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Anemia in Hospitalized Patients: A Cross-Sectional Study on Different Erythrocyte Indices and their Relationships

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Abstract

Background: The prevalence of anemia varies according to age, gender and ethnicity. Moreover, its occurrence in the significant proportions of hospitalized patients is a matter of concern for the healthcare practitioners. **Objective:** The objective of the study was to determine the prevalence of anemia in hospitalized patients in relation to age, gender, and ethnicity and to assess the relationships of different erythrocyte indices with hemoglobin. **Materials and Methods:** In a hospital-based, cross-sectional study, the hematological test results of 485 patients were analyzed. Participants were categorized according to gender, age and ethnicities and diagnosed as anemic based on hemoglobin levels <12.0 g/dL in females and <13.0 g/dL in males. Erythrocyte indices like hemoglobin, erythrocyte count, hematocrit, mean corpuscular volume, mean corpuscular hemoglobin and mean corpuscular hemoglobin concentration were compared between the anemic and normal participants apart from different subgroups. **Results:** The prevalence of anemia in the hospitalized patients was 65.8%. It was greater in females as compared to males. Likewise, it was the highest in the highest quartile of age and Indo-Aryan ethnic group. Hemoglobin concentration was significantly lower in the female participants than in the males ($p<0.001$); significantly different across different age groups (quartile of age) ($p<0.001$). Hemoglobin was found to be significantly and positively correlated with erythrocyte count, hematocrit, mean corpuscular volume and mean corpuscular hemoglobin ($p<0.001$). Hematocrit followed by erythrocyte count were the most efficient predictors of the diagnosis of anemia. Moreover, RBC count/HCT with MCV and MCH together could significantly explain the variance in hemoglobin levels, after controlling for age and gender ($p<0.001$). **Conclusion:** Anemia was found to be significantly prevalent in hospitalized patients. Moreover, the erythrocyte indices like erythrocyte count, hematocrit and hemoglobin concentration were effective in characterizing anemia.

Keywords: Anemia, Erythrocyte Count, Erythrocyte Indices, Hematocrit, Hemoglobin

1. Introduction

Anemia, a clinical entity characterized by an increased destruction and/or diminished production of erythrocytes, establishes as reduced mass of erythrocytes and adversely distresses the adequate conveyance of oxygen to the peripheral tissues. In the laboratory, this disorder can be evaluated by hemoglobin concentration, hematocrit, or erythrocyte count, although Hb concentration is the accepted one. The World Health Organization (WHO) has recommended the use of Hb levels as 12.0 g/dL in women and 13.0 g/dL in men as the cutt off values[1].

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It has been reported by many studies that the prevalence of anemia varies considerably amongst the different age groups, ethnicities apart from the two gender groups (male and female)[2,3]. Furthermore, many studies have reported the occurrence of this hematological abnormality in hospitalized patients with an unusual prevalence[3–6]. Apart from Hb concentration, other two major erythrocyte indices routinely measured in the laboratory are Hematocrit (HCT), and Red Blood Cell (RBC) count. Additional important parameters include Mean Corpuscular Volume (MCV), Mean Corpuscular Hemoglobin (MCH) and Mean Corpuscular Hemoglobin Concentration (MCHC)[7]. There are evidences suggesting the variations, in terms of diminished values, of the various parameters[8–10].

Although, the prevalence of anemia in women of Nepal is 36.0%, as defined according to Hb levels by the WHO, very few studies, if any, have been conducted to determine the prevalence of this disorder in hospitalized patients and also to assess the relationship of different hematological parameters with Hb levels. In this regard, the aim of the present study was to determine the prevalence of anemia in hospitalized patients. We also aimed to determine the prevalence of this abnormality in different genders, age groups and ethnicities. Additionally, our objective was to assess the relationship of different hematological parameters (RBC indices) and Hb levels.

