Original Article

A Comprehensive Cross-sectional Analysis of Prevalence of Congenital Color Vision Deficiency among Patients

Samra Ahmed[1*], M. Mumtaz Chaudhry[1], Qurat Ul Ain Malik[1], Adila Anwar[1], Hannia Talha Saad[1]

ABSTRACT

OBJECTIVE*:* To determine the frequency of color vision impairment among Pakistani adults at Polyclinic Hospital Islamabad.

METHODOLOGY: This descriptive, cross-sectional study was conducted at Federal Government Polyclinic Hospital, Islamabad. The research was conducted from March to May 2022, employing a consecutive non-probability sampling methodology. The study centred on a cohort of participants aged 10 to 55 who received medical attention at the Ophthalmology Outpatient Department. Sampling was done using the non-probability consecutive sampling technique. The sample size was 104 patients. All adults aged between 10-55 years were included except Patients having a history of Ocular or Neurological surgery, Trauma and Patients diagnosed with Diabetes or Hypertension were excluded. The gathered data was entered and analyzed using IBM SPSS Statistics version 20.

RESULTS: A total of 104 candidates underwent color vision assessment. 3.8% (4/104) of the candidates were color vision deficient. All of them were unaware of their condition.

CONCLUSION: The screened Population showed color blindness in 3.8% of the candidates. All of the individuals were unaware of the condition.

KEYWORDS: Color blindness, Pakistani Population, occupational hazard, Ishihara Chart, visual acuity, color vision

INTRODUCTION

The retina of the human visual system harbors three discrete groups of cone photoreceptors, which facilitate the detection of electromagnetic radiation ranging from 400 to 780 nanometers and encompassing the visible spectrum. The cones, which are photoreceptor cells, are classified into three distinct types based on their responsiveness to varying light wavelengths: blue, green, and red. Color vision deficiency (CVD) is a condition that impacts the perception of colors and can arise from either congenital or acquired factors.

In the case of congenital CVD, anomalies arise due to deficiencies in cone pigments or modifications in their spectral sensitivities. The genes responsible for encoding the red and green pigments are on the X chromosome. In contrast, the gene responsible for encoding the blue pigment is found on a separate chromosome 7. The prevalence of CVD has been documented in various countries and populations, revealing 6.0% in males and 0.25% in females in Europe[1,2], 7.4% in males, and 4.9% in males and 0.64% in females in the Asian population[3]. According to a study, 96% of those with CVD were unaware of their visual impairment; it is noteworthy that a sizable portion of them do not know they have the disease[4].

The faculty of color perception bears considerable significance in everyday existence, and any deficiency in this ability may lead to a certain level of incapacitation. This phenomenon remains unnoticed unless an individual undergoes a screening or medical assessment of their physical fitness. A lack of adequate self-awareness can lead to difficulties, particularly in occupations requiring flawless color vision as a fundamental prerequisite, such as the military, aviation, and railway sectors. Certain professions, such as textile color matching, printing and dyeing, color-based chemical analysis, horticulture, fine arts, and color photography, may experience a reduction in service quality[5]. Medical practitioners who have CVD encounter difficulties in identifying clinical manifestations such as jaundice, pallor, and reddened skin eruptions.

There is significant variation in the occurrence of CVD among various global regions. Insights into the occurrence of this condition can be gleaned from prevalence studies conducted in multiple countries, including Turkey, Iran, India and Saudi Arabia[6]. Nevertheless, the existing literature on the frequency of CVD in Pakistan is scarce.

Siddiqui conducted a comparative analysis in Pakistan between medical and non-medical students, which indicated an overall prevalence of color vision deficiency of 2.75% [7]. Hamida 2016[8] research conducted in Quetta, Pakistan, documented a

[1]*Department of Ophthalmology, Federal Government Polyclinic (FGPC), Hospital, Islamabad, Pakistan*
[*]***Correspondence:*** *samraahmed1907@gmail.com*
doi: 10.22442/jlumhs.2024.01090
Received: 15-11-2023 Revised: 28-03-2024
Accepted: 16-04-2024

prevalence rate of 2.48% within the Population. The results above underscore the necessity for conducting more extensive research on the frequency of CVD in Pakistan, given that a considerable number of instances are presumably undetected.

