A comparison of red-green color vision deficiency between medical and non-medical students in Pakistan

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ABSTRACT

الأهداف: تحديد مدى انتشار مرض عمى الألوان (CDV) بين طلاب التخصصات الطبية والأسنان ومقارنتهم بطلاب التخصصات الأخرى.

الطريقة: تقارن هذه الدراسة الوصفية المستعرضة مدى انتشار مرض (CDV) بين الطلاب الباكستانيين الذين يدرسون الطب وطلاب التخصصات الأخرى، حيث تمت مقارنة 926 طالبا في الطب والأسنان في جامعة بقاي الطبية، كراتشي، باكستان مع 7288 طالباً في جامعة ناديرشو إيدولجي دينشو للتقنية والهندسة (NED)، كراتشي، باكستان، و في مدارس باكستان العامة للقوات الجوية (PAF)، ماري وسرجودا، باكستان. لقد تم استخدام اختبار ايشيهارا للألوان والذي يعتمد على مجموعة من الألواح أو الصور (Ishihara color vision charts) من أجل عمل تقييم دقيق لمرض (CDV). يُعد الطالب مصاباً بعمى الألوان إذا أخطأ التعرف على ألوان أكثر من 3 صور وذلك من أصل 10 إلى 17 صورة، وأجريت هذه الدراسة خلال الفترة من سبتمبر 2003م إلى ديسمبر 2008م.

النتائج: أظهرت الدراسة بأن نسبة انتشار مرض (CDV) بين عامة الطلاب وصلت إلى 2.75% وأن ليس هناك فروقاً واضحة بين الطلاب الذكور في الكليات الهندسية والطبية (2.7% مقابل 4.4%، p=0.125)، أو بين المدارس والجامعات (3.1% مقابل 3.1%، p=0.930).

خاتمة: لقد كانت نسبة الإصابة بمرض (CDV) قليلة جداً بين السكان الباكستانيين، وكانت نسبة الإصابة غالبة في الذكور. كما أظهرت الدراسة بأنه ليس هناك فروقا واضحة بين طلاب الجامعات التقنية وطلاب الطب وكذلك بين طلاب الجامعات والمدارس في مختلف المناطق الجغرافية في باكستان.

Objectives: To investigate the prevalence of red-green color vision deficiency (CVD) among medical and dental students compared with non-medical students.

Methods: This descriptive, cross-sectional study compared the prevalence of CVD between medical and non-medical Pakistani students. A total of 926 medical and dental students from Baqai Medical University, Karachi, Pakistan were compared with 7288 non-medical students from Nadirshaw Edulji Dinshaw University of Engineering and Technology, Karachi, Pakistan, and Pakistan Air Force (PAF) Public Schools (Muree and Sargodha), Pakistan. Standard Ishihara color vision charts were used, which provided an accurate assessment of CVD. More than 3 mistakes from plates 10-17 identified students as having red green CVD. The study was carried out from September 2003 to December 2008.

Results: The overall prevalence of CVD in the study population was 2.75%. They were no significant differences between male students in engineering college versus medical college (2.7% versus 4.4%, p=0.125), or between schools and universities (3.1% versus 3.1%, p=0.930).

Conclusion: A small proportion of the Pakistani population suffers from red-green CVD, more prominent in males. We found no differences between students in engineering college versus medical college, or between schools and universities in different geographical locations within Pakistan.

