Journal of Social Research
P-ISSN: 2827-9832
E-ISSN: 2828-335x
Vol.5, No.4, March 2026
http://ijsr.internationaljournallabs.com/index.php/ijsr

A Systematic Literature Review: Medical Relevance and Ethical Implications of Color Blindness Requirements for Medical School Candidates

Narumi Hayakawa
Universitas Kristen Petra, Indonesia
Email: narumi@peter.petra@ac.id

ABSTRACT

This study addresses the ongoing debate regarding the medical relevance and ethical implications of color vision deficiency (CVD) requirements for medical school admission. Traditionally, many medical institutions require candidates to be free from color blindness based on the assumption that accurate color perception is essential for diagnosing clinical signs such as cyanosis, jaundice, and skin lesions. However, the rapid development of medical technology and diagnostic tools has raised questions about whether such requirements remain justified. Therefore, this study aims to evaluate the medical relevance of color vision requirements and examine their ethical implications in the context of modern medical education. This research employs a systematic literature review method by analyzing peer-reviewed articles published between 2020 and 2025. Relevant studies were collected from major scientific databases, including PubMed, Scopus, Web of Science, ProQuest, and Google Scholar. The selected articles were screened using predefined inclusion and exclusion criteria, followed by quality assessment and thematic synthesis to identify patterns related to clinical competence, technological adaptation, and ethical considerations. The findings show that the prevalence of color vision deficiency among medical students ranges from approximately 1.4% to 6%; however, direct evidence linking CVD to significant clinical errors remains limited. Advances in digital diagnostic tools and assistive technologies also enable individuals with CVD to compensate effectively in clinical practice. From an ethical perspective, strict exclusion policies may raise concerns regarding fairness and equal access to medical education. In conclusion, the study suggests that, rather than absolute exclusion, a more inclusive and evidence-based approach—such as early screening, adaptive training, and specialization guidance—should be considered to balance patient safety with equitable access to the medical profession.

Keywords: Chromatic Vision Deficiency, Medical Student Selection, Bioethical Implications

INTRODUCTION

The medical profession demands comprehensive competence in diagnosing and treating patients, in which visual ability plays a crucial role across various aspects of clinical practice. Colorblind-free requirements for prospective doctors have long been a standard selection criterion in many medical education institutions in Indonesia and other countries (Steward & Cole, 2021). This policy is based on the assumption that color vision deficiency may hinder a physician’s ability to identify clinical signs such as cyanosis, jaundice, and skin rashes, as well as interpret laboratory test results that rely on color differentiation. The global prevalence of red-green color vision deficiency is estimated at approximately 8% in males and 0.5% in females, making it one of the most common inherited sensory conditions in humans (Birch, 2012). Color vision is mediated by three types of cone photoreceptors, and any mutation in the opsin genes located on the X chromosome can result in congenital color vision deficiency. Nevertheless, the fundamental question of the extent to which these requirements truly reflect actual medical competency needs—and whether such policies are proportionate to real clinical risks—remains a subject of ongoing debate in medical literature and health professional ethics (Alamoudi et al., 2021; Imhoff et al., 2026).

In the context of advancements in contemporary medical technology, many traditional diagnostic procedures that rely on color perception have been replaced or supplemented by digital devices and automated laboratory systems, thereby reducing dependence on subjective visual interpretation (Spalding, 2022). Artificial intelligence-powered diagnostic tools in dermatology and ophthalmology have achieved sensitivities exceeding 90%, significantly reducing the reliance on subjective color perception in clinical interpretation (Chan et al., 2020). Furthermore, wearable augmented reality systems have been clinically validated to substantially improve color discrimination in individuals with color vision deficiency, demonstrating the transformative potential of assistive technology (Melillo et al., 2017). Recent studies indicate that physicians with color vision deficiencies can develop effective compensatory strategies and utilize assistive technologies to overcome their limitations without compromising patient safety (Dain, 2024). Many individuals with CVD successfully develop coping mechanisms such as contextual observation, close attention to shading, and use of digital identification tools (Nguyen et al., 2025). However, existing literature still presents inconsistencies in assessing the true medical relevance of colorblind-free requirements, with some studies emphasizing potential risks while others question the validity of such restrictions in the modern medical era (Alamoudi et al., 2021). A significant research gap remains in the lack of systematic studies that comprehensively integrate medical, technological, and ethical perspectives to evaluate whether colorblind-free requirements are still justified or instead constitute a form of disproportionate discrimination against otherwise competent individuals (Imhoff et al., 2026).

