

Implications of inherited color vision deficiency on occupations: A neglected entity!

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Purpose: To highlight the plight of individuals with congenital color vision deficiency (CVD). **Methods:** This is a retrospective study in which 191 electronic medical records of individuals with the diagnosis of inherited CVD, who visited the eye institute, between January 2010 and January 2021 were included. The inclusion criteria included diagnosis based on the failure in pseudoisochromatic plates (Ishihara/ Hardy, Rand and Rittler (HRR) and age range between 18 and 35 years. The patient's medical history, age, gender, type of defect, and preference for colored contact lenses was noted. Medical records were excluded if the participant had any other ocular pathology apart from congenital CVD. **Results:** At least 30% (57/191) of the individuals explicitly requested for color vision examination for a job-related purpose. Amongst them, the most common jobs aspired were army (~25%; [14/57]) followed by police (21%; [12/57]). There was only 2.6% (5/191) of individuals in which the type of CVD (protan/deutan) was classified. Only 5.2% of them (10/191) sought an X-Chrome contact lens trial. **Conclusion:** This study reported the occupational setbacks experienced by individuals with CVD. This study highlights the need to identify CVD at a younger age, thereby avoiding occupational-related setbacks later in life.

Key words: Abnormal color vision, congenital color vision deficiency, occupational vision, red/green color deficiency

Congenital color vision deficiency (CVD) is common and affects ~ 5 to 6% of Indian males.^[1-6] They are often diagnosed at the time of the pre-recruitment stage for a job^[7] and they are not aware of their condition until then.^[5,8] In some cases, they are diagnosed in an annual health screening, which makes it even worse than the pre-recruitment stage, as the individual's livelihood is immediately at stake. Thus, CVD diagnosis can have a negative psychological impact on their mental state^[9,10] and can adversely affect job prospects.^[11] They often end up putting considerable time and resources (financial and mental) toward an unattainable goal,^[9,10] which results in considerable disappointment, despair, and agony.^[12] However, a study by Cumberland *et al.*^[13] (2005) from the UK downplays the impact of congenital CVD on occupations. They observed a similar proportion of individuals with CVD and normal trichromats pursuing the "target" occupations, where normal color vision is required.^[13] However, they did not provide information, if the individuals with CVD who were working in the "target" occupations were efficient or had experienced/experiencing difficulties in the past or current jobs or were denied any job because of abnormal color vision.^[13] However, in a study conducted in Australia, Steward and Cole (1989) reported that 34% (35/102) of individuals with CVD have admitted their career choice has been affected by defective color vision^[11] and 24% (23/102) of them have been barred from specific

occupations such as police, army, railways/or, electronics and communication due to their abnormal color vision.^[11] In India, with regard to public-sector jobs in medicine, individuals with CVD are usually offered only "temporary" positions instead of "permanent" positions in fields such as cardiology, histopathology, radiology, pathology, biochemistry, and microbiology,^[7] which require a high-grade color vision (a pass in Lantern test, when a small aperture of 1.3 mm is used^[14]). However, apart from the medical profession, it is unclear from the literature regarding the occupational setbacks encountered by the cohort of CVD. Thus, it is important to understand the CVD problem from the occupational landscape in India because the restrictions enforced and exemptions offered to individuals with CVD for specific occupations are different across countries. For example, in 2009, the U.K. Civil Aviation Authority (CAA) introduced the color assessment and diagnosis (CAD) test criteria for flying regulations, which allowed 30 to 35% more aspirants with CVD to qualify as pilots compared to the previous regulations.^[15] In 2019, the New Zealand CAA adopted a new occupational color vision assessment (OCVA) for pilot aspirants, in which an individual's practical competency is assessed both, in-flight and on the ground.^[16] Such tests are more accommodating toward individuals with CVD. However, in India, prior to advocating

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any changes in color vision regulations, to safely accommodate individuals with CVD, it is important to understand the occupational setbacks that are commonly faced by them. This study aims to highlight the occupations commonly aspired by them and the professional plights encountered.

