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Color Vision Deficiency CVD among Medical Laboratory Students of Khartoum University, Sudan (2021-2022)

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Abstract: Background: *Color vision deficiency CVD is the absence of the competency to discriminate between certain colors. However, congenital red-green CCVD is an X-linked recessive disease; occurs almost exclusively in males, while the blue type is acquired. The progression of CVD is known to differ from euthenics groups and geographical regions of the world.* ***The objective of the study:*** *The existing study aimed to screen and ascertain CVD among laboratory students at the University of Khartoum (U of K), Sudan.* ***Subjects and Methods:*** *by using questionnaires statistical techniques and Ishihara charts. A group of 264 medical laboratory students with a mean age of (21 years ±2.4 standard deviation) was invited to the cross-sectional study.* ***Results:*** *The study revealed no significant association was found between age (P <0.685), gender (P <0.464), and CVD as well as between year of education (P < 0.405), region of birth (P <0.92), and CVD (P <0.05), respectively. The prevalence of definitive CVD was 1.5%. A Hundred percent (100) % of CVD victims are unaware of their condition. Females accounted for (73.1%). Three-quarters of the students with CVD were in the first year, whereas one-quarter is in the final year. No significant associations were enumerated between CVD status and region of birth.* ***Conclusions and Recommendations:*** *The study concluded that several medical students with CVD remain ignorant of their circumstances and subsequently may have numerous issues in their medical education, particularly in ascertaining color slides, and specimens, and examining certain physical signs. We recommend early screening of all school-age children, proper handling for medical students with definitive CVD to take care of their health, and being alert to their condition when choosing their specialties for the future. This will ensure avoidance of mistakes and any consequent medico-legal litigations in their professional lives.*

Keywords: *CVD, Color Vision Deficiency, CD Color Deficiency or Defects University of Khartoum (U of K), Medical laboratory students, the prevalence*

Introduction:

Color vision deficiency CVD is the absence of the capability to discriminate between certain colors. John Dalton is the first scientist who writes a scientific paper regarding Color deficiency CD He was a color deficient victim and that is why CVD was named previously 'Daltonism'. [1] The progression of CVD is different from euthenics groups and geographical regions of the world. [2-4] CD is a function of three types are [Tritan (blue) Duetan (green), and Protan (red)] of cone pigments present in the retina. Congenital red-green CVD is an X-linked recessive disease; as a result, it occurs almost exclusively in males, while the blue type is acquired. [5, 6] Consequently, some color-deficient people are not able to recognize any color and see the world as gray. [7] Remarkably in late 2012, a large random population survey conducted worldwide in Europe Asia, and African continents demonstrated that the prevalence of inherited red-green CD in different populations is extensively studied. The prevalence of CVD in European Caucasians is instituted 8% in men and 0.4% in women. Whereas, 4% and 6.5% in men of Chinese and Japanese ethnicity. Incoming migrants, genetic drift, rather than natural selection refer to these variances regarding CVD prevalence among gender and ethnicities as the interaction of the geographic areas that have been settled. In addition, this survey abstracted that the prevalence ratio for males/females is markedly different in Europeans and Asians. [8]

Many other studies validated that the most cause of CVD is related to inadequacy or genetic imperfection. Nonetheless, it might also be acquired through damage that affects the eye, nerve, and brain. Moreover, the abuse of definite chemicals might have played a role or shared the same conformity in disease incidence rates. [9] Recently, at King Faisal University (KFU), Saudi Arabia, a study was conducted to ascertain CVD prevalence among medical students. The prevalence of CVD was found to be 9/323 (2.7%) among the study participants. The Study originated that the red-green CVD was instituted in 5/194 (2.57%) for females whereas for males initiated in 4/129