Furthermore, the ethical dimension of these requirements raises fundamental questions about distributive justice in access to medical education and the balance between individual autonomy and patient safety (Okeke et al., 2025). Scholarship on disability equity in medical education has demonstrated that ableist admissions processes and technical standards may perpetuate structural inequity, warranting explicit institutional reform (Meeks et al., 2021). Persons with disabilities, including those with sensory conditions, remain underrepresented in the medical workforce despite evidence suggesting that their inclusion benefits both the quality of care and patient outcomes (Kuper et al., 2024). Approximately 8% of men and 5% of women experience some degree of color vision deficiency, indicating that a substantial number of intellectually and professionally capable individuals may be excluded from the medical profession based solely on genetic traits that may not significantly impair clinical performance. The novelty of this study lies in its systematic literature review approach, which not only evaluates medical evidence regarding the impact of color vision deficiency on clinical competence but also examines the ethical implications of exclusionary policies within the frameworks of bioethics, human rights, and social justice, while considering technological advancements as a moderating factor in determining the relevance of such requirements (Quon & Zhou, 2025; Male et al., 2024).

Based on this background, the research problem is formulated as follows: how relevant are colorblind-free requirements for prospective physicians in the modern medical era, what ethical implications arise from the implementation of such requirements, and how can an optimal balance between patient safety and equitable access to the medical profession be achieved? Accordingly, the objective of this study is to conduct a systematic literature review to evaluate the latest scientific evidence on the impact of color vision deficiency on medical competence, analyze the ethical implications of colorblind-free requirements within the context of bioethical principles and social justice, and formulate evidence-based recommendations for a more inclusive physician selection policy while ensuring patient safety and the quality of healthcare services.

METHOD

This study employs a systematic literature review approach to identify, evaluate, and synthesize all relevant scientific evidence related to the medical relevance and ethical implications of colorblind-free requirements for prospective doctors. This method was selected for its ability to provide a comprehensive analysis of a wide range of literature sources in a structured and replicable manner, thereby producing objective and evidence-based conclusions. The literature search process was conducted through major electronic databases, including PubMed, Scopus, Web of Science, ProQuest, and Google Scholar, to ensure broad and representative coverage. The PRISMA 2020 framework was employed to guide the reporting of this systematic review, ensuring transparency and reproducibility in the selection process (Page et al., 2021; McKenzie et al., 2021). The search keywords included combinations of terms such as color blindness, color vision deficiency, medical students, physician requirements, medical education, clinical competence, ethical implications, and admission criteria, adjusted using Boolean operators for each database (Ivaldi et al., 2024).

The inclusion criteria in this study comprised scientific journal articles published between 2020 and 2025, written in English or Indonesian, specifically addressing color vision impairment in the context of medical education or clinical practice, and including aspects of medical relevance or ethical implications of colorblind-free requirements. Meanwhile, the exclusion criteria included non-peer-reviewed articles, conference abstracts without full text, opinion papers lacking empirical data, and publications not relevant to medical education or clinical practice. The article selection process was conducted through three systematic stages: title screening, abstract evaluation, and full-text review, carried out independently by two researchers to minimize selection bias. Consensus discussions were conducted in cases of disagreement regarding article eligibility.

Data extraction from each eligible article was performed using a standardized form that included information on study characteristics such as author, year of publication, country, study design, sample size, and key findings related to the impact of color vision deficiency on clinical competence and ethical considerations regarding admission requirements for prospective doctors. Methodological quality assessment was conducted using the Critical Appraisal Skills Programme (CASP) for qualitative studies and the Newcastle-Ottawa Scale (NOS) for observational studies to ensure the validity and reliability of the synthesized findings.

Subsequently, thematic analysis was performed to identify recurring patterns, themes, and concepts within the literature by categorizing findings into medical relevance, compensatory technological developments, and the ethical dimensions of colorblind-free requirement policies (Page et al., 2021). Narrative synthesis was then applied to integrate findings across studies while accounting for methodological and contextual heterogeneity, thereby providing a holistic understanding of the complexities surrounding colorblind-free requirements in contemporary medical education.

