SCREENING OF 5TH YEAR MEDICAL STUDENTS AT
SEFAKO MAKGATHO HEALTH SCIENCES
UNIVERSITY FOR RED-GREEN COLOUR VISION
DEFICIENCIES

By

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DISSERTATION

Submitted in fulfilment of the requirements for the degree of
Master of Medicine
in
Department of Ophthalmology
Faculty of Health Sciences
At
Sefako Makgatho Health Sciences University

Supervisor: Prof J.F Olivier
Co-supervisor: Dr J.B Matlala
DEDICATION

To my parents, Osman and Maymoona Gani.

To my wife, Sumaya.

To my children, Lamiya and Amana.
DECLARATION

I, Aboobaker Gani, hereby declare that Screening of 5th Year Medical Students at Sefako Makgatho Health Sciences University for Red-Green Colour Vision Deficiencies is my own work. It is being submitted for the degree of Master of Medicine in the branch of Ophthalmology at the Sefako Makgatho Health Sciences University. It has not been submitted before for any degree or examination at any other University.

..........................................................
Aboobaker Gani

25/09/2017

.................................
Date
ACKNOWLEDGEMENTS

I would like to express my gratitude to the following individuals who provided me with invaluable assistance during this endeavour.

1. Professor J.F Olivier, my supervisor and Head of Department for always having an open door to assist and guide me.
2. Dr J.B Matlala, my co-supervisor for his willingness to guide and teach me.
3. Tshifhiwa Nkwenika, Biostatistics Unit of South African Medical Research Council, for the statistical analysis.
ABSTRACT

Purpose: The purpose of this study was to assess for the presence of red-green colour vision deficiency in medical students. This study was equipped to assess the prevalence and awareness of this deficiency. In the practice of Medicine, it is important to perceive colour as many clinical signs and tests use colour as a basis.

Design and Method: The study design was conducted as a prospective observational study. It involved screening of the 5th year medical students (n=203) of Sefako Makgatho Health Sciences University for congenital red-green colour vision deficiency during the year 2016. The Ishihara test plates were used as a screening tool.

Results: The overall prevalence for red-green colour vision deficiency amongst the males (n=85) was 8.2% (95% Confidence Interval (4%, 16%)) and females (n=118) was 3.4% (95% Confidence Interval (1%, 9%)). The difference in prevalence between males and females was statistically insignificant (Fisher’s Exact, p-value = 0.207, alpha = 0.05). In the subgroup of African males (n=69), the prevalence was 8.7% (95% Confidence Interval (4%, 18%)) and African females (n=99), the prevalence was 4.0% (95% Confidence Interval (2%, 10%)). The difference in prevalence between males and females of the African Race were statistically insignificant (Fisher’s exact, p-value = 0.320, alpha = 0.05). Of the students with red green colour vision deficiency (n=11), none were aware of their deficiency. No correlation was found between family history and deficiency (Fisher’s exact, p-value = 0.799, alpha = 0.05).

Conclusion: There is a relatively high prevalence of red-green colour vision deficiency in African females. No correlation was found between family history and the deficiency. None of the students with red-green colour vision deficiency were aware of their deficiency prior to the study. It is recommended that medical students should be screened for colour vision deficiency.
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CHAPTER 1: INTRODUCTION

Colour vision deficiency is commonly referred to as colour blindness. It is the decreased or inability to perceive colour, or differences in colour under specific lighting conditions. Ninety-nine percent of people classified as ‘colour blind’ are actually able to perceive colour.

1.1. Background to the study

There is a relatively high prevalence of congenital red-green colour vision deficiency. Eight percent (8%) of Caucasian males and 0.4% of Caucasian females have red-green colour vision deficiency. Other studies found the prevalence of red-green colour vision deficiency amongst African subjects to be lower compared to Caucasian subjects. Difficulties can be encountered by people in everyday life affecting several professions.

The ability to perceive colour is important in the practice of medicine. Many clinical signs and diagnostic tests use colour as its basis. The prevalence amongst medical professionals ranges between 6.7% and 14% with many professionals reporting difficulties. There is no formal or informal testing carried out for colour vision assessment in South African Medical Universities. Students are unaware of this deficiency and its effects in the medical profession. Due to this lack of awareness by medical students, no self-testing is sought. There is no cure for colour blindness. There is however aids like colour filters or computer based tools that may assist in perceiving colours.
Screening of medical students for colour vision deficiency during or prior to their clinical years will help create awareness about the deficiency. Those identified can then learn to manage this deficiency during training to become medical professionals.

1.2. **Aim**

To assess 5th year medical students at Sefako Makgatho Health Sciences University for red-green colour vision deficiencies.