(3.1%). However, two out of nine students had CVD and suffered from other vision problems. The remaining 7 were not suffering from any vision problems. Besides, 22.2% of the participants have had a CVD family history and 77.78% did not. The study exhibited no significant relationship between CVD and those who have a family history of CVD. Furthermore, the study proved that CVD among medical students in KFU is noticeable. Since this disorder can affect their performance in the future, they should be made aware of their condition and be guided to consider this problem while practicing their jobs. [9] Nevertheless, Non-recognition of any of the three colors is known as color blindness. Color blindness is the commonly used term for deficiency of color vision. The Word color blindness is a misnomer for anyone labeled, as it is extremely rare to be very colorblind hence more correctly called color vision deficiencies CVD. Problem statement: The incidence of CVD is commonly neglected in the medical profession. This ailment is known to affect the proper diagnosis and treatment of patients but it remains the most neglected aspect of vision in medical circuits. Color is a very important sign used in the medical profession, but there is no effective screening for CVD at any level of the medical profession. [8] The present study was undertaken to screen CVD in medical laboratory students, at Khartoum University (U of K), Sudan. Additionally, health professionals who suffer from CVD have faced many difficulties in detecting physical signs, body-color changes (pallor, cyanosis, jaundice), skin rashes and erythematic, Stage I pressure ulcers, blood or bile in urine, feces, sputum, vomit, melena, mouth, and throat conditions, test strips, color-coded medications, charts, slides, prints, and color sensitive monitors. Subsequently, the patients' safety is in danger if CVD is not tested both rely. CVD is a rare disease known by a few students, and another part of them does not even know about their condition. [10, 11] The medical laboratory students must be aware and alert of their deficiencies and they should know their severity. Therefore, special care in clinical practice is critically needed. [12] Thereinafter, the existing study will attempt to fill the gaps of knowledge in this neglected area. Therefore, the study justifies investigating the prevalence of CVD among U of K medical laboratory students and evaluating the awareness of the students about this disease and its confrontational effects on their future study careers. The objectives of the current study are to study Color vision deficiency CVD among medical laboratory students of Khartoum University, Sudan, to determine the prevalence of CVD among U of K medical laboratory students assess the alertness of the students regarding CVD

Material and Methods

3.1. Study Area:

The study was conducted at the Medical Laboratory College; University of Khartoum (U of K). It is located in Soba about 22 Km far from Khartoum downtown. The medical College has five-grade levels. Students in grade four divided into five specializations are Haematology, Parasitology, Clinical chemistry, Histology, and microbiology.

Fi: 3.1. The location of medical laboratory sciences university of Khartoum (Uof K)

3.2. Study design: A descriptive cross-sectional facility-based study.

3.3. Study duration: The study was done in a period from (May 2021 to May 2022)

3.4. Study population: Medical laboratory students (males and females) of all batches, aged between 18 and 25 years. The total population is 700.

3.5. Inclusion criteria:

1/Medical laboratory students of (Uof K)

2/students with ages ranging from (18-25) years.

3.6. Exclusion criteria:

1/Non-Sudanese students

2/Students with age classes ranging from ≤18≥ 25yrs

3.7. Sample size:

The sample size was calculated by using the population formula

n =N/ (1+N e2) [52]

Where:

n=corrected sample size

N=population size =700

e= margin of error, e=.05, based on the research condition=700/(1+700*.0025) =700/2.75=254.5 =255

Therefore, the actual number of the sample size is 255

3.8. Sample technique:

Systematic random sampling was used as a technique.

3.9. Data collection tools and methods:

The duration of collecting data for the existing study was about two months from the 4th of May to the 5th of July 2021

3.9. 1. Materials:

Verbal consent was obtained from each participant at the onset of this study. Two tools were used to investigate the problem:

3.9. 2. Questionnaire:
This questionnaire is structured with adaptation, taken from a study of the prevalence of color vision deficiency among medical students in KFU-SA (2014-2015). A pilot study of ten medical laboratory students was conducted to confirm that the questions in the questionnaire are well understood by participants to answer. Eighteen different questions were asked in the questionnaire.,4 questions about Sociodemographic data,7 questions about personal and family history,5 questions about awareness of CD , and 2 questions about the kind of chronic diseases which the participants currently have and the use of some drugs like sildenafil, ethambutol, and hydroxychloroquine.[9]

3.9. 3. Ishihara's chart
This chart was made in Japan, and it consisted of 38 plates called Ishihara plates, nine of them were visible to those with normal color vision, and invisible, or difficult to see, to those with CVD. [53]
First, lists of all students' names were obtained from the registration office of the faculty. Then the students who are selected by the systematic random sampling were asked to fill out the questionnaire, and read the chosen plates on the Ishihara's chart.
It is not required to apply the Color Vision Deficiency test to all 38 plates, but it is feasible to apply it to 24 specific plates. I used 24 plates, and those who were only able to read seven or less of the 24 plates were labeled as color vision deficiency victims.
I made these plates in a form of hard copy cardboard and used them for applying the test. For students who were abroad or not available at the university during the study period, an online form of the questionnaire and plates were dispatched to them to test for CVD.

