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Prevalence of Colour Blindness in School Children: A Prospective Study

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Abstract

Background: In India, colour vision impairment affects 3-4% of the population, and because of adjustments people make to survive, some people don't realize they have the condition until later in life.

Objectives: To find out the prevalence rate of colour blindness in school children of Muzaffarpur district of Bihar and to find out the type of colour blindness in affected individuals and prevalence of that type.

Material and methods: Present study has been carried out in school camps conducted in Muzaffarpur district of Bihar. Total 30 such camps in conducted in different parts of Muzaffarpur district schools and enrolled a total of 21,467 school children. Camps were selected by lottery method and the total number of school children selected for study came by random selection till sample size 5000 not achieved. Study design: Community based cross Sectional study. Period of study: August 2020 to July 2022 i.e., 24 months.

Results: Students in age group 5-15 years of 30 school camps were screened. A total of 5000 students were included in the study. Out of which 3232 were males and 1768 were females. On the basis of class in std V males are 818 i.e., 25.30% and females are 424 i.e., 23.98%, std VI males 628 i.e., 19.43% and females 368 i.e., 20.81%, std VII males 609 i.e., 18.84% and females 331 i.e., 18.72%, std VIII males 527 i.e., 16.30% and females 243 i.e., 13.74%, std IX males 332 i.e., 10.27% and females 231 i.e., 13.06% and std X males 318 i.e., 09.83% and females 171 i.e., 9.67% respectively. Total number of students found out to be CVD according to Ishihara chart was 213 i.e., 04.26%, out of which 200 i.e., 06.19% were males and 13 i.e., 0.73% were females. According to Ishihara's test deutan CVD was found out to be more prevalent affecting 148 i.e., 69.49% students who are examined, compared to protan CVD which was found to affect 65 i.e., 30.51% students. In the present study according to Ishihara's test mild CVD was found out to be more prevalent affecting 174 i.e., 81.69% students who were examined compared to strong CVD which was found to affect 39 i.e., 18.31% students.

Conclusion: In present study total number of students found out to be CVD according to Ishihara chart was 04.26%. Out of which 06.19% were males and 0.73% were females. According to Ishihara's test Deutan CVD was more prevalent than Protan CVD. Using Ishihara's test mild degree of CVD was more prevalent than strong degree.

Keywords: NIL

Introduction

Colour vision is the ability to discriminate a light stimulus as a function of its wavelength. The description and appreciation of colours depend upon the ability of receptors in retina i.e., rods and cones. Rods are mainly responsible for black and white vision whereas cone systems are mainly responsible for colour vision. Colours can be measured and quantified in various ways; indeed, a person's perception of colours is a subjective process whereby the brain responds to the stimuli that are produced

when incoming light reacts with the several types of cone cells in the eye. In essence, different people see the same illuminated object or light source in different ways. Light with wavelength between approximately 380 and 760 nm causes photoreaction on human retina, which leads to vision. Various sensory and cognitive processes combine to result in the sense of colour[1]. Prevalence of Colour vision impairment is 3- 4 % in India and it goes undetected till later in life as people develop certain adaptations to cope up to certain extent and while some remain unaware of the disease. The occurrence of a congenital deficiency in the appreciation of colour values has long been recognized (Huddart,1777; Lort,1778), but general interest was first aroused in the question by the observations of the chemist, John Dalton (1798), on his own case: hence originated the early term Daltonism. Since that time an enormous interest has been taken in the subject and an immense bibliography has accumulated which is almost unique in the literature of all science for its complexity, the profusion of contradictions in which it revels, and the acrimony with which they are expressed. It is to be remembered that a person in whom colour vision is defective may go through life quite unconscious of his inferiority and without making any incriminating mistakes, differentiating objects by their size, shape, and luminosity, using all the time a complete colour vocabulary based on his experience which teaches him that colour terms are applied with great consistency to certain objects and to certain achromatic shades, until circumstances are arranged to eliminate these accessory aids and he realizes that his sensations differ in some way from the normal[2].