1.3. **Objectives**

1) To determine the prevalence of red-green colour vision deficiency among 5th year medical students of Sefako Makgatho Health Sciences University using the Ishihara Test plates.

2) To determine the awareness of the students affected with red-green colour vision deficiency
CHAPTER 2: LITERATURE REVIEW

2.1. What is colour vision?

Colour vision is the ability to distinguish objects based on the wavelengths of light that it reflects\textsuperscript{10}. It depends on three populations of retinal cones in the human eye. Each of these cones have a specific sensitivity; blue (tritan) 414-424nm, green (deutan) 522-539nm and red (protan) 549-570nm. Normal colour vision requires all three cones peak sensitivities to fall within the spectrum. Having all three cones is known as trichromacy. A person with normal colour vision can perceive 17000 differences in colour due to a variety of hue, saturation and brightness\textsuperscript{11}.

2.2. Colour vision deficiency

Any cone may be deficient/malfunctioning (e.g. protanomaly - red weakness) or entirely absent cone (e.g. protanopia - red blindness)\textsuperscript{1,10}. Having all three cones, but a shifted spectrum of sensitivity for one of the cones is known as Anomalous Trichromacy. This results in perception of a narrower colour spectrum. Absence of one or two cones is referred to as dichromacy or monochromacy respectively. These anomalies result in a variety of defects. The prevalence of each type of colour vision deficiencies are depicted in Table 1.
Table 1: Prevalence of types of colour vision deficiency according to Gender

<table>
<thead>
<tr>
<th>TYPE</th>
<th>DENOMINATION</th>
<th>PREVALENCE</th>
<th>MALE</th>
<th>FEMALE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monochromacy</td>
<td>Achromatopsia</td>
<td>0.00003%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dichromacy</td>
<td>Protagonopia</td>
<td>1.01%</td>
<td>0.02%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Deuteranopia</td>
<td>1.27%</td>
<td>0.01%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tritanopia</td>
<td>0.00001%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anomalous Trichromacy</td>
<td>Protagonomaly</td>
<td>1.08%</td>
<td>0.03%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Deuteranomaly</td>
<td>4.63%</td>
<td>0.36%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tritanomaly</td>
<td>0.0002%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Spalding (1999)

2.3. Inheritance

Colour vision deficiencies may be congenital or acquired $^2, 12$. The acquired deficiencies are caused by ophthalmic and/or neuro-ophthalmic pathologies and/or certain drugs. Acquired deficiencies are generally due to either macular or optic nerve pathology. Macular pathology usually manifests as tritan defects and optic nerve pathology as deutran defects $^{12}$. Examples of these pathologies are diabetic retinopathy, glaucoma, macular degeneration, senile cataracts and treatment with chloroquine $^2, 12, 13$.

Congenital colour vision deficiencies are either due to red-green (protanopia/protanomaly / deuteranopia / deuteranomaly) colour vision deficiencies or blue-yellow (tritanopia / tritanomaly) colour vision deficiencies $^1, 2, 12$. Red-green colour vision deficiency is a X-linked recessive condition and a blue-yellow colour vision
deficiency is an autosomal dominant trait. Red-green colour vision deficiency accounts for more than 99% of all colour blindness. The genes for the red-green colour photo-pigments are carried on the X chromosome.

Males have one X chromosome, whereas, females have two X chromosomes. In order for a female to inherit a congenital colour vision deficiency, both X chromosomes need to be defective. In comparison to males, the only one X chromosome needs to be defective to manifest the deficiency. Therefore, red-green colour deficiency is more common in males than in females. It is inherited from grandfather to grandson and the mother is usually a carrier in between. Severity of the deficiency varies from person to person.

2.4. Prevalence

The published prevalence of congenital red-green colour vision deficiency in Caucasians males is 8% and 0.4% for Caucasian females. A literature review by J Birch showed a prevalence of red-green colour vision deficiency varying between 4% and 6.5% amongst males of other ethnicities. Table 1 highlights the prevalence amongst males and females for the varying types of colour vision deficiency. The prevalence of colour vision deficiency varies amongst different ethnicities. Other studies found the prevalence of red-green colour vision deficiency amongst African subjects to be lower when compared to Caucasian subjects.
2.5. Awareness

Awareness of the implications of colour vision deficiency is often limited in the general population and amongst those who suffer from it. Most individuals are unaware of their colour vision deficit and some are in denial. The high rate of unawareness of colour vision deficiency may be due to several factors. Most individuals with colour vision deficiency are able to perceive colour but perceive a slightly different hue of colour. Those with more severe deficiencies may rely on social cues and assumptions to identify colours.

