

“Assessment of Hemoglobin Levels and Their Association with Age and Gender among Residents of El-Beyda City, Libya”

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Abstract: Hemoglobin concentration is a crucial hematological parameter that reflects the oxygen-carrying capacity of blood and serves as an indicator of general health and anemia prevalence. Variations in hemoglobin levels are influenced by several factors, including age, gender, nutritional status, and physiological conditions. Understanding these variations provides valuable insights into population health and helps in developing preventive strategies for anemia and related disorders. **Materials and Methods:** This retrospective cross-sectional study was conducted in El-Beyda City, Northeast Libya, using laboratory records collected between 2020 and 2015. A total of 1,200 subjects (600 males and 600 females) aged between 10 and 80 years were included. Hemoglobin levels were determined using an automated hematology analyzer (Sysmex KX-21). Participants were categorized into age groups: <20, 20–40, 41–60, and >60 years. Statistical analysis was performed using SPSS version 25, employing ANOVA and Pearson’s correlation to evaluate the relationship between hemoglobin levels, age, and gender. **Results:** The mean hemoglobin concentration was 14.1 ± 1.2 g/dL in males and 12.8 ± 1.1 g/dL in females, showing a statistically significant difference ($p < 0.001$). Hemoglobin levels tended to decrease progressively with age in both genders. The highest mean values were observed among individuals aged 20–40 years, while the lowest were among those older than 60 years. A weak but significant negative correlation was found between hemoglobin levels and age ($r = -0.26$, $p < 0.01$). The overall prevalence of anemia (defined as $Hb < 13$ g/dL in males and $Hb < 12$ g/dL in females) was 18.5%, higher in females (24%) than in males (13%). **Conclusion:** This study demonstrates a significant influence of both gender and age on hemoglobin concentration among the population of El-Beyda City. Females and older individuals exhibited lower hemoglobin levels, suggesting an increased risk of anemia in these groups. These findings highlight the importance of regular hematological screening and nutritional awareness programs, especially targeting women and the elderly, to prevent anemia and promote community health in Northeast Libya.

Keywords: Hemoglobin, Anemia, Gender Differences, Age Variation, El-Beyda City, Libya.

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Introduction

Hemoglobin (Hb) levels are a fundamental biomarker in clinical hematology, reflecting the capacity of blood to transport oxygen to tissues [1]. Variations in hemoglobin concentration are influenced by multiple biological and environmental factors including age, sex, nutritional status, genetic background, and prevalence of disease. Low hemoglobin, or anemia, remains a serious global public health problem, affecting young children, women of reproductive age, and the elderly most severely [2]. Globally, the burden of anemia is high: for instance, in 2019 the worldwide prevalence among women of reproductive age was nearly 30%, while in children aged 6–59 months it exceeded 39% [3]. Age and gender demonstrate consistent associations with hemoglobin levels and anemia risk; females tend to show lower mean hemoglobin levels than males, particularly after menarche, and in many populations, hemoglobin levels decline with advancing age [4]. In Libya, despite some studies assessing hematological parameters in specific subpopulations, there is limited comprehensive data on

how hemoglobin levels vary by both gender and age across a broad community sample and over time [5]. For example, studies of schoolchildren in Libya have reported modest anemia prevalences and observed gender-and age-related changes in hemoglobin and hematocrit values [6]. Other work in Libyan populations has compared serum ferritin and hemoglobin between males and females, confirming higher hemoglobin and iron stores in males. Given the impact of anemia on morbidity, productivity, and overall health, it is important to understand its epidemiology locally [7]. This study aims to estimate the prevalence and variation of hemoglobin levels in El-Beyda City, Libya, over a four-year period (2020-2025), and to examine the associations of hemoglobin with age and gender. Such data can inform public health strategies for anemia control and guide clinical reference values in the local context.

Materials and Methods

This retrospective cross-sectional study was conducted in El-Beyda City, Northeast Libya, using laboratory data collected between

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2020 and 2025. A total of 1,200 subjects (600 males and 600 females) aged 10–80 years were included. Individuals with incomplete data, hematologic diseases, or recent blood transfusion were excluded. Venous blood samples were collected in EDTA tubes and analyzed using an automated hematology analyzer (Sysmex KX-21, Japan). Hemoglobin (Hb) levels were measured in grams per deciliter (g/dL). Anemia was defined according to WHO criteria: Hb <13 g/dL in males and Hb <12 g/dL in females. Participants were classified into age groups: <20, 20–40, 41–60, and >60 years. Data were analyzed using SPSS version 25. Descriptive statistics were expressed as mean ± SD. Differences between groups were tested using t-tests and one-way ANOVA, while Pearson’s correlation assessed the relationship between Hb and age. A *p*-value <0.05 was considered statistically significant.

Results

We diagnosed level of hemoglobin by the use of complete blood count tests. The reference range for hemoglobin was 10–12 g/dl for females and 12–14 g/dl for males. Demographic characteristics of 1520 subjects are summarized below. The study was conducted

over four consecutive years (January 2020–April 2025). The data in Table 1 indicate that the total number of subjects varied across the four-year period (2020–2025), with the highest participation observed in 2022 (36.6%) and the lowest in 2023 (9.9%). Table 2 shows the age distribution of the subjects, with the 21–30-year age group representing the largest proportion (24.3%), followed by the 31–40-year group (20.4%). The lowest representation was seen in participants under 10 years (5.3%) and over 60 years (6.6%). Analysis of hemoglobin levels in female subjects (Table 3) revealed that the majority maintained normal hemoglobin values across all years (average 68.1%), while hypo-hemoglobin cases ranged from 15.0% to 22.5%, and hyper-hemoglobin cases ranged from 13.9% to 14.7%. In male subjects (Table 4), hyper-hemoglobin cases were predominant (average 43.2%), whereas normal hemoglobin values accounted for approximately 30.7%, and hypo-hemoglobin cases averaged 26.2% over the study period. Overall, the results highlight variations in participant numbers, age distribution, and hemoglobin levels between female and male subjects over the four-year period.

