

Colour Vision Deficiency Screening Using Mobile Apps in School Children**Ushaswi G.¹, Gadipalli Ravichandra², Kalva Pravalika³**¹Assistant Professor, department of Ophthalmology, Prathima Relief Institution of Medical College (PRIMS), Hanumakonda²Assistant Professor, department of Ophthalmology, Mamata Medical College, Khammam³Consultant Ophthalmologist, Maxivision eye hospitals, Warangal

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Abstract:**Background:** Colour vision deficiency (CVD) is a common hereditary condition that often remains undiagnosed in children, potentially affecting learning and career choices. Smartphone-based applications offer a promising alternative to traditional Ishihara plate testing for large-scale screening.**Aim:** To assess the diagnostic accuracy, feasibility, and acceptability of a mobile application for CVD screening among school children compared to the standard Ishihara test.**Methods:** A prospective observational study was conducted at Prathima Relief Institute of Medical Sciences, Hanumakonda, from February to May 2025. Three hundred children aged 8–16 years underwent testing using both Ishihara plates and a validated mobile app. Statistical analysis using SPSS version 26 calculated sensitivity, specificity, PPV, NPV, and diagnostic accuracy.**Results:** CVD prevalence was 5.0% by Ishihara and 6.7% by the mobile app. The app demonstrated 93.3% sensitivity, 97.9% specificity, and 97.7% diagnostic accuracy. Most participants found the app easier and more engaging. No significant gender differences were observed.**Conclusion:** Smartphone-based screening is a reliable, quick, and child-friendly alternative for CVD detection. Its high accuracy and acceptability make it ideal for mass school-based vision screening programs in low-resource settings.**Keywords:** Colour Vision Deficiency, Ishihara Test, Mobile Application Screening, School Children, Diagnostic Accuracy.

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Introduction

Colour vision deficiency (CVD), often referred to as color blindness, is one of the commonest inherited visual disorders globally, affecting approximately 1 in 12 men and 1 in 200 women in many populations [1]. Early detection in school-age children is important not only because undiagnosed CVD may interfere with learning, safety (e.g. interpreting color-coded information), and career choice, but also because children are often unaware of their own deficiency [2]. Traditional screening approaches rely on printed pseudoisochromatic plates (such as Ishihara plates), but these demand physical materials, lighting control, and trained examiners. With the proliferation of smartphones and tablets, mobile apps for visual testing including color vision is emerging as a scalable and low-cost alternative [3]. Recent reviews suggest that mobile apps can mimic most traditionally paper-based tests of visual function and may enable even illumination, standardized administration, and digital record keeping [4].

In this context, our study aims to evaluate the diagnostic accuracy and feasibility of using a smartphone/tablet-based color vision app for screening CVD in school children, compared to the gold standard Ishihara test. This study could pave the way for scalable screening in low-resource settings and early identification of children with CVD for counselling or further evaluation.

Methods

This prospective, observational study was carried out in the Department of Ophthalmology, Prathima Relief Institute of Medical Sciences (PRIMS), Hanumakonda, between February 2025 and May 2025. Prior approval was obtained from the Institutional Ethics Committee, and written informed consent was secured from the parents or guardians of participating students. School authorities were contacted, and permission was granted to conduct vision screening sessions. The study targeted school children aged 8–16 years, attending classes from 3rd to 10th standard, as this

group is developmentally capable of understanding test instructions and represents the age when colour vision-related difficulties can impact learning. Children with known ocular diseases, history of ocular trauma, or congenital anomalies affecting the visual system were excluded from participation.

All participants underwent a comprehensive ocular examination, including visual acuity assessment using the Snellen's chart, anterior segment evaluation with a torch and loupe, and fundus examination with a direct ophthalmoscope to rule out ocular pathology. Following this, each child underwent colour vision testing using two modalities: the standard Ishihara pseudoisochromatic plates (24-plate edition) under daylight illumination, and a validated mobile application (Color Blind Check or equivalent) installed on a calibrated Android tablet. Testing was performed monocularly at a fixed distance of 75 cm, with screen brightness standardized at 80% and ambient lighting controlled to minimize glare. Each participant was instructed and allowed one practice trial before actual testing. Results from the app were automatically recorded, whereas Ishihara responses were manually entered in the proforma.

Data collected included age, gender, class, socioeconomic status, and colour vision test results. Children identified with suspected deficiency by either method were re-examined for confirmation. The Ishihara test served as the gold standard. Statistical analysis using SPSS version 22 calculated sensitivity, specificity, PPV, NPV, and diagnostic accuracy of the mobile app. Chi-square test assessed categorical variables, with $p < 0.05$ considered significant.

Results:

A total of 300 school children aged 8–16 years participated in the study, with a slight male predominance (56.7%). The majority (60.7%) belonged to the middle socioeconomic class. The overall prevalence of CVD by the Ishihara test was 5.0%, while the mobile application identified 6.7% as colour-deficient. Among the 20 cases identified by the mobile app, 14 were true positives confirmed by the Ishihara test, 6 were false positives, and only 1 false negative was recorded. The sensitivity of the mobile app was 93.3%, indicating its ability to correctly identify children with CVD, while specificity was 97.9%, confirming its reliability in detecting normal colour vision. The positive predictive value was 70.0%, suggesting a few false positives, while the negative predictive value was 99.6%, reflecting excellent accuracy in ruling out CVD. The overall diagnostic accuracy was 97.7%. Most participants reported that the mobile app was easier and more engaging to use compared to printed Ishihara plates. No significant gender differences were observed in CVD prevalence. These findings

suggest that smartphone-based colour vision screening is a reliable, quick, and child-friendly alternative to conventional methods, especially for mass school screenings in low-resource settings.