2. Materials and Methods

It was a hospital-based, cross-section study conducted in the Department of Physiology in collaboration with the Hematology Section (Central Clinical Laboratory) of College of Medical Sciences and Teaching Hospital, Bharatpur, Chitwan Nepal, a tertiary care center. After procurement of clearance from the Institutional Review Committee (IRC), results of hematological tests (performed in the months of September to December, 2017) of 600 different patients were randomly retrieved from the hospital Laboratory Information System (LIS) database. Out of these, 570 adult participants (Age > 14 years) were selected. After cleaning the outliers for different variables (including data in the range of 2.5th to 97.5th percentiles), 485 participants were finally deemed eligible for analysis. Participants of both gender (male and male) were considered and were categorized into different ethnic groups (Indo-Aryan, Tibeto-Burman, Newar, and Miscellaneous) as done in a previous study by Bhattarai et al[11]. The hematological parameters considered for analysis in the present study included hemoglobin concentration (Hb, g/dL), red blood cell (RBC) count (per µL), hematocrit (HCT, %), mean corpuscular volume (MCV, fL), mean corpuscular hemoglobin (MCH, pictogram, pg), and mean corpuscular hemoglobin concentration (MCHC, g/dL). Furthermore, using Hb<12.0 g/dL in women and Hb<13.0 g/dL in men as a WHO diagnostic criteria of anemia for adults, participants were further categorized as those with and without anemia.

2.1 Statistical Analysis

Data was initially entered in EXCEL 2007 and after preliminary cleaning, finally entered into Statistical Package for Social Science (SPSS) version 16.0, where final cleaning and analysis were performed. The categorical variables (gender, ethnic groups, and anemic-non-anemic groups were presented as frequency and percentage, with the comparison done by using Chi-Square test. Similarly, for continuous variables (Hb, RBC count, HCT, MCV, MCH, and MCHC), mean ± Standard Deviation (SD) was used for comparing across different groups of categorical variables using either independent t-Test or Analysis of Variance (ANOVA). Furthermore, correlation of various hematological parameters with Hb were done by Pearson's Correlation Test. Finally, Receiver Operating Characteristic (ROC) curve analysis for the prediction of diagnosis of anemia was performed using the hematological parameters as the independent variables. The statistical significance was defined with a cutoff value of 0.05, i.e., $p<0.05$.

3. Results

Of the total 485 adult participants, 278(57.3%) were females and 207(42.7%), males; similarly, 166(34.2%) were normal and 319(65.8%), anemic.

The prevalence of anemia was 70.9% in female and only 58.9% in male participants. Amongst the anemic patients, most (61.8%) were females and only 38.2% were males. Overall, the difference in proportions of normal and anemic patients was statistically significant between males and female participants ($p<0.05$) (Table 1).

The prevalence of anemia showed positive association with different quartiles of age; 53.3% (first quartile), 59.8% (second quartile), 72.4% (third quartile) and 77.5% (fourth quartile). Similarly, among the anemic patients, most were in the highest quartile of age (29.2%), followed by third (27.9%), second (25.2%) and least in the first quartile. Overall, the proportions in different age-quartiles were significantly different across the normal and anemic patients (p<0.001) (Table 1).

Most of the participants belonged to the Indo-Aryan ethnic groups (N=297, 61.2%), followed by Tibeto-Burman, Miscellaneous and Newar. The prevalence of anemia was the highest for Indo-Aryan group (69.0%), least in Tibeto-Burman (57.6%) and comparable in Miscellaneous and Newar groups (63.1% vs 66.7%). Similarly, amongst the anemic patients, most were from the Indo-Aryan (64.3%) and the least, from Newar groups (5.0%). Overall, the difference in proportion was not

Table 1. Distribution of study participants in different gender, age-groups and ethnic-groups based on diagnosis of anemia