It is advisable to conduct color vision impairment screenings for individuals in light of the impact that CVD may have on their occupational performance. This measure would facilitate the provision of suitable counselling, discouraging the pursuit of careers that require precise color discrimination due to the potential risks associated with such occupations.

It is imperative to advocate for the amalgamation of screening programs and educational initiatives to enhance public awareness and safeguard the welfare of individuals affected by CVD. Through this approach, impacted individuals can make well-informed decisions regarding their career paths, and suitable adjustments can be made to alleviate any potential difficulties related to color vision impairment. The progress made in scientific inquiry and heightened consciousness will facilitate a more comprehensive comprehension of CVD and its ramifications, ultimately facilitating the standard of living for those afflicted with this ailment.

METHODOLOGY

This descriptive, cross-sectional study was conducted at Federal Government Polyclinic Hospital, Islamabad. The research was conducted from March to May 2022, employing a consecutive non-probability sampling methodology. The study centred on a cohort of participants aged 10 to 55 who received medical attention at the Ophthalmology Outpatient Department. The exclusion criteria encompassed individuals with a medical history of ocular or neurological surgery, trauma, diabetes, hypertension, or glaucoma. Exclusion criteria encompassed patients prescribed central nervous system drugs, anti-tuberculosis medications, or chloroquine.

The principal aim of the investigation was to evaluate color vision deficiency using the Ishihara chart. Before the evaluation, the participants provided informed consent, and an assessment of unaided vision and best-corrected visual acuity was performed, including a near-vision examination. The evaluation of color vision was conducted while ensuring the presence of optimal correction. The Ishihara book, which consisted of 38 plates, was placed in a parallel position to the examinee's face at a distance of 75 cm. The patient was shown each plate for three to five seconds.

The present study sought to acquire dependable and precise information on color vision deficiency within the chosen sample by utilizing a rigorous methodology and adhering to standardized assessment tools. The results obtained from this investigation can augment the current scientific understanding regarding color vision deficiency and its incidence in the particular locality of Islamabad, Pakistan.

Participants who could successfully read all the plates were classified as possessing typical color vision. In contrast, those who encountered challenges in accurately reading the plates were recognized as having color vision impairment. The study examined color vision deficiencies using the chart-based key, a commonly employed screening technique for identifying color impairments.

A structured questionnaire was utilized to collect data on the candidates, encompassing various aspects such as age, gender, presenting complaint, visual acuity, and color vision. The gathered data was entered and analyzed using IBM SPSS Statistics version 20. The study utilized counts and percentages to report qualitative variables and means and standard deviations to present quantitative variables. Chi-square tests were used to evaluate the possibility of discrepancies in color vision deficiency prevalence between genders. A p-value was calculated, and a statistical significance level of less than 0.05 was deemed significant.

The present study endeavored to conduct a meticulous and methodical assessment of color vision deficiency in the cohort by utilizing a comprehensive methodology and statistical analysis, thereby ensuring scientific rigor and validity. Implementing standardized screening instruments, statistical software, and suitable significance levels guarantees the dependability and authenticity of the research outcomes. The study aims to enhance the current scientific knowledge of color vision deficiency by utilizing analytical techniques to uncover possible associations and disparities.

RESULTS

The research encompassed 104 subjects, comprising 54 male individuals (51.92%) and 52 female individuals (48.08%). Results illustrated that 29.80% of individuals under 20 years were color vision deficient, while this percentage was 4.20% and 6% for age strata of 20-30 years and 41-50 years, respectively. The mean age of the subjects was 28.79 years, with a standard deviation of 11.92.

Figure I depicts 29.80 % of the individuals tested for CVD were below 20. 27.88% of the patients lay in the age range of 31-40 years, while patients of ages between 20 and 30 years were 23.07%.

Out of the 104 candidates, a cohort of four participants, comprising 3.8% of the sample, manifested color vision deficiency. Notably, the entire proportion of individuals exhibiting color blindness in this study was composed of males. **Figure II** shows the results mentioned above.