3.10. Study variables:

3.10.1. Dependent variable: Color vision deficiency

3.10.2. Independent variable: age, gender, region of birth, year of study, optical problem, family history, history of eye or head trauma, exposure to chemicals, current health problem, it A in the diet, use of chronic disease medication, current chronic disease and use of drugs like sildenafil, ethambutol, and hydroxychloroquine

3.11. Methods of analysis: Two methods of analysis were used in the present study, namely descriptive statistics and chi-square test

3.11. 1. Descriptive statistics: They are used to describe the basic feature of the data in a study and to provide simple summaries about the sample and the measures.

3.12. Data analysis:
Data were collected according to the questionnaire technique, sorted, verify edited, processed, and analyzed. Likewise, the Chi-square test was applied to determine whether, there is a significant difference between CV and those who have a family history of CVD, and other vision problems. This test (x2) and other statistical tests were applied to explore the dependencies between the CVD and other parameters or variables, and when they were significant, they were reported along with the corresponding p-value. Statistical analysis was also performed using Statistical software besides individual descriptive measures. Data were cleaned, entered into Ms. Excel, analyzed by statistical analysis using SPSS version 22, and then presented tables and figures in terms of frequency, and percentages.[54]

3.13. Strengths and limitations of the study:

Among other reports, this study was the first to bring this problem (CVD) to the attention of laboratory medical students at the University of Khartoum.

3.13.1. Limitations: Cross-sectional studies, which are prone to confounding bias, are ineffective for examining rare diseases or disorders with short durations. Furthermore, the study's sample size was modest.

3.13. Ethical Considerations:

The ethical approval was obtained from the community medicine department (U of K) and permission was obtained from the Faculty of laboratory sciences. Every participant gave verbal consent as an essential safeguard in research ethics.

Results

4. I. Sociodemographic data of medical laboratory students according to their CVD status Two hundred sixty-four medical laboratory students were recruited to participate in the standing study. Table 1 shows Socio-demographic characteristics based on CVD status. No significant association was found between age *(P <0.461)*, gender *(P <0.461)*, and CVD as well as between year of education *(P < 0.616)*, region of birth gender *(P <0.405)*, and CVD respectively. The prevalence of definitive CVD was 1.5%, as shown in (Fig: 4. 1.), A hundred percent of the victims were unaware of their condition. Females accounted for (73.1%) and males accounted for (25.4%). The mean age of the participants was (21 years ±2.4 standard deviation). Three-quarters (75%) of the students with CVD were in their first whereas one-quarter of them (25%) are in the final year. No significant associations were found between CVD status and region of birth. Personal and family history of medical students according to their CVD status present in (Table: 4 .2).

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Professionals with CVD have had difficulties in reading X-rays, while 127 (48.3%) have had not (Table: 3).

The results of the contemporaneous study disclose that the most common type of CVD as answered by the participants presented in (Fi: A). A Percent of 72 (27.3%) participants are unaware of the type of (CVD). Whereas 183(69.3%) correctly identified) (red, green), 3(1.1%) indicated yellow, and 6(2.3%) specified that it is blue. Whereas, the transmission of CVD across generations is demonstrated in (FI: B). A percent of 53 through inheritance and acquisition, however, 10(3.8%) thought via acquisition, and a whole 97(36.7%) supposed through inheritance. The transmission of CVD is Based on gender exposure in (Fi: C). A percentage of 84 (32%) participants specify that they do not have any knowledge regarding the transmission of CVD among gender. However, 152 (58%) recognized that it is instituted more in males than females. Nonetheless, 17 (6%) of the participants claimed that it is found more in females than males and10 (4%) of them declared that it is equally distributed between both genders. The name of the test that was used to detect CVD is cited in (FI: D), in the study survey, an entire 216(82%) participants had no idea about the test used to detect CVD, while 24(9%) of them documented the Ishihara chart as the test used to detect CVD. A whole of 9 (3%) of the participants thought the test used to detect CVD was the smelling chart. The slit lamp test, and, was chosen by 14(5.4%) of the participants to diagnose CVD.