Groups	Normal	Anemia	Total
Gender			
Female	81 (29.1%)[a](48.8%)[b]	197 (70.9%%)[a](61.8%)[b]	278 (57.3%)[b]
Male	85 (41.1%)[a](51.2%)[b]	122 (58.9%)[a](38.2%)[b]	207 (42.7%)[b]
Total	166 (34.2%)[a]	319 (65.8%)[a]	485
Chi-Square Test (with continuity correction): Test statistic=6.976 (p=0.008)			
Age Groups (Quartiles of age)			
First Quartile	56 (46.7%)[a](33.7%)[b]	64 (53.3%)[a](20.1%)[b]	120 (24.7%)[b]
Second Quartile	49 (40.2%)[a](29.5%)[b]	73 (59.8%)[a](22.9%)[b]	122 (25.2%)[b]
Third Quartile	34 (27.6%)[a](20.5%)[b]	89 (72.4%)[a](27.9%)[b]	123 (25.4%)[b]
Fourth Quartile	27 (22.5%)[a](16.3%)[b]	93 (77.5%)[a](29.2%)[b]	120 (24.7%)[b]
Total	166 (34.2%)[a]	319 (65.8%)[b]	485
Pearson's Chi-Square Test: Test statistic=19.858 (p<0.001)			
Ethnic Groups			
Indo-Aryan	92 (31.0%)[a](55.4%)[b]	205 (69.0%)[a](64.3%)[b]	297 (61.2%)[b]
Tibeto-Burman	42 (42.4%)[a](25.3%)[b]	57 (57.6%)[a](17.9%)[b]	99 (20.4%)[b]
Newar	8 (33.3%)[a](4.8%)[b]	16 (66.7%)[a](5.0%)[b]	24 (4.9%)[b]
Miscellaneous	24 (36.9%)[a](14.5%)[b]	41 (63.1%)[a](12.9%)[b]	65 (13.5%)[b]
Total	166 (34.2%)[a]	319 (65.8%)[a]	485
Pearson's Chi-Square Test: Test statistic=4.567 (p=0.206)			

a: Distribution along the row
b: Distribution along the column

statistically significant across different groups (p>0.05) (Table 1).

Female participants had a significantly lower mean hemoglobin levels as compared to the males [11.10±1.58 vs 12.31±1.80 g/dL; Independent t-Test (p<0.001)]. Similarly, one-way Analysis of Variance (ANOVA) result showed that the mean hemoglobin concentrations were significantly different across different age groups (quartiles of age), although post-hoc analysis revealed this statistical significance to hold true between first quartile and third or fourth quartiles of age (p<0.05). Nonetheless, the mean Hb level was comparably distributed among the different ethnic groups, with no significant difference (p>0.05) (Table 2).

Mean values of RBC count, hematocrit, mean corpuscular volumes and mean corpuscular hemoglobin were significantly lower in the anemic participants (Independent t-Test; p<0.001). However, mean corpuscular hemoglobin concentration showed no significant difference between the two groups (p>0.05), albeit the anemic patients had slightly lower mean values (Table 3).

Table 2. The comparison of mean±SD of hemoglobin concentration (g/dL) between different gender, age-groups and ethnic-groups

	Hb (g/dL) Mean ± SD	**Statistical Analysis**	**Significance (p-value)**
Gender			
1. Female (N=278)	11.10±1.58	**Independent t-Test** (t = −7.948)	**p<0.001**
2. Male (N=207)	12.31±1.80		
Age Groups (Quartiles of age)			
1. First Quartile (Q_1) (N=120)	12.02±1.60	**One-way ANOVA** (F = 4.081)	**p = 0.007** **Tukey's Post-hoc** Q_1 vs Q_3**(p=0.049)** Q_1 vs Q_4**(p=0.007)**
2. Second Quartile (Q_2) (N=122)	11.71±1.91		
3. Third Quartile (Q_3) (N=123)	11.43±1.87		
4. Fourth Quartile (Q_4) (N=120)	11.28±1.65		
Ethnic Groups			
1. Indo-Aryan (N=297)	11.49±1.83	**One-way ANOVA** (F = 1.387)	p = 0.246
2. Tibeto-Burman (N=99)	11.81±1.72		
3. Newar (N=24)	11.59±1.60		
4. Miscellaneous (N=65)	11.88±1.78		

Table 3. Comparison of the mean±SD of different hematological parameters between normal and anemic participants

