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RESEARCH ARTICLE

# Awareness and Educational Gaps in Color Vision Deficiency: A Survey-Based Analysis from Gujarat, India

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ABSTRACT: Color blindness (or Color Vision Deficiency (CVD)) affects millions of people worldwide, impacting the ability to differentiate colors. This study investigated how many people in Gujarat, India, are aware of the consequences of CVD. A survey conducted on 482 individuals (including students, teachers, parents, and professionals) revealed unawareness and a lack of school testing policies. Participants supported awareness programs, better teaching materials, and smartphone apps for CVD individuals. Logistic regression and decision trees are promising techniques to identify key factors influencing awareness. The results highlight the need for more testing, education, and support in Gujarati schools.

KEYWORDS: Color Vision Deficiency, Awareness Survey, logistic regression, Decision Tree Classification.

## Introduction

Color blindness or Color Vision Deficiency (CVD) is a prevalent genetic illness.[1] Most individuals remain unaware that a family member may be affected by CVD, leading to delayed identification and support.[2] Awareness of CVD at the initial stage is limited. This affects everyday life and professional environments.[3] In India, the issue is underreported and underexplored. Limited literature is available that investigates awareness of color blindness. No study was found related to children. Ahmad *et al*. found that commercial drivers often ignore their color blindness.[4] Harikrishnan and Mohan similarly observed a lack of CVD awareness among professionals in the visual media field in Kerala, India.[5] Dhaliwal *et al*. noted that while some doctors perceive CVD as a risk, others support inclusive policies through proper training.[6]

Technology offers new opportunities to support colorblind individuals. AI-powered tools and mobile applications can assist with color identification.[7] Salih *et al*. introduced wearable devices that enhance color perception in time.[8] Tigwell worked on inclusive design, addressing CVD awareness gaps among product developers.[9] Despite technological advances, schools in India still lack structured screening policies for CVD, especially in developing countries like India. Senjam *et al*. found limited access to assistive technologies, even in specialized schools.[10] Pinner highlighted the need for adaptations for CVD students.[11] Cohen *et al*. further revealed that people often do not notice missing colors in their vision, underscoring how CVD can go undetected.[12]

This study surveys awareness levels, knowledge gaps, and available spaces for colorblind individuals in Indian municipal schools of Gujarat. It builds on the epidemiological work by Fareed *et al*. and newer studies emphasizing the role of education, policy, and assistive technology.[1] This study is based on the hypothesis that awareness of CVD among school communities is predominantly associated with individual roles, age, prior exposure to color confusion, and familiarity with diagnostic tools such as the Ishihara test. Objectives of the study are as follows:

- To assess awareness of CVDs among students, teachers, parents, and professionals.
- To understand the testing and accommodating policies of schools.
- Examine the psychological and social impact.
- Analyze career challenges.
- Identify key demographic and behavioral factors influencing awareness.

## Methods

A Google survey was done in 319 Gujarat municipal schools, collecting responses from 482 individuals (172 females, Figure 1(a)): 274 students, 63 teachers, 53 parents, and 92 professionals responded to the form (Figure 1(b)). A convenience sampling strategy was used to select participants. Participation was voluntary, and survey links were distributed via school administrators and online educational groups. Participants varied in age group, classified as 0-10, 10-20, 20-30, 30-40, 40-50, 50-60, 60-70, and 70-80 years. Major participants were in the age group of 10-50 years old (Figure 1(c)). The questionnaire consisted of 30 items, including multiple-choice questions. It was divided into four sections: demographic details, general awareness of CVD, personal or familial experience with CVD, and perspectives on educational support and career impact. Statistical analyses were applied to ascertain significant relationships between age, role, color confusion, and other variables with the levels of awareness. A logistic regression model was developed to predict support for school counseling and awareness programs based on role, awareness of CVD, and experiences with face color confusion. A decision tree classifier was also trained using Gini impurity, a max depth of 5, and a minimum split of 10 samples to determine influencing factors for awareness. All statistical analyses and machine learning models were implemented using MATLAB R2024b.



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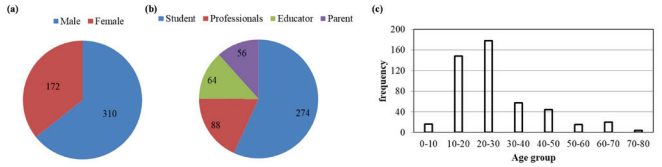


**Figure 1:** (a) Gender distribution showing counts of male and female participants, (b) participant roles categorized as student, professional, educator, and parent, and (c) age group distribution of all respondents represented across predefined age intervals. The participant pool was predominantly male students. Most respondents were under 30 years of age.