A study questionnaire by Steward JM was administered to 102 people with colour vision deficiency. The study found that the choice of career was affected by those participants with colour vision deficiency.

2.6. Implications in the Medical Profession

The ability to perceive colour is important in the practice of medicine. Many clinical signs and diagnostic terms use colour as a basis. The screening for colour vision deficiency amongst medical students is not routinely carried out in South Africa. Colour vision screening is only carried out at one United Kingdom (UK) university and it is rare or not carried out at all in other western countries. In the Far East, this practice is more common.

A review article on colour vision deficiency in the medical profession highlights the prevalence and the difficulties encountered by medical and dental professionals with this deficiency. The prevalence amongst males with
congenital colour vision deficiency varies between 6.7% and 14%. It has been recognized that doctors with an inherited defect of colour vision would have difficulties with certain clinical skills\textsuperscript{12, 19, 26}. Some of the difficulties encountered may be; but not limited to; the observation of cyanosis, pallor, test strips for blood and urine and examination of histology slides\textsuperscript{9, 20, 21}. Others experience difficulties with Ophthalmoscopy in differentiating between haemorrhages and pigment or identifying disc pallor\textsuperscript{22}.

2.7. Tests for colour vision

There are several tests available to test for colour vision: Ishihara, Hardy-Rand-Rittler, City University, Farnsworth-Munsell 100-hue, Farnsworth Lantern Test, Anomaloscope and Farnsworth D15 hue discrimination tests. Other tests like the Giles-Archer lantern tests have been described but are not widely used today.

The most common screening tool is the Ishihara test as it identifies the most common red-green colour deficiencies\textsuperscript{1, 10, 23}. The test is based on pseudoisochromatic plates. The advantages are that it is simple to use, widely available, cost effective and easily interpreted. The disadvantage is that it only identifies the red-green colour deficiency but does not quantify the degree of severity.

The standard version of the Ishihara test consists of 38 plates\textsuperscript{1, 10, 23}. There are also concise versions of the test consisting of 24 plates and another of 14 plates.
The test used in this study consisted of 14 plates of coloured spots with a number embedded within and a control plate as well. The number on the control plate is seen by those with a colour vision deficiency. The test is carried out under standard illumination. Incorrect identification of 4 or less plates indicates normal colour vision. Incorrect identification of 5 or more plates indicates red-green colour vision deficiency.

As this test is qualitative and not quantitative, it would not be correct to postulate that those who make more errors have a more severe deficiency. However, a small number of errors may indicate a mild colour vision deficiency. On the numeral plates, if one fails to see the red number, this may indicate protanomaly or protanopia and failure to see the red-purple number may indicate deuteranomaly or deuteranopia. However, these plates do not fully differentiate between protan and deuteran colour vision deficiency and therefore the exact type of deficiency is not identified.

Another test that uses the principle of pseudoisochromatic plates is the Hardy-Rand-Rittler test. This test consists of 24 plates. The advantage of this test over the Ishihara is that it can detect all three different forms of colour vision deficiencies. The disadvantage of this test is that it is not well known and not widely available.

The City University test is a computer based colour vision test. It also based on the principle of pseudoisochromatic plates as well as arrangement tests with constantly changing colours. The Farnsworth Lantern test was developed by the
US Navy and US Army. This test was designed to pass individuals with colour
vision deficiencies if the deficiency was not too severe\textsuperscript{1,2}.

The Farnsworth-Munsell 100-hue test tests for acquired and congenital colour
defects. The test consists of 85 hue caps which makes the test very time
consuming and not widely available. This test is however the most sensitive of all
the different colour vision tests\textsuperscript{10}.

A similar test, the Farnsworth D15 hue discrimination is much less time
consuming as it utilizes only 15 caps\textsuperscript{10}. These arrangement tests are good to
classify the type of colour deficiency and have the advantage over the Ishihara in
grading the severity of the deficiency\textsuperscript{1}.

Newer tests have been developed on computers and mobile devices\textsuperscript{1,2}. The
problem with these modern computer/mobile tests is that monitors are based on
the use of three main colours namely blue, green and red. The brightness, colour
range and light source vary with the different monitors. The major advantage of
these tests is that they are now widely available and cheap\textsuperscript{1}. 
CHAPTER 3: RESEARCH METHODOLOGY

3.1. Research Design
The study was conducted as a prospective observational study involving screening of 5th year medical students at Sefako Makgatho Health Sciences University for congenital colour vision deficiency.

3.2. Study sample and size
The sample population consisted of all 5th year medical students during their clinical year in 2016. Age and race were not the determinant of inclusion and only those who have acceded to participate and signed an Informed Consent Form were included. The class comprised of 212 students of which 203 took part in the study.

