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RESEARCH ARTICLE
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"CLINICAL PROFILE OF THALASSEMIA, IRON DEFICIENCY ANEMIA, G6PD DEFICIENCY ANEMIA, LYMPHOMA AND LEUKEMIA IN KHYBER PAKHTUNKHWA PAKISTAN"

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Abstract

Background: In Khyber Pakhtunkhwa (KP), Pakistan, anemia and hematologic malignancies are major challenges of the KP steady public health since there are limitations in genetic, dietary, socioeconomic, and diagnosis issues. Such conditions as Thalassemia, Iron Deficiency Anemia (IDA), G6PD Deficiency, Leukemia and Lymphoma.

Objective: To assess the clinical, demographic and diagnostic characteristics of five major hematologic disorders in KP.

Methods: The descriptive cross-sectional study was conducted at the Lady Reading Hospital Department of Hematology in Peshawar from January to June 2025. After ethical approval, non-probability sequential sampling selected 200 patient records. Demographics, symptoms at presentation, study tests (CBC, peripheral smear, electrophoresis, ferritin, G6PD analysis, bone marrow biopsy), and family history were acquired from hospital records and laboratory databases. Descriptive analysis was done in R (4.2.3).

Results: The most affected occupational groups were the students, housewives and tailors. Thalassemia and G6PD Deficiency were highly familiarly associated. Geographic concentration in Kohat, Mansehra and Swabi was reported in IDA and Leukemia. Gender distribution indicated that Thalassemia is common in females whereas Leukemia and IDA are common in males. The patterns of symptoms depended on the diagnosis, but fatigue, bone pain and fever were prevalent symptoms. Thalassemia had the lowest level of hemoglobin whereas Leukemia cases had elevated levels of WBCs and reduced numbers of platelets.

Conclusion: Anemia and hematologic malignancies in KP are occupational, geographical, and gender-specific. Genetic disorders are strongly linked to family history. Even in low-income nations, diagnostic profiling can improve early diagnosis, community health, and health care planning.

Key Words: Anemia, IDA, Thalassemia, Leukemia, G6PD Deficiency Anemia

Introduction:

Hematologic diseases continue to be a significant health problem in developing countries especially those with few diagnostic and treatment facilities. In Khyber Pakhtunkhwa (KP), Pakistan, Thalassemia, Iron Deficiency Anemia (IDA), G6PD Deficiency Anemia, Lymphoma, and Leukemia are the conditions associated with high morbidity and mortality but underrepresented and not well clinically understood(1). The current work is intended to offer a clinical profile of the two conditions in KP noting predominant diagnostic trends as well as demographic characteristics and treatment challenges. Cases of Thalassemia, particularly of beta-thalassemia major are very common in KP because of poor consanguineous marriages (2). Although it is of a genetic nature and poses serious complications that can lead to death, preventive screening and early diagnosis is weak(3).

In the same way, IDA is quite prevalent to the population especially to the women and children because of the lack of proper nutrition as well as health education and supplementation. Even though there are lower rates of G6PD Deficiency Anemia, compared to ASC, there exist severe hazards of hemolysis in the impacted individuals who are exposed to some drugs or infections, but have not been identified yet because of absence of regular testing (4).Lymphoma and Leukemia is the malignant side of the spectrum hematological (5). A large number of patients who develop these cancers in KP visit hospitals at advanced stages and it is mainly attributed to late symptom recognition, inadequate diagnostic facilities and oncology coverage especially in the rural parts of KP (6). Healthcare in KP also faces poverty, illiteracy and socially-anchored beliefs that demoralize admission to medical care at the right time. To fill in this data gap therefore, this study aims at analyzing clinical cases in hospitals and diagnostic centers in the province. This study seeks to improve the regional needs of KP, s population by recording the clinical profiles of these disorders as a means to assist in early diagnosis of these disorders, and assist in informing the public health policy as well as making database-based informed decisions in managing these disorders regardless of region.

Material and Methods:

This descriptive cross-sectional study was conducted at the Department of Hematology, Lady Reading Hospital (LRH), Peshawar, from January 1, 2025, to June 30, 2025, spanning six months. The research utilized secondary data obtained from hospital records and laboratory information systems. A total of 299 records were analyzed based on established eligibility criteria. A non-probability consecutive sampling method was employed due to constraints related to the availability and completeness of medical records. The collected data were documented in a structured proforma, encompassing demographic information, presenting symptoms, clinical findings, diagnostic test outcomes (CBC, peripheral smear, hemoglobin electrophoresis, serum ferritin, G6PD enzyme assay, bone marrow biopsy, and immunophenotyping where applicable), and family history.