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The retina contains rods and cones that are photoreceptors for vision. The rods are responsible for night vision or vision in dim light, and the cones for vision in daylight and color vision. There are 3 primary color cones and their stimulation by different wavelengths of light results in the perception of blue, green, and red colors. The ability of the eye to see approximately 150 different colors, distinguishes humans from other species.[1] The final perception of color is in the visual cortex in the occipital lobe. Color vision deficiency (CVD) is mostly congenital because of the absence or weakness of one or more of these primary cones. Most cases of congenital CVD are characterized by red green deficiency. Most cases are males as it is an X-linked disorder. The X-linked red green deficiency affects approximately 8% of the male population and only 0.4% of females in most Western countries.[2] It is a non-progressive and an untreatable condition. Most cases of CVD remain undiagnosed, resulting in various handicaps. Worldwide, CVD is considered to be an occupational hazard where serious problems can occur in daily life. The problems faced by people with CVD include affecting their choice of career (33%), job disabilities (25%), difficulty recognizing road traffic signals (13%), and judgment difficulties in daily routines (75%).[3] Color is often used as a clinical sign in medicine for identifying anemia and cyanosis, which serves a vital role in helping to recognize and diagnose diseases. There have been only a few studies investigating the effects of CVD on doctors' medical skills. Physicians, pediatricians, hematologists, and histopathologists with CVD may have problems with diagnoses related to color, especially those working in conditions where proper sunlight is not available. Thus, medical students should be screened for this deficiency and advised on choosing specialties accordingly. Studies regarding the prevalence of congenital CVD in males have shown that the prevalence in the medical profession is similar to the general population.[4] Studies have shown difficulties faced by clinicians with CVD.[5] Electronic engineers also need to have normal color vision to identify color-coding of capacitors, resistors, and cables. Similarly other fields, such as textiles and fine arts, or those concerned with traffic control, like pilots and drivers, require normal color vision.[6] Common clinical tests include the Ishihara plates 2-17 from the 38 plate series, Farnsworth D15 color sorting test (3 or more cross over errors is a fail), Farnsworth -Munsell 100-Hue test and anomaloscopy. The Ishihara series of plates is designed to provide a quick and accurate assessment of congenital CVD, and is most commonly used to detect congenital CVD and red-green deficiency. The most suitable color vision tests are the Ishihara charts, and the American Optical Company-Hardy Rand Rittler tests, which provide clear results, and are easy to interpret. Those having found to have CVD should undergo the Medmont C 100 test, for classification of CVD, and Farnsworth D-15 test, for CVD severity.[7] The quantitative estimation of severity of CVD is usually not required, but if desired can also be carried out by the Nagel Anomaloscope. The present study aims to find the prevalence of red-green CVD in medical and dental students in Pakistan and to compare the results with non-medical students.

Methods. ***Subjects.*** This was a descriptive, cross-sectional study, carried out through non-probability convenience sampling. A total of 926 undergraduate medical (MBBS) and dental (BDS) students of Baqai Medical University (BMU), Karachi, Pakistan were selected for this study. The study was carried out on all students attending Physiology practical classes from September 2003 to December 2008. Informed consent was obtained before the study commenced, and the BMU ethical committee approved the study. Among the MBBS students, 372 (53.2%) were females and 327 (46.8%) males, and among the BDS students 144 (63.4%) were females and 83 (36.6%) males. The age range was 19-20 years. Ishihara charts were used to detect CVD. The subjects were examined in broad daylight between 11 am and 1 pm. They were naïve to the aims of the study. There are a total of 38 plates in the Ishihara chart and plates no.1 to 25 were shown to the subjects. The plates were held 75 cm from the subject and tilted so that the plane of the paper was perpendicular to the line of vision. The subject read the Ishihara chart, and one examiner noted this down. This was compared with a checklist provided by a booklet on the Ishihara chart. If the subject had more than 3 mistakes from plate no. 10-17, they were declared as having red-green deficiency. This data were compared with the data of other students of Pakistan. The technique and charts were identical. Three other institutes were studied, Nadirshaw Edulji Dinshaw (NED) University of Engineering & Technology, Karachi, Pakistan, and the Pakistan Air Force (PAF) Public School Lower Topa, Muree and PAF Public School, Sargodha, Pakistan. Students were examined at these institutes as part of their admission requirements between September 2004 to December 2008. We included 1,868 students from NED, 1,763 from Muree, and 3,657 from Sargodha. These latter 2 schools are approximately 1,400 km north of Karachi and all these students were male. The NED University and the PAF schools had only one examiner each; they were both medical doctors. The age range for NED students was 19-20 years, while that of PAF students was 17-18 years. All students enrolled in the BMU MBBS or BDS program, and applying for admission in NED or PAF schools were included

in the study. All students who might have previously undergone the Ishihara chart test (by repeating a year or re-applying) or had congenital eye disease were excluded from study.

Data analysis. Epistat was used to calculate odds ratios (OR) with 95% confidence intervals (CI). The Pearson's Chi squared (χ^2) and Fisher's exact tests were used to determine statistically significant associations in categorical variables, between male and female students and between medical and non-medical institutions. The significance level was set at 0.05.