Variables	**Mean ± SD**		**Statistical Analysis**	
	Normal	**Anemia**	**t-value**	**Significance (p-value)**
1. RBC Count[a] [x 10^6/µL]	4.62±0.39 *(N=166)*	3.85±0.57 (N=319)	15.598	**p<0.001**
2. HCT[b] [%]	38.05±3.35 *(N=166)*	30.63±4.23 (N=319)	19.604	**p<0.001**
3. MCV[c] [fL]	82.06±5.86 *(N=166)*	79.83±6.79 (N=319)	3.603	**p<0.001**
4. MCH[d] [pg]	29.07±2.08 *(N=166)*	27.86±2.52 (N=319)	5.323	**p<0.001**
5. MCHC[e] [g/dL]	34.78±2.64 *(N=86)*	34.75±2.52 (N=177)	0.093	p = 0.926

Hemoglobin was found to be positively correlated with all the hematological parameters. However, the association was statistically significant (P<0.001) with RBC count, hematocrit, mean corpuscular volume and mean corpuscular hemoglobin only, with an insignificant association mean corpuscular hemoglobin concentration (p>0.05).The ROC curve analysis showed that hematocrit, followed by RBC count were the most efficient predictors of the diagnosis of anemia (areas under the curve, AUC: 0.919 and 0.872 respectively). The optimal cutoff value of hematocrit for diagnosis of anemia was 33.1% (sensitivity: 73.4% and specificity: 95.3%); it was 4.37x10^6/µL (sensitivity: 83.1% and specificity: 83.7%) for RBC count. Similarly, the cutoff values with sensitivities and specificities for MCV, MCH and MCHC were 80.15fL (50.8%; 67.4%), 27.85pg (49.7%; 74.4%) and 35.95g/dL (72.3%; 39.5%) respectively (Table 4; Figure 1 and 2).

Finally, hierarchical multiple regression model was used to evaluate the predictive ability of the components (RBC count/HCT, MCV, and MCH)for Hb concentrations, after adjusting for the impact of age and gender. Pilot analyses were run to make certain that the assumption of normality, linearity, multicollinearity, and homoscedasticity were notbreached. Age and gender were inputted in first phase; these could elucidate 15.8% of the variance in Hb levels. In second step, after entry of the RBC count, MCV and MCH, the total variance explained bythe model collectively was 96.5% F(5, 479) = 2666.26, p<0.001] and was 98.7% [F (5, 479) = 7399.32, p<0.001], for HCT, MCV and MCH. RBC count, MCV and MCH explained an additional 80.8% of the variance in Hb levels, after controlling for age and gender [R square change=0.808, F change (3, 479) = 3718.33 p<0.001], whereas HCT, MCV and MCH explained an additional 82.90%, after adjustment [F change (3, 479) = 10363.65, p<0.001]. Finally, in the model consisting of RBC count, MCV and MCH, RBC count (beta=0.974) and MCH (beta=0.549) were highly significant statistically (p<0.001). Nevertheless, contributions of age (p=0.021) and gender (p=0.023) were also statistically significant.In another model with HCT, MCV and MCH, all the three control measures were statistically significant (p<0.001), with the beta values being 1.019, 0.561, and −0.522, respectively.

4. Disussion

A dynamic steadiness amid erythropoiesis and macrophage-mediated removal of senescent Red Blood Cells (RBCs) maintains the total RBC count in the circulation. Anemia refers to a clinical entity characterized by an augmented destruction and/or diminished production of RBCs, manifesting as reduced mass of RBC and adversely affecting the sufficient delivery of oxygen to the peripheral tissues[1].

In the laboratory, anemia can be rationally quantified by either hemoglobin concentration, hematocrit, or RBC count. Of these, is the hemoglobin concentration found to be fancied by most clinical practitioner to define ane-

Table 4. Correlation of the hemoglobin (g/dL) with age and different hematological parameters along with Receiver Operating Characteristic (ROC) curve analysis for prediction of diagnosis of anemia