Data analysis was performed using R software (version 4.2.3). Descriptive statistics such as frequencies, percentages, means and standard deviations were determined. Bubble plots and heat maps were applied to summarize and show trends based on gender, region, occupation, and blood indices as well as age distributions. The scatter plots, donut charts, and raincloud plots were employed to interpret the trends based on gender, region, occupation, blood indices, and age distributions.

All those patients: all ages, and both genders Male patient had more than one of the following diagnoses: Thalassemia, Iron Deficiency Anemia, G6PD Deficiency, Lymphoma or Leukemia Access to complete clinical and laboratory information is possible. Uncompleted or insufficient patients record Concomitant chronic Systemic illnesses (e.g. Chronic kidney or liver illness) Duplication or repetition of entries in the study period.

RESULT:

Occupation wise Anemia Distribution:

The bubble chart (Figure 1) illustrates the distribution of anemia across various occupations. The dimensions and hue of the bubbles indicate the frequency and severity of various kinds of anemia. The most affected category is students, who had 22 cases of leukemia and iron deficiency anemia each. Housewives exhibit several cases, including 18 occurrences of thalassemia, 13 of iron deficiency anemia, 11 of leukemia, and 11 of G6PD deficiency. Tailors and workers are significantly impacted. For instance, tailors exhibit 17 occurrences of thalassemia and G6PD deficiency, whereas laborers present with 13 instances of iron deficiency anemia and 11 cases of leukemia. Conversely, occupations such as driving, electrical work, farming, child care, preschool education, and teaching have a limited number of instances, often ranging from 1 to 3 per category. The table indicates that occupational characteristics significantly influence the prevalence of anemia, particularly among students, housewives, and tailors. Socioeconomic and lifestyle variables may contribute to these disparities.

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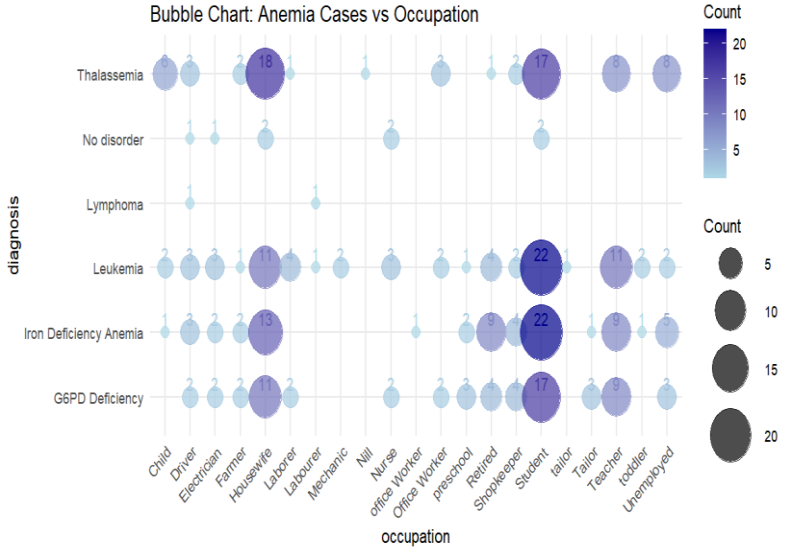

Figure No.1

Region wise Anemia's Distribution:

Figure 2 illustrates the geographical distribution of anemia diagnoses. Thalassemia, No Disorder, Lymphoma, Leukemia, Iron Deficiency Anemia, and G6PD Deficiency are listed on the vertical axis, whereas the horizontal axis represents the locations of these diagnoses. The intensity of color, ranging from light-red to dark-red, signifies the number of cases, with darker hues denoting a greater frequency and lighter hues suggesting fewer or no occurrences. Iron insufficiency Anemia and leukemia are prevalent in Kohat, Mansehra, and Swabi, identified as hotspots. Thalassemia and G6PD deficiency exhibit lower prevalence in certain regions. The diagnoses of lymphoma and No Disorder are few, indicating potential underreporting or a low prevalence of sickness. The heatmap indicates that high-incidence areas such as Kohat and Swabi require focused medical efforts, whereas regions with lower prevalence may necessitate more investigation into access or diagnostic issues.

