimetric calculations are used in the different textile mills for quality insurance. As different illuminants are used for different purposes for different tasks variations also matter. The luminance of D65 ranges from 5000 to 6000lux while from 3000 to 5000lux is the output of light that is received by the persons. On the other hand, the average ability of the normal human eye can tolerate the luminance of light from 500 to 1000lux (15).

Generally, the luminance of the D65 is much higher to tolerate with the normal human eye and it will have visual function defects (16). Light is necessary for seeing. The pupil contracts in response to an increase in light level to lessen retinal illuminance and scattering of light, thus enhancing visual acuity. In the range below 0.05 lux and above 49 lux, the human eye uses pure scotopic vision and pure photopic vision, respectively (17).

An enhanced VA score of 0.12 Log-MAR has been achieved with increases in illumination from 50 to 500 lux (18). A chemical-electrical signal is produced by these cells to interpret the light signal, and it is transmitted to the visual cortex. Peripheral vision is not as sharp as foveal vision. Rod photoreceptor cells process their impulses differently before collapsing upon a single ganglion cell. Three different types of cones one sensitivity to red, green, and blue light allow for colour vision, however, the scarcity of rod cells prevents colour (19). Protanopes primarily utilize the color names "yellow" and "white" when responding to 200 cd/m². 2° diameter spectral stimuli; frequency of other basic color names increases when brightness is dropped to mesopic levels. Protanopes' color space, which was created using the color-naming data, has a collapsed "redblue" dimension that is used to distinguish between lights that are between 520 and 675 nm in wavelength instead of two chromatic dimensions. Protanopes' ability to see color at low brightness may have slightly improved due to greater spatial separation of stimuli at 0.2 cd/m (20).

Despite having less intensity, UV-A (315-400 nm) can cause damage to the macula, the area of the retina that is responsible for central field of vision, as it can penetrate far into the eye. Presumably more hazardous, UV-B (280-315) nm rays mostly absorb through the cornea and lens of the eye, where they might cause harm to those tissues (16). D65 tube light, a harmful light source, can cause eye symptoms like excessive squint, eye strain, ocular pain, and inflammation. Australian researchers found that UV radiation from D65 can increase the risk of 12% of eye diseases, including cataracts, and can lead to long-term damage (24).

The retina receives visual information from the surroundings focuses it, and converts it into neural signals that the retina can interpret before delivering to the brain via the optic nerve. As a result, the retina is essential for gathering and evaluating detailed visual information including visual acuity, colour and motion detection, which is subsequently processed by the brain (25). The need for further research into this component of the visual system is confirmed by the retina's easy accessibility, its crucial function in creating visual pictures and interacting with the environment, and the fact that the majority of sensory input is of a visual character (26).

OPERATIONAL DEFINITIONS

Visual acuity: The ability of eye to see small details of comparatively tiny objects.

Colour vision: The ability of the eye to separate out colours of different spectrums.

OBJECTIVES

- To evaluate the effect of D65 white tube light on visual acuity, contrast sensitivity.
- To evaluate the effect of D65 white tube light on colour vision.
- And compared the baseline reading with the current reading that was taken after one year.

RATIONALE

The purpose of the study was to protect subjects from various visual function impairments. Bringing the illuminance of D65 at the normal range was beneficial. Taking the illuminance to the normal level could prevent loss of vision. This study had aided in educating people on how they can save

their eyes and prevent different visual defects by keeping the illuminance at its normal level that was tolerable to the human eye. Also, educate and protect the subjects from visual function defects. If they feel any ocular discomfort they should consult their nearby eye specialist.

MATERIALS AND METHODS

3.1: Study design: It was a retrospect study.

3.2: Place of study: This study was conducted in the Kalash textiles miles, Faisalabad.

3.3: Duration of study: This study was conducted from February, 2023 to June 2023.

3.4: Sample size: A total of 40 participants were selected in this study which were included as 20 for visual acuity testing and 20 for color vision testing.

3.5: Sampling technique: A non-probability purposive sampling technique was used.

3.6: Inclusion criteria

- Participants of age from 20 to 30 were included.
- Both male and females were included who regularly work at the quality assurance department.
- Emmetropes with normal colour vision were included.

3.7: Exclusion criteria:

- Participants with any refractive errors, Ocular pathology and Ocular surgical history were excluded.
- Participants with any accommodative anomalies and convergence anomalies were excluded.

3.8: Data collection instruments:

These instruments were used in this study

Log MAR chart: Log MAR chart was used in this study as it was more accurate than any other visual acuity taking chart. The LogMAR chart has the same number of test letters on each line. Letter sizes

of the Sloan font vary logarithmically from line to line and line spacing is also logarithmic. Rows of letters are used in a LogMAR chart to measure visual acuity. This chart, as opposed to others (like the Snellen chart), was made to allow for a more accurate estimation of acuity. The LogMAR chart is advised as a result, especially in a research environment. As implied by the chart's name, visual acuity is measured using the Logarithm of the Minimum Angle of Resolution when utilising the LogMAR chart. Since the base-10 logarithm of 1 equals 0, an observer who can discern details as fine as 1 minute of visual angle scores LogMAR 0. Keep track of each eye's visual acuity independently.