Colour blindness is the commonly used term for deficiency of colour vision that is inability to perceive differences between certain colours that a normal person can distinguish. David Brewster introduced the term colour blindness[1]. The characteristic of all defects of colour vision is that the abnormal people see fewer hues than normal. The defects of colour vision may be classified into two types- Dyschromatopsia: abnormal appreciation of colour exists and Achromatopsia- all sensations of colour are absent[2]. Dyschromatopsia itself may be divided into two main types: Anomalous Trichromatic Vision, wherein, although colour vision is a function of three variables, the relative qualities of the colour mixtures differ from normal. Types are: Protanomaly-Relative failure in the appreciation of red. Deuteranomaly- Relative failure in the appreciation of green. Such a condition affecting blue is unknown[2].

Dichromatic Vision- colour vision is a function of two variables, Protanopia- Red sensation is absent, Deuteranopia-Green sensation is absent and Tritanopia- Blue sensation is absent[2]. It will suffice to define shortly the seven typical defects which may occur classified according to the ability of dyschromats to match colours, particularly yellow with a mixture of red and green (the Rayleigh equation, 1882). In the normal trichromat all colours of the spectrum, as well as white light, can be matched by suitable admixture of three lights (red, green, blue)[2].

1) In Protanopia all colours as well as white light can be matched by a suitable mixture of two lights, green and blue; green can be equalized with a luminous yellow and red with a dark yellow. Protanopes, therefore, confuse reds and greens and, in addition are insensitive to red light[2].
2) In Protanomaly Three colours are required for these matches but the proportions are abnormal: to match a homogenous yellow with a mixture of red and green, redder is required than normal[2].
3) Extreme Protanomaly is an intermediate stage between PROTANOPIA and PROTANOMALY wherein red itself may be matched with yellow[2].
4) In Deuteranopia all colours and white lights can be matched by the mixture of red and blue; both green and red can be matched with a yellow of equal intensity. Like Protanopes, Deuteranopes confuse reds and greens, but, unlike, protanopes, they are sensitive to red light[2].
5) In Deuteranomaly the normal match of yellow with green is not accepted but a greater proportion of green is required[2].
6) In Extreme Deuteranomaly green itself may be equated with yellow[2].
7) In Tritanopia all colours and white light can be matched by a mixture of red and green. In this condition red and green are not confused[2].

In all cases the discrimination of hue is defective and reliance is placed on differences of luminosity which

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colour defectives are very apt in interpreting. The photopic luminosity curves are diminished in height and displaced, in the protan type towards the violet end of spectrum, in the deuteran type towards the red end, while in tritanopia the maximum lies between 558 and 650 mμ instead of 550 and 560 mμ; the scotopic luminosity curves, however, are invariably normal[2].

Colour blindness of the red green type is usually sex linked; while tritanopia is linked to chromosome 7.1. Two types of total colour blindness exist, Cone Monochromatism wherein the defect is confined so far as is known to the colour sense, and Rod Monochromatism, which is associated with other pathological changes[2]. Cone Monochromatism, wherein the visual function remains good and pathological evidences are lacking except the absence of all colour sense, is extremely rare; it has been estimated to occur in a proportion of 1 in 100 million of the population, but this probably an underestimate. There is no firm evidence of hereditary tendency[2]. Rod Monochromatism, is always associated with marked pathological changes. In contrast to cone monochromatism, central vision is invariably poor, nystagmus is usually present and bright light, while not producing actual pain, gives rise to an unpleasant sensation and leaves the subject in comparative blindness for some considerable time. In some cases, indeed, even when the macula is ophthalmoscopically normal, a central scotoma exists, although this is by no means invariable. The disease is rare and affects both sexes in approximately equal proportions[2]. The cause of achromatopsia is unknown. From the physiological nature of the defect the generally accepted hypothesis has been that it was due to an absence of cones in the fovea, a surmise, however, which pathological investigations have failed to confirm. Moreover, the presence of at least two visual pigments in the foveal cones (in cone monochromatism) would indicate that the defect is almost certainly central in nature[2].

However, most of colour blinds remain undetected in general population due to absence of proper screening. Various tests are used to identify colour blind individuals which include colour confusion tests, arrangement tests, colour matching tests, lantern tests. The Ishihara colour test is a widely used test to determine if a patient has colour blindness. It was named after Dr. Shinobu Ishihara who first published the test in 1917 as a professor at the University of Tokyo[1].