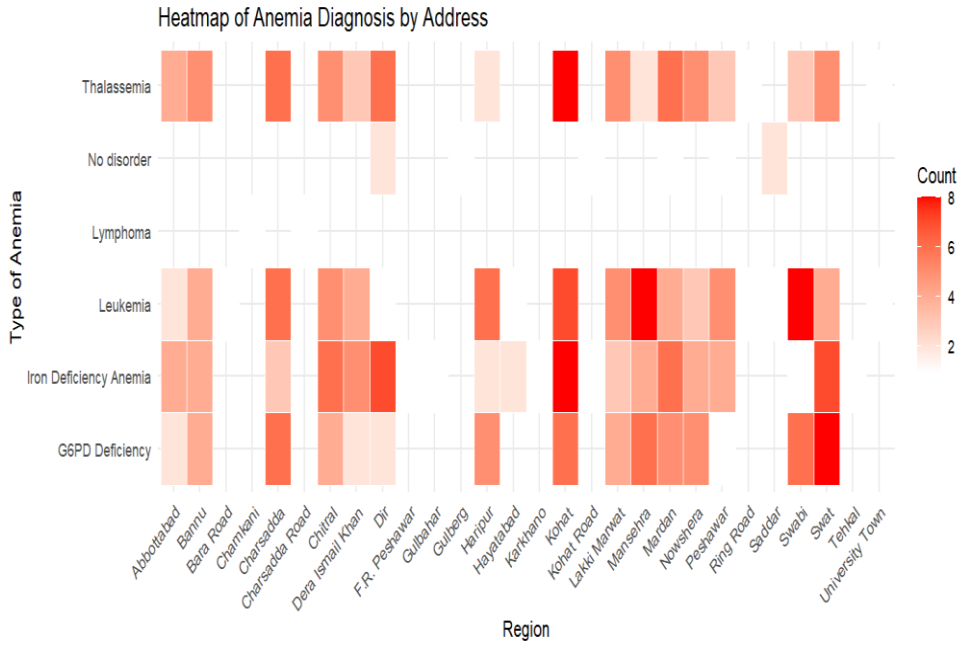

Figure No.2

Gender wise Anemia's Distribution:

Figure 3 juxtaposes two donut charts depicting gender-specific anemia diagnoses. Thalassemia (27%), Leukemia (24%), and Iron Deficiency Anemia (23%) are the predominant anemias among women (left chart). Only 3% of women are free from anemia, but G6PD Deficiency is prevalent at 22%. Female lymphoma is absent due to underreporting or low incidence. Leukemia constitutes the most common diagnosis among males at 28%, following by Iron Deficiency Anemia at 27%. The prevalence of Male Thalassemia is 19%, whereas G6PD Deficiency is 22%, identical for both genders. Lymphoma, the least common diagnosis in men, occurs in 1% of cases, whereas anemia is present in 2%. Gender inequalities in types of anemia are evident: Thalassemia is more prevalent in females, but leukemia and iron deficiency anemia are more common in males. G6PD deficiency is equivalent in both sexes. Lymphoma and "No Disorder" are both rare, with a little higher incidence in males.