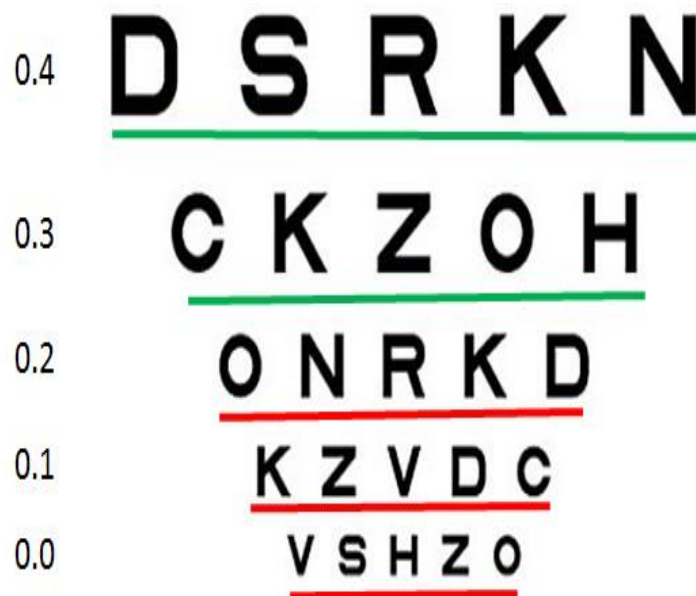


Figure 3.1: Log MAR chart

Procedure: First of all, the patient needs to be told to proceed with the test. Then, make sure patients sit comfortably. Now, Log MAR charts perform at 4 meter distance. Record the LogMAR unit as shown on the right of the chart if the patient reads five letters in a row. On the line, every letter adds 0.02 log units. The higher the LogMAR value, the worse the patient's VA. To the

LogMAR line value, add the log units for each letter that was not read. To the LogMAR unit on the right of the chart, add 0.02 if the patient can only read four letters in a row.

D-15: The Farnsworth D-15 Colour Vision Test is one of the most widely used colour arrangement tests. Mr. Farnsworth first devised the D-15 dichotomous test in 1947. One test known as an arrangement test is the D-15 test. The basis for these colour blindness tests is a collection of coloured plates or discs that must be placed in the right order. People who are colorblind will find it challenging to arrange the colours and may make mistakes. It is possible to determine the type and severity of your colour blindness based on these errors and the confusion vector that results. Only 53.5% sensitivity (but 100% specificity) has been reported in several investigations when compared to the "standard gold" anomaloscope. The Farnsworth D-15 Colour Vision Test should be conducted in a viewing booth that closely mimics natural light in order to provide reliable results.



Figure 3.2: D15 Farnsworth

Procedure: In this test, take a patient and tell the complete procedures of this test. Then, the patient should be sitting comfortably. These colour tests consist of a certain number of coloured discs or plates which have to be arranged in the correct color order. One of the most common color arrangement tests is the Farnsworth D-15 Color Vision Test. It contains 15 colour plates or discs, which then instructs to arrange them in the correct colour coded order. The test subject is required

to arrange the discs in the tray in a way that produces a spectrum of progressively shifting colour. Tritan faults, in instance, are one type of dichromacy that can be identified with the Farnsworth D-15 Colour Vision Test.

3.9: Data collection tool: Self-designed proforma was used.

3.10: Data Collection Method: The study was conducted in the department of quality checking assurance. The procedure started with the taking of the history of the participants and then took the visual acuity with the Log MAR chart. The colour vision was measured by D15 and then compare the data from the initial data of visual acuity, contrast sensitivity and colour vision when they start the work in that company and then according to that complete the proforma.

3.11: Data analysis: Data was analyzed by SPSS software version 23.

3.12: Ethical Consideration: Both verbal and written consent was obtained from the patient briefing them sufficiently about the objectives and design of the study, presuming adequate opportunity to consider all the options, to ensure that the included subjects were understood this information, to volunteer subject matter and continue to provide information, exchange information and ask questions.

RESULT

The study allocated 40 textile industry workers (n=40) which was further divided into 2 groups. Group 1 is male worker and group 2 is female workers. Visual acuity and colour vision was recorded before 1 year. And after 1 year same reading was taken. For the assessment of visual acuity and colour vision paired T test was applied. The result was analyzed by using SPSS version 23.

4.1: Age

40 textile industry workers were taken for the study. The range of the age that was taken was between 20 to 30. After statistical analysis the minimum age range was 21 and the maximum age range was 30, there mean reading was 25.15 and the standard deviation is ± 2.424 .

