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# Assessment of Color Vision in Blood Cancer Patients

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## Abstract

Color vision is the eyes capacity to distinguish between distinct light wavelengths, which allows for the experience of color. The retinas cone cells, which react too various light wavelengths to create a variety of colour experiences, help with this function. The objective of this study is to "Assessment of color vision in blood cancer patients". This descriptive cross-sectional study includes 100 clinically diagnosed blood cancer patients between the age range of 20-40. Color vision was assessed by Ishihara plates. The study included 100 participants, with a higher proportion of males (62%) compared to females (38%). The majority of participants had leukemia for 1-12 months (79%), while 21% had leukemia for 13-24 months. Regarding right eye diagnosis, 80 participants (80%) had normal vision, 11 (11%) had protanopia, and 9 (9%) had deuteranopia. For the left eye, 72 participants (72%) had normal vision, 19 (19%) had protanopia, and 9 (9%) had deuteranopia. When analysing vision diagnosis by gender, among males, 46 had normal vision in the right eye, 9 had protanopia, and 7 had deuteranopia, while among females, 34 had normal vision, 2 had protanopia, and 2 had deuteranopia. In the left eye, 41 males had normal vision, 14 had protanopia, and 7 had deuteranopia, whereas among females, 31 had normal vision, 5 had protanopia, and 2 had deuteranopia. To investigate the relationship between leukemia duration and vision diagnosis, a chi-square test was conducted. For the right eye, the test result ($\chi^2 = 1.330$, $p = 0.514$) showed no significant association between leukemia duration and vision impairment. Similarly, for the left eye, the chi-square test ($\chi^2 = 1.525$, $p = 0.466$) also indicated no significant relationship. These findings suggest that the duration of leukemia does not have a statistically significant impact on vision diagnosis in either eye. No significant association was found between gender, leukemia duration, and the diagnosis categories for both the right and left eyes.

**Key words:** Leukemia, Color Vision, Blood Cancer, Protanopia, Deuteranopia

**Introduction:**

Color vision is the eye's capacity to distinguish between distinct light wavelengths, which allows for the experience of color. (1) The retinal cone cells, which react to various light wavelengths to create a variety of colour experiences, help with this function. (2) Although the majority of people have normal colour vision, some disorders can cause impairments in colour vision, such as trouble telling red from green. (3) In medical settings, systemic disorders and associated therapies may affect colour vision. The visual system may be impacted by blood malignancies, especially leukemia, and the treatment plans that go along with them (such as chemotherapy and radiation), which could result in deficiencies in colour vision. This is important since colour vision impairment can have an impact on a patient's quality of life and could be a symptom of underlying ocular or neurological conditions. (4) Cones are specialized photoreceptor cells in the retina that are mostly responsible for colour perception. Three different types of cones, short (s-cones), medium (m- cones), and long (l- cones), are found in the human retina, and they are each sensitive to distinct light wavelengths. Red, green, and blue light are detected by these cones, respectively. From violet (the colour with the shortest wavelength) to red (the colour with the longest wavelength), the visible spectrum spans from 400 to 700 nanometers (nm). (5) Within this spectrum, the human eye's sensitivity peaks in the green region (around 555nm) under photopic (daylight) conditions. For example, the most common type, red-green color blindness, results from Color vision deficiencies (CVDs), often referred to as color blindness, which result from anomalies in one or more of the three types of cone cells in the retina. (6) Color vision deficiencies are relatively common, particularly among males. The prevalence of red-green color blindness, the most widespread type, affects about 8% of males and 0.5% of females of Northern European descent. (7) Color vision deficiencies are primarily categorized into three types: Protanopia: about 1% of men and 0.01% of women suffer from this condition, which is caused by L-cone dysfunction and impairs their capacity to see red light. Deuteranopia: 1% of males and 0.01% of females also have M-cone malfunction, which impairs their capacity to perceive green light. Tritanopia: about 0.01% of people have this rarest kind, which affects how blue light is perceived. (8) The eye is a complex organ that can be significantly affected by systemic diseases. Conditions such as diabetes, hypertension, autoimmune disorders, and cancers can impair visual function by impacting various components of the eye, including the retina and the optic nerve. (9) The optic nerve transmits visual information from the retina to the brain. Damage to the optic nerve, as seen in conditions like optic neuritis (due to vascular problems), can impair color vision and contrast sensitivity. (9) Leukemia is a clonal proliferation of hematopoietic stem cells in the bone marrow. The four broad subtypes most likely to be encountered by primary care physicians are acute lymphoblastic, acute myelogenous, chronic lymphocytic, and chronic myelogenous. Acute lymphoblastic leukemia occurs more often in children, whereas the other subtypes are more common in adults. (10) Leukemia is the most prevalent pediatric malignancy diagnosed worldwide, and it is also one of the most expensive to cure. The increase of mature B-lymphocytes in the blood, bone marrow, lymph nodes, and spleen is a hallmark of chronic lymphocytic leukemia (CLL), the most prevalent leukemia in adults in the Western world.