Results. In total, data from 8,214 students were collected between 2003-2008 (**Table 1**). Out of these students, 2.75% had red-green CVD. There were 6,950 males, of whom (3.1%) had CVD (**Table 2**), and 1,264 females, of whom only (0.6%) had CVD. Comparison between Universities in Karachi. The overall prevalence of CVD in NED and BMU students was 2%, and there were no significant differences in the prevalence of CVD between NED and BMU students (χ^2=0.000385, p=0.984). The ratio of the odds of having CVD (to not having CVD) in NED students, compared to BMU students was 1.306 (95% CI: 0.571-1.867). As CVD is found more in males than females, the same data was analyzed for males only. The overall prevalence of CVD in male NED and BMU students was 3.1% (**Table 3**). There were no significant differences in the prevalence of CVD between male NED and BMU students (χ^2=2.358, p=0.125). The ratio of the odds of having CVD (to not having CVD) in NED students, compared to BMU students was 1.668 (95% CI: 0.882-3.136). Comparison by genders within the same University in Karachi. The overall prevalence of red-green CVD in male and female BMU students was 2.1% (**Table 4**)

Table 1 - Data showing the percentage of red-green CVD in different educational institutes in Pakistan and the year of data collection.

Name of institute	Year of data collection	N	CVD subjects n (%)
PAF Sargodha	2004	870	18 (2.1)
PAF Sargodha	2005	709	23 (3.2)
PAF Sargodha	2006	796	25 (3.1)
PAF Sargodha	2007	754	38 (5.0)
PAF Sargodha	2008	528	18 (3.4)
PAF Lower Topa	2007	721	19 (2.6)
PAF Lower Topa	2008	1042	29 (2.8)
NED University	2007-2008	1868	37 (2.0)
BMU	2003-2008	926	19 (2.1)
Total	**2003-2008**	**8214**	**226 (2.8)**

CVD - color vision deficiency, PAF - Pakistan Air Force, NED - Nadirshaw Edulji Dinshaw, BMU - Baqai Medical University

Table 2 - Data of students from all 4 institutions, based on their gender.

Institute	Total no. of subjects	CVD subjects n (%)
PAF Sargodha*	3657	122 (3.3)
PAF Lower Topa*	1763	48 (2.7)
NED males	1120	30 (2.7)
BMU males	410	18 (4.4)
Total males	**6950**	**218 (3.1)**
NED females	748	7 (0.9)
BMU females	516	1 (0.2)
Total females	**1264**	**8 (0.6)**

*all males, CVD - color vision deficiency, PAF - Pakistan Air Force, NED - Nadirshaw Edulji Dinshaw, BMU - Baqai Medical University

Table 3 - Difference in prevalence of red-green color vision deficiency (CVD) in male students from a non-medical university compared with a medical university in Karachi, Pakistan.

Institute	Normal color vision n (%)	CVD n (%)	Total
Non-medical	1090 (97.3)	30 (2.7)	**1120**
Medical	392 (95.6)	18 (4.4)	**410**
Total (%)	**1482 (96.9)**	**48 (3.1)**	**1530**

χ^2 = 2.358, p=0.125

Table 4 - Difference in prevalence of red-green CVD between male and female university students from BMU in Karachi, Pakistan.

Gender	Normal color vision n (%)	CVD n (%)	Total
Male	392 (95.6)	18 (4.4)	**410**
Female	515 (99.8)	1 (0.2)	**516**
Total (%)	**907 (98.0)**	**19 (2.05)**	**926**

Fisher's exact test, p=0.00000388, CVD - color vision deficiency, BMU - Baqai Medical University

Table 5 - Difference in prevalence of red-green color vision deficiency (CVD) between male university students compared to male school students in Pakistan.

Institute	Normal color vision n (%)	CVD n (%)	Total
University	1482 (96.9)	48 (3.1)	1530
School	5250 (96.9)	170 (3.1)	5420
Total	**6732 (96.9)**	**218 (3.1)**	**6950**

χ^2 = 0.0067, P = 0.930

Male students had a significantly higher prevalence of CVD than female students (p=0.00000388).

Comparison of data from different institutes within Pakistan. The prevalence of red-green CVD in both male students from universities and in school students was 3.1% (**Table 5**). There were no significant differences in the prevalence of CVD between university and school male students (χ^2=0.0067, p=0.930). The ratio of the odds of having CVD (to not having CVD) in university students, compared to school students was 1.00 (95% CI: 0.714-1.403).