Table 4.1: Age Distribution

	N	Minimum	Maximum	Mean	Std. Deviation
Age of the patient	40	21	30	25.15	2.424

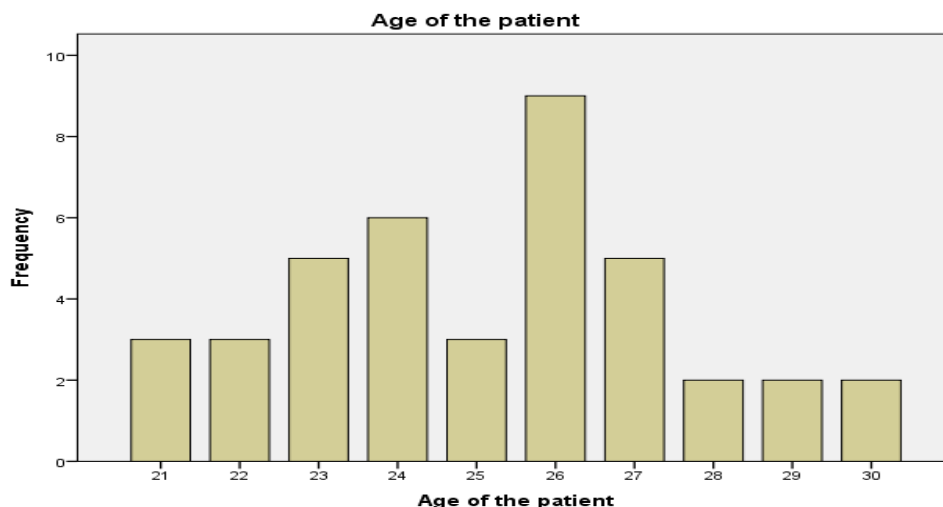


Figure 4.1: Frequency age bar graph

4.2: Gender

Table shows the frequencies of male and female population. Out of 40 workers, 29 were males having frequency (72.5%) and 11 were females having frequency (27.5%).

Table 4.2: Gender Distribution

	Frequency	Precent	Valid Percent	Cumulative precent
Male	29	72.5	72.5	72.5
Female	11	27.5	27.5	100.0
Total	40	100.0	100.0	

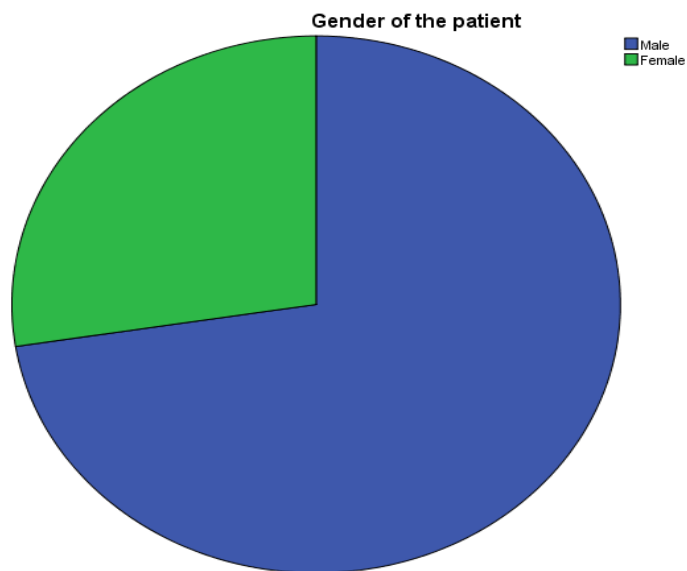


Figure 4.2: Pie Chart of Gender Distribution

4.3: Evaluation of pre and post visual acuity

The mean value and stranded deviation of pre recored visual acuity of 40 workers was (0.00) and (± 0.000) respectively. And the mean value and stranded deviation of post recored visual acuity of 40 workers were (0.224) and (± 0.1947) as described in the table 4.3.

Table 4.3 Mean value of pre and post recorded visual acuity

Pair 1	Mean	N	Std. Deviation	Std. Error Mean
Visual acuity pre	0.00	40	0.000	0.000
Visual acuity post	0.224	40	0.1947	0.0308

After using paired sample t-test, the paired difference mean and standard deviation of pre and post recorded visual acuity was (0.2245) and (± 0.1947) respectively. There was a significant difference in pre and post visual acuity with $p < 0.05$ ($p = 0.00$) described in table 4.4.

Table 4.4 Paired samples T-test pre and post recorded visual acuity

Pair 1	Paired differences				Sig.(2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence interval of the Difference	
				Lower	
Visual acuity pre - Visual acuity post	-0.2245	0.1947	0.0308	-0.2868	0.000