Table: 1. Socio-demographic characteristics of medical laboratory students according to their color vision deficiency status (n=264)

Factors	**parameters**	**CVD status**		***P-value***
		Deficient	Normal	
Age(Mean±SD)		(n=4);1.5% N(%)	(n=260);98.5% N(%)	0.685
		21.01±2.407	21.01±2.407	
Gender	Male			0.464
	Female	0	193(73.1%)	
Year of educations	first	3(2.9%)	99(35.7%)	
	second	0	50(18.9)%	
	Third	0	40(1552)%	0.405
	fourth	0	44(16.7%)	
	fifith	1(0.4)	27(10.2%)	
Region of birth	In Sudan	4(!.5%)	234(98.5%)	
	Abroad	0	26(9.8%)	0.92

Table. 2: Personal and family history of medical students according to their color vision deficiency status (n=264)

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Parameters	History	Normal n=260;98.5% N(%)	Deficient n=4;1.5%	Misdiagnosed n=1;0.4% N(1%)	p-Value
Optical problem	Yes	51(19.3%)	0	1(0.4)	0.631
	No	212(80.3%)	0		
Family history of CVD	Yes	10(3.8%)	0		0.616
	No	254(996.2%)	0		
History of eyes or head trauma	Yes	11(4.25%)	0	1(0.4)	0.941
	No	252(95.8%)	0		
Exposure to Chemical	Yes	18(6.8%)	0		0.466
	No	245(93.2%)	0	1(0.4)	
Current health problem	Yes	26(0.9%)	0		0.222
	No	237(90.1%)	0		
Sufficient vitamins of A taken in the diet	Yes	201(76.1%)	0		0.283
	No	62(23.5%)	0	1(0.4)	
Medications used like sildenafil, ethambutol, and hydroxychloroquine	Yes	8(3%)	0		0.352
	No	255(96.6%)	0	1(0.4)	

Table: 3. Parameters of physical signs regarding the problems facing health professional workers Associated with CVD

Parameters of Physical signs:	Valid	Frequency	percent	Valid Percent	Cumulative percent
health professionals with CVD will face problem	No	77	29.2	29.3	29.3
	Yes	186	70.5	70.7	100
	Total	263	99.6	100	
	Missing	System	1	0.4	
	Total		264	100	
Skin rashes pallorand cyanosis	No	134		50.8	51
	Yes	129		48.9	49
	Total	263		99.6	100
	Missing	System	1	0.4	
	Total		264		100
ReadingXrays	No	127	48.3	48.3	43.1
	Yes	136	51.7	51.7	100
	Total	263	96.6	100	
	Missing syste	1	0.4		
		Total	264		

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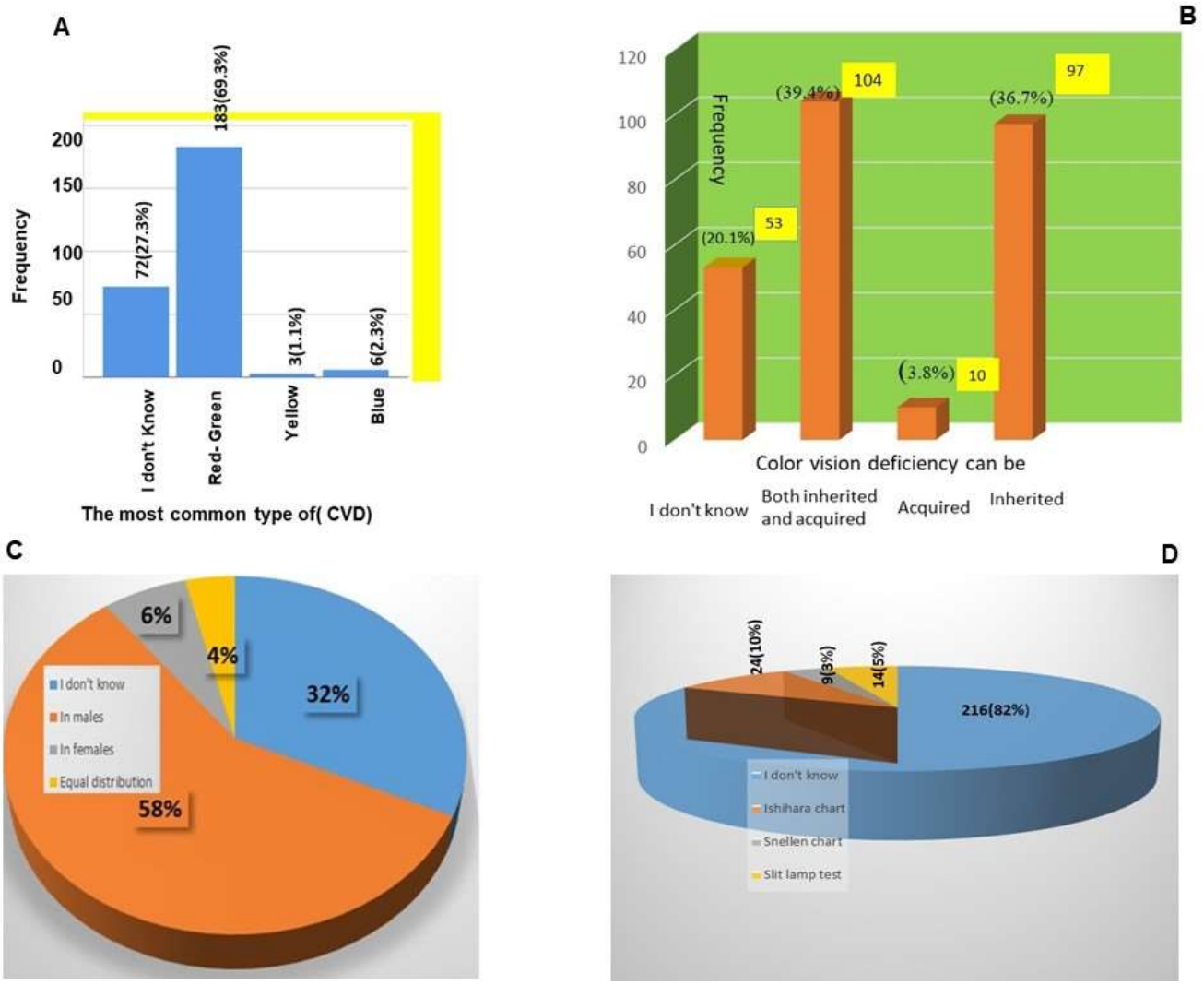