Variables	**Bivariate Correlation with Hb (g/dL)**		**Prediction of Diagnosis of Anemia (ROC Curve Analysis)**			
	Correlation Coefficient	**Significance (p-value)**	**AUC**	**Cutoff**	**Sensitivity**	**Specificity**
Age [Years]	−0.163	**p<0.001**	0.628	47.50	55.8%	65.1%
RBC Count[a] [x 10^6/ µL]	0.825	**p<0.001**	**0.872**	**4.37**	**83.1%**	**83.7%**
HCT[b] [%]	0.902	**p<0.001**	**0.919**	**33.1**	**73.4%**	**95.3%**
MCV[c] [fL]	0.173	**p<0.001**	0.591	80.15	50.8%	67.4%
MCH[d] [pg]	0.275	**p<0.001**	0.639	27.85	49.7%	74.4%
MCHC[e] [g/dL]	0.031	p = 0.613	0.513	35.95	72.3%	39.5%

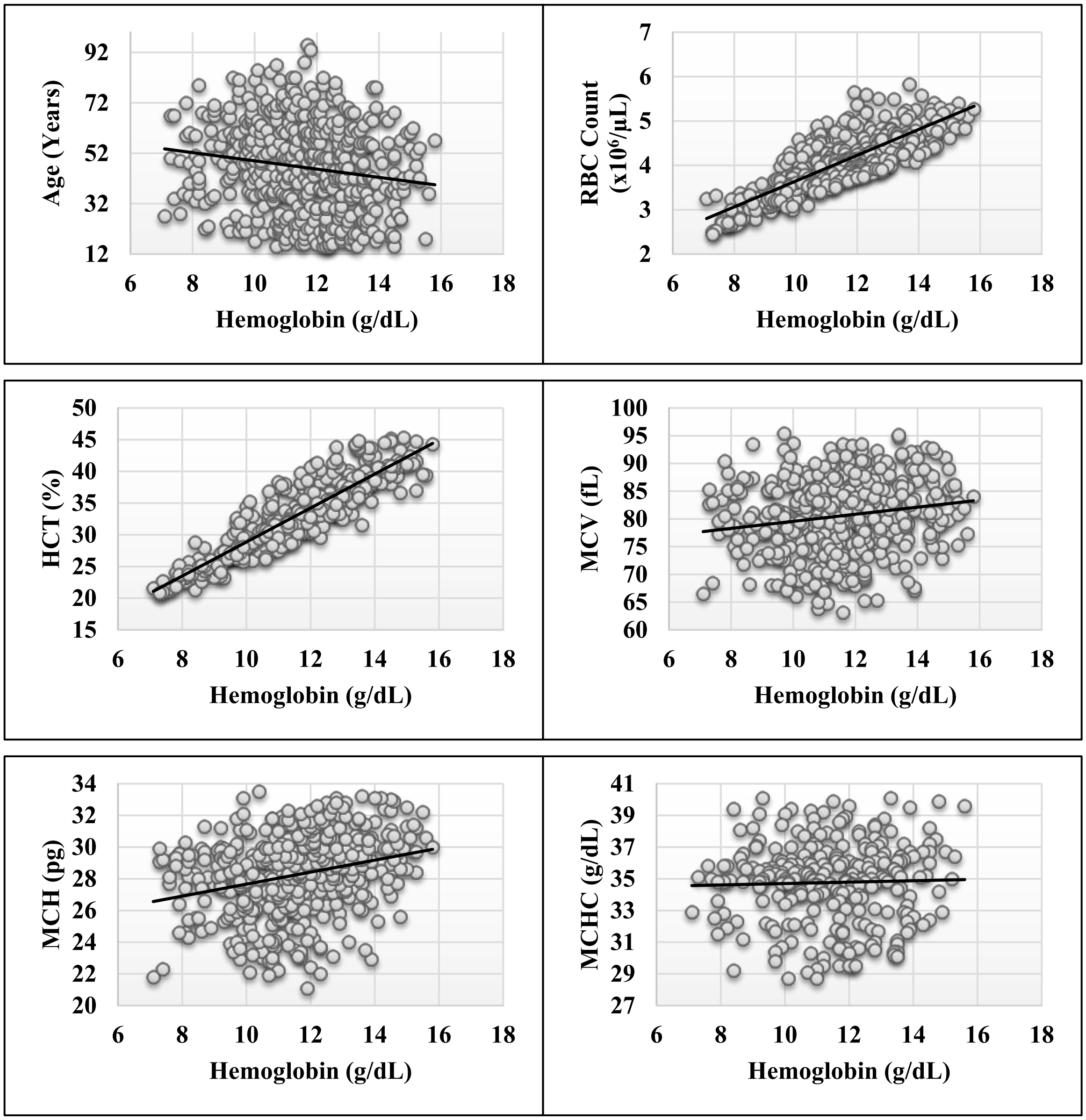

Figure 1. Correlation (linear regression curves) of hemoglobin (g/dL) with age (years) and different hematological parameters.