A distinctive immunophenotype and a particular pattern of histopathological infiltration in the bone marrow and lymph nodes are characteristics of chronic lymphocytic leukemia (CLL). From milder forms to more aggressive cancers, its clinical course varies greatly. (11) Systemic disease can cause inflammation, compromised blood flow, and neurodegenerative processes that may damage retinal cells or optic nerve fibers. Cancer and its treatment, such as chemotherapy, radiation, and targeted chemotherapies, can have direct and indirect effects on the visual system. (12) Usually, CLL/SLL develops in two stages: a transformation phase that is characterized by extramedullary proliferation and a surge in larger, immature cells, and an initial phase that is characterized by small tumor cells with low proliferation and prolonged survival. (13) A complete blood count and immunophenotyping make the diagnosis of CLL simple; the clinical progression

varies. (14) Treatment for leukemia often includes chemotherapy, radiation therapy, immunotherapy, and stem cell transplantation. These interventions, while essential for managing the disease, can come with various side effects that impact overall health, including ocular function. (15) Treatment-related secondary causes or blood abnormalities brought on by the disease are frequently the cause of eye symptoms in acute myeloid leukemia (AML). Retinal hemorrhage, ocular blood vessel obstructions, infections, impaired vision, and vision loss are typical symptoms. Chemotherapy, steroids, bone marrow transplants, and total body radiation therapy are among the AML treatments that commonly cause these side effects. moreover, unusual blood disorders brought on by AML itself can worsen ocular problems. (16)

**Material and Methods:**

This descriptive cross-sectional study was conducted at Shaukat Khanum Memorial Hospital and Research Center, Inmol Hospital Lahore, over 6 months following synopsis approval. A total of 100 participants were recruited using a purposive sampling technique, based on a calculated sample size with Sample size (n) = [DEFF*Np(1−p)]/ [(d2/Z21-α/2*(N−1) +p*(1−p)]

**Inclusion Criteria:** Both genders (male and female). Age between 20 to 40 years. Participants diagnosed with leukemia. **Exclusion criteria** were Patients with mental retardation Uncooperative patients unable to complete the color vision test. Patients with low vision. Individuals diagnosed with ocular diseases (e.g., Age-Related Macular Degeneration (ARMD), Glaucoma). After obtaining informed consent, demographic and clinical histories were recorded. **Personnel training:** Train research staff on the study protocol, including administering the Ishihara Color Vision Test, data collection methods, and ethical considerations. **Identification of participants:** Utilize purposive sampling to identify eligible leukemia patients attending the hospital for treatment. **Demographic Data Collection:** Collect relevant demographic information from participants, including age, gender, type of leukemia diagnosis, duration of treatment, previous treatments, and current medications. This information will be gathered using a standardized questionnaire. **Conduct the Ishihara test:** In a controlled and well-lit environment to minimize external factors that may affect color perception.

**Results:**

The study analyzed 100 participants, with a gender distribution of 62% males and 38% females. Most participants (79%) had leukemia for one year, while 21% had it for two years. The diagnostic distribution showed that 72-80% had normal vision, while 9-19% had protanopia or deuteranopia. Males had a higher prevalence of color vision deficiencies than females. The study also examined the link between leukemia duration and vision diagnosis, finding no significant association ($p > 0.05$). Regardless of leukemia duration, most participants had normal vision. These results suggest that leukemia duration does not impact color vision.