## Result and Discussion

The poll results show modest knowledge levels; 66.4% of respondents had heard of CVDs, but just 33.4% knew their frequency. 37.1% of respondents knew that most cases include red-green color deficit; awareness of the Ishihara test was 42.6%. 91.3% have never been tested for CVD (Figure 2). 12.6% of participants have a CVD family member (Figure 3). 66.6% of participants agreed that CVD reduces self-confidence, particularly among students (Figure 4). 60.2% of affected patients said they had never witnessed taunting due to CVD (Figure 4). Respondents expressed strong worry about career challenges caused by CVD. While 38.5% supported alternate work assessments to accommodate a CVD individual, 30.2% agreed that job rejection due to CVDs was appropriate. 73.6% of participants favored changes in teaching materials and examination techniques. 65.5% supported teacher training programs, while 87.2% supported school counseling activities for CVD students. 86.9% of respondents had never utilized color blindness assistance, while 75.5% were interested in a color identification smartphone application.

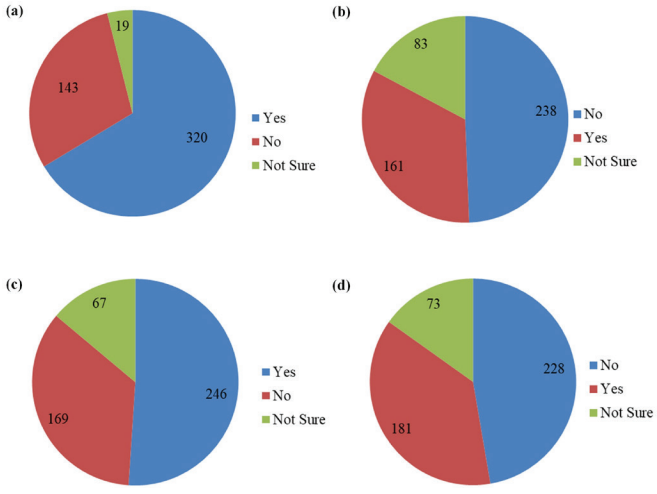


**Figure 2:** Participant responses on various aspects of Color Vision Deficiency (CVD): (a) general awareness of color blindness, (b) knowledge of its prevalence, (c) familiarity with the Ishihara Test and school screening procedures, and (d) understanding of the broader impact of CVD. Most participants were aware of color blindness, but significant gaps existed in understanding its prevalence, testing methods, and broader impact, highlighting the need for enhanced education and awareness efforts.

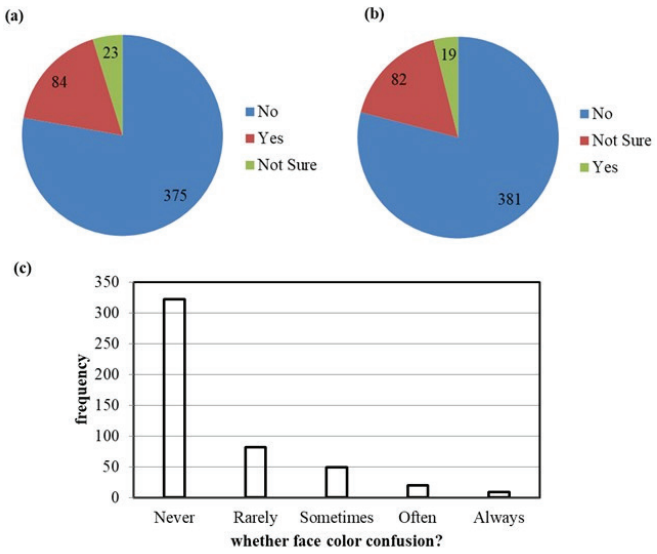


**Figure 3:** Statistics on participant experiences related to Color Vision Deficiency (CVD): (a) whether the participant has undergone CVD testing, (b) the presence of CVD in any family member, and (c) instances of color confusion experienced by the participant in daily activities. Most participants reported not being tested for CVD and were unaware of any family history of the condition. Additionally, the majority stated they never experience color confusion in daily life, which suggests limited direct engagement with CVD-related challenges.