mia; albeit, HCT is equally pragmatic and unswerving. As equivocally accepted by many clinical laboratories, separate threshold levels of hemoglobin exist for defining anemia in adult male and female patients, i.e., 14.0 g/dL and 12.0 g/dL respectively. To this end, World Health Organization (WHO) has advocated the use of 12.0 g/dL in women and 13.0 g/dL in men. The elderly individuals can be evaluated considering the slightly lowered threshold Hb concentration[1].

A 2011 estimate by WHO showed the average Hb levels worldwide to be 11.1g/dL, a value not so different from our study (11.6±1.78g/dL). Likewise, the prevalences of anemia as reported in the same document varied significantly between children (42.6%), pregnant women (38.2%), non-pregnant women (29.0%) and all women of reproductive age (29.4%). The same document goes on to report that the greatest number of children and women with anemia resided in the South-East Asia Region. These

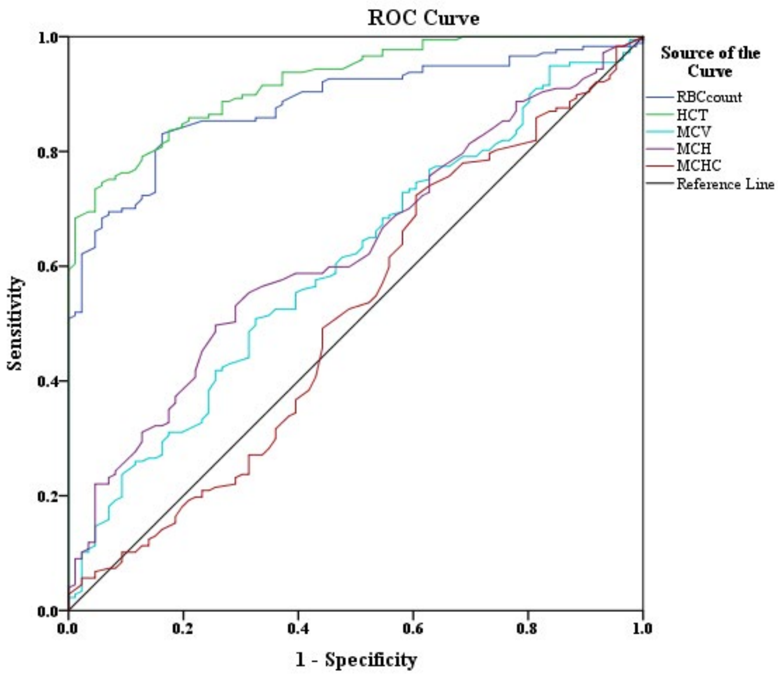

Figure 2. Receiver Operating Characteristic (ROC) curve analysis for the prediction of the diagnosis of anemia using different hematological parameters.

scenarios have been found to have taken a slight twist for Nepal where, the average Hb levels of the population was reported to be 12.4 g/dL with the prevalence of anemia in women as being 36.0%[2]. These findings were in sheer contrast to the prevalence of 65.8% (70.9% in females and 58.9% in males) as found in the present study. Additionally, female participants had a significantly lower mean hemoglobin levels as compared to the males (p<0.001). A common notion agreed upon by many studies that women are almost twice as likely to suffer from anemia as compared to males is also in consensus with the present study[3].

Notably though, a subset of studies has also suggested substantially higher prevalence of anemia in patient population in the hospital setting. In a study by Hung et al., 54.4% of the patients undergoing cardiac surgery in the hospital chanced WHO benchmarks for anemia[3,4]. To this end, findings not supporting our study are also noteworthy. In another study by Rachoin et al., of the total hospitalized patients, 10.4% were reported as being anemic[5]. Nathavitharana et al., in their study reported that 33.3% of the patients had anemia (WHO criteria) at time of admission with higher prevalence in males (38.1%) as compared to the females (28.2%)[6].