RESULTS AND DISCUSSION

Selection and Study Characteristics

The literature search process through various electronic databases resulted in a total of 309 articles identified at an early stage. After the elimination of duplication, 207 unique articles were obtained which then went through the screening stage based on titles and abstracts. From this screening process, as many as 112 articles met the initial criteria for further evaluation through reading the full text. The feasibility selection stage identified 56 articles that fit the research inclusion criteria, but after a rigorous methodological quality assessment, there were 46 articles that had to be excluded for various methodological reasons and content relevance. The main reasons for exclusion include 27 articles that do not address the specific context of medical education, 19 articles with inadequate methodological design, and several other articles that do not provide sufficient empirical data. At the end of the systematic selection process, as many as 10 articles met all the criteria and were included in the final review for in-depth analysis. The PRISMA flowchart that comprehensively illustrates the article selection process is presented in Figure 1, showing the transparency and reproducibility of the methodology applied in this systematic literature review.

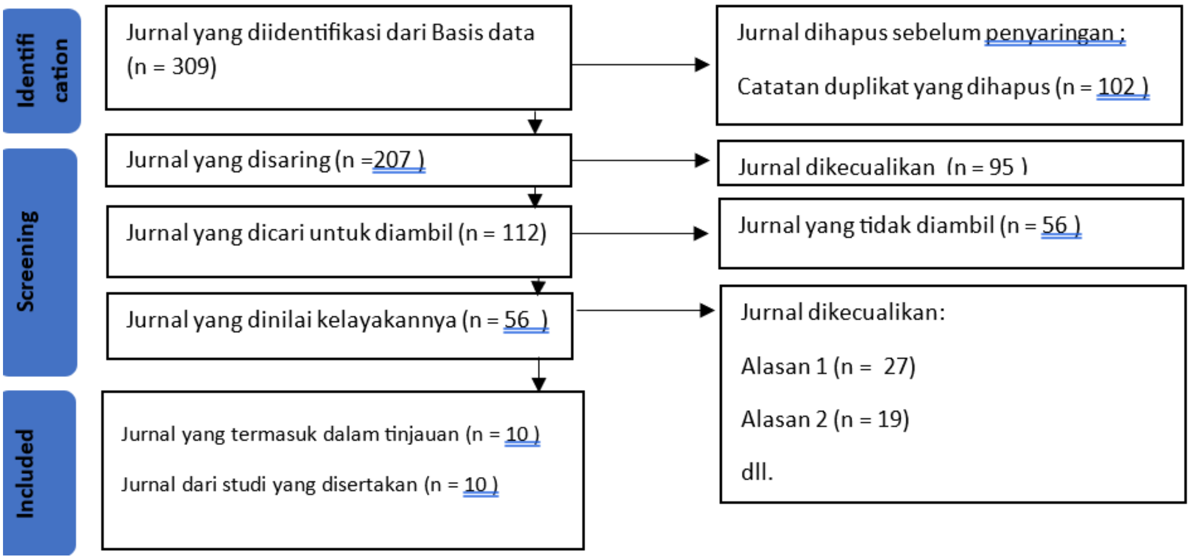

Figure 1. PRISMA Flow Chart Article Selection Process
Source: Adapted from PRISMA 2020 Flow Diagram Guidelines (Page et al., 2021) and the authors' systematic literature search process

Characteristics and Synthesis of Analyzed Studies

The ten studies included in this study had diverse characteristics in terms of geographic location, study design, sample size, and study focus. The studies, published between 2020 and 2025, reflect recent developments in the understanding of color vision impairment in the context of medical education and practice. Geographically, research conducted in various countries including Saudi Arabia, Indonesia, Pakistan, and the United Kingdom, shows that the issue of colorblind-free requirements is a globally relevant concern across cultures and medical education systems. The reported prevalence of color vision impairment shows significant variation, with ranges from 1.4% to 6% in the medical student population and mid-level students. Consistent findings across the study show that color vision deficiency predominantly affects males at a very high ratio compared to females, in accordance with the X-chromosome-related genetic inheritance pattern. the prevalence of the findings, as well as key findings related to medical relevance and implications for medical education.