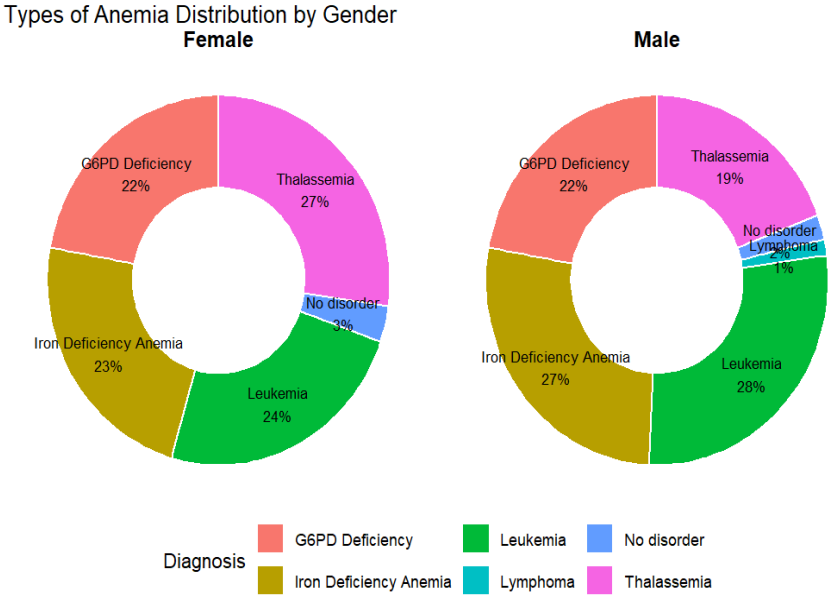

Figure No.3

Family History VS Anemias:

Figure 4 illustrates family history by anemia type with six pie graphs for clarity. Each chart contains red and teal areas for No and Yes. The graphs show family history in G6PD Deficiency, Iron

Deficiency Anemia, Leukemia, Lymphoma, no condition, and Thalassemia. In G6PD Deficiency, 48% of persons have no family history of the condition, while 52% do. In contrast, 55 percent of Iron Deficiency Anemia patients have no family history and 45 percent do. The leukemia distribution is similar, with 51% of participants having no family history and 49% having a family history. Lymphoma is also evenly distributed, with half of the cases having no family history and the other half having a family history. All of the No disorder patients had no family history, hence their % was 100. Like Thalassemia, 54% of patients have no family history and 46% do. Overall, the graphic provides solid information on the relationship between family history and anemia by showing family history distributions by kind of anemia.

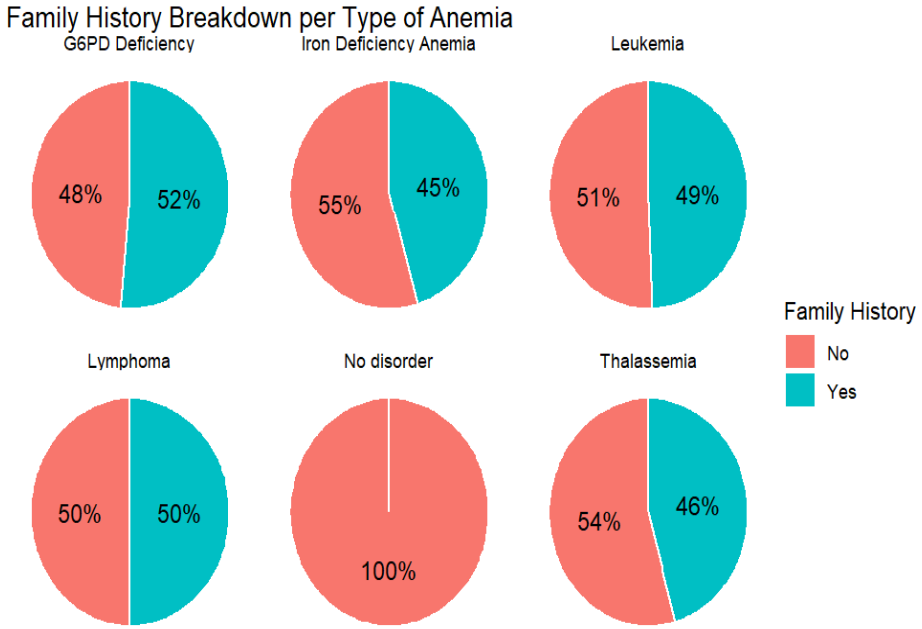

Figure No.4

Blood Smear Images of Anemias:

Figure 5 describes blood smear images for different types of anemia. Anemia types are shown in sections: Abnormal, Anisopoikilocytosis, Blast cells, Microcytic hypochromic, Normal, Normocytic normochromic, Spherocytes, and Targets cells. Lymphoma, Iron deficiency Anemia, Leukemia, Thalassemia, and G6PD Deficiency have dots in their scatter plots, which are colored differently. The x axis shows the count (4–12) while the y axis shows the anemia kind. The graph shows blood smear images of different forms of anemia and their distribution and features. The graph can help doctors diagnose and classify anemia. Abnormal anemia is characterized by Lymphoma (2 people), Iron Deficiency Anemia (5 people), Leukemia (10 people), and Thalassemia (2 people), while Anisopoikilocytosis is associated with G6PD Deficiency (14 people), Iron Deficiency Anemia (12 people), Leukemia (13 people), and Thalassemia (13 people).The graph also depicts blast cells in 11 G6PD deficient people, Iron deficiency, and Microcytic hypochromic anemia has G6PD Deficiency 6, Iron Deficiency Anemia 14, Leukemia 6, and Thalassemia 8, while normal anemia has G6PD Deficiency 10, Leukemia 2, and Thalassemia 2. Spherocytes are present in G6PD Deficiency (8 people), Iron Deficiency (12 people), Leukemia (11 people), and Thalassemia (11 people) in normocytic normochromic anemia. The last target cells are G6PD Deficiency (14), Iron Deficiency Anemia (10), Leukemia (10), and Thalassemia (10). Overall, the image shows blood smear photos of various kinds of anemia and their features and distributions. Healthcare providers can utilize this to improve anemia diagnosis and classification drugs.

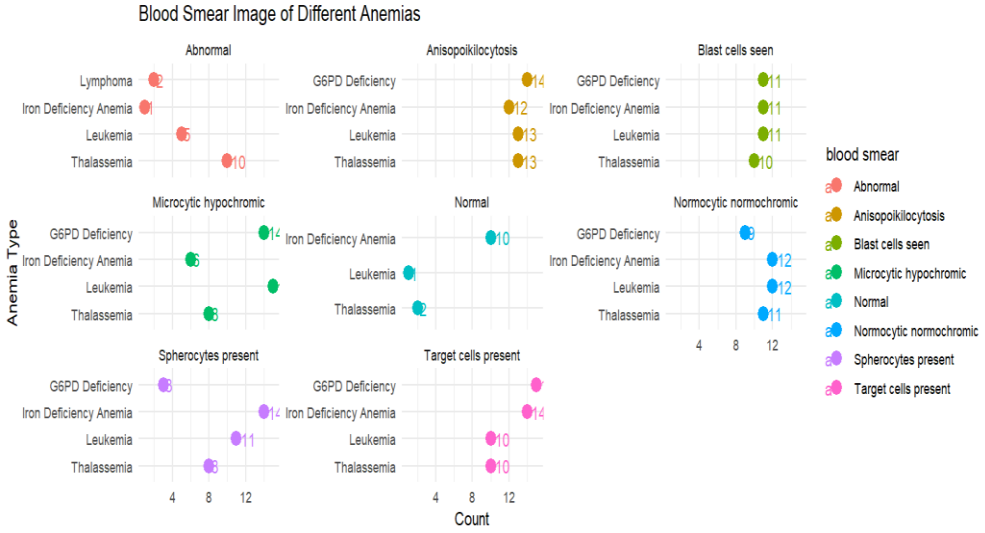

Figure No.5

Distribution of Sign and Symptoms in Anemias:

Figure 6 illustrates the mean symptoms correlated with several forms of anemia, encompassing G6PD Deficiency, Iron Deficiency Anemia, Leukemia, Lymphoma, No Disorder, and Thalassemia. The y-axis enumerates the symptoms, whilst the x-axis delineates the type of anemia. The graph has a color-coded scheme, with pink bars representing the percentage prevalence of each symptom. In G6PD Deficiency, notable symptoms are dark urine (67%), weariness (65%), and jaundice (56%). Iron Deficiency Anemia is defined by weakness, bone pain, and pallor, each occurring at a rate of 60%. Leukemia has a significant incidence of fever (69%), recurrent infections (35%), and weight loss (64%). Lymphoma, conversely, presents with edema (50%), abdominal distension (50%), and tachycardia (50%). Thalassemia is characterized by considerable weariness (60%), bone discomfort (63%), and delayed development (39%). The graph illustrates the differing severity of symptoms among kinds of anemia, with edema prevalent in Lymphoma (50%) but seldom in G6PD Deficiency (2%) and Iron Deficiency Anemia (1%). Bleeding occurs more frequently in leukemia (31%) compared to other forms. This comparison provides comprehensive insights into the symptoms of each form of anemia, assisting medical professionals in diagnosis and the selection of the most suitable treatment based on common symptoms.