Whereas no female participant displayed any impairment of color vision. This finding was statistically significant, with a p-value of 0.05.

It was also revealed that a pair of subjects manifested a red-green chromaticity impairment, whereas an additional duo of participants evinced total achromatopsia.

Table I shows the frequency of color blindness by

gender. It is noted that male frequency is 3.84% while 0% for females. **Table II** presents a comparative analysis of color vision impairments among diverse age cohorts. CVD is observed as a maximum (6.4%) for the age group under 20 years, while it is a minimum (0%) for the age group of 31.

Figure I: Pie chart for age group stratification

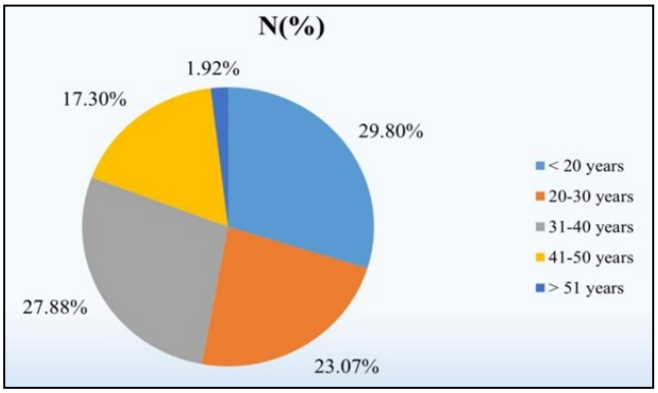

Figure II: Pie chart for color blindness

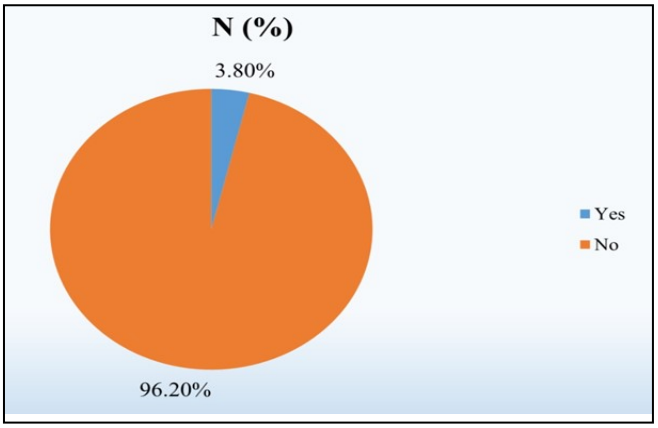

Table I: Frequency of color blindness by gender

Gender	Frequency of Color-blindness
Male	4/104 (3.284 %)
Female	0/104 (0%)

Table II: Age group stratification of vision

Age group	N(%)	Color vision deficient	Normal vision
20 years	29.80-31	2(6.4%)	29(93.6%)
20-30 years	23.07-24	1 (4.2%)	23(95.8%)
31-40 years	27.88-29	0(0%)	29(27.88%)
40-50 years	17.30-18	1(5.6%)	17 (94.4%)
>51 years	1.92-2	0(0%)	2(1.92%)

The present study's results illuminate the frequency of color vision deficiency among the examined sample. The gender disparity that has been observed, wherein all instances of color vision deficiency are found in males, underscores the significance of comprehending the genetic and hormonal factors that play a role in these variations. Furthermore, categorizing distinct forms of chromatic vision deficiencies, such as protanopia and achromatopsia, confers significant perspectives on the portrayal of chromatic vision impairments within the analyzed group. The objective of this study is to contribute to the current body of knowledge on color vision deficiency by presenting the findings succinctly and scientifically. Subsequent research can expand on these discoveries by exploring plausible risk factors, genetic correlations, and the societal ramifications of color vision impairments, culminating in enhanced diagnostic approaches and assistance for individuals affected by such disorders.