Methods

This is a retrospective study based on convenient sampling because it included only the data available. The study was approved by the Institutional Review Board of the author's institute. The consecutive patients with a diagnosis of congenital CVD who visited the eye institute between January 2010 and January 2021 were included in the study. All subjects failed either the screening plates of HRR or Ishihara plates. In Ishihara plates, if there are more than two errors in the plates between 2 and 17, then they are considered to have CVD. In the case of HRR, plates 7 to 10 were used for screening for red/green CVD. Each plate is shown for 3 sec at a 75 cm viewing distance. Only if all the following three questions are answered correctly, it is considered that the plate is read. a) How many shapes are there on the page? b) What are the shapes? c) Identify the location of the shapes? Even, if one question is answered incorrectly, then they are considered to have failed the test.

The color vision test was administered by the optometrist according to the instructions provided in the test manual. The inclusion criteria for the study were visual acuity of at least 0.0 log MAR (20/20) with or without refractive correction and diagnosis of CVD. The subjects within the age range 18 to 35 years were included to better understand the occupational concerns. The patient's medical history was manually checked to identify the reason for the hospital visit. The experimenter also noted the age, gender, occupation aspired, refractive error, visual acuity, and any significant ocular findings for each of the records. The medical records were excluded if any of the patients had any other ocular disease that can affect color vision. The main outcome variable is reported in the percentage of individuals who opted for a specific occupation.

Results

There was a total of 247 medical records that was diagnosed as congenital CVD; however, 10 records were excluded as they had other pathologies (disc pallor [2], amblyopia [6], pituitary adenoma [1], and retrolbulbar neuritis [1]), where color vision might be compromised. We excluded further 46 records whose age was < 18 years or > 35 years to keep it relevant with regard to occupational aspirants. There were 191 records in total with the diagnosis of CVD within the age of 18 to 35 years for analysis. The age considered was at the time of the visit. Most of them were males (99.47% [190/191]). The typical history of a patient with CVD is presented in Fig. 1. The mean age and standard deviation of the cohort were 26.55 ± 3.65 years. The majority of them were between 20 and 30 years of age [Fig. 2]. The mean (\pm SD) spherical equivalent of the right eyes was -0.88 (2.02) D. All individuals had a visual acuity of 0.0 log MAR (20/20: Snellen equivalent) with or without refractive correction in place.

The medical history of individual records was shifted to obtain the following information. About 30% (57/191) of individuals with CVD explicitly mentioned that they required color vision assessment for a job-related purpose and were anxious if the color vision defect could cost them their job.

Amongst those subjects, some individuals had disclosed the profession they were aspiring for and whereas others did not specify or was it for a private job. The majority of them were applying for government jobs, such as police, army, and other civil services [Fig. 3a]. The mean age of the aspirants was 26.28 ± 3.92 years and the mean age in each of the occupations aspired is shown in Fig. 3b. Additionally, as expected, ~80% (46/58) of these aspirants are emmetropes [Fig. 3c]. Only 2.1% (5/237) of individuals with CVD were subclassified as protan/deutan defects using the Farnsworth D15 test. Only 4.2% (10/237) of the individuals requested for X-chrome lens trial.

Discussion

There are three main findings from the study. 1. The majority of individuals in this cohort got tested for CVD only after the age of 20 years. At least one-quarter of the individuals had been denied jobs, such as in the army and police, due to color vision defects. 2. Only 2% of the subjects tested were subclassified according to the type of CVD (protan/deutan). 3. Only 4% of the subjects sought management options such as X-Chrome contact lenses.