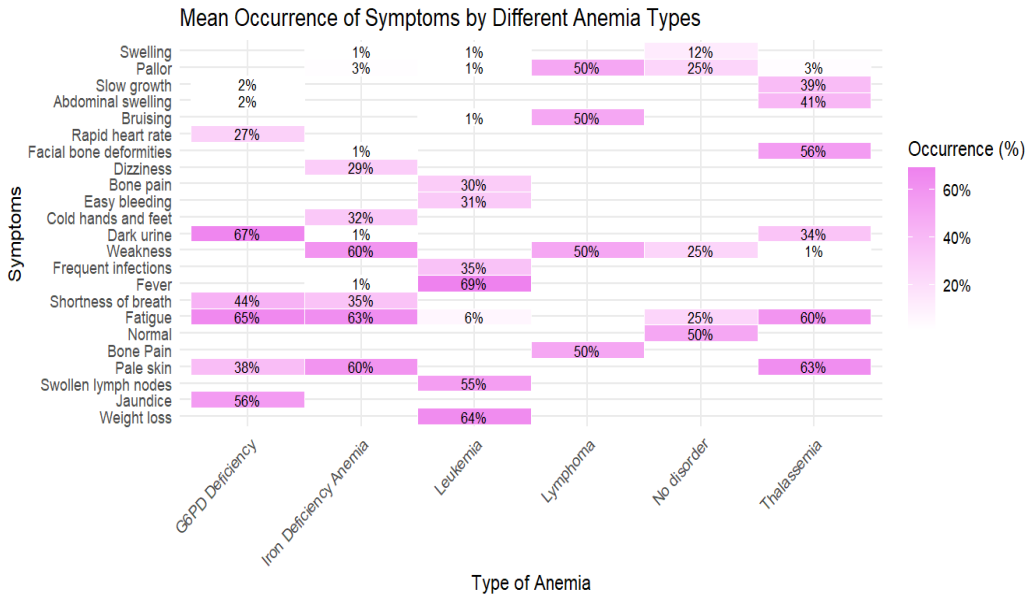

Figure No. 6

Hemoglobin, Wbcs and Platelets Count in Anemias:

Figure 7 displays scatter plots illustrating the distribution of hemoglobin levels, platelet counts, and white blood cell (WBC) counts across five diagnoses: G6PD Deficiency, Iron Deficiency Anemia, Leukemia, Lymphoma, and Thalassemia. Hemoglobin levels in G6PD Deficiency, Iron Deficiency Anemia, and Leukemia have comparable distributions, primarily concentrated between 7.5 and 12.5 g/dL, with medians about at 9.5 g/dL. Lymphoma has elevated hemoglobin concentrations, predominantly within the normal range (10.0–12.5 g/dL), whereas Thalassemia presents the lowest levels, with all measurements within the normal range of 12.5–17.5 g/dL. Lymphoma has the greatest hemoglobin levels, whilst Thalassemia regularly demonstrates the lowest. Platelet counts in G6PD Deficiency, Iron Deficiency Anemia, and Thalassemia range from 200,000 to 400,000 platelets per microliter, with medians approximately at 300,000. The platelet count in leukemia is diminished, varying from 0 to 200,000 platelets per microliter. Lymphoma has a limited dataset, predominantly ranging from 100,000 to 300,000 platelets per microliter. White blood cell counts for G6PD deficiency, iron deficiency anemia, and thalassemia are about zero, signifying low levels, but leukemia exhibits elevated white blood cell counts, varying from 0 to 100,000 per microliter. Lymphoma has a scarcity of data points, predominantly approaching zero. The results indicate that Leukemia correlates with elevated WBC counts and diminished platelet counts, while G6PD Deficiency, Iron Deficiency Anemia, and Thalassemia have reduced WBC numbers and increased platelet counts.