DISCUSSION

Color vision deficiency, also known as color blindness, pertains to the incapacity to differentiate between specific hues or, in extreme instances, to perceive colors altogether. Frequently, it is disregarded as it does not commonly impact the sharpness of vision. The incidence of color vision deficiency exhibits notable heterogeneity across diverse nations, and Pakistan has a shortage of population-centric investigations about this ailment. Several research studies in Pakistan have documented the prevalence rates of color vision deficiency, with figures of 5.1% in Rawalpindi and 1.41% in Karachi reported[9]. Furthermore, Hamida 2016[8] documented a prevalence rate of 2.48% within the Quetta population, whereas Akhtar MS 2019[10] ascertained a prevalence rate of 2.75% among students of Pakistani origin. The results above align with the conclusions drawn from our inquiry. The investigation revealed a 3.8% occurrence rate (4 out of 104) of color blindness among male subjects, while no color deficiency was detected among female subjects[11]. The prevalence of color vision deficiency among males was found to be similar to the rates documented in Ethiopia (3.75%), India (3.89%), Western Nepal (3.8%), and Iran (3.5%)[12]. Nonetheless, the prevalence rates observed in males were comparatively lower than the global prevalence rates reported in Belgium (8%), the United States (8%), Turkey (7.33%), and South Korea (6.5%)[13,14]. Furthermore, the investigation conducted by our study has demonstrated a more significant incidence proportion in contrast to prior findings in Saudi Arabia (2.1%), India (1.2%), Iran (2.56%), and textile mill research carried out in Lahore, Pakistan (0.8%)[15-17]. The greater incidence of color vision deficiency among males can be attributed to its X-linked recessive mode of inheritance, whereby females typically serve as carriers. Our study's findings align with prior research conducted in Saudi Arabia, India, Cameroon, and Pakistan, which also observed that color vision deficiency was exclusively reported in males[18,19]. Various studies have documented the occurrence rates of color vision deficiency among females in diverse nations, ranging from 0.54% in Denmark to

3.2% in Iraq[20]. Research conducted in Faisalabad, Pakistan, has indicated a greater incidence of color vision deficiency among female individuals than their male counterparts, indicating the necessity for additional inquiry into this subject[7]. This study enhances comprehension of color vision deficiency in the Pakistani Population by presenting its findings in an appealing and scholarly style. The findings underscore the significance of taking gender inequalities into account and the necessity for additional investigation to examine the frequency and attributes of color vision deficiency in diverse geographical areas and communities.

Although color blindness is not considered a disability, the inability to distinguish between colors can impede an individual's ability to perform specific tasks and may lead to potential occupational risks. According to a study conducted in Iran, medical laboratory technicians with color vision deficiencies exhibited a high frequency of errors in laboratory tests, suggesting that they may not be suitable for providing medical services in this capacity. Several studies have demonstrated that medical professionals with color vision deficiencies perform inferior in specific medical procedures compared to those with trichromatic vision. This study's participants were all previously unaware of their color vision deficiency, and the screening test administered was their initial assessment of color vision. Of the four patients with color vision deficiency, two were aged 17 and 24, corresponding to a period in an individual's life when actively pursuing their career aspirations. The diagnosis of a condition by chance can have a detrimental impact on an individual's self-assurance, and the process of transitioning to a profession that aligns with this impairment can be debilitating. One of the four patients diagnosed with CVD was a 41-year-old individual who was already midway through their professional career and had not yet been aware of their medical condition. The revelation of a CVD diagnosis at this juncture can be harmful to one's mental well-being, as research indicates that such a diagnosis may have an adverse psychological effect.

Congenital color blindness is known to persist unchanged throughout an individual's lifetime. Despite several proposed therapies in the past, such as iodine injection, electrical stimulation of the eye, and high doses of vitamins, none have demonstrated efficacy in enhancing chromatic vision. A limited number of optometrists allowed colored spectacle lenses or a singular red-tinted contact lens to be placed over the non-dominant eye. Although this modification enhanced the discernment of certain hues by modifying the wavelength of each color that enters the eye, it also rendered other colors more difficult to distinguish. A recent study has proposed the implementation of graded color filters as a means of correcting color perception deficiencies. This approach is based on a quantitative analysis of the individual's color sensitivity spectrum.