The majority of them were males and it was not a surprising finding, considering red/green CVD has an X-linked inheritance pattern.^[17] The majority of individuals with CVD seek color vision examination after the age of 20 years, suggesting many of them have already decided on a career path. This could be attributed to a lack of awareness of their condition^[18] and there is no compulsion for color vision testing as part of a comprehensive eye exam. This is consistent with a previous retrospective study on screening for pre-employment recruitment, which reported that 77.3% (10,196/13,179) of individuals aged between 20 and 29 years seek their first color vision examination.^[7] Besides, it has been noted that only 4.2% (21/500) of individuals who came for pre-recruitment examination were aware of their condition.^[18]

Let us assume that 5% of individuals with CVD aspire for jobs, such as police, army, or firefighting services, integrating the prevalence data of CVD^[1-6] with the number of males <30 years in the country,^[19] the estimated magnitude of the problem is huge—at least 1 million job aspirants could be potentially denied a job due to CVD. Therefore, this study highlights the need for screening for CVD and counseling at a younger age to avoid disappointments at a later age. The screening can be done either at the school level or alternatively introducing mandatory color vision testing of all children and young adults between the age range 5 and 20 years in an ophthalmic setup. Identifying children with CVD at a younger age would help them cope better in school with various color-related activities in sports and science.^[20] Previously, a study had reported that 63.4% of children with CVD between 10 and 18 years of age chose a career that was not suitable in the presence of color vision defect.^[21] Therefore, children at a tender age are more likely to be open to suggestions of change in career aspirations rather than young adults. Although there are corrective options such as X-chrome contact lenses, most of the jobs in the fields, such as the army, air force, railways, and navy, prohibit the use of color-corrective lenses such as X-chrome. However, corrective lenses may be used for activities such as personal business. The person should be made aware

Category	MRNo.	UHID	Age	Profession	Location	Donor
			21/M	STUDENT	Pathipalli, Warangal, Telangana	--
PATIENT MEDICAL HISTORY						
Case History						
Pt. came for general check up, wants to go for Army job. c/o unable to read the color vision chart yesterday for army selection.						
Category	MRNo.	UHID	Age	Profession	Location	Donor
			25/M	STUDENT	Mundlapadu, Prakasam, Andhra Pradesh	--
PATIENT MEDICAL HISTORY						
Case History						
Chief Complaints						
Complaints of having color blindness in both eyes after being diagnosed at an army medical test 2 years ago No vision related complaints. No other specific complainths.						
Category	MRNo.	UHID	Age	Profession	Location	Do
			31/M	STUDENT	Rudrakshapally, Khammam, Telangana	-
Case History						
Chief Complaints						
Patient is not having any specific visual complaints. K/C/o Color blindness ,Patient never experienced any problem in color identification .He came to know condition when he was rejected for the Constable selection Came here for the further management regarding the color blindness						

Figure 1: Examples of typical medical history noted in individuals with CVD seeking color vision testing for the job-related purpose

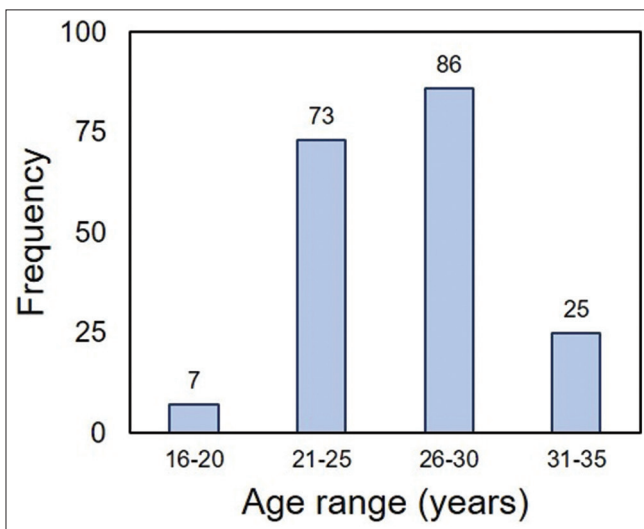


Figure 2: The histogram shows the age-wise distribution of individuals with CVD who came for assessment of color vision

of the potential setbacks associated with it, such as rivalry, loss of depth, perception, and contrast.