3.3. Exclusion Criteria
1. Any ocular pathology related to colour vision deficiencies.
2. Any medication related to colour vision deficiencies.

3.4. Study setting
The study took place at the Department of Ophthalmology of the Dr George Mukhari Academic Hospital.
3.5. **Data collection and Procedure**

Initially every student was given a detailed explanation about colour vision, its deficiencies and the nature of the study. Screening for colour vision deficiency was performed using the Ishihara test plates. The test consisted of 15 plates each carrying randomly inscribed number. The first plate was a control plate and even students who have red-green colour vision deficiencies are able to see the number. The test was carried out under standard illumination and the student determines the number on each plate.

Students who incorrectly identified 5 or more of the plate numbers were classified as having a colour vision deficiency. Those identified underwent a complete eye examination. Any pathology noted in the eye related to colour vision excluded the student from the study. Those not excluded from the study were adjudged to have a congenital colour vision deficiency.

Data from the study was entered onto a data collection form specifically designed for the study. The form enabled entry of information relating to each participant in terms of demographics, awareness of colour vision deficiency, family history of colour vision deficiency and colour vision assessment. A copy of the data collection form is attached to this protocol as Appendix 3.
3.6. Data Analysis

Data generated from the study was analysed by descriptive statistics using indices of mean values, standard deviation and significant differences. The prevalence of red-green colour vision deficiency among the 5th year students was calculated and expressed using proportions with its associated standard errors and 95% confidence intervals. Fisher’s exact test was calculated to establish the impact of gender, race and awareness on the occurrence of colour vision deficiency. 'P-values' can be interpreted as evidence against the null hypothesis, independently of whether they are statistically significant or not 25. 'P-values' are considered as statistically significant if they are equal or smaller than 0.05 for the significance level. All statistics were evaluated at a 5% significant level.

3.7. Reliability and Validity

Reliability:

This refers to the reproducibility and consistency of information or data and the degree to which a method gives the same result when used on more than one occasion under the same condition 25. In the study reliability was ensured through the following steps:

I. All the 5th year medical students were encouraged to participate in the study to ensure the results of the study represent the extent of the problem in the select group of students.
II. The tool used for assessment in this study (Ishihara test Plates) is a standard and internationally recognized method of assessing colour vision deficiency to ensure that variation in assessment is eliminated.

III. Only the Researcher was responsible for documenting the identification of plate numbers by the participating students.

Validity:

This is the concept of accuracy of a study and it reflects the degree to which the measurements in the study represent the true values of the variables. In the study, validity was censured by:

I. The instrument of data collection (Data Collection Form) has been developed to include all relevant variables that are indicated in the objectives.

II. The tool used for assessment of colour vision assessment is a standardized instrument that requires no repeated calibration and therefore not subject to performance variation.

III. The application of the 15 test plates will not follow a fixed sequence so as to prevent students examined earlier, relating their experiences to those who are to be examined later.

3.8. Bias

This refers to any effect at any stage of a research process that tends to produce results that depart systematically from the true value. The types of bias which may occur and for which steps are to be taken in this study are:
i. Selection Bias: This did not occur as all 5th year medical students were informed and encouraged to participate in the study.

ii. Transcription Bias: The demographics and all data generated from assessment of colour vision defects were immediately entered into the individual participant’s data collection form to avoid wrongful entries.

iii. Data presentation: An appropriate research methodological approach was adopted in presenting results emanating from the study. The interpretation of results was assessed by a statistician.

iv. Over-generalization of findings from this study and making wrong inferences on results was avoided, in order to avoid unnecessary bias.

3.9. Ethical Consideration

A clearance certificate was obtained from Sefako Makgatho Health Sciences University Research Ethics Committee prior to commencement of the study which included an ethical approval (Appendix 4). A letter was issued by the hospital management, authorizing the conduct of the study within the hospital’s Department of Ophthalmology (Appendix 5). The test performed was non-invasive. The informed consent form designed for the study was signed by each participant (Appendix 1). All personal and test information of participating students were treated with confidentiality.
CHAPTER 4: RESULTS

4.1. Prevalence

The prevalence of red-green colour vision deficiency calculated in the sample population was 5.4% with a 95% confidence interval of (3%, 10%). The total sample population was 203 students of which 11 students had colour vision deficiency.