FI. A: Illustrates the most common type of CVD as answered by the participants

FI.B: Displays the transmission of CVD across generations as answered by the partakers

Fi: C: Demonstrates the transmission of CVD Based on gender

Fi: D: Validates the name of the test used to detect CVD

Table: 4. 4. Illustrates the relationship between the study variables, and Color vision deficiency CVD

parameters studied	Chi X2 value	df	*P-value*
Age	1.551	2	0.685
Gender	0.167	2	0-464
Region of birth	8.299	8	0.92
year of study	0.969	2	0.405
Family history of CVD	2.528	2	0.616
Sufficient vitamins of itamin A in the diet	4.398	2	0.283
Chronic disease medication	3.954	6	0.111
Medications used like sildenafil, ethambutol, and hydroxychloroquine	2.088	2	0.352
optical diseases	0.921	2	0.631
Current health problem	8.221	6	0.222
chronic diseases	0.694	2	0.707
Exposure to Chemical	1.527	2	0.466
History of eyes or head trauma	22.146	34	0.941
Awareness of participant versus eye diseases	31.383	42	0.885

Discussion

The current study shows the prevalence of CVD among medical laboratory students at the University of Khartoum, Sudan (U of K), and assesses the awareness of the students about the disease itself. In the post-screening survey on awareness of CVD, we found that 8 (3%) out of 264 students were highly aware, 105(39.8%) were moderately aware and 151(57%) were lowly aware. In contrast, in a study conducted in India to study the prevalence and awareness of CVD in School Children in 2018. Seven hundred fifty-two (752) students knew CVD. Two hundred forty-eight (248) students could not define color blindness. A large proportion of 87.6% of those who knew took precautions compared to only 9.3% who did not know.[55] Besides, a study was done in Pakistan to study the awareness of color blindness among university students. The study concluded that most students are aware of the etiology of color blindness disease while some are not fully aware of this disease.[56]

However, in this study, the prevalence of CVD among medical laboratory students (U of K) was found to be 1.5%. These results are inconsistent with a cross-sectional study performed among dental students at King Khalid University Saudi Arabia,[10] as well as in Egypt, Nigeria, and medical students at King Faisal University, Saudi Arabia. [42, 47, 57] Moreover, the prevalence was lower than in similar studies conducted among medical students at the University of Ain shams Egypt, [50]India, [58]Pakistan, [48]Congo, Uganda, Libya,[59] and Sudan. [40, 60] where the prevalence of CVD was 6.9%; 4.87%; 6%; 1.8%;1.9%, 2.2 %and 3% respectively. In contrast, the current prevalence was lower when compared to another study done in Ireland (6, 9%). [61] Consanguineous marriages are very common among the Sudanese inhabitants. However, opposing our predictions, the prevalence was not as high as it was found in the latest systematic global review of CVD prevalence.[62] All the affected participants with CVD in the present study population were males. No case of CVD was observed in females. [48, 51, 63] Despite the absence of affected females in this study, different studies on medical workers have found cases in females. Contrariwise, the incidence is lower in male subjects in a study conducted in Pakistan than in females which were found to be (4.5% for females and 2.4%, for males, correspondingly). [64] Nonetheless, this could be attributed to the study population of females (n = 1250) compared to (n = 750) male colleagues. The study concluded that there is an acute need for more research for better exploration of this problem. Therefore, these results indicate that males are at a greater risk of being affected than females. This is due to the X-linked mode of inheritance of red-green CVD. Even though several affected participants in the standing study (1.5%) reported, no family history of CVD. This finding conforms to the results that showed no significant association between CVD and family history of the disease. In general, according to the answers received from the affected ones. I think these outcomes were not the same as that found in universe studies. This may be