Impact of colour blindness: Many people are affected by colour blindness but many of them remain undetected as they simply adapt to the environment to certain extent and also because of unawareness of the disease. Colour blind individuals have difficulty in comprehension because of increased reaction time and will only experience a few hundred shades of colour, versus those with normal vision that experience millions of shades. Unfit for certain jobs like traffic policemen, defence personnel, electrician, electronic engineer, artist, pilot which require proper perception of colours which may lead to lesser efficiency in work as well as may cause accident.

So, it is important to look at the prevalence of colour blindness and identify the problems associated with it. Keeping the above aspects in mind the study has been carried out to find out the prevalence of colour blindness in school children and to make parents and their teachers aware of this disease so that they can modify their teaching methods and choosing and adjusting with suitable profession[1].

Objectives: To find out the prevalence rate of colour blindness in school children of Muzaffarpur district of Bihar and to find out the type of colour blindness in affected individuals and prevalence of that type.

Material and methods:

Study area: Present study has been carried out in school camps conducted in Muzaffarpur district of Bihar. Total 30 such camps in conducted in different parts of Muzaffarpur district schools and enrolled a total of 21,467 school children. Camps were selected by lottery method and the total number of school children selected for study came by random selection till sample size 5000 not achieved. Study design: Community based cross Sectional study. Period of study: August 2020 to July 2022 i.e., 24 months.

Informed consent was taken from parents and guardians. The school children were tested for colour vision deficiency using Ishihara's Type Tests for colour Blindness, 38 Plates Edition. The colour vision testing plates was held at 75 cm from the subject and tilted at right angle to the line of vision. The test was done in adequate lighted room resembling natural day light. Subjects were asked to read the numbers seen on the test plates and answer

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was noted down. The time given for telling the number on a plate was 5 sec. Appropriate Statistical tests were applied.

Inclusion criteria: Healthy school children with normal ocular examination findings, age 10-15 years, willing to participate in the study.

Exclusion criteria: Chronic drug therapy (more than one month).

Statistical Analysis The data were entered into the Microsoft Excel and the statistical analysis was performed by statistical software SPSS version 21.0. The quantitative (numerical variables) was present in the form of mean and SD and the qualitative (categorical variables) was present in the form of frequency and percentage. The student's t-test was used for comparing the mean values between the two groups, whereas Chi-square test was applied for comparing the frequency. P-value was considered to be significant when <0.05.

The Ishihara test is a colour perception test for red-green colour, the first in a class of successful colour vision tests called pseudo-isochromatic plates ("PIP"). The test consists of a number of coloured plates, called Ishihara plates, each of which contains a circle of dots appearing randomized in colour and size. Within the pattern are dots which form a number or shape clearly visible to those with normal colour vision, and invisible, or difficult to see, to those with a red-green colour vision defect. Other plates are intentionally designed to reveal numbers only to those with a red/green colour vision deficiency, and be invisible to those with normal red/green colour vision. The full test consists of 38 plates, but the existence of a severe deficiency is usually apparent after only a few plates. There is also an Ishihara test consisting 10, 14 or 24 test plates.9 The plates make up several different test designs: Demonstration plate (plate number one, typically the numeral "12"); designed to be visible by all persons, whether normal or colour vision deficient. For demonstration purposes only, and usually not considered in making a score for screening purposes. Transformation plates: individuals with colour vision defect should see a different figure from individuals with normal colour vision. Vanishing plates: only individuals with normal colour vision could recognize the figure. Hidden digit plates: only individuals with colour vision defect could recognize the figure. Diagnostic plates: intended to determine the type of colour vision defect (protanopia or deuteranopia) and the severity of it. Proper testing technique is to give only three seconds per plate for an answer, and not allow coaching, touching or tracing of the numbers by the subject. The test is best given in random sequence, if possible, to reduce the effectiveness of prior memorization of the answers by subjects. Some pseudo-isochromatic plate books have the pages in binders, so the plates may be rearranged periodically to give a random order to the test[4].

Results: This community based cross Sectional study has been carried out in 30 school camps conducted in Muzaffarpur district of Bihar and enrolment of 21,467 school children and sample size taken as 5000 over period of August 2020 to July 2022 i.e., 24 months after approved from ethical committee under Declaration of Helsinki.