Discussion

In the present study, the prevalence of CVD among school children using the gold standard Ishihara test was 5.0%, which aligns closely with previous studies conducted among Indian and Asian populations, where reported prevalence ranges from 3% to 8% in males and less than 1% in females [1]. The slightly higher overall prevalence (6.7%) detected by the mobile application suggests the presence of some false positives, but also indicates its high sensitivity in identifying potential CVD cases. A higher detection rate by digital methods has been previously documented, as smartphones provide consistent illumination, magnification, and uniform colour rendering compared to printed plates [5]. The predominance of CVD in males in this study is consistent with the X-linked recessive inheritance pattern of red-green deficiency, which remains the most common type across populations [6]. The inclusion of school-aged children (8–16 years) is particularly significant, as early detection at this stage allows for appropriate educational and career guidance to prevent psychosocial and academic challenges.

Diagnostic validation of the mobile application showed high sensitivity (93.3%) and specificity (97.9%), demonstrating excellent concordance with the Ishihara test. The negative predictive value of 99.6% underscores the potential utility of mobile-based screening in large-scale community or school programs where traditional printed plates are not readily available. Comparable findings were reported by Bassi et al. (2024), who found that smartphone-based colour vision testing achieved diagnostic accuracy exceeding 95% under controlled lighting [7]. Furthermore, children in this study reported greater comfort and engagement while using the app, reflecting the advantages of digital interaction in paediatric populations. The few false-positive results may be attributed to variations in screen calibration and ambient light. Nevertheless, this study supports the feasibility of smartphone-based CVD screening as a low-cost, portable, and user-friendly alternative, especially beneficial in resource-limited educational settings where ophthalmic screening resources are scarce.

The present study demonstrated that the mobile application achieved 93.3% sensitivity and 97.9% specificity compared with the Ishihara test, indicating strong diagnostic reliability. High sensitivity reflects the app's capacity to accurately detect children with CVD, reducing the likelihood of missed cases. Similarly, the high specificity underscores its precision in correctly identifying

those with normal colour vision, minimizing false alarms. The PPV (70.0%) suggests that while most app-detected cases were true positives, a few false positives may have arisen from variations in screen calibration or ambient lighting. However, the NPV (99.6%) highlights the app's excellent performance in ruling out CVD among normal individuals, ensuring that children with normal colour perception are rarely misclassified. These findings are consistent with previous validation studies that demonstrated smartphone-based vision tests could reach diagnostic accuracy levels comparable to conventional tools under standardized conditions [5]. A 2024 study by Bassi et al. also reported over 95% concordance between digital and traditional methods, supporting their clinical utility for community and school-based screening [7]. Thus, smartphone-based colour vision testing can serve as a reliable, cost-effective, and scalable screening approach in pediatric ophthalmology.

The present study demonstrated an overall diagnostic accuracy of 97.7% for the mobile application when compared with the standard Ishihara test, affirming its strong potential as a dependable screening tool for CVD. The minimal discrepancy between both methods reflects high agreement and reinforces previous research showing that digital screening tools, when properly calibrated, can achieve accuracy levels nearly identical to clinical standards [5]. The higher engagement and ease of use reported by participants in this study highlight the educational and psychological benefits of technology-based testing in school-aged children. Such digital interaction fosters better attention, reduces anxiety during testing, and enables wider participation in mass screenings [8]. Moreover, the high diagnostic accuracy observed in this study demonstrates that even low-cost, smartphone-based tools can reliably detect red-green deficiencies, which account for more than 95% of congenital CVD cases worldwide [6]. This technology could thus serve as a valuable adjunct to existing school vision programs, especially in rural or resource-limited regions where traditional equipment and trained ophthalmic personnel are scarce.

Importantly, the study also found no significant gender difference in CVD prevalence, consistent with epidemiological data showing that while males are predominantly affected due to X-linked inheritance, small samples and random variation may obscure statistical differences. The child-friendly interface and reduced testing time offered by the app make it ideal for use in school health initiatives, promoting early detection and educational guidance for affected students. Similar outcomes were observed in a study by Bassi et al. (2024), which reported high user satisfaction and

diagnostic equivalence between mobile app testing and standard colour vision plates [7]. The portability, automated data capture, and ease of deployment of smartphone applications also enable large-scale epidemiological mapping of colour vision anomalies. Overall, the present findings support the integration of mobile-based screening into national school eye health programs as a cost-effective, accurate, and scalable alternative to conventional testing methods.

Conclusion

The present study demonstrated that smartphone-based colour vision screening applications are highly accurate, user-friendly, and feasible alternatives to traditional Ishihara tests. With a diagnostic accuracy of 97.7%, high sensitivity, and specificity, the mobile app effectively identified children with colour vision deficiency while engaging participants through its interactive interface. The absence of significant gender differences and positive user feedback reinforce the suitability of digital screening tools for school settings. This approach can revolutionize paediatric ophthalmic screening by enabling large-scale, low-cost, and rapid detection of colour vision defects, particularly in resource-limited and rural educational environments.

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