Table 2: Prevalence of Red-Green Colour Vision Deficiency

<table>
<thead>
<tr>
<th>Deficiency</th>
<th>Percentage (%)</th>
<th>Confidence Interval (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO</td>
<td>94.6</td>
<td>90, 97</td>
</tr>
<tr>
<td>YES</td>
<td>5.4</td>
<td>3, 10</td>
</tr>
</tbody>
</table>

4.2. Demographics

4.2.1. Age

The age of the female students ranged from 20 to 40 years with a median of 23 years of age. The age of the male students ranged from 22 to 34 years with a median of 23 years of age.

Table 3: Median Age of Participants

<table>
<thead>
<tr>
<th>AGE</th>
<th>Female</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>2.930</td>
<td>2.161</td>
</tr>
<tr>
<td>Minimum</td>
<td>20</td>
<td>22</td>
</tr>
<tr>
<td>Maximum</td>
<td>40</td>
<td>34</td>
</tr>
</tbody>
</table>
4.2.2. Gender

Of the total of 203 students in the study, female students were in the majority. There were 118 female and 85 male students comprising the total.

Table 4: Gender Profile of Students

<table>
<thead>
<tr>
<th>GENDER</th>
<th>Frequency (students)</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>118</td>
<td>58.1</td>
</tr>
<tr>
<td>Male</td>
<td>85</td>
<td>41.9</td>
</tr>
</tbody>
</table>

4.2.3. Race

The majority of the students were African comprising 82.8% of the total. Caucasians comprised the second largest group at 10.3%.
4.2.4. Awareness

Of the students with colour vision deficiency, none were aware of their deficiency prior to the test.

4.2.5. Family History

Only 4 of the 203 students (2.0%) had a family history of red-green colour vision deficiency. Three of the 4 students with a positive family history identified the father to be colour vision deficient and the 4th identified the mother to be colour vision deficient. The majority (98.0%) had a negative family history. None of those affected with red-green colour vision deficiency had a positive family history.

<table>
<thead>
<tr>
<th>Family History</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO</td>
<td>199</td>
<td>98.0%</td>
</tr>
<tr>
<td>YES</td>
<td>4</td>
<td>2.0%</td>
</tr>
</tbody>
</table>

Graph 2: Family History of Colour Vision Deficiency
4.3. Associations

4.3.1. Red-Green Colour Vision Deficiency and Gender

The combined prevalence for males and females for red green colour vision deficiency was 5.4%. The male cohort comprised of 85 students (41.9%). The prevalence amongst this cohort was 8.2%. The female cohort comprised of 118 students (58.1%). The prevalence amongst this cohort was 3.4%. (Fisher’s Exact, p-value = 0.207, alpha = 0.05)
4.3.2. Red-Green Colour Vision Deficiency and Race

The majority of the students were of the African race (82.8%). From the 11 students with this deficiency, 10 were of the African race and only 1 was of the Indian race. A Fisher's exact test was conducted showing the independence of race and red-green colour vision deficiency (Fisher’s Exact, p-value = 0.462, alpha =0.05).

**Graph 4: Deficiency and Race**

<table>
<thead>
<tr>
<th>Race</th>
<th>Deficiency</th>
<th>No Deficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>African</td>
<td>10</td>
<td>158</td>
</tr>
<tr>
<td>Caucasian</td>
<td>0</td>
<td>21</td>
</tr>
<tr>
<td>Indian</td>
<td>1</td>
<td>12</td>
</tr>
<tr>
<td>Mixed</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

4.3.3. Red-Green Colour Vision Deficiency and Awareness

None of the students were aware of their deficiency prior to the study.

4.3.4. Red-Green Colour Vision Deficiency and Family History

Of the 11 students identified with the deficiency, none had a positive family history. Although 4 students had a positive family history, none of those 4 students were found to have red-green colour vision deficiency. A Fishers exact test was conducted showing independence of family history and red-green colour vision deficiency (Fishers exact, p-value = 1.00, alpha = 0.05).
4.3.5. Gender and Race

Of the total 203 students in the study; 99 were African females, 69 were African males, 11 were Caucasian females, 10 were Caucasian males, 7 were Indian females, 6 were Indian males and 1 female was of mixed race.

Graph 5: Gender and Race

4.3.6. Prevalence, Gender and African Race

In the group of males of all races in the study (n=85), the prevalence was 8.2% (95% Confidence Interval (4%, 16%)). In the group of females of all races (n=118), the prevalence was 3.4% (95% Confidence Interval (1%, 9%)).

Table 5: Prevalence in Males and Females

<table>
<thead>
<tr>
<th></th>
<th>Prevalence (%)</th>
<th>95% Confidence Interval (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>8.2</td>
<td>4, 16</td>
</tr>
<tr>
<td>Female</td>
<td>3.4</td>
<td>1, 9</td>
</tr>
</tbody>
</table>
In the subgroup of African males (n=69), the prevalence was 8.7% (95% Confidence Interval (4%, 8%)) and in African females (n=99), the prevalence was 4.0% (95% Confidence Interval (2%, 10%)).