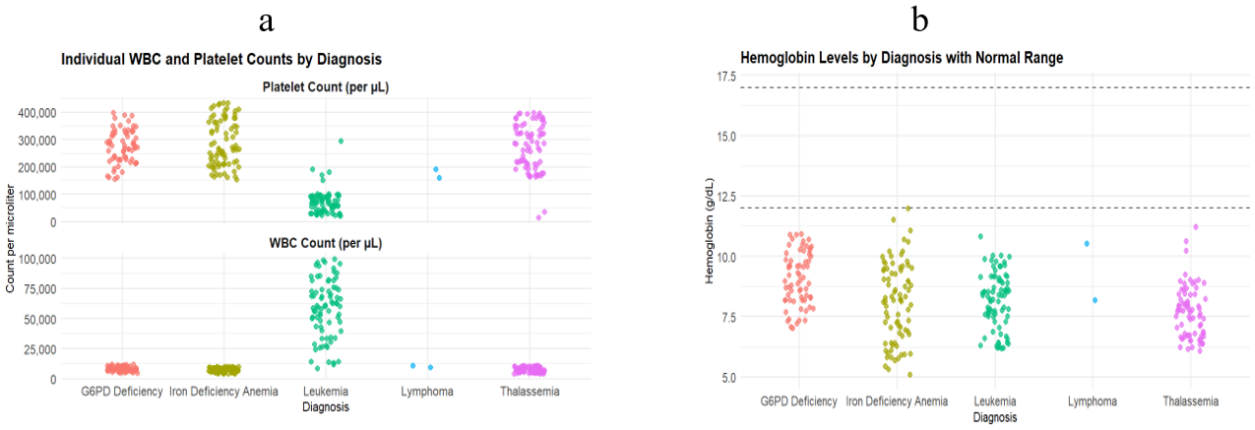

Figure No.7

Age wise Distribution of Anemia:

Age of patient clinical distribution plotted in this raincloud plot indicates the diagnosis-level distribution with regard to the five diagnoses involving anemia namely, G6PD Deficiency, Iron Deficiency Anemia, Leukemia, Lymphoma, and Thalassemia. Each category is supplemented by a violin plot of the age density and boxplot of the central tendency and a dot showing a certain age. G6PD Deficiency and Iron Deficiency Anemia cover a wide age group, and the medians are in the middle of the 30s and a bit younger, respectively. Leukemia is also age-wide with an average above 30s. The age group in which lymphoma is focused is between age 35-45 indicating that lymphoma is basically a disease that affects the middle-aged population. Thalassemia is also mostly represented by younger patients with most being below the age of 40 years with a central figure of about 25. It is also evident that other illnesses such as G6PD Deficiency are also age specific with others affecting much wider age groups such as Leukemia and Lymphoma.

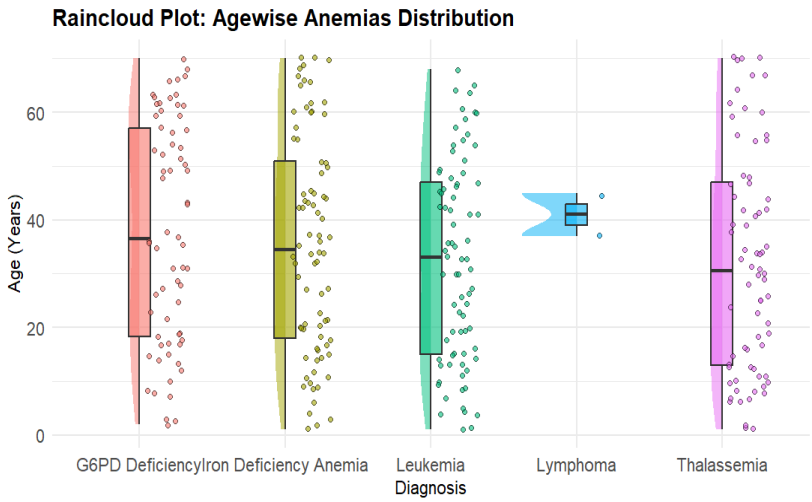

Figure No.8

Discussion:

The results of the present study provide a detailed picture about multifactorial distribution of the different types of anemia based on demographic, occupational, geographic, clinical and hematological levels. Interestingly, the types of anemia were not balanced which may point at some causes that may be related to the socioeconomic background, environment, and genetic factors. The occupational profile indicates that the most affected by anemia are students, housewives and tailors (7). A noticeable number of students had leukemia and iron deficiency anemia with an occurrence of 22 each. This might indicate the nutritional deficiencies that usually affect young people under academic pressure and with poor eating habits (8).An increased prevalence of thalassemia and G6PD deficiency was observed among housewives, which may imply their hereditary transmission and the lack of routine screening and health measures (9).