attributed to the lack of knowledge about the use of CVD confirmation tests and the absence of awareness of CVD ailment in the previous generations. [65] A different percentage was also reported in another study of Sudanese medical students at the University of Gezira (3%), which was also statistically significant.[40] This may be frequently the reason that both populations are from the same region of Sudan (Central Sudan). In the present study, Students with a family history of CVD were classified either as having hereditary or acquired CVD (1.5%), and (98.5%) having a normal color vision or carriers. Further, a previous study on medical students conducted in Gezira state, reported that the number of Sudanese medical students who had acquired CVD was greater than those with inherited CVD.[60] In Iran, research conducted on 2157 participants showed that 9.3% had hereditary CVD, and 20.2% acquired it.[51] The high percentage of acquired CVD in several studies could be due to changes associated with age, differences in race and environment, current health problems, and ocular conditions such as vision problems. However, in our study, there was no significant association between CVD and other optical diseases. Color-deficient people may face many difficulties in their daily accomplishments. This is particularly important for general practitioners owing to the nature of their work and the difficulties they may face during their practice. .[66] These problems begin in medical school among medical students with CVD since they tend to make more errors than their color-normal peers. The nature of their errors suggested that the students had issues in learning specific subjects and specialties. However, medical doctors with mild CVD reported fewer issues in their practice than those with severe forms. It is worth mentioning that CVD includes misinterpretation of the widespread body color changes such as pallor, cyanosis, jaundice, rashes, and erythema of the skin.[66] Likewise, a recent study showed that general practitioners with CVD had difficulty identifying ten clinical photographs compared to their color-normal peers who did so easily.[51] Our study showed that the majority of the affected participants were not aware of their color vision problems. Likewise, medical students in Egypt were not aware of their CVD deficiency.[50] Whereas, in Saudi Arabia (87%) of the affected participants were not aware of their color Vision problem. A highly statistically significant association was found between the history of vision problems and CVD status ($P < 0.008$). No, significant associations were found for nationality, marital status, family history of CVD, history of eye surgery, and eye trauma.[51] In similarity, in the post-screening survey on awareness of CVD in India, originating 26 (86.6%) out of 30 affected students were 1st generation learners. None of the affected students was aware of the disease but only (6.67%) of them were aware of CVD.[67] Moreover, many doctors and health workers do not know the severity of their condition and tend to assume it is slight, and a few do not even know they have a disability.[66] In addition, in India, medical students and health workers are screened before the start of their medical school training. These recommendations applied to upgrading the awareness of students and health workers about the severity of CVD status. Screening of medical students helps to understand their limitations for ensuring safe practice in the future.[68] Color recognition is an essential concern in life, and therefore, the importance of screening may be extended to school age. Children with CVD has been reported in several studies conducted on school-age students with a prevalence ranging from 1.7% to 8.2% in boys and from 0.2% to 2.9% in a girl.[51] Interestingly, early detection allows parents to give proper support to their children, and teachers to adjust their teaching methods to make them more beneficial to their students. Although the tool used was a screening tool for protan and deutan defects with high sensitivity and specificity,[55] it is remarkably recommended that a further confirmatory tool (Richmond HRR test) be used to detect Tritan deficiencies. Discriminating protan from deutan imperfections is likewise recommended for the affected participants using Medmont C100 Test, and Farnsworth–Munsell 100 Hue Test to assess the severity and different patterns. Furthermore, the cross-sectional nature of this study and the sample used to limit the generalization to only a similar age group. We recommend further explanation of different age groups, such as children, adolescents, adults, and geriatrics for an in-depth exploration of the nature of the disease whether it is acquired or inherited, or both.

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