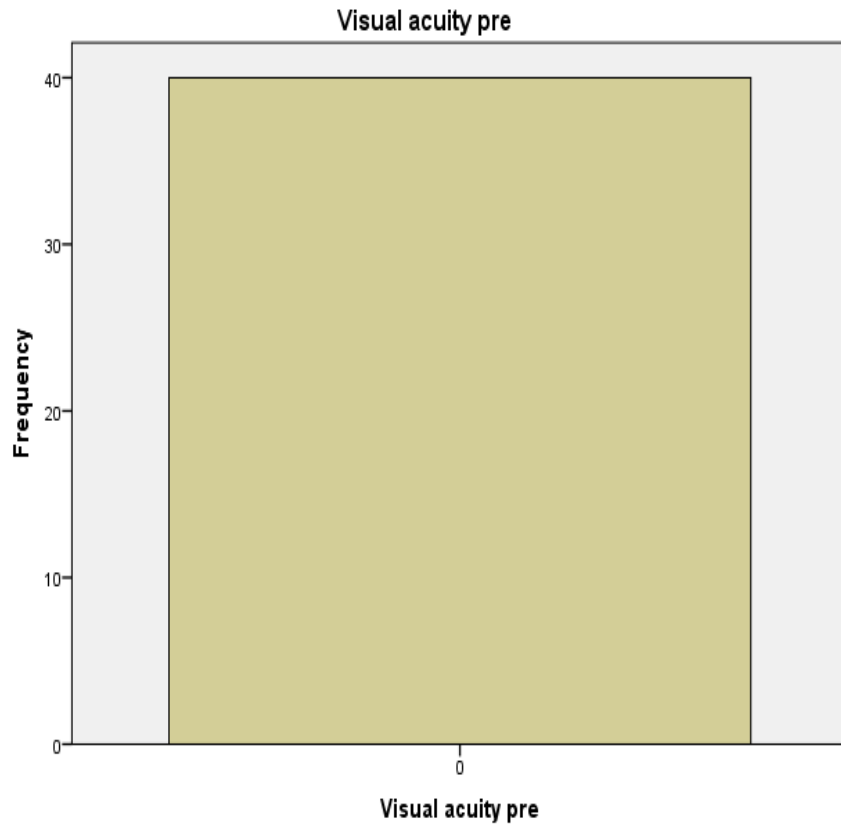


Figure 4.3: Pre- recorded visual acuity bar chart

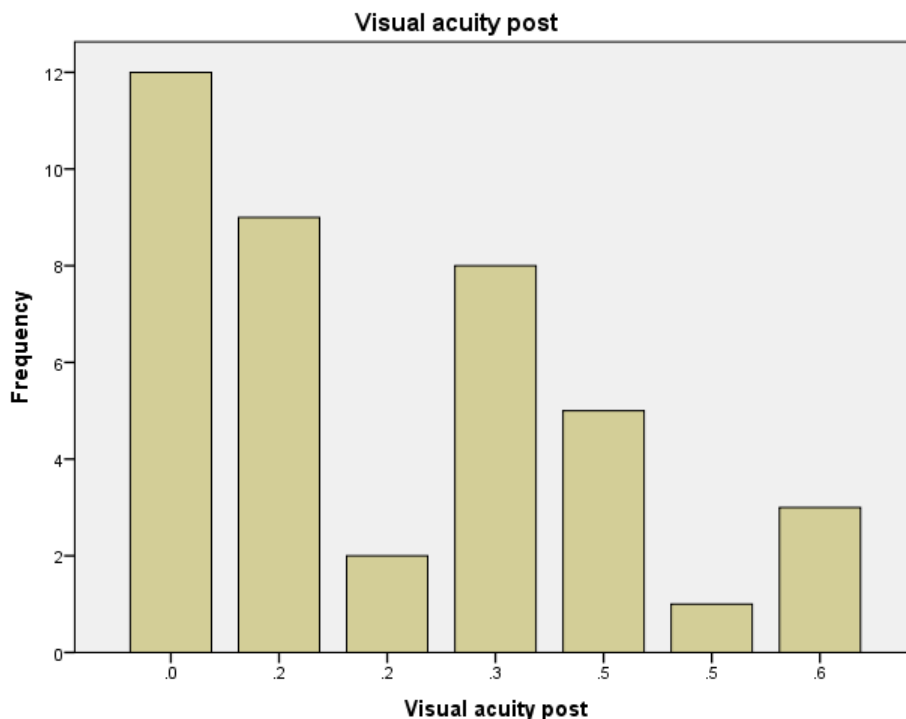


Figure 4.4: Post-recorded visual acuity

4.4: Evaluation of pre and post colour vision

The mean value and standard deviation of pre recorded colour vision of 40 workers was (1.00) and (± 0.000) respectively. And the mean value and standard deviation of post recorded color vision of 40 workers were (1.28) and (± 0.452) as described in the table 4.5.

Table 4.5 Mean value of pre and post recorded color vision

Pair 1	Mean	N	Std. Deviation	Std. Error Mean
Colour vision pre	1.00	40	0.000	0.00
Colour vision post	1.28	40	0.452	0.71

After using paired sample t-test, the paired difference mean and standard deviation of pre and post recorded colour vision was (-0.275) and (± 0.071) respectively. There was a significant difference in pre and post colour vision with $p < 0.05$ ($p = 0.00$) described in table 4.6.