**Table 1: Frequency table for Gender distribution.**

| Gender distribution | Frequency (n) | Percentage % |
|---|---|---|
| Male | 62 | 62% |
| Female | 38 | 38% |
| **Total** | **100** | **100%** |

This table depicts the gender distribution of study participant's male percentage was more then females that was 62% and 38% respectively.

**Fig No.1**

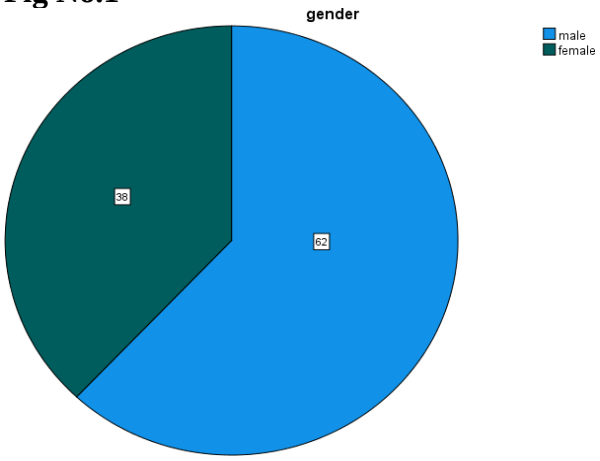


**Fig 5.1:** The pie chart shows information about the number of male and female among the 100 patients suffering from blood cancer, 62% were male and 38% were female among them.

**Table 5.2: Frequency table for Duration of Leukemia**

| Duration | Frequency | Percentage % |
|---|---|---|
| 1-12 months | 79 | 79% |
| 13-24 months | 21 | 21% |
| **total** | **100** | **100%** |

This table shows the frequency of leukemia duration among participants. Out of 100 participants, 79 (79.0%) had leukemia for one year, while 21 (21.0%) had leukemia for two years.

**Fig no. 2**

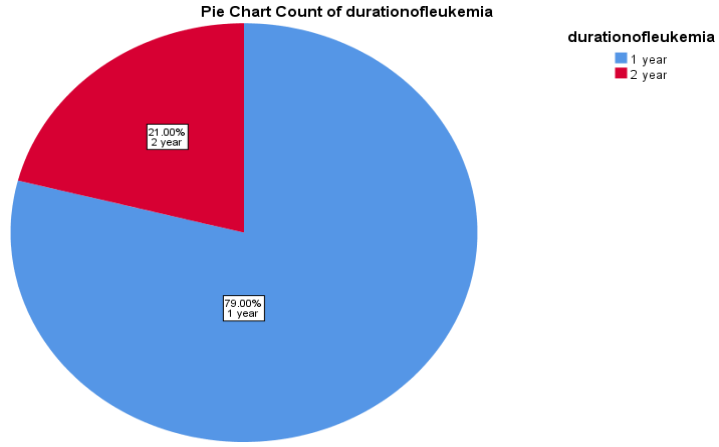


**Fig 2:** This pie chart describes the duration of leukemia. Patients suffering from blood cancer from 1 year is 79% and patients suffering from blood cancer from 2 year is 21%.

**Table 3: Frequency table for Diagnosis Category of Right eye**

| Diagnosis | Frequency | Percentage |
|---|---|---|
| Normal | 80 | 80.0 % |
| Protanopia | 11 | 11.0 % |
| Deuteranopia | 9 | 9.0.0 % |
| **Total** | **100** | **100.0 %** |

This table provides a frequency distribution of the diagnostic categories among

participants. It shows that out of 100 participants, 80 were classified as having a normal diagnosis (80.0%), 11 were diagnosed with protanopia (11.0%), and 9 with deuteranopia (9.0%).