Table No. 1: Distribution of Students according to Class and gender

Classes	Students examined		
	Male	Female	Total
Std V	818 (25.30%)	424 (23.98%)	1242 (24.84%)
Std VI	628 (19.43%)	368 (20.81%)	996 (19.92%)
Std VII	609 (18.84%)	331 (18.72%)	940 (18.80%)
Std VIII	527 (16.30%)	243 (13.74%)	770 (15.40%)
Std IX	332 (10.27%)	231 (13.06%)	563 (11.26%)
Std X	318 (09.83%)	171 (09.67%)	489 (09.78%)

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Total	3232 (100%)	1768 (100%)	5000 (100%)

In present study total number of students screened was 5000, out of which 3232 were males and 1768 were females. On the basis of class in std V males are 818 i.e., 25.30% and females are 424 i.e., 23.98%, std VI males 628 i.e., 19.43% and females 368 i.e., 20.81%, std VII males 609 i.e., 18.84% and females 331 i.e., 18.72%, std VIII males 527 i.e., 16.30% and females 243 i.e., 13.74%, std IX males 332 i.e., 10.27% and females 231 i.e., 13.06% and std X males 318 i.e., 09.83% and females 171 i.e., 9.67% respectively (Table 1).

Table 2: Class wise distribution of Colour vision deficient students according to Ishihara chart.

Class	Colour vision deficient students according to Ishihara chart		
	Male	Female	Total
Std V	68 (34%)	02 (15.38%)	70 (32.86%)
Std VI	48 (24%)	02 (15.38%)	50 (23.47%)
Std VII	31 (15.50%)	03 (23.07%)	34 (15.96%)
Std VIII	25 (12.50%)	02 (15.38%)	27 (12.67%)
Std IX	17 (08.50%)	02 (15.38%)	19 (08.92%)
Std X	11 (05.50%)	02 (15.38%)	13 (06.10%)
Total	200 (100%)	13 (100%)	213 (100%)

In present study total number of students found out to be CVD according to Ishihara chart was 213 i.e., 04.26%, out of which 200 i.e., 06.19% were males and 13 i.e., 0.73% were females. On the basis of classes, in std V males are 68 i.e., 34% and females are 02 i.e., 15.38%, std VI males 48 i.e., 24% and females 02 i.e., 15.38%, std VII males 31 i.e., 15.50% and females 03 i.e., 23.07%, std VIII males 25 i.e., 12.50% and females 02 i.e., 15.38%, std IX males 17 i.e., 08.50% and females 02 i.e., 15.38% and std X males 11 i.e., 05.50% and females 02 i.e., 15.38% respectively (Table 2).

Table 3: Classification of types of CVD according to Ishihara's test.

Type	Male	Female	Total
Protan	62 (31%)	03 (23.07%)	65 (30.51%)
Deutan	138 (69%)	10 (76.93%)	148 (69.49%)
Total	200 (100%)	13 (100%)	213 (100%)

In the present study according to Ishihara's test deutan CVD was found out to be more prevalent affecting 148 i.e., 69.49% students who are examined, compared to protan CVD which was found to affect 65 i.e., 30.51% students. Deutan CVD affected 138 males i.e., 69% and 10 females i.e., 76.93% while protan CVD encountered in 62 males i.e., 31% and 03 females i.e., 23.07% respectively (Table 3).

Table 4: Distribution of students according to the gender and severity of colour vision deficiency by Ishihara's test.

Degree	Male	Female	Total
Mild	165 (82.50%)	09 (69.23%)	174 (81.69%)

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Strong	35 (17.50%)	04 (30.77%)	39 (18.31%)
Total	200 (100%)	13 (100%)	213 (100%)

In the present study according to Ishihara's test mild CVD was found out to be more prevalent affecting 174 i.e., 81.69% students who were examined compared to strong CVD which was found to affect 39 i.e., 18.31% students. Mild CVD affected 165 males i.e., 82.50% and 09 females i.e., 69.23% while strong CVD accounted for 35 males i.e., 17.50% and 04 females i.e., 30.77% respectively (Table 4).