Table 6: Prevalence in African Males and Females

<table>
<thead>
<tr>
<th></th>
<th>Prevalence (%)</th>
<th>95% Confidence Interval (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>African Male</td>
<td>8.7</td>
<td>4, 18</td>
</tr>
<tr>
<td>African Female</td>
<td>4.0</td>
<td>2, 10</td>
</tr>
</tbody>
</table>

The prevalence in Males from all races (8.2%) when compared to the prevalence in African Males (8.7%) is statistically non significant (Fishers exact, p-value = 1.00, alpha = 0.05). The prevalence in Females (3.4%) from all races when compared to the prevalence in African Females (4%) is statistically non significant (Fishers exact, p-value = 1.00, alpha = 0.05).

Table 7: Prevalence for Gender and Race

<table>
<thead>
<tr>
<th>Prevalence</th>
<th>No Deficiency</th>
<th>Deficiency</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males of all Races</td>
<td>78 (91.8%)</td>
<td>7 (8.2%)</td>
<td>85</td>
</tr>
<tr>
<td>African Males</td>
<td>63 (91.3%)</td>
<td>6 (8.7%)</td>
<td>69</td>
</tr>
<tr>
<td>Females of all Races</td>
<td>114 (96.6%)</td>
<td>4 (3.4%)</td>
<td>118</td>
</tr>
<tr>
<td>African Females</td>
<td>95 (96.0%)</td>
<td>4 (4.0%)</td>
<td>99</td>
</tr>
</tbody>
</table>
CHAPTER 5: DISCUSSION

The study population comprised of 5th year medical students at Sefako Makgatho Health Sciences University. The majority of the participants were of the African race with a greater proportion of African females. The prevalence of red-green colour vision deficiency in this study population was comparable to other studies 1, 3, 5, 6, 9.

The prevalence of red-green colour vision deficiency amongst the African male participants in this study correlates with the known prevalence amongst Caucasian males in other studies 1, 3, 9. There are varying results for the prevalence of colour vision deficiencies amongst African males 3, 5, 6. A study on the worldwide prevalence for colour vision deficiency found an increasing prevalence in African males 3. This is in contrast to other studies; which found the prevalence of colour vision deficiency amongst African males to be less than half when compared to Caucasian males 5, 6.

The prevalence of red-green colour vision deficiency amongst the African female participants in this study is higher than the known prevalence amongst Caucasian females in other studies 1, 3. In a South African study, a higher prevalence was noted amongst African females 5.

In a study done in Tehran on secondary school students (n=2058), assessing for red-green deficiency using Ishihara plates; males had 8.2% and females a 0.42%
prevalence of colour vision deficiency 15. Another study assessing red-green deficiency in school children in India showed 2% prevalence amongst females 17.

The relatively high prevalence of red-green colour vision deficiency amongst females in this study may be due to a higher prevalence in the African female population. There may be an increased prevalence of mothers who are female carriers and fathers with colour blindness resulting in an increased prevalence amongst females. Half of daughters born to these parents would be colour vision deficient if both X-chromosomes are affected. Other genetic factors may account for the higher prevalence of colour vision deficiency in the African female population.

None of the students in the study, who were found to have colour vision deficiency, were aware of their deficiency. This is not uncommon when compared to other studies 14, 21, 27, 28. A recent study of school students in India showed that none of the 30 students with colour vision deficiency out of a total of 738 students were aware of their deficiency 17.

People who have colour vision deficiency may be unaware of their deficiency as they may perceive only a slightly different hue of a colour. Those with more severe deficiencies may rely on social cues and assumptions to identify colours1. An example of an assumption would be the ‘green grass’ and the ‘blue sky’.

Although red green colour vision deficiency is mostly due to a genetic inheritance, a very small sample of students had a positive family history. None of these
students with a positive family history had red-green colour vision deficiency themselves.

Of the students with a red green colour vision deficiency, none had a positive family history. No correlation was found between family history and the deficiency in this study. This could be due to a general lack of awareness of colour vision deficiencies.

A comparable number of medical students in this study had red-green colour vision deficiency. A review article by Spalding concluded that the prevalence for congenital colour vision deficiencies amongst medical professionals is comparable to the population at large 9. Several studies assessed the prevalence specifically in male medical professionals had results varying from 7.9% to 13% 20, 21, 23, 24, 26. The Ishihara test plates were used in these studies.