**Fig no. 3**

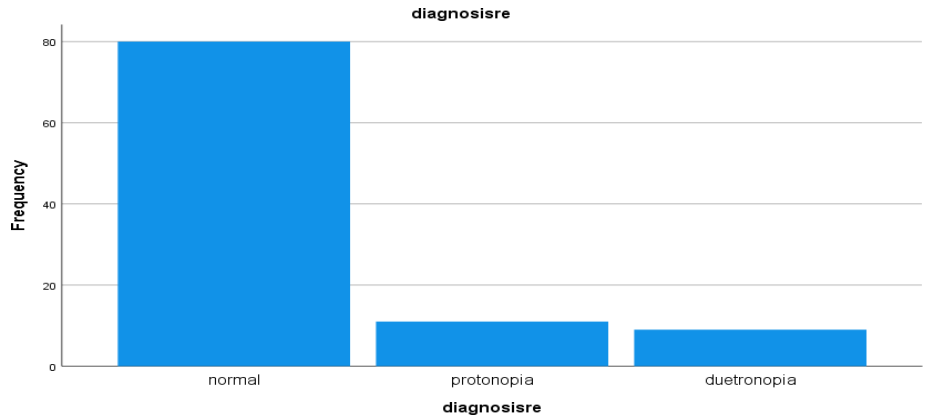


**Fig3:** A bar chart illustrating the distribution of diagnosis categories, with 80% representing normal individuals, 11% representing protanopia and 9% representing deuteranopia.

**Table 5.4: Frequency table for Diagnosis Category of left eye**

| Diagnosis | Frequency | Percentage |
|---|---|---|
| Normal | 72 | 72.0 % |
| Protanopia | 19 | 19.0 % |
| Deuteranopia | 9 | 9.0 % |
| **Total** | **100** | **100.0 %** |

**Table no. 4**

This table provides a frequency distribution of the diagnostic categories among participants. It shows that out of 100 participants, 72 were classified as having a normal diagnosis (72.0%), 19 were diagnosed with protanopia (19.0%), and 9 with deuteranopia (9.0%).

**Fig no. 4**

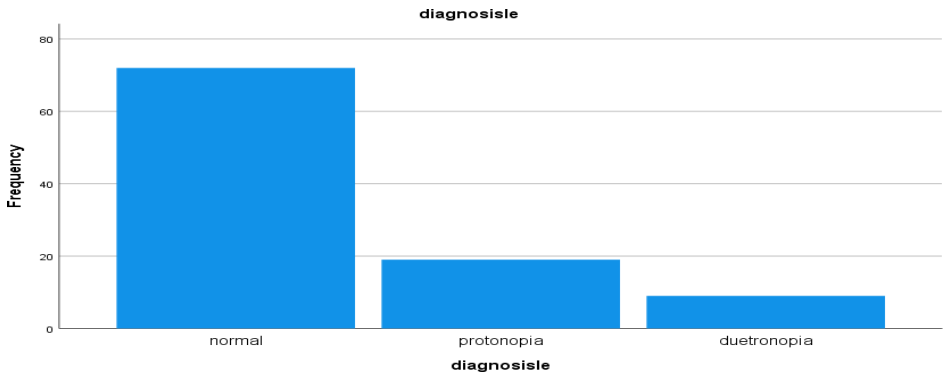


**Fig 4:** a bar chart illustrating the distribution of diagnosis categories, with 72% representing normal indiviuals, 19% representing protanopia and 9% representing deuteranopia.

**Table 5: Crosstab of Gender and Diagnosis of Right eye**

| | | | Normal | Protanopia | Deuteranopia | Total |
|---|---|---|---|---|---|---|
| **Gender** | **Male** | count | 46 | 9 | 7 | 62 |
| | **Female** | count | 34 | 2 | 2 | 38 |
| **Total** | | count | 80 | 11 | 9 | 100 |
| | | % Within diagnosis RE | 100.0% | 100.0% | 100.0% | 100.0% |

**Table no. 5**

This table examines the relationship between gender and diagnostic categories. Among the 62 males, 46 (57.5%) were classified as normal, 9 as protanopia and 7 as deuteranopia. Among the 38 females, 34 were classified as normal, 2 as protanopia and 2 as deuteranopia.

