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Varying Trends of Red Cell Indices across Different Age Groups in A Widely Ranging Urban Demographic Population and Anaemia Patterns: A Comprehensive Study on Prevalence, Morphological Variations, and Policy Implications

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Abstract

Background: Anaemia remains a significant global health challenge, particularly in South-East Asia. India's "Anaemia Mukt Bharat" initiative aims to address this issue; however, comprehensive studies on anaemia patterns in urban populations remain limited.

Aims and Objectives: This study assesses the prevalence and morphological patterns of anaemia in urban demographics, examining the influence of age, gender, and nutrition on red cell indices and platelet counts while comparing urban and rural disparities.

Materials and Methods: Blood samples from 406 diverse participants were collected using EDTA anticoagulant and analyzed via an Automated 5-Part Differential Haematology Analyser. Unpaired T-tests were conducted using WHO reference ranges to evaluate gender-specific variations and anaemia prevalence across age groups.

Results: Haematological parameters varied with age and gender. Males exhibited significantly higher red cell counts, haematocrit, and haemoglobin in specific age groups, while females had higher platelet counts, increasing MCV with age, and a greater prevalence of microcytic hypochromic anaemia. Normocytic normochromic and macrocytic anaemia were more common in males. Anaemia prevalence was higher in rural areas than urban areas, though not statistically significant.

Conclusion: This study highlights the persistence of anaemia in urban populations, revealing gender and age-related differences. Factors such as food insecurity, nutritional deficiencies, and lifestyle stress contribute to anaemia in urban settings. Current policies primarily target rural populations, underscoring the need for tailored interventions to address anaemia in urban communities.

Keywords: Anemia Prevalence, Iron Deficiency, Hematological Parameters, Urban vs. Rural Anemia, Gender Disparities, Morphological Classification, Nutritional Deficiencies, Public Health Interventions

Introduction

1. Prevalence of Anemia

A) Global Prevalence and Action

Children under five years old, newborns, and children under two years old, teenage girls, menstruating women, as well as pregnant and postpartum women, constitute the demographic groups most susceptible to anemia. Worldwide, it is estimated to affect 269 million children aged 6 to 59 months and half a billion women aged 15 to 49. In 2019, 37% (32 million) of pregnant women and 30% (539 million) of non-pregnant women aged 15 to 49 experienced anemia. With an estimated 106 million women and 103 million children in Africa, and 244 million women and 83 million children in South-East Asia suffering from anemia, the WHO regions of Africa and South-East Asia are the most impacted. Globally, the prevalence of anemia in 2019 was 1.76 billion, marking an increase from 1.44 billion in 1990. Anemia caused 50.3 million years lost due to disability in 2019, with the major causes being dietary iron deficiency, thalassaemia, sickle cell trait, and malaria. [1.1]

The Comprehensive Implementation Plan on Maternal, Infant, and Early Child Nutrition includes the reduction of anemia as one of the six World Health Assembly Global Nutrition Targets. Moreover, one of the goals of the UN 2030 Agenda for Sustainable Development is the reduction of anemia in women aged 15 to 49.The World Health Organization (WHO) has pledged to assist nations in lowering anemia. At the Nutrition for Growth Summit in 2021, WHO made a commitment to create a comprehensive framework for action to prevent, diagnose, and treat anemia using a multisectoral approach. WHO and UNICEF are also forming an Anaemia Action Alliance, bringing stakeholders from various sectors together to assist with the framework's implementation at the national level. [1.2]

B) Implications and management of Anaemia in India

"Anemia Mukt Bharat," an initiative launched by the government of India, aims to address this issue. The recommended prophylactic iron doses for different age groups are as follows: biweekly 20 mg, weekly 45 mg, weekly 60 mg, 60 mg, and 60 mg daily. For folate, WHO recommends weekly doses of 100, weekly 400, 500, 500, and 500 for age groups 0-5, 5-9, 10-19, 20-49, and pregnant women, respectively. Hepcidin levels can increase after a single iron intake, inhibiting iron absorption and causing irritative symptoms. Based on studies by Schofel et al., Schrier et al., it is suggested that 65 mg of iron should be taken every other day instead of three doses daily (TDS). [2][3][4][5]