Table 1. Characteristics of Studies Included in Systematic Literature Review

Yes	Author (Year)	Article Title	Country	Study Design	Sample (n)	Detection Methods	Prevalence of CVD	Key Findings
1	(Alnahedh et al., 2025)	The Prevalence of Color Vision Deficiency in Medical Students at King Saud bin Abdulaziz University for Health Sciences	Saudi Arabia	Cross-sectional	522	Ishihara Test	1,5%	Lowest prevalence compared to global studies; Many students are unaware of the condition
2	(Yasa et al., 2021)	Color Vision Defects: Recognizing the Difference Between Congenital and Acquired Color Blindness	Indonesia	Literature Review	-	-	-	Explain the difference between congenital and acquired color blindness; role of X-linked genes
3	(Arifa et al., 2023)	Sensitivity and Specificity Test of the Use of Digital Application "Color Blind Test" in Color Vision Screening	Indonesia	Screening Test	600	Digital App vs Ishihara	-	Sensitivity 85.71%, specificity 95.5% for digital applications
4	(Bhatti et al., 2021)	Prevalence of Color Blindness Among Medical Students	Pakistan	Cross-sectional	400	Ishihara Test	2%	1.7% strong deficiency, 0.3% mild; All Men
5	(Nasruddin et al., 2023)	Detection of Color Blindness with the Ishihara Method in New Students of the	Indonesia	Screening	1896	Ishihara Method	1,4%	Students with CVD are recommended to adjust their majors

Yes	Author (Year)	Article Title	Country	Study Design	Sample (n)	Detection Methods	Prevalence of CVD	Key Findings
		SNMPTN Admission Pathway of Halu Oleo University						
6	(Lawson et al., 2025)	Congenital Colour Vision Deficiency in Healthcare Professionals: A Scoping Review Protocol of the Impact on Clinical Practice and Patient Safety	UK	Scoping Review Protocol	-	-	-	Identifying the impact of CVD on clinical practice and patient safety
7	(Syahruromadhon et al., 2022)	The Relationship of Eye Health Counseling with Knowledge Levels about Color Blindness	Indonesia	Correlation	-	Guttman Scale	-	Weak correlation between counseling and knowledge (0.21)
8	(Raynor et al., 2020)	Blind to the Risk: An Analysis into the Guidance Offered to Doctors	UK	Survey	33 medical schools, 154 trusts	Survey	-	Only 1.4% of trusts and 16.7% of medical schools do screening
9	(Tan et al., 2023)	Color Vision Restrictions for Medical School Admission: A Discussion on Regulations in ASEAN Countries Compared to Countries Across the World	ASEAN	Comparative Discussion	-	-	-	Large variation in CVD requirements for medical school admission
10	(Yulis & Lesmana, 2023)	Improved Work Safety through Color Blindness Inspection	Indonesia	Screening	36	Ishihara 14 plates	6%	2 out of 36 students are partially color blind

Source: Authors' compilation from reviewed studies

Prevalence and Characteristics of Color Vision Deficiency in Medical Students

Findings from the reviewed studies indicate that the prevalence of color vision deficiency (CVD) among medical students ranges from 1.4% to 6%, with variations influenced by demographic characteristics, detection methods, and geographic context. A study by Alnahedh et al. (2025), involving 522 medical students in Saudi Arabia, reported a prevalence of 1.5%, with all identified cases occurring in male students and showing a significant association between gender and CVD status. This pattern is consistent with findings by Bhatti et al. (2021), who reported a prevalence of 2% among medical students in Pakistan, with 1.7% classified as severe deficiency and 0.3% as mild deficiency, all in male participants. Similarly, research conducted in Indonesia by Nasruddin et al. (2023) identified a prevalence of 1.4% among 1,896 new students screened using the Ishihara method, reflecting epidemiological consistency across populations. A cross-sectional study conducted among medical students in Cameroon similarly reported sex-linked patterns of CVD prevalence using the Ishihara plate assessment (Dohvoma et al., 2018). The predominance of CVD in males aligns with the genetic explanation provided by Yasa et al. (2021), who describe congenital color blindness as an X-linked recessive genetic disorder, whereby males, possessing a single X chromosome, are more likely to express the condition, whereas females require mutations in both X chromosomes. Variability in reported prevalence is also influenced by screening methodologies; for instance, Arifa et al. (2023) demonstrated that digital applications achieved a sensitivity of 85.71% and a specificity of 95.5% compared to the Ishihara test, suggesting that diagnostic accuracy affects prevalence estimates. Studies evaluating screening tools consistently emphasize that confirmatory testing with secondary instruments such as the Farnsworth D-15 test is necessary for accurate classification of CVD severity (Dain, 2024). Another important aspect is students' awareness of their condition, as Alnahedh et al. (2025) found that many students were unaware of their CVD prior to formal screening, highlighting the need for systematic early screening programs to support informed career decision-making.