**Fig 5.**

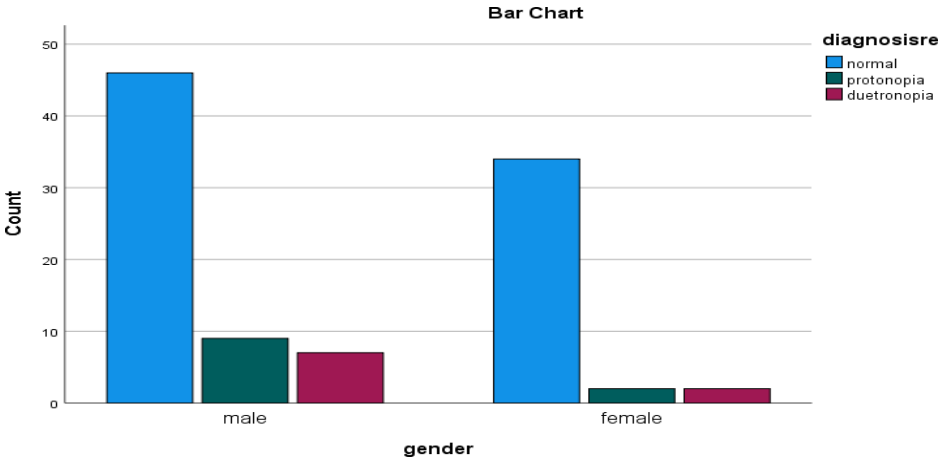


**Table 6: Crosstab of Gender and Diagnosis of Left Eye**

| | | | Normal | Protanopia | Deuteranopia | Total |
|---|---|---|---|---|---|---|
| **Gender** | **Male** | count | 41 | 14 | 7 | 62 |
| | **Female** | count | 31 | 5 | 2 | 38 |
| **Total** | | count | 72 | 19 | 9 | 100 |
| | | % Within diagnosis LE | 100.0% | 100.0% | 100.0% | 100.0% |

**Table no. 6**

This table examines the relationship between gender and diagnostic categories. Among the 62 males, 41 (56.9%) were classified as normal, 14 as protanopia and 7 as deuteranopia. Among the 38 females, 31 were classified as normal, 5 as protanopia and 2 as deuteranopia.

**Fig no. 6**

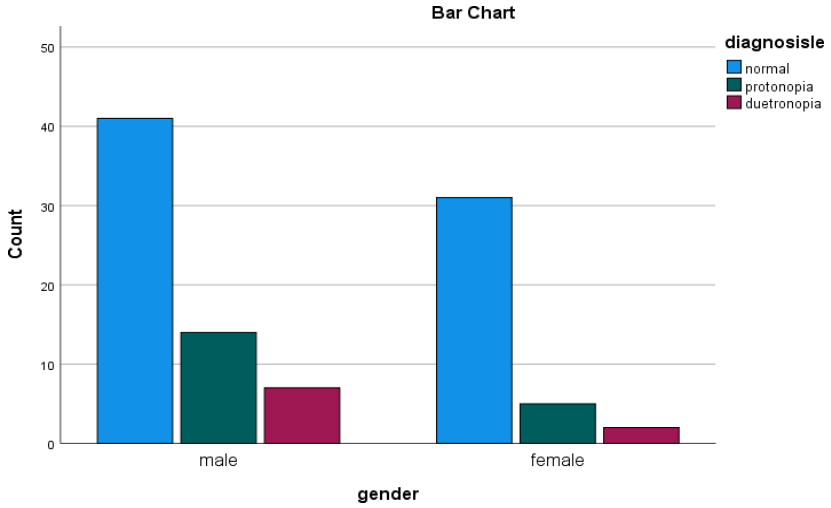


**Fig 6:** A bar chart showing the distribution of gender and diagnosis categories. For both male and females, blue represent normal individuals, green represents protanopia, and red represents deuteranopia.

**Table 7: Crosstab and Chi-Square Test for Leukemia Duration and Right Eye Diagnosis**

| Duration of leukemia | Normal | Protanopia | Deuteranopia | Total | p-value |
|---|---|---|---|---|---|
| 1-12 months | 65 | 8 | 6 | 79 | 0.514 |
| 13-24 Months | 15 | 3 | 3 | 21 | |
| **Total** | 80 | 11 | 9 | 100 | |
| % Within diagnosis RE | 100% | 100% | 100% | 100% | |

**Table no. 7**

This table investigate the relationship between the duration of leukemia and diagnostic categories. For participants with one year of leukemia, 65 were classified as normal, 8 as protanopia and 6 as deuteranopia. For those with two years of leukemia, 15 were normal, 3 had protanopia and 3 had deuteranopia. The chi-square test ($\chi^2 = 1.330$, $p = 0.514$) indicates no significant association between leukemia duration and vision diagnosis