Table 4.6 Paired samples T-test pre and post recorded colour vision

Pair 1	Paired differences					Sig.(2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence interval of the Difference		
				Lower	Upper	
Colour vision pre- colour vision post	-0.275	0.452	0.071	-0.420	0.120	0.000

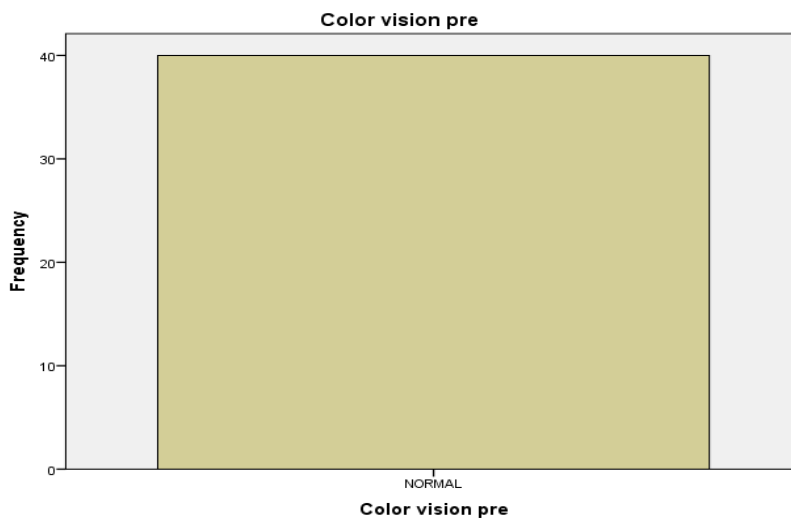


Figure 4.5 Pre-recorded colour vision

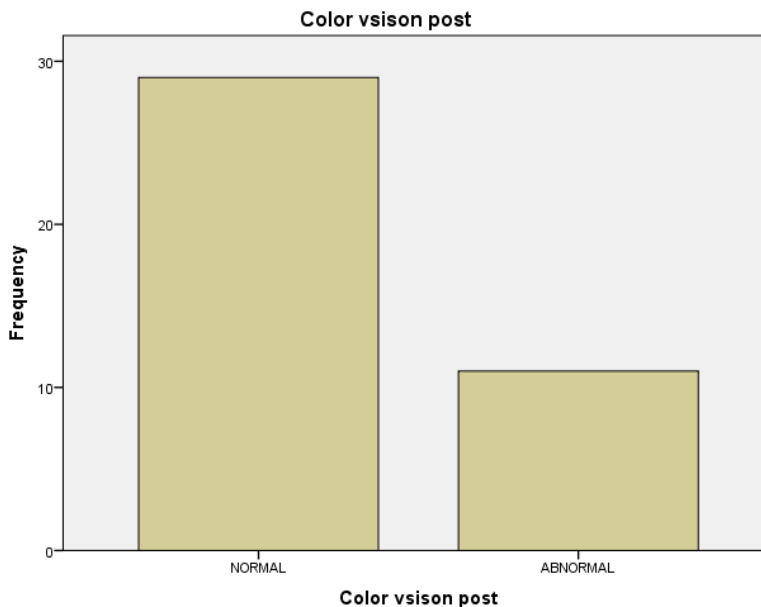


Figure 4.6: post recorded colour vision

Discussion

In our study that was conducted at Kalash textile miles, we chose 40 subjects out of which 29 were male and 11 were female. Their ages ranged between 20 to 30 years. All the subjects were working in quality assurance department under D65 white tube light have the luminance ranges from 5000 to 6000 lux. We took the reading of visual acuity of all the subjects and after one complete year, we again took the reading of visual acuity. All the subjects were 20\20 visual acuity. Subjects with refractive errors, ocular pathology and ocular surgical history were excluded. Participants with any accommodation anomalies and convergence were excluded. And after one year their visual acuity decreased at a significant level ($p < 0.05$) $p = 0.00$ with high illumination. In a research that was held in 2016 by Tidbury LP, et al studied altering illumination affects stereo and visual acuity. They evaluated twenty-eight participants, ranging in age from 21 to 60. A computer-controlled halogen lighting rig was used to give 15 distinct illuminance levels (ranging from 50 to 8000 lux) for the assessment of emmetropic participants' monocular visual acuity (ETDRS). Each patient received

lenses to induce three different levels of myopia (-0.50DS , -1.00DS , and 1.50DS), and their visual acuity (VA) was retested in the same lighting circumstances. The assessment of stereo acuity (TNO) was conducted with identical illumination levels. A substantial shift of 0.060 LogMAR ($p < 0.001$) is observed with a one log unit change in illuminance level (lux), an effect that is amplified in the presence of induced myopic refractive error ($p < 0.001$). There are statistically significant overall differences between illuminance levels based on stereoacuity scores ($p < 0.001$). The results of this investigation show that variations in illumination have a statistically significant impact on VA, which could be a factor in test/retest variability. An enhanced VA score of 0.12 LogMAR was obtained with increases in illumination from 50 to 500 lux (27).