Discussion. As found in many studies worldwide, we also have shown that a small proportion of the Pakistani populace suffers from red-green CVD. As commonly reported, CVD was more prominent in males compared to females. Our data also showed there were no differences between students in engineering college versus medical college, or between schools and universities within Pakistan. The final comparison, between school students in the North of the country and university students based in the South of the country, suggests that there are unlikely to be differences in CVD prevalence based on geographical locations within Pakistan. Color vision deficiency is a serious handicap for many occupations, including medicine and the creative arts.[8,9] Persons with CVD also have a greater risk when driving.[10] All CVD persons face difficulties in daily routines as color is now widely used in printed material and computer displays. They are at a disadvantage in comparative color tasks that involve precise matching of colors or discrimination of fine color differences because of an anomalous perception of colors.

In a study conducted on UK medical practitioners with CVD, it was shown that compared to controls, they identified fewer photos of fresh blood or a rash and also less bacilli in a given photograph of Ziehl-Neelsen stained sputum.[2] Surprisingly medical practitioners are usually unaware of suffering from CVD,[5] because screening policies usually do not exist in most countries, including the UK.[11,12] Thus, it has been suggested that practitioners and medical students should be aware of their CVD, and should undergo further tests to find out the severity of deficiency, which will help them ensure safe clinical practice.[2,12,13] The results of our study are not in accordance with a study of congenital color blindness in young Turkish men,[14] as they have reported a higher prevalence (7.3%). In the UK studies, an incidence of 8% has been reported in males,[4] however, in a larger study, the prevalence was 6.7% in males.[1] Data from Jordan and Iran showed similar prevalences of 8.7 and 8.2%.[15,16] It is interesting to note our data had the lowest prevalences of CVD for males, 3.1%. Males of Indian origin children living in Singapore were found to have a CVD prevalence of 4.9%,[17] while another study from India reported a prevalence of between 2-3%.[18] Therefore, it is likely that either under-reporting occurred in our data, or there might be genetic differences, where South Asians have lower prevalence rates than Caucasians. There is not much handicap for CVD affected children in education as they do equally well compared to their peers.[19] Similarly, unintentional injuries are also not common in school going children, and based on these findings normal color vision is not a prerequisite for safe working in most occupations.[19] There is a difference in opinion regarding school CVD screening programs.[13,19,20] We support awareness programs in young people, informing them of the potential occupational difficulties they might face in future, and we strongly suggest that CVD persons must be referred to a specialist to help them in planning suitable careers. Resources are available to help medical students, allied medical staff, and medical practitioners who have CVD.[21-23] The prevalence of CVD in the medical field may be the same as the general population, but this needs special attention. The prime objective is that the general public should not be affected in any way. At the general practitioner level, cases can still be referred, but at a higher level where a decision lies on identifying color dependent clinical signs, serious errors can occur. Important features like pallor, erythema, icterus, glucose stick testing, naked eye examination of stools for melena, urine for hematuria, or in cases where diagnosis is based on histopathological slides, staining of slides, number of bacilli counted, must not be missed by color blind medical professionals.[2,10-12] In Pakistan, the situation is different from the western world. Proper screening programs do not exist in most schools and universities. Moreover, much competition at limited career facilities exists, which requires a lot of planning and programming. Job insecurity and nonexistent health and insurance policies are problems. Rising inflation and poverty are further aggravating circumstances. Thus, proper detection and awareness programs for CVD must be organized to help in choosing careers early, so as to avoid mishaps. Further career rejection must be on the basis of severity of CVD only. Studies at more advanced levels to show job disabilities in these sufferers of CVD are strongly recommended.

Limitations of the present study include the use of 3 different examiners, however given the experience of the examiners, and the straightforward nature of the texts we would expect internal consistency. We decided to observe and record only red-green CVD. Although this method of CVD classification has its drawbacks, we felt it was easy to measure with the Ishihara chart and

it is more commonly used.[17] The age of school students was slightly lower than that of university students, but since CVD is primarily congenital, we would not expect this to affect the results.

We recommend that CVD screening tests must be carried out in medical schools so that the sufferers are aware of the problems and chose a specialty that will not affect their patients. These findings strengthen the growing challenge to establish population screening at the school and university level and providing proper career guidance based on individual needs.

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