The gene therapy under experimentation aims to convert individuals with congenital color blindness into trichromats. Gene therapy involves the introduction of a functional gene copy into the patient's cells, enabling the production of normal proteins that can potentially address the underlying cause of the disease. Studies conducted on animals have demonstrated that the introduction of a gene that lacks photo pigment has the potential to bestow the ability to see color. Currently, few clinical trials are being conducted in gene therapy. It is anticipated that for optimal efficacy, such therapies will need to be administered during childhood, underscoring the significance of early screening for CVD.

CVD is an ailment, and its prevalence varies across different regions and populations. Insufficient data is currently available from Pakistan to understand the extent of the disease's impact comprehensively. The present study exhibits shortcomings in distinguishing between various forms of CVD. It does not include a subsequent inquiry into the potential effects of a CVD diagnosis on individuals' psychological well-being, professional trajectories, or any job-related challenges they may face. It is recommended that a study with a larger sample size be conducted that includes an in-depth exploration of the nature of the disease and its impact on the lives of individuals with color deficiency.

CONCLUSION

To summarize, the capacity to perceive and discriminate colors is fundamental for a comprehensive comprehension of the visual realm. Individuals who experience color vision deficiencies may face challenges in multiple facets of their everyday lives. Thus, the present study underscores the significance of timely screening for CVD and dispensing suitable guidance to those affected. Through acknowledging and understanding their limitations, individuals can make informed decisions regarding their career paths and select options that align with their capabilities. Establishing inclusive environments is paramount in aiding individuals with color vision deficiencies surmount their limitations. Minor modifications such as using high-contrast boards and alternative hues to communicate warnings and dangers, can significantly enhance the well-being of these people. Through implementing these measures, it is possible to guarantee that individuals, irrespective of their color vision capabilities, can effectively navigate their environment and engage in all aspects of society. The intricate and captivating domain of investigation pertains to the human ability to perceive color, commonly called "color vision". Additional investigation is necessary to enhance our comprehension of the fundamental mechanisms and genetic elements contributing to color vision deficiencies. Moreover, delving into the social and psychological ramifications of color vision deficiencies can yield significant findings that enhance the well-being of those impacted. The present study

underscores the significance of timely identification, counselling, and establishing inclusive settings to assist individuals with color vision deficiencies. Adopting a scientific and empathetic methodology makes it possible to facilitate the resolution of personal obstacles and cultivate a society that is more accommodating to all individuals.

Ethical permission: Federal Government Polyclinic (Postgraduate Medical Institute) Islamabad, Pakistan, IRB letter No. FGPC.1/12/2020/Ethical Committee.

Conflict of Interest: No conflicts of interest

Financial Disclosure / Grant Approval: No funding agency was involved in this research.

Data Sharing Statement: The corresponding author can provide the data proving the findings of this study on request. Privacy or ethical restrictions bound us from sharing the data publicly.

AUTHOR CONTRIBUTION

Ahmed S:	Data collection
Chaudhry MM:	Proofreading and writing
Malik QA:	Data analysis
Anwar A:	Manuscript writing
Saad HT:	Literature search