Anemia can have various implications, affecting school performance (through developmental delays and behavioral disorders like decreased motor activity, social interaction, and attention to tasks), adult productivity, and overall quality of life. Anemia during pregnancy has been linked to poor maternal and birth outcomes, including early birth, low birth weight, and maternal mortality. Beyond physical repercussions, anemia can have significant financial consequences for individuals, families, communities, and governments. It is projected that for every dollar invested in lowering anemia in women, a dollar in economic returns might be generated. [6]

C) Rationale for study selection

Anemia remains a significant public health issue, especially in urban settings where unique socio-economic and lifestyle factors contribute to its prevalence. While rural anemia has garnered considerable attention in health policy frameworks, urban anemia, particularly in relation to gender and age differences, remains underexplored. This research focuses on urban anemia, examining how poverty, food insecurity, and the demands of urban living contribute to its persistence, despite the often-perceived advantages of living in urban areas.

Urban areas are frequently viewed as centers of better healthcare access and improved living conditions. However, many urban populations, particularly in low- and middle-income countries, reside in pockets of poverty, where economic disparities and food insecurity mirror, if not exceed, those found in rural regions. These urban poor are often overlooked in anemia-related interventions, which primarily focus on rural populations. Despite being in proximity to healthcare facilities and diverse food markets, individuals in urban environments may face economic barriers that prevent them from accessing nutrient-rich foods. High living costs, coupled with low wages and insecure employment, can lead to diets lacking in essential micronutrients, particularly iron, folate, and vitamin B12. These deficiencies are further compounded by the limited social safety nets available to the urban poor.

Methodology and Materials

we sampled the healthy red cell indices and across different age groups in a widely ranging urban demographic population-paediatrics, adult and geriatric to see the varying trends especially in indian urban scenario, [as studies for the same haven't been done in detail for urban scenario, they are usually for rural scenario] and to estimate the morphological picture of anaemia and how it varies according to age.

In the study, a total of 406 participants were enrolled, comprising 190 men and 216 females, distributed across various age groups: under 15, 16-30, 31-45, 46-60, and above 60 [60-75]. Following the collection of blood samples, sterile plastic containers with EDTA K3 anticoagulant were utilized, alongside 24 G needles for drawing blood from syringes after area disinfection. The laboratory analysis of individual results was conducted, and the outcomes were documented on paper. Blood samples were processed using an Automated 5-Part Differential Haematology Analyser [ERBA H 560] in a standardized pathology lab setting. The participants were subsequently categorized into different age groups, and the resulting data were tabulated using Microsoft Excel 365. To assess the significance between genders, an unpaired two-tailed T-test, assuming unequal variance, was applied to individual parameters across all age groups. The obtained P-values were organized into a table for reference (Table No. 2, 3, 4). Furthermore, the total number of anemic individuals, based on WHO reference ranges, was analysed and tabulated for both genders across different age groups. For a more detailed analysis, the anemic population was stratified into those with anemia (based on hemoglobin limits) and morphological anemia (considering red blood cell mean corpuscular volume and mean corpuscular hemoglobin). Tables presenting this information are included below (Table No.1 and Table No. 2).

Table 1: Age and Gender-wise distribution in the sample age group

age group	males	females
Under 15	35	38
16-30	40	45
31-45	32	42
46-60	38	44
Above 60	45	47

Results

Haematocrit: is the proportion of blood that is cellular, expressed as a percentage. It represents the volume of red blood cells in relation to the total blood volume or adult males: 38.3% to 48.6%. For adult females: 35.5% to 44.9%Ÿ MCV (Mean Corpuscular Volume): is a measure of the average volume or size of a red blood cell. Typically, the normal range for MCV is around 80-100 femtoliters (fL).Y MCH (Mean Corpuscular Hemoglobin): MCH represents the average amount of hemoglobin in a single red blood cell. It is calculated by dividing the total amount of hemoglobin by the total number of red blood cells in a blood sample. The normal range for MCH is usually about 27-33 picograms (pg) per cell. Y RDW (Red Cell Distribution Width): RDW is a measure of the variation in size of red blood cells in a blood sample. It reflects the heterogeneity of red blood cell sizes. The normal range for RDW is often given as 11.5% to 14.5%, but this value can vary slightly depending on the laboratory. [10] Y Haemoglobin: a protein found in red blood cells that binds to oxygen and carries it from the lungs to the rest of the body.