In our study that was conducted at Kalash textile mills, we chose 40 subjects out of which 29 were male and 11 were female. Their ages ranged between 20 to 30 years. All the subjects were working in quality assurance department under D65 white tube light have the luminance ranges from 5000 to 6000 lux. We took the reading of visual acuity of all the subjects and after one complete year, we again took the reading of visual acuity. All the subjects were $20/20$ visual acuity. Subjects with refractive errors, ocular pathology and ocular surgical history were excluded. Participants with any accommodation anomalies and convergence were excluded. And after one year their visual acuity decreased at a significant level ($p < 0.05$) $p = 0.00$ with high illumination. In the research that was held in 1999 by Glover. S. et al studies visual acuity which was affected by the light illumination at different levels of distance. Then, researchers randomly took 50 subjects (98 eyes) and tested their visual acuity by using different types of illumination levels of the room and different intensities of light to find visual acuity by using the Snellen chart. There was a different intensity of light with normal room light on 1300 lux to reduce the room illumination level to 90 lux. In each scenario, the pupil's size was measured and the residual refractive error was assessed. Overall, there was a significant difference between the two lighting settings in terms of visual acuity, with illumination enhancing it ($6/9+4$ in the lighted room vs. $6/9+2$ in the non-illuminated room; $t = 4.653$, $p = 0.001$). The non-emmetropic group ($6/12+3$ in the lit room vs. $6/12$ in the darkroom) showed a larger difference. In a limited subset of subject eyes ($n = 18$), the visual acuity level decreased by more than

one line in the dark room. This difference's cause could be attributed to optical factors including accommodation and night myopia that affect visual acuity. When evaluated in a non-illuminated room, there seems to be a slight drop in visual acuity, which is larger (about three to four letters on a Snellen chart) in patients with an uncorrected refractive defect (31).

In our study that was conducted at Kalash textile miles, we chose 40 subjects out of which 29 were male and 11 were female. Their ages ranged between 20 to 30 years. All the subjects were working in quality assurance department under D65 white tube light have the luminance ranges from 5000 to 6000 lux. We took the reading of colour vision of all the subjects and after one complete year, we again took the reading of visual acuity. All the subjects have normal colour vision. Subjects with refractive errors, ocular pathology and ocular surgical history were excluded. Participants with any accommodation anomalies and convergence were excluded. And after one year their colour vision..... In the research that was held in 1991 by Guth S.L. explained a colour model with many zones. It included neuronal compression towards the end of the visual pathway, nonlinear receptor gainregulation, and two postreceptor opponent-colours processing phases. It was previously believed that both the test light itself and receptor responses from various adapting fields would cause gain control (self-adaptation). While apparent hues and saturations are mediated by the second processing stage, apparent brightnesses and visual discriminations are mediated by the first processing phase. The model considered a broad range of data, including the effects of chromatic adaptation on colour appearances, disparities in visual perception between chromatic and achromatic lighting under various adaptation conditions, and nonlinear hue shifts in the colour solid (32).

In our study that was conducted at Kalash textile miles, we chose 40 subjects out of which 29 were male and 11 were female. Their ages ranged between 20 to 30 years. All the subjects were working in quality assurance department under D65 white tube light have the luminance ranges from 5000 to 6000 lux. We took the reading of colour vision of all the subjects and after one complete year, we again took the reading of visual acuity. All the subjects have normal colour vision. Subjects with refractive errors, ocular pathology and ocular surgical history were excluded. Participants with any accommodation anomalies and convergence were excluded. And after one year their colour

vision.....In the research that was held in 1940 by Helson.H, et al studied Fundamental problems in color vision hue,lightness, and saturation of selective samples in chromatic illumination. They take 3 groups 1:60 factors under the normal intensity of light 2:96 under the hue bright light and 3:96 under the hue bright light with a filter. Studies that stimulated the entire retina with homogenous andalmost homogeneous illuminants and varying intensities in different regions of the field have demonstrated that a few previously overlooked parameters have predictable effects on saturation, colour, and brightness. This is relevant to Hue, brightness, and saturation are influenced by the reflectance of the background and other objects just as much as the composition and intensity of light coming from an object. Compared to non-selective samples,which tend to be tinged with the illuminant's hue or its complementary, selective samples exhibit more stability in chromatic illuminants. Additionally, if their dominant wavelength is present, the former retain their daylight hue. The colours of the samples and the illuminant do not anticipate the object's colour consistency or resistance to chromatic illumination. The primary factors that determine this are the reflectance of the samples and backdrops, as well asthe observer's attitude and dominating way length of light. In the current work, a reversed formula was discovered to be required for reflectance adjustments in order to achieve the criterion. It produces an adaption lightness value that is reasonably consistent with observations. It has been noted how this study's specific findings relate to earlier research and hypotheses, with new evidence mostly supporting differentiate stimulation(34).

5.1: Conclusion

This was a retrospective cohort study. A purposive sample of 40 subjects with ages between 20-30 of both genders was included. The study concluded the comparison of visual acuity and colour vision of the subjects and evaluate the pre and post readings.

- This study concluded that, there was significant difference of visual acuity after one year working under D65 white tube light $p < 0.05$ (0.000).
- This study concluded that, subjects' visual acuity decreased after one year working under D65 white tube light.

- This study concluded that, subjects' colour vision also disturbed after working under D65 white tube light. Result was significant $p < 0.05$ (0.000).
- This study also concluded that, irrespective to gender D65 white tube light effect the visual acuity and colour vision.
- This study showed that, the UV content of D65 white tube light have devastating effect on visual acuity and colour vision.