Similar to present study:

Class	Present study males	Present study females	**Gupta C.S et al[5] (2017)** males	**Gupta C.S etal[5] (2017)** females
Std V	818 (25.30%)	424 (23.98%)	85 (21.19%)	84 (24.92%)
Std VI	628 (19.43%)	368 (20.81%)	105 (26.18%)	91 (27.02%)
Std VII	609 (18.84%)	331 (18.72%)	94 (23.44%)	75 (22.25%)
Std VIII	527 (16.30%)	243 (13.74%)	117 (29.17%)	87 (25.81%)

In present study total number of students found out to be CVD according to Ishihara chart was 213, out of which 200 i.e., 93.89% were males and 13 i.e., 06.11% were females.

Classes	Present study males	Present study females	**Gupta C.S et al[5] (2017)** males	**Gupta C.S etal[5] (2017)** females
Std V	68 (34%)	02 (15.38%)	04 (21.05%)	00 (00.00%)
Std VI	48 (24%)	02 (15.38%)	07 (36.84%)	01 (05.26%)
Std VII	31 (15.50%)	03 (23.07%)	03 (15.78%)	00 (00.00%)
Std VIII	25 (12.50%)	02 (15.38%)	03 (15.78%)	01 (05.26%)

The above table shows **Gupta C.S et al[5] (2017)** study found 17 boys and 02 girls having colour blindness out of 738 students. Similarly, **Reddy A.V et al[6] (2017),** A prospective study was done on 1629 students to evaluate the prevalence of colour blindness. Colour blindness was seen in 31 students (01.9%) including 28 (01.71%) males and 3(0.184%) females. **Chakrabarti A et al[7] (2015),** study was to determine the occurrence of CVD among students of Nalgoradham-Baikuntha Vidyapith, a village based high school of West Bengal, India as well as to explore the awareness of CVD among them and their family members. Of the 738 students, 30 were affected (4.06%). The total number of affected males was 22 (6.37%) while affected females were 08 (2.03%). Just similar to present study where male CVD students are more than the female. **Sree B.K et al[8] (2018),** The present study was conducted under National School Eye Screening Programme. A total number of 13149 school children were screened in the present study. 156 schools were screened consisting of 50.68% males and 49.31% females. Out of 118 children with colour vision deficiency 105 are males and 13 are females. **Mughal I.A et al[11] (2013),** A total of 2,000 medical students including 750 males and 1,250 females between ages 18–21 years were examined for CVD in different medical colleges of Faisalabad. Participant's colour vision was tested using Ishihara's Charts (Plates). Among 750 boys, 18 were colour deficient (2.4 %). Among 1250 girls, 56 were colour deficient (4.48 %). Just contrast to present study where males are more screened than females and male having CVD greater than females.

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Discussion: The present community based cross-sectional study was carried out among 5,000 school children in Muzaffarpur district of Bihar irrespective of their gender/ background /socio economic status. 5000 students aged between 10-15 years were included in the study. In present study total number of students screened was 5000, out of which 3232 were males and 1768 were females.

Also, **Reddy A.V et al[6] (2017),** study was done on 1629 students to evaluate the prevalence of colour blindness. Students of 6 schools were screened in the age group of 10 to 15 years. 1629 students were included in the study; 841(51.62%) were males and 788 (48.37%) females. **Chakrabarti A et al[7] (2015),** study was to determine the occurrence of CVD among students of Nalgoradham-Baikuntha Vidyapith, a village based high school of West Bengal, India as well as to explore the awareness of CVD among them and their family members. In contrast of present study this study screened more male persons than females i.e., of the 738 students, 345 males and 393 females. **Sree B.K et al[8] (2018),** The present study was conducted under National School Eye Screening Programme.Total13,149 school children were screened consisting of 6484 (49.31%) girls and 6665 (50.68%) boys. **Saha D et al[9] (2016),** Total 300 medical students of first year MBBS class has been studied. Of these, 168 boys and 132 girls aged between 19 - 22 years have been tested for CVD in Medical Colleges, Kolkata and **Shrestha RK et al[10] (2014),** A cross-sectional descriptive study was designed with purposive sampling of students from various schools of Kathmandu Valley. A total of 2001 students were examined, 1050 male students and 951 females.