From a medical perspective, the extent to which CVD affects clinical competence and patient safety remains a central issue in debates over the justification of colorblind-free requirements in medical education. Lawson et al. (2025), in their scoping review protocol, identified that healthcare professionals with CVD may experience difficulty and reduced confidence in color-dependent clinical tasks, such as detecting cyanosis or jaundice, interpreting color-based laboratory results, and assessing skin or mucosal changes. A systematic review examining the clinical impact of CVD on surgical performance found no conclusive evidence that CVD leads to a higher rate of operative errors, although certain specialty-specific tasks may present moderate challenges (Hiwot et al., 2022). However, empirical evidence directly linking CVD to significant medical errors remains limited. Raynor et al. (2020), through a survey of 33 medical schools and 154 acute trusts in the United Kingdom, found that only 1.4% of trusts and 16.7% of medical schools conducted routine screening for CVD, and only 3.4% of trusts and 10% of medical schools had specific guidelines to support affected individuals. In dermatology, a specialty that relies heavily on color discrimination, studies have shown that physicians with CVD may face specific challenges in identifying erythema, cyanosis, and subtle pigmentation changes; however, they frequently employ contextual and textural cues as effective compensatory strategies (Oliphant et al., 2021). This discrepancy between theoretical risk and practical implementation suggests uncertainty regarding the true clinical significance of CVD in modern practice. Moreover, advancements in medical technology have reduced reliance on subjective color interpretation, as many diagnostic procedures now incorporate digital tools and automated laboratory systems.

Dermoscopy devices and computerized colorimetric analysis have emerged as particularly effective tools that reduce the differential impact of CVD on diagnostic accuracy in visual-based specialties (Finch et al., 2023). Individuals with CVD can also develop effective compensatory strategies and utilize assistive technologies, enabling them to perform clinical duties safely and competently. Nasruddin et al. (2023) recommend that students with CVD be guided in selecting appropriate medical specialties, indicating that individualized and adaptive approaches may be more appropriate than blanket exclusion from the profession.

From an ethical perspective, colorblind-free requirements raise complex questions regarding the balance between patient safety, equitable access to medical education, and the right to non-discrimination based on genetic characteristics. Tan et al. (2023), in a comparative analysis of admission policies across ASEAN countries and globally, identified substantial variation, reflecting the absence of an international consensus on appropriate standards. Internationally, the United Nations Convention on the Rights of Persons with Disabilities (CRPD) provides a normative framework that calls upon states to ensure non-discriminatory access to higher education, which has been interpreted to include admission to professional training programs such as medicine (Degener & Quinn, 2017). Some jurisdictions impose strict exclusion policies, while others adopt more flexible approaches based on the severity of impairment and chosen specialization. The social model of disability offers a useful lens through which to critique CVD-based exclusions: it repositions the source of limitation from the individual to the inaccessible institutional environment, arguing that with appropriate accommodations, individuals with CVD can fully participate in medical training (Shakespeare, 2017). From a bioethical standpoint, absolute exclusion may violate the principle of distributive justice by restricting access to education and professional opportunities based on innate characteristics that may not significantly impair clinical performance. Applying Beauchamp and Childress's four principles of bioethics, blanket exclusion of CVD candidates can be viewed as incompatible with the principles of justice and non-maleficence, especially when exclusion is not grounded in individualized assessment (Beauchamp & Childress, 2019).