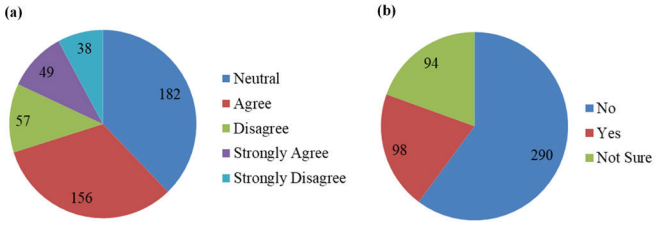


**Figure 4:** (a) Participant opinions on the impact of Color Vision Deficiency (CVD) on self-confidence, and (b) responses regarding observations of teasing or bullying related to CVD at school or in the workplace. Participants agreed that CVD can impact self-confidence, although many remained neutral. Most respondents reported not witnessing teasing or bullying related to CVD.

Statistical analyses showed that younger respondents (<30 years) had significantly higher awareness (t-test, p=0.018), awareness varied by profession (ANOVA, p=0.0026), age had a weak negative correlation with awareness (-0.15), role had a moderate association with awareness (Cramer's V=0.29), and gender and job disqualification opinions had weak associations with awareness (0.18 and 0.16, respectively).

The Logistic Regression model, with 76.8% accuracy, has been given in Eq. (1). The decision tree classifier achieved an accuracy of 72.16%, with the best performance in predicting color blindness awareness (Yes class, 86% recall). The most influential factors were awareness of Ishihara tests, prior color blindness testing, and family history. The most influential factors are given in Figure 5.

$$\log\left(\frac{P(Y=1)}{1-P(Y=1)}\right) = -1.78 + 0.42(Role) + 1.12(Awareness) + 0.68(Color\ Confusion) \quad (1)$$

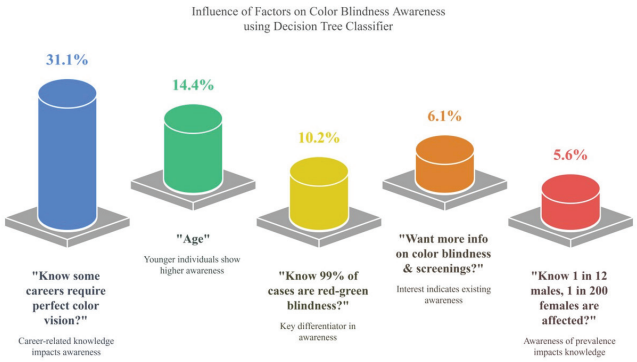


**Figure 5:** Influencing factors for Color Vision Deficiency (CVD) awareness identified using a Decision Tree Classifier. The figure illustrates the factors that influence selected variables in predicting awareness of color blindness, including career-related knowledge, age, understanding of red-green color blindness, interest in screenings, and awareness of prevalence statistics. Career-related knowledge is the most influential factor in predicting CVD awareness, followed by age and understanding red-green blindness.

This study has a few limitations. The data was collected from municipal schools in Gujarat, which may not represent the broader population across India or globally. All responses were self-reported, possibly introducing biases or inaccuracies in understanding and experiences. The study did not include clinical testing to confirm CVD, relying on participants' awareness and perception. Additionally, the use of online surveys may have excluded individuals without internet access or digital literacy, potentially limiting the diversity of the sample.

## ■ Conclusion

This study inspected the awareness of CVD patients from Gujarat's municipal schools. Among all 482 participants, 66.4% heard of CVD, and 33.4% understood its prevalence. Most participants have not had them tested or even heard of the associated tests (for example, the Ishihara test). Students, teachers, and parents have limited knowledge about the impact of CVD on daily life. Most participants with CVD have acknowledged that the condition affects their confidence and limits their career choices. This study suggested a need for teacher training, school counseling, color-friendly materials, and mobile apps. Machine learning models (Logistic regression and decision tree models) exhibited that awareness and personal experience were key determinants of support for CVD awareness programs. Though performed in Gujarat schools, this study highlighted an urgent requirement for early screening, awareness campaigns, and revised education policies.

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Freya Prajapati is a Grade 9 student with a deep interest in biology and veterinary sciences. As the Co-founder of Aiding Colors, she actively participates in the colorblindness screening camps. She has surveyed 482 individuals to understand the awareness and accommodation in schools for colorblind students. Seeing her brother, Aahan, struggle to differentiate between colors motivated her to use technology to help people with invisible disabilities.

Aahan Prajapati is a Grade 11 student with a deep passion for computational biology, focusing on computational vision science and visual perception modeling. Being red-green colorblind, he aims to develop innovative healthcare solutions that can positively impact people's lives with his project, Aiding Colors – An initiative for screening and counseling for colorblindness.



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