The review article also highlighted the many difficulties that are encountered by medical and dental professionals with colour vision deficiencies 9, 26. Other studies also showed that doctors with an inherited colour vision deficiency had difficulties with certain clinical skills 12, 19. Observation of cyanosis, pallor, blood and urine test strips and examination of histology slides are just some of the difficulties encountered 9, 20, 21, 26. Other medical professionals also experienced difficulties with Ophthalmoscopy 22.
CHAPTER 6: SUMMARY, RECOMMENDATIONS, CONCLUSION

6.1. Summary

The prevalence of red-green deficiency in this study was 5.4% with 8.2% for males and 3.4% for females. The subgroup of African females had a prevalence of 4.0% which was higher than the known prevalence in the female Caucasian population. The Ishihara test plates were used to screen 203 students for red-green colour vision deficiency. Many clinical tests and signs in the practice of medicine use colour as a basis. It is therefore important that medical professionals with colour vision deficiency should be aware of their colour vision deficiency. None of the 11 students with red-green colour vision deficiency were aware of their deficiency prior to the test. There is no cure for colour blindness but there are aides that might assist in the perception of colours.

6.2. Recommendations

- Screening for colour vision deficiencies should be carried out for medical students in order to identify those with the deficiency.
- Future studies should be carried out in other medical Universities to confirm the findings of this study.
- A program like the “Colour Blind Awareness” group that screens school children in UK schools would be beneficial to raise awareness and to assist in managing the deficiency.
Further studies with larger sample sizes should be carried out to confirm the prevalence amongst African females due to the higher prevalence found in this study.

Other colour vision tests could be carried out to identify and quantify the type of colour deficiency.

6.3. Limitations

- Only 203 of the 212 students took part in the study.
- The number of participants from other race groups was not enough to make statistically significant conclusions.
- The Ishihara test plates were used for this study which only identifies red-green colour vision deficiency but does not quantify the extent of the deficiency.

6.4. Conclusion

Colour assessment is important in the practice of medicine. African female students have a relatively high prevalence of red-green colour vision deficiency. Family history was not a correlating factor of this deficiency. No students are aware of their red-green colour vision deficiency. This highlights the need for screening for colour vision deficiencies amongst medical students.
REFERENCES


Statement concerning participation in a Research Project.

Name of Study

SCREENING OF 5TH YEAR MEDICAL STUDENTS AT SEFAKO MAKGATHO HEALTH SCIENCES UNIVERSITY FOR RED-GREEN COLOUR VISION DEFICIENCIES

I have heard the aims and objectives of the proposed study and was provided the opportunity to ask questions and given adequate time to rethink the issue. The aim and objectives of the study are sufficiently clear to me. I have not been pressurized to participate in any way.

I understand that participation in this Study is completely voluntary and that I may withdraw from it at any time and without supplying reasons. This will have no influence on the regular treatment that holds for my condition neither will it influence the care that I receive from my regular doctor.

I know that this Study has been approved by the Sefako Makgatho University Research Ethics Committee (SMUREC), Sefako Makgatho Health Sciences University and Dr George Mukhari Hospital. I am fully aware that the results of this Study will be used for scientific purposes and may be published. I agree to this, provided my privacy is guaranteed.

I hereby give consent to participate in this Study.

........................................................................................................................................................................................................
Name of Student ........................................................................................................ Signature of Student

........................................................................................................................................................................................................
Place. ........................................................................................................ Date. ........................................................................................................ Witness

Statement by the Researcher

I provided verbal information regarding this Study
I agree to answer any future questions concerning the Study as best as I am able.
I will adhere to the approved protocol.

........................................................................................................................................................................................................
Name of Researcher ........................................................................................................ Signature ........................................................................................................ Date ........................................................................................................ Place
The Chairperson,
Sefako Makgatho University Research Ethics Committee (SMUREC),
Box 163
SEFAKO MAKGATHO HEALTH SCIENCES UNIVERSITY

Dear Sir/Madam

STATISTICAL ANALYSES

I have studied the research protocol of

DR ABOOBAKER GANI

titled: _SCREENING OF 5TH YEAR MEDICAL STUDENTS AT SEFAKO MAKGATHO HEALTH
SCIENCES UNIVERSITY FOR RED-GREEN COLOUR VISION DEFICIENCIES_

and I agree to assist with the statistical analyses.