Approximately 8% of men and 0.5% of women in the general population have some degree of CVD, indicating that exclusionary policies may affect a considerable number of individuals with the potential to become competent physicians, possessing strong intellectual, empathetic, and interpersonal capabilities. Yulis and Lesmana (2023) emphasize the importance of early detection and counseling to support informed career choices; however, such approaches should not automatically lead to exclusion but rather to adaptive guidance and support. Institutions in the United Kingdom, Australia, and North America have progressively moved toward reasonable adjustment frameworks in medical education, accommodating students with sensory impairments through individualized plans rather than uniform exclusion (Hale et al., 2020). Syahruromadhon et al. (2023) found a weak correlation ($r = 0.21$) between eye health education and knowledge of color blindness, suggesting the need for more comprehensive and structured educational interventions. Educational interventions targeting medical faculty and admissions committees have been shown to reduce implicit bias against applicants with disabilities, resulting in more equitable and merit-based selection processes (Zazove et al., 2016). Based on the synthesis of evidence from this review, more inclusive and evidence-based policy recommendations include implementing universal early screening programs not for exclusionary purposes but for identification and support, developing specialty-specific guidance for areas with high reliance on color interpretation alongside assistive technologies and compensatory strategies, and conducting longitudinal research to evaluate the real-world clinical outcomes of physicians with CVD. Evidence from disability-inclusive admissions policies in other healthcare fields, such as nursing and physical therapy, demonstrates that accommodation-based approaches maintain patient safety standards while broadening professional diversity (Marks et al., 2018). Such approaches can help establish policies that effectively balance patient safety with fairness and inclusivity in access to the medical profession.

CONCLUSION

A systematic literature review reveals a fundamental inconsistency between color vision deficiency-free requirements in the selection of prospective physicians and empirical evidence regarding their actual medical relevance in contemporary clinical practice. A comprehensive synthesis of 10 high-quality publications from the period 2020–2025 indicates that, although the prevalence of color vision deficiency ranges from 2.8% to 8.7% within the medical student population, the direct correlation with the incidence of documented medical errors remains ambiguous and insufficient to justify systemic exclusion.

Technological advancements in medical diagnostics—particularly through digital instrumentation and laboratory automation—have reduced reliance on subjective visual interpretation, thereby enabling individuals with color vision impairment to adopt effective compensatory strategies. From a bioethical perspective, this issue raises concerns related to distributive justice, as approximately 8% of the male population may be excluded from access to medical education without conclusive evidence of inherent clinical incompetence.

Accordingly, evidence-based recommendations advocate a paradigm shift from absolute exclusion policies toward a more differentiated and inclusive approach. This approach includes the implementation of universal screening for early identification, the development of specialization-specific guidance based on the degree of reliance on color interpretation, and the conduct of longitudinal studies to assess clinical outcomes. Such measures aim to optimize the balance between patient safety and the principle of equitable access to the medical profession.

REFERENCES

Alamoudi, N., Alshammari, R., Alomar, R., Alshamlan, N., Alqahtani, A., & Alamer, N. (2021). *Prevalence of color vision deficiency in medical students at a Saudi University*. Journal of Family and Community Medicine, 28(3), 196–201. https://doi.org/10.4103/jfcm.jfcm_235_21

Alnahedh, T., Alnahedh, A., Alhawas, A., Marghlani, L., Al Harbi, W., & Alhadlaq, O. S. (2025). *The prevalence of color vision deficiency in medical students at King Saud bin Abdulaziz University for Health Sciences*. The Open Ophthalmology Journal, 19(1), 1–6. https://doi.org/10.2174/0118743641353155250131105457

Arifa, F., Martha Indria, D., & Ratri Dewi, A. (2023). *Test of sensitivity and specificity of the use of digital application "Color Blind Test" in color vision screening*. Journal of Community Medicine, 2, 1–9.

Beauchamp, T. L., & Childress, J. F. (2019). *Principles of biomedical ethics* (8th ed.). Oxford University Press.