G6PD deficiency and thalassemia were also found in large numbers in tailors, probably due to either occupational exposure or inadequate health provision among socioeconomically disadvantaged populations. In the meantime, other occupations like drivers, teachers, and farmers were reported to have lower cases that could imply less prevalence of the disease or resultant assessment because of their low healthcare-seeking tendency. Kohat, Mansehra, and Swabi became geographical hotspots as far as anemia and especially iron deficiency anemia and leukemia are concerned. The poor areas are probably affected by lack of proper dieting, unavailability of enriched food as well as unavailability of detection services (10).

The data presented in the heatmap demonstrates the importance of the establishment of specific public health communication and medical intervention programs in these locations. Interestingly, there were a few areas where the diagnosis of anemia was low and this begs the question of underreporting or lack of healthcare infrastructure that should be further investigated. Analysis by gender-wise showed different trends. The highest prevalence rate was associated with thalassemia mainly in females and leukemia together with iron deficiency anemia in males (11). This may have to do with both environmental and genetic factors. As an illustration, women are more likely to develop thalassemia following iron loss that occurs during menstruation and pregnancy whereas in males' anemia may develop as a result of occupational risk factors and lifestyle problems (12).The approximately equal distribution in both sexes fits well with the X-linked inheritance in which the heterozygous females and the hemizygous males are able to express the phenotype depending on genetic expression(13).

The connection between anemia and family history also proves that some types of anemia are hereditary, especially thalassemia and G6PD deficiency. As an example, the positive family history was present in more than 50 percent of the cases of thalassemia and G6PD deficiency that is why the

significance of genetic counseling and carrier screening, particularly in area of increased rate should not be underestimated. This complies with previous reports that posit the efficiency of the family-based screening programs in lightening the loads of the hereditary anemias (14). Morphologically, the blood smear analysis exhibited specific characteristics in each type of anemia which was useful in the establishment of a differential diagnosis (13).

Leukemia and thalassemia were characterized by frequent Anisopoikilocytosis and blast cells, which is in line with the evidence that indicates the presence of altered erythropoiesis and immature cells in two conditions (15). Normocytic normochromic and microcytic hypochromic morphologies also made the rounds and these are consistent with the usual hematologic classification schemes. The results agree with the clinical usefulness of peripheral blood smears, being a cheap but potent diagnostic instrument. The type of differences in regards to the diagnosis was also emphasized on the symptomatology data. As an example, fatigue and jaundice prevailed in G6PD deficiency, fever, weight loss, and frequent infections were characteristic in leukemia, which were classical symptoms of bone marrow dysfunction. Swelling was unique and abdominal discomfort was also observed in lymphoma patients indicating lymphadenopathy and abdominal lymphocytosis. These symptom patterns would serve as a clinical model of early suspicion and testing to minimize delays in diagnosis(16).

Hemoglobin concentration was less than normal in the majority of the various types of anemia, and the lowest median hemoglobin concentration was in thalassemia. On the other hand, the values of hemoglobin in lymphoma patients were closer to normal probably because of its distinct pathophysiology. The counts of platelets and WBC showed huge fluctuations between the diagnoses. In leukemia, the WBC counts were significantly high and the platelets were low in anticipation of marrow infiltration and thrombocytopenia(13). Other anemias such as deficiency in G6PD and iron deficiency exhibited normal to slightly higher platelet levels, which indicates that the marrows were not suppressed in such conditions (17).

Finally, age distribution showed that thalassemia mainly occurs in younger people and that agrees with the situation of being genetic and early onset. On the other hand, lymphoma was most common in the age group of 35-45 and it is in line with previous epidemiological findings linking the disease to a higher rate in middle aged adults(18). Leukemia, G6PD deficiency and iron deficiency anemia had generally wider distributions across ages and it was promising that they were age-neutral which supported the need to adopt age-neutral screening policies on them.

Conclusion:

This study highlights the multi-factorial epidemiology of anemia and points out to the importance of multifaceted intervention measures. There are socioeconomic, occupational, genetic, and regional factors that highly contribute to distribution of anemia. The combination of clinical, morphological, and demographic information gives a solid base in case of targeted diagnostics, planning of public health, and early intervention.

Recommendation:

Future studies should include molecular diagnostics and expand on community-level data to capture undiagnosed or underreported cases.

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