The proportion of individuals with CVD barred from jobs in specific fields, such as army and police, reported in this study are similar to the numbers previously reported.^[11] However, the numbers reported here are a conservative estimate, as there is a lack of detailed history in some individuals and also due to the absence of a specific query regarding occupation in history-taking. Moreover, dichromats and protans are more frequently disallowed from a particular job such as police and army compared to individuals with anomalous trichromacy and deutans, respectively.^[11]

The type of color vision defect (protan/deutan) was not documented in at least 98% of the cases. Protans are considered as a relatively more severe form of color vision defect compared to deutans because of relatively closer peak spectral sensitivity curves between long-wavelength sensitive (L) and medium-wavelength sensitive (M) cones.^[22] Besides, the type of CVD (e.g., protans worse than deutans) and severity of CVD (dichromat worse than anomalous trichromats) determine if they are likely to face difficulties in occupational color-related tasks, career choices, and everyday tasks compared to deutans.^[11] There are recommendations that protans should not be allowed to drive commercial vehicles because of their reduced efficiency to identify red light.^[23] Previously, it has

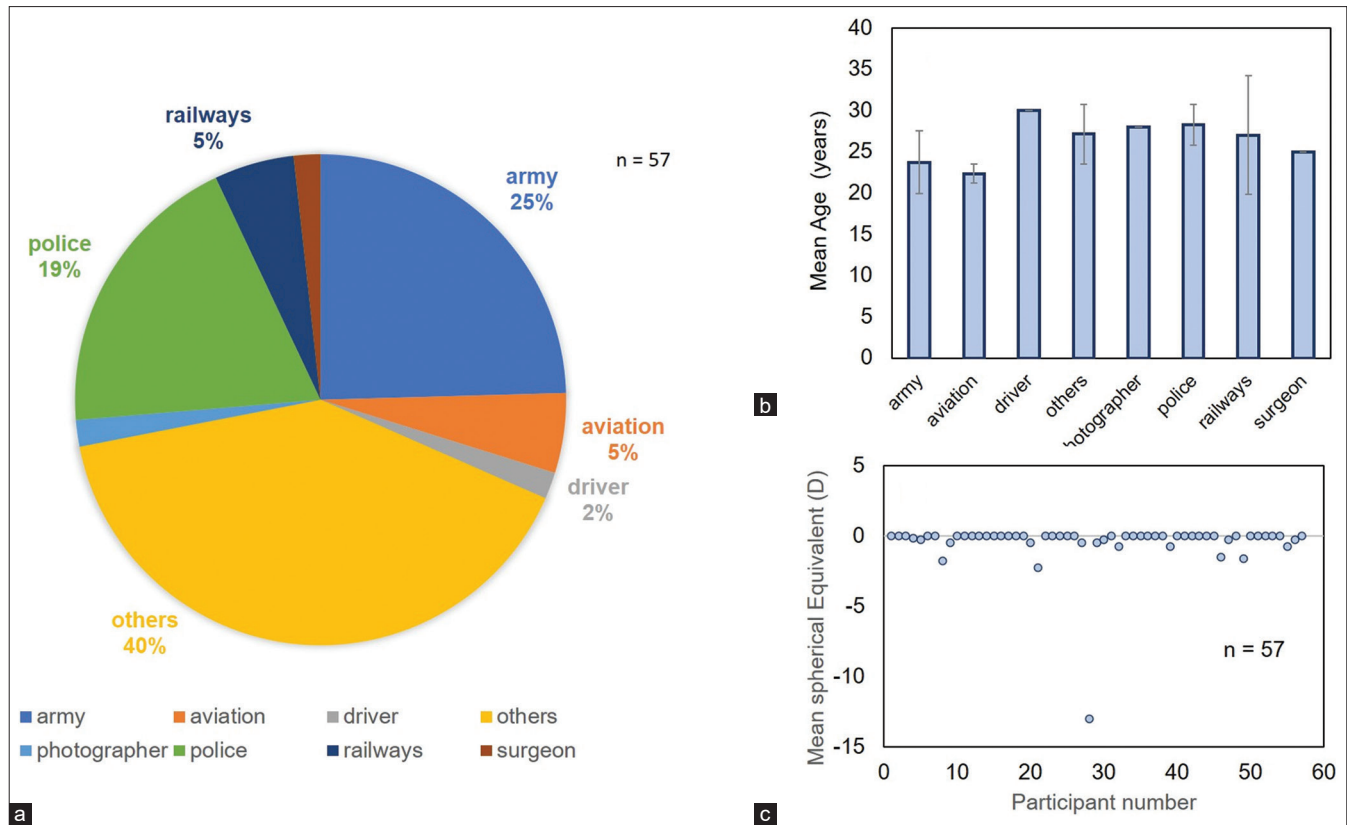


Figure 3: Profile of individuals with CVD who had been barred from different jobs due to their abnormal color vision. Panel (a) Pie chart showing the distribution of professions aspired by individuals with CVD ($n = 65$). Others include competitive government and private jobs. Panel (b) shows the mean (SD) in each age group. Panel (c) shows the spherical equivalent of each individual in the subset

been reported that ~ 50% (18/37) of dichromats and 39% of the protans (14/36) had difficulty in identifying traffic signal lights.^[11] Besides, more proportion of individuals with CVD (38.4%; 48/125) prefer to drive in the daytime relative to normal trichromats (6.7%; 17/252).^[24] This highlights the need to identify the type and severity of the defect in place of current occupational norms in India.^[25]

The number of people with CVD who sought an X-chrome contact lens trial was very low. There are no previous studies to compare this result. Various reasons that could be attributed are as follows: Unlike refractive correction spectacles, any colored filters (such as X-chrome) are not allowed while taking up occupational color vision tests, which might have discouraged the individuals to try it.^[26] Besides, the potential beneficial effect in improving the color perception is limited,^[27-30] in addition to the apparent interocular differences in contrast resulting in undesirable effects, such as rivalry between the eyes and loss in depth perception.^[27-30]