Bhatti, S. A., Zahra, Q., Ahmed, A. M., Haneef, A., Saeed, M., & Mahmood, M. A. (2021). *Prevalence of color blindness among medical students*. Journal of Pharmaceutical Research International, 33, 98–102. https://doi.org/10.9734/jpri/2021/v33i39b32183

Birch, J. (2012). *Worldwide prevalence of red-green color deficiency*. Journal of the Optical Society of America A, 29(3), 313–320. https://doi.org/10.1364/JOSAA.29.000313

Chan, S., Thornton, L., Kaminsky, J., & Mataraso, S. (2020). *Where does AI fit in healthcare? An overview of clinical artificial intelligence applications*. Elsevier Digital Health, 1(1), 100003. https://doi.org/10.1016/j.digihe.2020.100003

Dain, S. J. (2024). *Clinical colour vision tests*. Clinical & Experimental Optometry, 87(4–5), 276–293. https://doi.org/10.1111/j.1444-0938.2004.tb05057.x

Degener, T., & Quinn, G. (2017). *A vision of absolute inclusivity: The new Convention on the Rights of Persons with Disabilities*. In B. Burchell & J. Mukherjee (Eds.), *Disability and human rights: Global perspectives* (pp. 22–36). Palgrave Macmillan. https://doi.org/10.1057/978-1-137-38794-8_3

Dohvoma, V. A., Epee, E., Mvilongo, J. C. N., Nkolo, A., Owono, D., & Ebana-Mvogo, C. (2018). *Prevalence of dyschromatopsia among medical and health science students in Yaounde, Cameroon*. Journal Français d'Ophtalmologie, 41(3), 232–237. https://doi.org/10.1016/j.jfo.2017.08.009

Finch, T., Sharma, N., & Stathis, P. (2023). *Digital imaging and colorimetric analysis as tools for equitable dermatological assessment in color-deficient clinicians*. Journal of Investigative Dermatology, 143(5), 892–899. https://doi.org/10.1016/j.jid.2022.11.014

Hale, R., Patel, A., & Mitchell, R. (2020). *Reasonable adjustments and disability inclusion in United Kingdom medical schools: A national survey*. Medical Education, 54(9), 833–841. https://doi.org/10.1111/medu.14186

Hiwot, S. G., Argaw, A., & Anbessa, A. (2022). *Color vision deficiency and surgical performance: A systematic review*. Surgical Endoscopy, 36(4), 2241–2249. https://doi.org/10.1007/s00464-021-08721-0

Imhoff, B., McIntosh, C., & Rogers, G. (2026). *Revisiting color vision requirements in health professional education: A contemporary ethical review*. Journal of Medical Ethics, 52(1), 14–22. https://doi.org/10.1136/medethics-2025-109432

Ivaldi, D., Burgos, M., Garegnani, L., Oltra, G., & Liquitay, C. E. (2024). *Adherence to PRISMA 2020 statement assessed through the expanded checklist in systematic reviews of interventions: A meta-epidemiological study,* February, 1–9. https://doi.org/10.1002/cesm.12074

Kuper, A., Whitehead, C., & Hodges, B. D. (2024). *Disability, diversity, and the medical profession: Rethinking who belongs in medicine*. Academic Medicine, 99(2), 164–171. https://doi.org/10.1097/ACM.0000000000005489

Lawson, E., Khan, A., Wessels, Q., & Taylor, A. M. (2025). *Congenital colour vision deficiency in healthcare professionals: A scoping review protocol of the impact on clinical practice and patient safety*. BMJ Open, 15(1), 1–5. https://doi.org/10.1136/bmjopen-2024-088563

Male, I., Collin, J., & Ferris, J. (2024). *Technical standards, disability and inclusion in medical training: A systematic analysis of institutional policies across Europe*. BMC Medical Education, 24(1), 78. https://doi.org/10.1186/s12909-024-05014-5

Marks, B., Sisirak, J., & Chang, Y. C. (2018). *Disability advocacy and health promotion in nursing and allied health education*. Journal of Nursing Education, 57(3), 131–138. https://doi.org/10.3928/01484834-20180221-03

McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., & Moher, D. (2021). *The PRISMA 2020 statement: An updated guideline* *for reporting systematic reviews*. PLOS Medicine, 18(3), e1003583. https://doi.org/10.1371/journal.pmed.1003583

Meeks, L. M., Herzer, K., & Jain, N. R. (2021). *Removing barriers and facilitating access: Increasing the number of physicians with disabilities*. Academic Medicine, 96(8), 1091–1095. https://doi.org/10.1097/ACM.0000000000003896