Yours sincerely,

Signature: Statistician

_TSHFHIWA_
Name in block letters

_18/09/2017_
Date
## APPENDIX 3

### Data Collection Sheet

<table>
<thead>
<tr>
<th>Participant Number</th>
<th>1. Age</th>
<th>2. Gender</th>
<th>3. Race</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>AFRICAN</td>
</tr>
<tr>
<td>4. Are you aware of any colour deficiency that you may have?</td>
<td>YES</td>
<td>NO</td>
<td></td>
</tr>
<tr>
<td>5. Family History of colour blindness (please specify which family member) e.g. Mother’s father, Brother</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Ishihara Test Answer Sheet

<table>
<thead>
<tr>
<th>PLATE NUMBER</th>
<th>NORMAL RESPONSE</th>
<th>SUBJECT’S RESPONSE</th>
<th>PLATE NUMBER</th>
<th>NORMAL RESPONSE</th>
<th>SUBJECT’S RESPONSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>12</td>
<td></td>
<td>9</td>
<td>56</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td></td>
<td>10</td>
<td>27</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>42</td>
<td></td>
<td>11</td>
<td>89</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>56</td>
<td></td>
<td>12</td>
<td>86</td>
<td></td>
</tr>
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<td>74</td>
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</tr>
<tr>
<td>7</td>
<td>5</td>
<td></td>
<td>15</td>
<td>47</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Incorrect Responses of the Student**

<table>
<thead>
<tr>
<th>≤4</th>
<th>≥5</th>
</tr>
</thead>
</table>

**Score of Ishihara Test**

| 15 |

**Does the student have a congenital red-green colour vision deficiency?**

<table>
<thead>
<tr>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
</table>
APPROVAL NOTICE – CONTINUATION OF STUDY

01 June 2017

Dr A Gani
Department of Ophthalmology
P.O Box 86
Medunsa, 0204

MEETING:

04/2016
05/2017

SMUREC Ethics Reference Number:
SMUREC/M/92/2016: PG

The New Application received on 20 April 2016, was reviewed by members of Sefako Makgatho University Research Ethics Committee 04 May 2016 and was approved on 04 May 2016.

On the 01 June 2017 SMUREC approved continuation of this study.

Title: Screening of 5th year medical students at Sefako Makgatho Health Sciences University for red-green colour vision deficiencies

Researcher: Dr A Gani
Supervisor: Prof JF Olivier
Co-supervisor: Dr JB Maitia
Hospital Superintendent: Dr S Mogotsi (DGMAH)
Department: Ophthalmology
School: Medicine
Degree: MMed Ophthalmology

Please note the following information about your approved research protocol:

Protocol Approval Period: 04 May 2017 – 04 May 2018

Please remember to use your protocol number (SMUREC/M/92/2016: PG) on any documents or correspondence with the REC concerning your research protocol. Please note that the REC has the prerogative and authority to ask further questions, seek additional information, require further modification, or monitor the conduct of your research and the consent process.

After Ethical Review: Please note a template of the progress report is obtainable in the Research Office and should be submitted to the Committee before the year has expired. The Committee will then consider the continuation of the project for a further year (if necessary). Annually a number of projects may be selected randomly for an external audit. Translation of the consent document in the language applicable to the study participants should be submitted.

International Organisation (IORG0008691), Institutional Review Board (IRB00010386) Expiry date: 09 December 2018, Federal Wide Assurance (FWA000023943) Expiry date: 03 March 2021 and NHREC No: REC 210408-003

Sincerely

PROF C BAKER
DEPUTY CHAIRPERSON SMUREC
APPENDIX 5:

Dr. George Mukhari Academic Hospital

Office of the Director Clinical Services
Enquiries: Dr. PMT. Mabusela
Tel: (012) 529 3880
Fax: (012) 560 0099
Philly.mabusela@gauteng.gov.za
Kedibone.matsimela@gauteng.gov.za

To: Dr. Aboobaker Gani
   Department of Ophthalmology
   University of Sefako Makgatho Health Sciences
   PO Box 66
   MEDUNSA
   0204

Date: 02 February 2016

PERMISSION TO CONDUCT RESEARCH

The Dr. George Mukhari Academic Hospital hereby grants you permission to conduct research on “Screening of 5th year Medical Students at Sefako Makgatho Health Sciences University for Congenital Colour Vision Deficiencies at Dr. George Mukhari Academic Hospital.”

This permission is granted subject to the following conditions:

☐ That you obtain Ethical Clearance from the Human Research Ethics Committee of the relevant University
☐ That the Hospital incurs no cost in the course of your research
☐ That access to the staff and patients at the Dr George Mukhari Hospital will not interrupt the daily provision of services.
☐ That prior to conducting the research you will liaise with the supervisors of the relevant sections to introduce yourself (with this letter) and to make arrangements with them in a manner that is convenient to the sections.

Yours sincerely

[Signature]

DR. PMT MABUSELA
DIRECTOR: CLINICAL SERVICES

[Return address]