Limitations

The study has a few limitations. First, based on the history, it has been ascertained that most of the individuals were not aware of their CVD and the first detection of color vision defect happened in an occupational setting. Second, it cannot be commented on whether the severity and type of defect played a role in the subset of subjects, who were not allowed to pursue their job because of defective color vision. Another limitation is that there is a lack of information on the current job that they are pursuing. However, it could be because many

of them were “between” jobs or attempting to for their “first” job. We have also not reported if the career choice made by individuals with CVD were affected by defective color vision. Because this is a retrospective study, the data are generated only by the information that was previously collected and such specific information regarding the career choice made in the context of color vision was not available. Therefore, there is also potential to conduct a comprehensive questionnaire survey to better identify the difficulties with regard to career choices and also regarding the coping mechanisms adopted by them in their occupation.

Conclusion

This study identified key issues regarding the occupational setbacks encountered by individuals with CVD. Previously, the data of CVD prevalence and its implication was limited to medicine-related fields.^[7] However, this is the first study to provide novel data regarding the impact of CVD on specific jobs in sectors, such as the air force, army, and police. Full exemptions for individuals with CVD cannot be provided; however, identifying the type and severity of the defect in occupational settings would provide relief for at least some individuals with a mild-to-moderate level of CVD. The implications of this new knowledge with regard to CVD and occupational setbacks would be the first step toward voicing advocacy changes in the recruitment process in various professions based on the type, severity of color vision loss, and critical color-related task in the work environment.

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Conflicts of interest

There are no conflicts of interest.

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