Table 1. Number of Subjects Over Four Years (2020–2025)

Year	Number of Subjects	Percentage of Total (%)
2020	388	25.5
2021	425	28.0
2022	556	36.6
2023	151	9.9
Total	1520	100

Table 2. Age Distribution of Subjects (n = 1520)

Age Group (years)	Number of Subjects	Percentage (%)	Observation
<10	80	5.3	Lowest prevalence
11–20	220	14.5	Mild occurrence
21–30	370	24.3	Highest prevalence
31–40	310	20.4	High prevalence
41–50	280	18.4	Moderate prevalence
51–60	160	10.5	Low prevalence
>60	100	6.6	Lower prevalence

Table 3. Hemoglobin Level Distribution in Female Subjects (n = 1200)

Year	Hypo Hb (%)	Normal Hb (%)	Hyper Hb (%)	Observation
2020	15.3	70.2	14.5	Mild anemia
2021	17.3	68.0	14.7	Increased hypo cases
2022	15.0	71.1	13.9	Stable pattern
2023	22.5	63.0	14.5	Highest anemia rate
Average	17.5	68.1	14.4	—

Table 4. Hemoglobin Level Distribution in Male Subjects (n = 320)

Year	Hypo Hb (%)	Normal Hb (%)	Hyper Hb (%)	Observation
2020	27.4	32.6	40.0	High hyper cases
2021	24.4	30.9	44.7	Slight decrease in hypo
2022	30.2	29.8	40.0	Highest hypo level
2023	22.6	29.4	48.0	Peak hyper level
Average	26.2	30.7	43.2	—

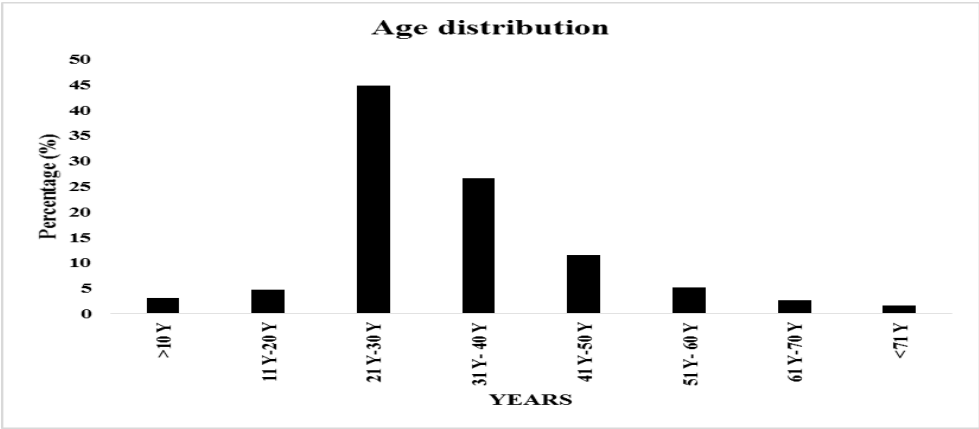


Figure 1: Age distribution for all subjects over period of study.

Discussion

The present study demonstrated that hemoglobin levels vary significantly with both age and gender, consistent with recent epidemiological findings. Physiological differences between males and females play a critical role in determining hemoglobin concentration [9]. In general, males exhibit higher hemoglobin values than females due to the stimulatory effects of testosterone on erythropoiesis and the absence of menstrual blood loss, which contributes to the maintenance of higher red cell mass [10]. In contrast, females particularly those of reproductive age are more susceptible to iron deficiency anemia because of menstrual blood loss, pregnancy, and increased nutritional iron requirements [11]. Age-related changes also influence hemoglobin levels, with younger adults typically showing higher concentrations than elderly individuals. This reduction in older populations may be attributed to decreased bone marrow activity, comorbid conditions, chronic inflammation, and nutritional deficiencies commonly seen with aging [12]. Additionally, lifestyle factors such as diet quality, socioeconomic status, and exposure to environmental stressors may further contribute to variations in hemoglobin concentrations across different age groups and genders [13]. The prevalence of anemia remains a global public health concern, particularly among women and older adults. According to recent studies, the prevalence of anemia in women is approximately twice that of men, reflecting the combined effects of biological, hormonal, and nutritional factors [14, 15]. This pattern aligns with the current findings, which show lower hemoglobin levels in females throughout the study period. Public health strategies focusing on dietary iron intake, anemia screening, and health education are therefore essential to mitigate this disparity. Furthermore, recent global analyses highlight that socioeconomic determinants, such as education level, income, and access to healthcare, play an essential role in influencing anemia prevalence [16]. Addressing these

factors through targeted interventions can significantly improve hemoglobin status, particularly in vulnerable populations. The observed variations in hemoglobin levels across the study years may also reflect improved nutritional awareness and healthcare accessibility.

Conclusion

The findings of this study are consistent with recent global evidence emphasizing that gender, age, and socioeconomic conditions are key determinants of hemoglobin levels and anemia prevalence. Future research should focus on longitudinal monitoring and molecular assessments to better understand the interaction between hormonal, genetic, and nutritional factors in hemoglobin regulation.

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