In the present study according to Ishihara's test deutan CVD was found out to be more prevalent affecting 148 i.e., 69.49% students who are examined compared to protan CVD which was found to affect 65 i.e., 30.51% students. **Shrestha RK et al[10] (2014),** study shown among the 41 students having colour vision defects, six were found with total colour blindness, 34 were found to be Deutan and rest Protan. The results of this study were similar to our study having deutan CVD more prevalent affecting 82.92% individuals while protan CVD accounted for only 0.09% individuals. **Fareed M et al[12] (2015),** study shown 42 students were found to have colour vision defects out of which 32 accounted for deutan CVD (76.19%) including 29 males (69.04%), 3 females (7.14%) and only 10 students had protan CVD (23.80%) including 9 males (21.42%),1 female (2.38%). These results were corresponding to our study. **Ahsana SH et al[13] (2013),** study shown out of 126 CVD individuals Deutan CVD was found in 89 students (63.57%) out of which 11 were females (12.35%) rest 78 males (87.65%), whereas Protan CVD was found in 37 students (26.43%), out of which 8 were females (21.62%) rest 29 males (78.38%). These results were corroborative with our findings. **Chakrabarti A et al[7] (2015),** study shown similar to our study out of 30 CVD individuals 18 had Deutan CVD (60%) including 13 males (72.22%) and 5 females (27.78%) while 12 had protan CVD (40%) including 9 males (75%) and 3 females (25%). **Gupta C.S et al[5] (2017)** study shown that protanomaly was observed in 13 students out of 19 colour blindness. Among 13 protanopes, 11 were boys and 02 were girls. Deuteranomaly was observed in 6 students out of 19 colour blindness. Among 6 deuteranopes, 6 were boys and no such cases observe in females. In contrast to present study Protan CVD was more prevalent and found in 68.5% individuals and deutan CVD was found in 31.5% individuals. **Reddy A.V et al[6] (2017),** study observed that Protanomaly was observed in 28 students out of 31 colour blind students accounting to 90.3% of total colour-blind students. Among 28 protanopes, 26 were males and 2 were females. Deuteranomaly was observed in 3 students out of 31 colour blind students. Among 3 deuteranopes, 2 were males and 1 was females. So, among colourblinds, protanopia (90.3%) is more common than deuteranopia (9.7%). In protanopia also males were predominantly affected (92.8%) as compared to females (7.2%). The results of this study were also in contrast to present study.

In the present study according to Ishihara's test mild CVD was found out to be more prevalent affecting 174 i.e., 81.69% students who were examined compared to strong CVD which was found to affect 39 i.e., 18.31% students. **Chakrabarti A et al[7] (2015),** study shown that out of the 30 CVD students, 17 (56.67%) students were found out to be having mild degree of CVD, including 13 males (76.47%) and 4 females (23.53%) while 13 (43.33%) students had severe degree of CVD, including 9 males (69.23%) and 4 females (30.77%). **Fareed M et al[12] (2015),** study also shown Mild degree CVD

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accounted for 29 students (69.05%);27 males (93.10%) and 2 females (6.90%) while strong degree CVD was present in 13 students (30.95%);12 males (92.31%) and 1 female (7.69%) out of 42 CVD students. Also, **Ahsana SH et al[13] (2013),** study shown, 83 students (65.87%), 75 males (90.36%) and 08 females (9.64%) had mild degree CVD; while 43 students (34.13%), 32 males (74.41%) and 11 females (25.59%) had strong degree CVD. According to above studies it was found that mild degree of CVD was more prevalent than severe degree of CVD which was consistent with our study but the prevalence of mild degree CVD was significantly lower than our study.

Conclusion: In present study total number of students found out to be CVD according to Ishihara chart was 213 i.e., 04.26%. In present study total number of students found out to be CVD according to Ishihara chart was 213 i.e., 04.26%, out of which 200 06.19% were males and 0.73% were females. According to Ishihara's test Deutan CVD was more prevalent than Protan CVD. Using Ishihara's test mild degree of CVD was more prevalent than strong degree. So, it is very important that school children should be screened for colour vision impairment and chose their career later on wisely.

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