**Fig no. 7**

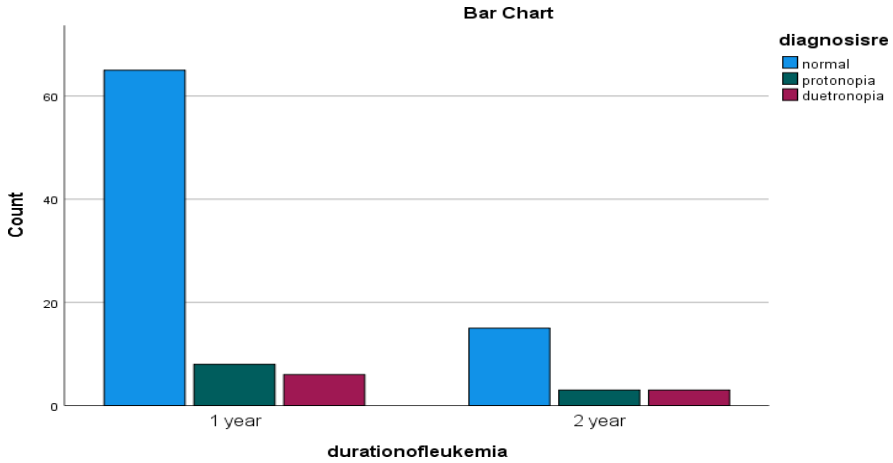


**Fig 7:** A bar chart illustrating the relationship between the duration of leukemia (1 year and 2 years) and diagnosis categories. The chart indicates that the number of 1-year patients is higher compared to 2-year patients across all diagnosis categories.

**Table 8: Crosstab and Chi-Square Test for Leukemia Duration and Left Eye Diagnosis**

| Duration of Leukemia | Normal | Protanopia | Deuteranopia | Total | p-value |
|---|---|---|---|---|---|
| 1-12 months | 59 | 14 | 6 | 79 | 0.466 |
| 13-24 months | 13 | 5 | 3 | 21 | |
| Total | 100 | 19 | 9 | 100 | |
| % Within diagnosis LE | 100% | 100% | 100% | 100% | |

Table no. 8

This table investigate the relationship between the duration of leukemia and diagnostic categories. For participants with one year of leukemia, 59 were classified as normal, 14 as protanopia and 6 as deuteranopia. For those with two years of leukemia, 13 were normal, 5 had protanopia and 3 had deuteranopia. The chi-square test ($\chi^2 = 1.525$, $p = 0.466$) shows no significant association between leukemia duration and vision diagnosis.

**Fig no. 8**

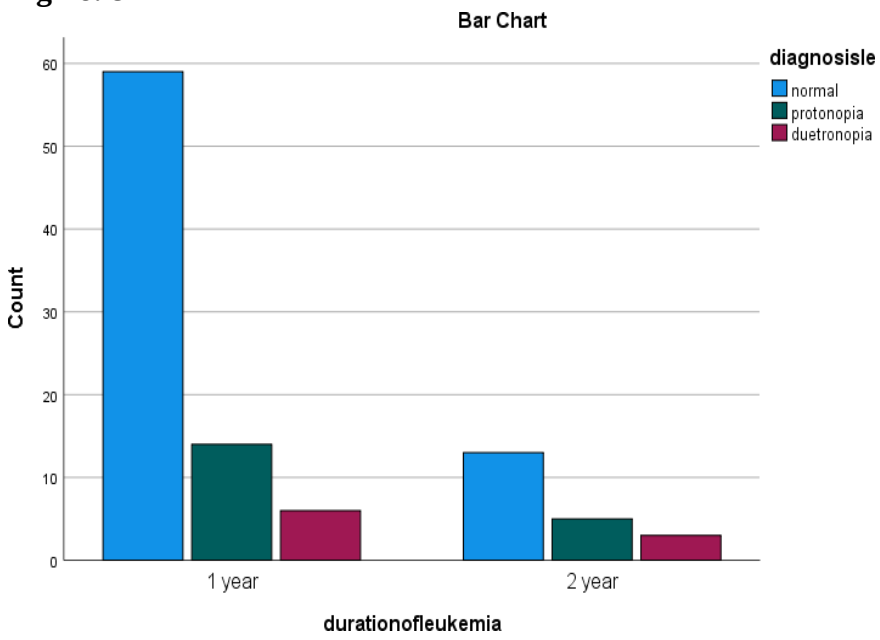


**Fig 8:** A bar chart illustrating the relationship between the duration of leukemia (1 year and 2 years) and diagnosis categories. The chart indicates that the number of 1- year patients is higher compared to 2-year patients across all diagnosis categories.