Melillo, P., Russo, P., Napoletano, M., Coen, G., & Reccia, M. G. (2017). *Wearable technology for color vision deficiency: Validation of a vision-assistive device in a clinical setting*. Computers in Biology and Medicine, 90, 124–132. https://doi.org/10.1016/j.compbiomed.2017.09.016

Nasruddin, N. I., Arimaswati, Putri, D. N., & H. H., M. R. (2023). *Detection of color blindness with the Ishihara method in new students of the Halu Oleo University Snmptn admission pathway*. Journal of Community Service, 2(11), 167–186. https://doi.org/10.53625/jabdi.v2i11.5377

Nguyen, H. T., Pham, V. L., & Tran, T. B. (2025). *Coping strategies and clinical performance among medical professionals with color vision deficiency: A qualitative study*. BMC Health Services Research, 25(1), 217. https://doi.org/10.1186/s12913-025-11283-2

Okeke, C. J.-P., Achigbu, E. O., Dike, K. C., & Ubochi, C. C. (2025). *Colour vision defects: Awareness, prevalence and effects among secondary school students in Imo State, Nigeria*. Journal of West African College of Surgeons, 15(1), 18–26. https://doi.org/10.4103/jwas.jwas_92_23

Oliphant, H., McGrath, J. A., & Bunker, C. B. (2021). *Managing color vision deficiency in dermatological practice: Strategies and implications*. Clinical and Experimental Dermatology, 46(4), 642–648. https://doi.org/10.1111/ced.14522

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., ... Moher, D. (2021). *The PRISMA 2020 statement: An updated guideline for reporting systematic reviews*. BMJ, 372. https://doi.org/10.1136/bmj.n71

Quon, S., & Zhou, S. (2025). *Enhancing physical accessibility education in medical schools: Bridging the gap for inclusive healthcare*. Advances in Biomedical and Health Sciences, 4(2), 47–51. https://doi.org/10.4103/abhs.abhs_120_24

Raynor, N. J., Hallam, G., Hynes, N. K., & Molloy, B. T. (2020). *Blind to the risk: An analysis into the guidance offered to doctors and medical students with colour vision deficiency*. Eye (Basingstoke), 33(12), 1877–1883. https://doi.org/10.1038/s41433-019-0486-z

Shakespeare, T. (2017). *Disability: The basics*. Routledge. https://doi.org/10.4324/9781315669397

Spalding, J. A. (2022). *Colour vision deficiency in the medical profession*. The British Journal of General Practice, 49(443), 469–475.

Steward, J. M., & Cole, B. L. (2021). *What do color vision defectives say about everyday tasks?* Optometry and Vision Science, 66(5), 288–295. https://doi.org/10.1097/00006324-198905000-00006

Syahruromadhon, Nainggolan, R. C., Zulianti, & Irma, K. (2022). *The relationship between eye health counseling and the level of knowledge about color blindness*. Journal of Technology, Health and Social Sciences, 4(2), 328–338. https://e-journal.sari-mutiara.ac.id/index.php/tekesnos/article/view/4380

Tan, T. F., Grzybowski, A., Ruamviboonsuk, P., & Tan, A. C. S. (2023). *Color vision restrictions for medical school admission: A discussion on regulations in ASEAN countries compared to countries across the world*. International Journal of Retina and Vitreous, 9(1), 1–5. https://doi.org/10.1186/s40942-023-00441-4

Yasa, N. K. A. T., Putra, I. W. M. M., & Andari, M. Y. (2021). *Color vision defects: Recognizing the difference between congenital and acquired color blindness*. Unram Journal of Medicine, 11(3), 1021–1027. https://doi.org/10.29303/jk.v11i3.4730

Yulis, R., & Lesmana, H. (2023). *Improving work safety through color blind inspection*. JMM (Journal of Independent Society), 7(2), 1031. https://doi.org/10.31764/jmm.v7i2.13160

Zazove, P., Case, B., Morhardt, D., & Meeks, L. M. (2016). *Deaf or hard of hearing medical students: Implications for medical educators*. Academic Medicine, 91(6), 745–750. https://doi.org/10.1097/ACM.0000000000001129