Table 2: Age and gender-wise distribution of haemoglobin [Hb] in grams per decilitre [g/dl] and RBC [red blood cell] count per million 10^{12} per litre 10^{12}/L, [P Value has been rounded off upto two decimal points]

Parameter	Age Group	Mean ± Standard Deviation		P Value
		M	F	
Haemoglobin(g/dL)	Under 15	11.45 ± 1.36	11.74 ± 1.05	0.38
	16-30	14.16 ± 1.46	12.26 ± 1.04	0.00
	31-45	13.76 ± 1.28	11.9 ± 0.94	0.00
	46-60	13.59 ± 1.34	11.78 ± 1.39	0.00
	Above 60	13.21 ± 0.75	11.27 ± 1.02	0.00
Red Blood Cell Count(per million)	Under 15	4.58 ± 0.36	4.44 ± 0.28	0.11
	16-30	5.05 ± 0.73	4.41 ± 0.38	0.00
	31-45	4.76 ± 0.67	4.36 ± 0.48	0.01
	46-60	4.58 ± 0.41	4.44 ± 0.4	0.02
	Above 60	4.67 ± 0.37	4.31 ± 0.55	0.00

Hemoglobin (Hb) values and red cell count exhibited an increase until the age of 16-30, reaching their peak values. Subsequently, there was a decline, and the observed variation between the sexes was notably significant across age groups 16-30, 31-45, 45-60, and above 60. Males consistently demonstrated higher red cell counts compared to females across all age groups. However, an exception to this trend was noted for hemoglobin levels in females below the age of 15, where females exhibited higher values. It's worth noting that this difference was not deemed statistically significant, as the p-value exceeded 0.05.

Table 3: Age and gender wise distribution of haematocrit [%], red cell distribution width[RDW] in femtolitres [fl], platelet count in thousands or 10^9 per litre [P Value has been rounded off upto two decimal points]

Parameter	Age Group	Mean ± Standard Deviation		P Value
		M	F	
Haematocrit(%)	Under 15	35.26 ± 3.63	34.36 ± 4.6	0.41
	16-30	41.42 ± 4	41.09 ± 7.04	0.83
	31-45	44.83 ± 52.33	41.56 ± 4.81	0.74
	46-60	40.34 ± 3.06	36.18 ± 2.75	0.00
	Above 60	40.21 ± 2.72	34.3 ± 3.44	0.00
Red Cell Distribution Width(femto-litres)	Under 15	13.73 ± 1.47	13.52 ± 0.96	0.52
	16-30	13.5 ± 1.03	14.01 ± 1.31	0.16
	31-45	13.7 ± 0.54	13.54 ± 1.1	0.36
	46-60	13.95 ± 2.29	13.88 ± 0.78	0.49
	Above 60	14.01 ± 2.52	14.41 ± 1.93	0.63

Hematocrit exhibits an upward trend until the age of 31-45, reaching its peak, with higher values observed in males. However, this difference is not statistically significant. In the age groups 46-60 and above 60, males consistently show significantly higher hematocrit values than females.

RDW increases with age in both males and females, peaking in old age. Generally, it tends to be higher in males than females, except in the age groups 16-30 and above 60, where it is higher in females.

Table 4: Age and gender wise distribution of MCV [mean corpuscular volume] in femtolitres [fl],mean corpuscular haemoglobin [MCH] in picograms[pg] [P Value has been rounded off upto two decimal points]

Parameter	Age Group	Mean ± Standard Deviation		P Value
		M	F	
Mean Corpuscular Volume(fL)	Under 15	86.93 ± 6.11	84.03 ± 6.78	0.091973414
	16-30	89.09 ± 5.96	85.66 ± 6.6	0.042196943
	31-45	90.28 ± 6.67	87.09 ± 6.5	0.070286746
	46-60	90.28 ± 6.67	88.1 ± 5.81	0.189735864
	Above 60	91.4 ± 5.82	89.84 ± 6	0.317646773
Mean Corpuscular Haemoglobin (pG)	Under 15	26.03 ± 4.27	25.67 ± 3.74	0.729185758
	16-30	29.95 ± 6.63	28.15 ± 5.44	0.263292031
	31-45	30.4 ± 5.58	29.58 ± 4.26	0.53361231
	46-60	33.53 ± 6.07	31.55 ± 5.78	0.209385847
	Above 60	27.56 ± 5.46	28.47 ± 4.47	0.317950652