5.2: Limitations

- Visual acuity testing by using different types of chart, like Snellen chart may be given different value of the visual acuity.
- On the other hand, if we recorded colour vision by using ishihara test the values may be different.
- Study duration was very limited.
- Some staff members work duration was too short and too long. So staff members don't work properly.
- Some subjects did more than one job.
- Numbers of subjects were not come under the inclusion criteria of the study.

5.3: Recommendations

- Ophthalmologist and optometrist should check the visual acuity and colour vision of the workers' in routine medical checkup.
- Workers' should seek advice from eye care specialist refraction correction and work.
- They should also recommend some kind of filters that protect them from the harmful effects of high luminance.
- Further research should be conducted on this topic by using different types of instruments such as Ishihara, Snellen chart etc.

- It should be beneficial to examine other factors, such as contract sensitivity, pupil size, accommodation and degenerative changes.
- This study focused on the effects of D65 white tube light on visual acuity and color vision, there must be an alternate source of D65, and the luminance must be balanced at a certain level that is not harmful.
- The UV content of D65 must be stracted because UV not only damage the ocular function but also cause number of other systemic diseases such as skin cancer.
- The LED light source is better than D65 white tube light because it takes much shorter voltage than D65 white tube light. LED lights have almost no content UV radiation. LED is already used in industry for color matching.

Summary

D65 white tube light, with a colour temperature of 6400 Kelvin, is used to represent daylight in textile mills for quality assurance. Its luminance ranges from 5000 to 6000lux, which is higher than the normal human eye's ability to tolerate. The pupil contracts to reduce retinal illuminance and enhance visual acuity. UV is an excellent D65 simulator, with marginally less UV content than D65. The retina forms an image through the cornea and lens, with rod and cone cells being specific types of light-sensitive cells. Visibility may become blurry when exposed to D65 white tube light due to UV radiation from 400-500nm. The wavelength of the beam affects how much UV light is absorbed by various eye structures, with the tear film being the first to absorb UV light. Major UV filters, such as the cornea and lens cortex, mostly absorb wavelengths in the shorter, more active UVB band. Rod photoreceptor cells process impulses differently before collapsing onto a single ganglion cell. Protanopes use color names "yellow" and "white" when responding to 200 cd/m spectral stimuli. UV-A and UV-B rays can cause damage to the macula and cornea, increasing the risk of eye diseases like cataracts and long-term damage. The retina is essential for gathering and evaluating detailed visual information, including visual acuity, color, and motion detection.

A retrospective study was carried out at Kalash textiles miles in Faisalabad. Purposive sampling technique was used. This study was conducted from February, 2023 to June 2023 which was included as for visual acuity testing and for color vision testing. A total of 40 participants were selected in this study .Log MAR was used to measure visual acuity . The colour vision was measured by D15. Subjects who fulfil the inclusion criteria were included in our study. Subjects were divided into two groups. Where take both visual acuity and color vision of the same person. One group of 40 people were those who work under the D65 tube light. The other group contained the same 40 people who were working under the D65 tube light. Visual acuity and color vision was noted at baseline and after 1 year to take both visual acuity and color vision of that participant. The pair t-test was used for statistical analysis.

According to results, it was significant. It indicates that there was study allocated 40 textile industry workers which was further divided into 2 groups. Group 1 is male worker and group 2 is female workers. Visual acuity and colour vision was recorded before 1 year. And after 1 year the same reading was taken. In comparison, both visual acuity and color vision under D65 cause before and after. Both visual acuity and color vision will be disturbed.

References:

- Covantsev S, et al. Pancreatic ductal anatomy: More than meets the eye. *Surgical and Radiologic Anatomy*. 2022;44(9):1231-8.
- Meena K. et al. "Eye MG 3D Application-A comprehensive ocular anatomy and pathophysiology 3D atlas with real-time true color confocal images to enhance ophthalmology education and e-Counseling." *Indian Journal of Ophthalmology* 70, no. 4 (2022): 1388.
- Galloway, et al. Basic anatomy and physiology of the eye. In *Common Eye Diseases and their Management 2022* (pp. 7-18). Cham: Springer International Publishing.
- Galloway NR, et al. Basic anatomy and physiology of the eye. In *Common Eye Diseases and their Management 2022* (pp. 7-18). Cham: Springer International Publishing.