**Discussion**

In our research we had total 100 participants. The data was collected from Shaukat khanum memorial cancer hospital and research center and Inmol Hospital Lahore. The study examined the frequency distribution of leukemia duration among participants and its potential association with color vision deficiencies. Among the 100 participants, 79% had leukemia for one year, while 21% had it for two years. The diagnostic classification revealed that, in one set of data, 80% of participants had a normal diagnosis, 11% were diagnosed with protanopia, and 9% with deuteranopia. Another dataset showed slightly different distributions, with 72% classified as normal, 19% diagnosed with protanopia, and 9% with deuteranopia. Gender-based analysis of diagnostic categories highlighted differences in prevalence. Among 62 male participants, normal vision was observed in 57.5%, while 9 were diagnosed with protanopia and 7 with deuteranopia. In contrast, among 38 female participants, 34 had normal vision, while 2 were diagnosed with

protanopia and 2 with deuteranopia. A second set of data showed a slightly different distribution, with 56.9% of males classified as normal, 14 diagnosed with protanopia, and 7 with deuteranopia. Among females, 31 were classified as normal, while 5 had protanopia and 2 had deuteranopia. Further analysis investigated the relationship between leukemia duration and diagnostic categories. Among participants with one year of leukemia, 65 had normal vision, 8 had protanopia, and 6 had deuteranopia. For those with two years of leukemia, 15 had normal vision, 3 had protanopia, and 3 had deuteranopia. The chi- square test ($\chi^2 = 1.330$, $p = 0.514$) indicated no significant association between leukemia duration and vision diagnosis. Another dataset showed a slightly different distribution, with 59 participants with one year of leukemia classified as normal, 14 with protanopia, and 6 with deuteranopia. Among those with two years of leukemia, 13 had normal vision, 5 had protanopia, and 3 had deuteranopia. The chi-square test ($\chi^2 = 1.525$, $p = 0.466$) similarly showed no significant association between leukemia between leukemia duration and color vision deficiencies. A previous similar study Saleh Shah et al in 2020 conducted a study in uncommon occurrence of episodic white-out vision and subjective intermittent bilateral color vision loss as early signs of chronic myeloid leukemia (CML). The patient experienced unusual previously uninvestigated vision problems that were initially misdiagnosed as diabetic retinopathy. The hyper viscosity syndrome, which is brought on by excessive leukocytosis, was identified as the source of the visual abnormalities. This condition affects color vision and retinal blood flow. The patient's visual complaint was alleviated and the WBC count was (8.0%). (17) A randomized electrophysiologic and color contrast sensitivity test of a patient with acute myelocytic leukemia (AML) revealed acquired color vision disorder (dyschromatopsia), which recovered with treatment. (18) Ahmed N Buzaid et al in 2017 Chronic myelogenous leukemia (CML) is a stem cell disorder linked to the Philadelphia chromosome, often presenting with anemia, granulocytosis, and splenomegaly. This case reports a 36-year-old male with progressive vision loss due to bilateral retinal hemorrhage, later diagnosed with CML. Treatment with tyrosine kinase inhibitors led to complete remission and full vision recovery. Notably, the patient's color vision remained unaffected despite retinal involvement. (19) A thorough analysis of acquired color vision deficit that covers the illness connections and mechanisms, including systemic conditions that may have an impact on color vision. (20)

**Conclusion**

This study explores the relationship between gender, leukemia duration and color vision deficiencies among blood cancer patients. The result showed no statistically significant association between gender and the prevalence of protanopia and deuteranopia. Similarly, leukemia duration did not have a significant impact on the frequency or severity of color vision impairments. The majority of participants were diagnosed as normal color vision with protanopia and deuteranopia being less common.

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