MCV rises with age and is greater in males compared to females, with the difference being statistically significant for the 16-30 age group. The MCH value increases until 46-60, being higher in males than females. After 60, it decreases, but in this age group, it is higher in females than males. Importantly, none of these observations are statistically significant.

Table 5: Age and gender wise distribution of various morphological classification of anaemia

Age(Yr)	Microcytic Hypochromic		macrocytic normochromic		Normocytic normochromic	
	M	F	M	F	M	F
Under 15	14 [20%]	9 [23%]	1 [2.22%]	1 [3%]	3 [8%]	6 [18%]
16-30	2 [5%]	6 [13.3%]	1 [2.5%]	1 [2.22%]	3 [7.5%]	3 [6.66%]
31-45	2 [6.25%]	8 [19%]	1 [3.125%]	1[2.3%]	5 [15.625%]	5 [11.9%]
46-60	2 [5.2%]	8 [18.22%]	3 [7.9%]	1 [2.27%]	3 [13.1%]	4 [9.1%]
Above 60	5 [11.1%]	15[33.33%]	2 [4.44%]	1 [2.22%]	7 [15.55%]	8 [17%]

The prevalence of anemia varies across age groups, demonstrating statistically significant differences, with a higher incidence in females compared to males. In males under 15, 16-30, 31-45, 46-60, and above 60, the percentages of microcytic hypochromic cases were 20%, 5%, 6.25%, 5.2%, and 11.1%, respectively. Normocytic normochromic cases were 8%, 7.5%, 15.63%, 13.1%, and 15.55%, while macrocytic normochromic cases were 2.22%, 2.5%, 3.12%, 7.9%, and 4.4%, contributing to a total of 30.22%, 15%, 25.16%, 26.2%, and 31% across the age groups. On the other hand, females under 15, 16-30, 31-45, 46-60, and above 60 had percentages of 23%, 13.3%, 19%, 18.22%, and 33.33% for microcytic hypochromic cases, 3%, 2.22%, 2.3%, 2.27%, and 2.22% for macrocytic normochromic cases, and 18%, 6.66%, 11.9%, 9.1%, and 17% for normocytic normochromic cases, contributing to a total of 34%, 21.22%, 30.9%, 29.55%, and 52.55%.In the age group under 15, anemia is the second most prevalent, decreasing in the subsequent age group, and then exhibiting an increasing trend in the older age groups, reaching a peak in the elderly. Morphologically, macrocytic anemia is more prevalent in males from >15 years onwards, and everywhere it is more male anemia than females while in the 15-30, 30-45, and 45-60 age groups, normocytic normochromic anemia is more common in males. Across all cases, anemia in females is greater than in males. normocytic normochromic anemia, male anemia is significantly higher compared to female anemia, except in <15 and 60-75 age groups where females have higher percentage of anemia

Table 6: The table showing the population of anemia in Mumbai across age groups

Anaemia in urban Mumbai [in percentages]		
	male	female
Under 15	30.22	44
16-30	15	22.22
31-45	25.16	33.2
46-60	26.2	29.55
Above 60	31	52.55

Discussion

1. **Urban Anemia in India In contrast with urban anemia across world**

According to our studies the urban anaemia in males is 25.16% and that in females is 33.2% as compared to The findings about anemia in Serbia, the prevalence of anaemia in adults in Vojvodina was 7.7%, with women (20%) being more affected than men (3.86%). The most common was normocytic anaemia, while microcytic anaemia was less common [7.4] Urban china has 6.8% anemia for males and 12.8% anemia for females [7.4] which is significantly lower than indian perspective, the prevalence of urban anemia was found to be twice higher in males than females in Ethiopian study which was attributed to addiction [9.0] which again differs from indian perspective where urban female anemia has more load [table 6]

In an Ethiopian study Females had 1.78 times the odds of anaemia as males in the multivariable logistic regression analysis .Anaemia was found in 20.1% of urban residents and finding contradicted a study conducted in central and eastern China, where the finding was nearly identical, 13.6% in urban areas and 13.3% in rural areas.[7.1] Possible explanations include low socioeconomic status, a lack of iron-rich foods, a lack of adequate nutrition information, and a higher number of illiterates in rural areas than in urban areas in this study.