- Disatham, et al. "Changes in DNA methylation hallmark alterations in chromatin accessibility and gene expression for eye lens differentiation." *Epigenetics & Chromatin* 15, no. 1 (2022): 1-27.
- Liu, Z., Huang, S., Zheng, Y., Zhou, T., Hu, L., Xiong, L., Li, D.W.C. and Liu, Y. The lens epithelium as a major determinant in the development, maintenance, and regeneration of the crystalline lens. *Progress in retinal and eye research*. 2023 92, p.101112.
- Liu Z, Huang S, Zheng Y, Zhou T, Hu L, Xiong L, Li DW, Liu Y. The lens epithelium as a major determinant in the development, maintenance, and regeneration of the crystalline lens. *Progress in retinal and eye research*. 2023 1;92:101112.
- Asare, Frederick A., Roger S. Anderson, Pádraig J. Mulholland, and Julie-Anne Little. "Mesopic conditions optimise the detection of visual function loss in drivers with simulated media opacity." *Scientific Reports* 12, no. 1 (2022): 13165.
- Asare FA, Anderson RS, Mulholland PJ, Little JA. Mesopic conditions optimise the detection of visual function loss in drivers with simulated media opacity. *Scientific Reports*. 2022 1;12(1):13165.
- Cao, Lina, et al. "Full-spectrum white light-emitting diodes enabled by an efficient broadband green-emitting CaY₂ZrScAl₃O₁₂: Ce³⁺ garnet phosphor." *ACS Applied Materials & Interfaces* 14.4 (2022): 5643-5652.
- Cao L, et al. Full-spectrum white light-emitting diodes enabled by an efficient broadband green-emitting CaY₂ZrScAl₃O₁₂: Ce³⁺ garnet phosphor. *ACS Applied Materials & Interfaces*. 2022 Jan 25;14(4):5643-52.
- Thibos LN. Formation and sampling of the retinal image. In *Seeing 2000* (pp. 1-54). Academic Press.
- Green DG. The contrast sensitivity of the colour mechanisms of the human eye. *The Journal of physiology*. 1968 196(2):415-29.

NeitzJ,NeitzM.

Thegeneticsofnormalanddefectivecolorvision.Visionresearch.201113;51(7):633-51.

HeX.Design,fabricationandoptimizationofIII-

nitridemicrolightemittingdiodesforopticalcommunication.

KramesMR,David

AJ,inventors;SoraInc,assignee.CircadianfriendlyLEDlightsource.UnitedStatespatent US9,410,664.2016Aug 9.

Smet KA, et al. Chromaticity of unique white in illuminationmode.Optics express.2015;23(10):12488-95.

Yuan T, et al. Towardphosphorescent and delayed fluorescent carbon quantum dots for next-generationelectroluminescentdisplays.JournalofMaterialsChemistryC. 2022;10(7):2333-48.

ChenJ,etal.Perovskitewhitelightemittingdiodes:progress,challenges,andopportunities.ACSnano.2021;15(11):17150-74.

RubinGS,etal.AcomprehensiveassessmentofvisualimpairmentinapopulationofolderAmericans.

TheSEE Study. Salisbury Eye Evaluation Project. Investigative ophthalmology & visualscience.1997;38(3):557-68.

Trinh VQ et al. Determination and Measurement of MelanopicEquivalentDaylight(D65)Illuminance(mEDI)intheContextofSmartandIntegrativeLighting.Sensors.2023;23(11):5000.

Hirschler R, et al. Quality of the daylight sources for industrial colour control. Coloration Technology. 2011;127(2):88-100.

Majdi M, et al. The role of ultraviolet radiation in the ocular system of mammals. InPhotonics 2014 Oct 22 (Vol. 1, No. 4, pp. 347-368). MDPI.

Hurvich LM, et al. An opponent-process theory of color vision. Psychological review. 1957; 64 (6p1):384.

- Asare FA, et al. Mesopic conditions optimise the detection of visual function loss in drivers with simulated media opacity. *Scientific Reports*. 2022;12(1):13165.
- Cao L, et al. Full-spectrum white light-emitting diodes enabled by an efficient broadband green-emitting CaY₂ZrScAl₃O₁₂: Ce³⁺ garnet phosphor. *ACS Applied Materials & Interfaces*. 2022 25;14(4):5643-52.
- Maqsood F. Effects of varying light conditions and refractive error on pupil size. *Cogent Medicine*. 2017;4(1):1338824.
- Tidbury LP, et al. Fiat Lux: the effect of illuminance on acuity testing. *Graefe's Archive for Clinical and Experimental Ophthalmology*. 2016;254:1091-7.
- Shandiz JH, et al. Effect of cataract type and severity on visual acuity and contrast sensitivity. *Journal of ophthalmic & vision research*. 2011;6(1):26.
- Bühren J, Terzi E, Bach M, Wesemann W, Kohnen T. Measuring contrast sensitivity under different lighting conditions: comparison of three tests. *Optometry and Vision Science*. 2006 May;83(5):290-8.
- Glover S, Kelly M, Wozniak H, Moss N. The effect of room illumination on visual acuity measurement. *Australian Orthoptic Journal*. 1999;34:3-8.
- Guth SL. Model for color vision and light adaptation. *JOSA A*. 1991 Jun 1;8(6):976-93.
- Helson H, et al. Fundamental problems in color vision. II. Hue, lightness, and saturation of selective samples in chromatic illumination. *Journal of Experimental Psychology*. 1940;26(1):1.
- Walls HL, Walls KL, Benke G. Eye disease resulting from increased use of fluorescent lighting as a climate change mitigation strategy. *American journal of public health*. 2011;101(12):2222-5.