REFERENCES

1. Morgan JI, Chui TY, Grieve K. Twenty-five years of clinical using adaptive optics ophthalmoscopy. Biomed Opt Express. 2023; 14(1): 387-428. doi: 10.1364/BOE.472274.
2. Male SR, Shamanna BR, Bhardwaj R, Gandhi R, Bhagvati C, Theagarayan B Impact of color vision deficiency on the quality of life in a sample of Indian Population: Application of the CVD-QoL tool. Indian J Ophthalmol. 2023; 71(5): 2204-11. doi: 10.4103/ijo.IJO_1975_22.
3. Jansone-Langina Z, Ozolinsh M. Evaluation of color vision related quality of life changes due to cataract surgery. J Opt Am A Opt Image Sci Vis. 2023; 40(3): A139-A148. doi: 10.1364/JOSAA. 477090.
4. Alkhalaf AW, Al-khafaji RS. Prevalence and Allele Frequency of Colour Blindness In Al-Najaf Al Ashraf Province. Med Sci J Adv Res. 2022; 3(2): 69-74. doi: 10.46966/msjar.v3i2.43.
5. Ma J, Wang G, Gu C, Xu L. Large-field color vision in anomalous trichromats based on a trichromatic display. SSRN Electronic J. 2022; 74: 1-10. doi: 10.2139/ssrn.4054229.
6. Barnett BS, Sweat NW, Hendricks PS. Case report: Prolonged amelioration of mild red-green color vision deficiency following psilocybin mushroom use. Drug Sci Pol Law. 2023; 9. doi: 10.1177/20503245231172536.
7. Saleem H, Iqbal Y, Malik A, Zia S, Qureshi UA, ul Hassan M. Detecting color vision deficiency in patients presenting with ocular complaints. Professional Med J. 2023; 30(04): 456-60. doi: 10.29309/TPMJ.2023.04.7308.
8. Hamida, Sajid T, Bibi A. Incidence of Protanopia and Deuteranopia, defects of color vision in Quetta, Pakistan. Pak J Zoology. 2016; 48(4): 1045-1049.
9. Omair QM, Imtiaz H, Iqbal M. Color vision defects among textile mill workers in Lahore. Pak J Ophthalmol. 2020; 36(4): 408-411. doi: 10.36351/pjo.v36i4.1100.
10. Akhtar MS, Aslamkhan M, Zar MS, Hanif A, Haris AR. Dichromacy: Color Vision Impairment and Consanguinity in Heterogenous Population of Pakistan. Int J Front Sci. 2019; 3(1): 41-56. doi: 10.37978/tijfs.v3i1.47.
11. Mitiku RG, Tolera BS, Tolesa ZG. Prevalence and allele frequency of congenital colour vision deficiency (CCVD) among students at Hawassa University, Ethiopia. J Egypt Public Health Assoc. 2020; 95: 10. doi: 10.1186/s42506-020-00037-y.
12. Woldeamanuel GG, Geta TG. Prevalence of color vision deficiency among school children in Wolkite, Southern Ethiopia. BMC Res Notes. 2018; 11(1): 838. doi:10.1186/s13104-018-3943-z.
13. Kim H, Ng JS. Prevalence of Color Vision Deficiency in an Adult Population in South Korea. Optom Vis Sci. 2019; 96(11): 866-873. doi: 10.1097/OPX.0000000000001441.
14. Alamoudi NB, AlShammari RZ, AlOmar RS, AlShamlan NA, Alqahtani AA, AlAmer NA. Prevalence of color vision deficiency in medical students at a Saudi University. J Family Community Med. 2021; 28(3): 196-201. doi: 10.4103/jfcm.jfcm_235_21. Epub 2021 Sep 7.
15. Kireker Koylu O, Kasapkara CS. Ophthalmological Findings in Metabolic Diseases. Turkish J Pediatr Dis. 2023; 17(3): 508-513.
16. Zhou J, Chen B. Retinal Cell Damage in Diabetic Retinopathy. Cells. 2023; 12(9): 1342. doi: 10.3390/cells12091342.
17. Heydarian S, Jafari R, Dailami KN, Hashemi H, Jafarzadehpour E, Heirani M et al. Ocular abnormalities in beta thalassemia patients: prevalence, impact, and management strategies. Int Ophthalmol. 2020; 40(2): 511-27. doi: 10.1007/s10792-019-01189-3. Epub 2019 Oct 10.
18. Kar SS, Agrawala M. A study on colour vision deficiency among medical students of Odisha. J Evid Based Med Healthc. 2018; 5(9): 806-808. doi: 10.18410/jebmh/2018/162
19. Dohvoma VA, Ebana Mvogo SR, Kagmeni G, Emini NR, Epee E, Mvogo CE. Color vision deficiency among biomedical students: a cross-sectional study. Clin Ophthalmol. 2018: 1121-4. doi: 10.2147/OPTH.S160110.
20. Karim KJ, Saleem MA. Prevalence of congenital red-green color vision defects among various ethnic groups of students in Erbil City. Jordan J Biol Sci. 2013; 6(3): 235-238.