An additional factor linked to anemia in both adults and children is exposure to smoke from burning biomass.[7.2]The cross-sectional study found that the participants' mean HB was 12.6 ± 2.1 g/dL and their anemia prevalence was 49.1%. The study examined the relationship between numerous sources of smoke exposure and the risk of anemia/HB level. We discovered exposure-response connections for the quantity of several waste types burned publicly at the same time, fuel stacking, and the frequency of rubbish burning by a neighbor who was at risk for anemia and had a high HB level. Additionally, an exposure-response association was noted for the following: frequency of cooking, location of cooking, length of cooking with HB, exposure to SHS, and current smoking behavior. The HB level was also correlated with living near a busy road, smoking fish, and any indication of smoke or odors in the neighborhood.[7.2] it might explain one of the reasons for anemia prevalence in urban area

A high prevalence of anemia in the younger age group (<15) can be linked to a diet with low iron content, characteristic of a middle-income country that emphasizes less meat consumption and is rich in carbohydrates.

Evidence from affluent nations suggests a need to lower hemoglobin cutoffs for defining anemia in children aged 6 months to 2 years. Anemia cutoffs in African and Asian children and adolescents were notably lower (1-2 g/dL) in several datasets compared to WHO recommended cutoffs. However, drawing conclusions about norms is challenging due to limited studies specifically excluding individuals with iron deficiency or inflammation. For older populations, comparability exists, indicating no necessity for reclassification.

2. **Urban Anemia in India In contrast to rural anemia load in India and its Etiology and Pathophysiology**

In a study conducted in Ahmednagar, Maharashtra, to provide insights into the adult rural population, especially females, in contrast to our own adult population (Table 5) [7.5], microcytic anemia was most prevalent (44.06% in rural females vs. 19 % in urban females). These rates were higher than those in rural men (4.88%) and urban men (15%). The primary cause of microcytic anemia is often iron deficiency, with females in India being highly prone to iron deficiency anemia. Other causes include thalassemia trait, sideroblastic anemia, chronic diseases, inflammation, lead poisoning, etc. [9].For normocytic normochromic anemia, the rates were higher in rural women (27.11%) compared to urban women (11.9%) and in rural men (34.16%) compared to urban men (6.25%). Normocytic anemia was more common in males, often attributed to acute blood loss and inflammatory conditions. Additional reasons for normochromic anemia include liver and kidney disease, autoimmune diseases such as aplastic anemia, PNH, hereditary spherocytosis, G6PD deficiency, and occasionally AIDS [7.5].

Macrocytic anemia in females was 10.16% in rural areas and 2.3% in urban areas, while in males, it was 9.76% and 3.12%, respectively. Macrocytic normochromic anemia is associated with megaloblastic anemia (B12 or folate deficiency), alcoholism, liver disease, reticulocytosis, multiple myeloma, and hypothyroidism. B12 deficiency is more prevalent in vegetarian populations [7.5] Anemia is more prevalent in women than men, except for macrocytic anemia and normocytic normochromic anemia in rural where men have a higher incidence of anemia . Rural areas generally have higher rates of anemia than urban areas, with variations across age groups [7.5]

The predominance of anemia in females is evident in both urban setting. However, the disparity is more pronounced in rural areas, even during childhood. This difference, though not statistically significant in comparison to urban settings, is influenced by a patriarchal society favoring male children, resulting in the allocation of more resources, including food and nutrition, to male children [9]. Additionally, illiteracy hampers access to health schemes, contributing to higher anemia rates in rural populations. The increased prevalence of macrocytic anemia in rural settings reflects greater vegetarianism due to limited financial access to meat-based resources, which are more expensive. Caste hierarchical structures in rural areas associate vegetarianism with purity, making it favored. These factors are less prominent in urban settings [7.3].

In terms of anemia prevalence, males exhibit a higher prevalence of normochromic anemia compared to iron deficiency anemia. In contrast, females show the inverse trend, with iron deficiency anemia being more common. Endurance exercise induces hemoconcentration during workouts, causing the body to compensate by adding fluid, salts, and albumin to the blood, expanding baseline plasma volume and diluting down Hb levels. This results in endurance athletes having slightly lower hemoglobin levels than the general population, leading to dilutional pseudoanemia.

The difference in hemoglobin levels increases beyond the age of 16 due to higher testosterone levels in males, aiding erythropoiesis and increasing hemoglobin concentration. Androgens and erythropoiesis are closely related, stimulating the hematopoietic system through various mechanisms, including raising bone marrow activity and releasing erythropoietin. Androgen therapy, used before recombinant erythropoietin (rhEpo), also has the side effect of polycythemia [10].

Erythropoiesis regulation is well established, with anoxia being the primary stimulus for erythropoiesis, resulting in the release of erythropoietin. Factors such as sexual activity and cortical steroids from the adrenal gland affect erythropoiesis [11]. Gender-based variation in Hct levels may have a genetic basis, with EPOR alleles EPORA1 and EPORA10 found at a significantly higher frequency in females than males. EPOR5 is less frequent in females than in males. The allelic frequency of the EPO polymorphism does not differ significantly by gender or Hct group [12].s

According to the data in this AMJ HEMATOL article, iron deficiency increases megakaryopoietic differentiation and changes platelet phenotype without affecting megakaryocyte growth factors, specifically TPO. Iron deficiency induced thrombocytosis may have evolved to maintain or increase coagulation capacity in chronic bleeding conditions.[12.1]

3. Comparing Variations in Hematological Parameters in India with Other Studies done in the world:

In contrast to a similar study conducted in the Korean population, sex-related differences were observed in most CBC parameters (P<0.05). Hematocrit (Hct), hemoglobin (Hb), and red blood cell (RBC) count exhibited an increasing trend with age until late childhood (12–14 years) in both sexes. Notably, sex-related differences were noted from puberty (15–17 years) onwards, persisting until 45 years of age, after which a decline occurred in the geriatric age group. Females had a narrower range due to decreased muscle mass, reduced metabolic demands, and lower iron reserves compared to males. In the Indian context, Hb and RBC counts reached a maximum value in the 16-30 age group and began decreasing thereafter. Although the hematocrit in the Korean study showed a significant difference between sexes, such differences were not significant in the Indian context across all age groups. It was observed that values reached a maximum in the 30-45 age group and declined thereafter [13] [table 3].

In Korean studies for males, the RBC count increased until adulthood (45 years) and then decreased in the geriatric age. However, in Indian males, it continued to decrease after 16-30, while for females, it was higher in less than 15, then decreased in the 16-30 age group, and later increased until reaching a maximum value in the 46-30 age group. This divergence may be attributed to the fact that, due to effective nutrition programs in Korea, RBC count increases post the growth phase. In the Indian context, it plateaus due to improper nutritional diet, and lower counts in earlier scenarios are attributed to poor nutrition and menstrual factors.

In the Korean study, Red Cell Distribution Width (RDW) was higher in males, except during puberty and adulthood where it was higher in females (P<0.005). It was highest in those older than 75 years in both sexes. Generally, RDW is higher in males than in females, and its values are higher in blacks compared to whites and other ethnicities. In the Indian context, RDW was higher for males, except in the [16-30] and [above 60] age groups. RDW increased with age for both genders. This anomaly of higher RDW can be attributed to high iron deficiency anemia in extremes of young and old ages.

Black women (13.1 ± 0.03) and men (13.4 ± 0.02) had higher RDW compared to women of white (12.9 ± 0.02) and other (13.0 ± 0.07) ethnicities and men of white (13.3 ± 0.02) and other (13.3 ± 0.07) ethnicities. RDW generally increased with age and was higher in the elderly than in the young [14].

This discrepancy can be attributed to the higher poverty rate in the Indian subcontinent, leading to inadequate nutrition, reduced meat consumption, higher intake of carbohydrates and fats, and a predominantly plant-based diet. The deficiency in protein also contributes to this overall clinical picture, resulting in stunted development [9].

According to an Iranian study that examined Mean Corpuscular Volume (MCV), Mean Corpuscular Hemoglobin Concentration (MCHC), Hemoglobin (Hb), and Red Cell Distribution Width (RDW), similar conclusions were drawn. Adolescent populations are not uniform, leading to inadequate quantification of hematological parameters, particularly hematological indices. Regardless of age, there were significant differences in RBC variables between male and female participants, favoring males, who exhibited slightly higher hematological indices.[15]

In terms of sex differences, male participants demonstrated significantly higher hemoglobin content ($P<0.001$), hematocrit ($P<0.001$), and red blood cell count ($P<0.001$). Although the WHO criteria's cutoffs did not specifically represent the global population, they were still deemed applicable to the Indian context, particularly for older populations [13][16].

Mean Corpuscular Volume (MCV) increases with age and is higher in males than females [17]. This finding aligns with our research, where MCV demonstrated a similar pattern of increase with age. However, the noticeable difference was statistically significant only in the 15-30 age group.[15]

Limitations

There are a few restrictions on this study. To choose healthy individuals, the Clinical and Laboratory Standards Institute advises employing a direct sampling technique. We obtain the information from health camp information sheets. Even though our data comes from health examinations and examinees were disqualified based on their medical histories, values from unhealthy individuals might have been included because clinical criteria wasn't applied. And moreover, we were unable to include study participants younger than one year old because late cord clamping could cause the hb to appear falsely elevated and distort the findings. Because a smaller population was sampled, this study can be repeated in larger settings.

Additionally, more blood smears could be performed to further investigate anisopoikilocytosis on smears

Strengths

One of the study's strengths is that the CBC results were obtained using the same contemporary five-part hematology analyzer with the same settings and operations. The combined data of health examinees from camps, ranging in age from one to seventy-five, was examined. It permitted

us to determine representative age and sex ranges for the urban Indian population, as well as the hematologic changes that occur over time from early childhood to late geriatric age. Because the Automated 5-Part differential hematology analyzer [ERBA H 560] is standardized, the age- and sex-specific intervals for red cell indices would be applicable in any other setting. [18]

Furthermore, red cell indices have the potential to enhance the precision of anemia monitoring in adult, pediatric, and elderly patients, particularly with regard to the anemia's morphological characteristics.

Scope: this study can be replicated on wider scale to further understand urban anemia load

Conclusions

1. Impact of Busy Lifestyles and Nutritional Deficiencies: Another factor unique to urban living is the fast-paced, high-stress lifestyle. Many urban residents, particularly those in working-age groups, face significant time constraints due to long working hours, commutes, and other responsibilities. As a

result, there is limited time to prepare and consume balanced meals. This often leads to the consumption of fast food, which, while convenient, is typically low in nutritional value. The combination of poor diet quality and erratic eating patterns exacerbates the risk of nutritional deficiencies, leading to an increased incidence of anemia in urban populations.

2. Gender and Age-Related Disparities: The burden of anemia in urban areas also reveals significant gender and age-related disparities. Women, especially of reproductive age, are particularly vulnerable due to the increased iron demands of menstruation, pregnancy, and lactation. Urban women, despite having greater autonomy in theory, may still face barriers to accessing healthcare and nutritional resources due to social or economic constraints. This gender gap is especially concerning among pregnant women, where undiagnosed or untreated anemia can have severe consequences for both maternal and neonatal health outcomes
3. Similarly, elderly urban residents, who may experience reduced access to food due to financial or mobility challenges, are at higher risk of anemia. Aging populations also have specific nutritional requirements that, if unmet, can contribute to a decline in overall health. Despite these well-documented vulnerabilities, public health interventions rarely address the unique needs of older urban dwellers in the context of anemia prevention and treatment.
4. Policy Gaps and the Need for Targeted Interventions: Current public health policies largely target anemia in rural settings, where malnutrition and limited healthcare access are seen as primary drivers. However, the oversight of urban anemia in these policies is evident. Many programs designed to combat anemia do not take into account the complexities of urban environments, where food security and healthcare access may be influenced by a wide range of factors, including economic inequality, social isolation, and the prevalence of chronic stress.

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