In the young adult population, prevalence of anemia has been reported to be unusually high as a result of factors such as bleeding as a result of trauma, menstruation, etc, apart from other causes of bleeding and hemolysis and iron deficiency in childbearing age in women. With increasing years of life, frequency of anemia can be expected to increase in lieu of other common causes of bleeding in the respective age groups like gastrointestinal and uterine bleeding, besides the situation of long-standing anemia. Most importantly, increasing incidence of cancers in advanced age also poses risk of development of anemia as a result of bleeding, bone marrow infiltration. In this regard, our study has reported the prevalence of anemia to increase with age; 53.3% (first quartile), 59.8% (second quartile), 72.4% (third quartile) and 77.5% (fourth quartile). Evidently, the hemoglobin concentrationdecreased with increasing age; the mean Hb levels were significantly different across different quartiles of age (p<0.001)[3].

Different ethnic backgrounds may also differ in their prevalences of anemia. Different factors possibly account for such discrepancies. Foremost, many ethnicities do have genetic predisposition to development of anemias like thalassemia, sickle cell anemia apart from others. Secondly, different degrees of socioeconomic benefits (e.g., diet, health careservice, etc) disseminated across the diverse races residing in different geographical terrains also account for such variations. Finally, certain population with constant exposure to chronic infectious diseases like malaria, tuberculosis, etc are at increased risk of developing anemia which is again compounded by their poor socioeconomic status[3,12–15]. As reported in our study, anemia was differently prevalent in different racial groups, i.e., Indo-Aryan (69.0%), Tibeto-Burman (57.6%), Newar (66.7%) and Miscellaneous (63.1%). However, mean Hb level was comparably distributed among the different ethnic groups, with no significant difference ($p>0.05$).

Apart from Hb concentration, Hematocrit (HCT), and RBC count per unit volume are the principal RBC indices that are routinely quantified in the laboratory. Other equally important parameters include Mean Corpuscular Volume (MCV), Mean Corpuscular Hemoglobin (MCH) and Mean Corpuscular Hemoglobin Concentration (MCHC). Majority of hematological auto-analyzers used by contemporary laboratories directly determine the Hb concentration, RBC count, and MCV; these, in turn, are used to calculate the HCT, MCH and MCHC[7].

RBC count decreases significantly in the course of development of anemia, specifically iron deficiency anemia. Iron deficiency results in decreased production of RBC from the erythropoeitic progenitor cells. The lifetime of RBC is reduced in addition to the increased apoptosis (eryptosis). The membrane of RBC also gets stiffened with the ensuing phagocytosis and elimination from the circulation[8]. Significantly decreased hematocrit with low MCV are indicative of iron deficiency anemia as a result of abnormal hemoglobin synthesis during erythropoiesis. Hematocrit, in particular, can show variation according to factors like age and gender[9]. Similarly, in conditions like iron deficiency anemia, some cases of anemia of chronic diseases amongst others, MCV and MCH can be appreciably decreased. Notwithstanding, folate and vitamin B_{12} deficiency result in increased MCV and MCH. Anemia in acute blood loss, hemolytic anemia can still present as normal MCV and MCH.[10]In the present study, mean values of RBC count, hematocrit, Mean Corpuscular Volume (MCV) and Mean Corpuscular Hemoglobin (MCH) were significantly lower in the anemic participants (Independent t-Test; $p<0.001$). However, Mean Corpuscular Hemoglobin Concentration (MCHC) showed no significant difference between the two groups ($p>0.05$). Similarly, hemoglobin concentration was found to be significantly correlated positively with RBC count, hematocrit, mean corpuscular volume and mean corpuscular hemoglobin. ($p>0.05$). Moreover, amongst all parameters, hematocrit (sensitivity: 73.4%; specificity: 95.3%), followed by RBC count (sensitivity: 83.1%; specificity: 83.7%) were the most efficient predictors of the diagnosis of anemia. Moreover, it was found that RBC count, MCV and MCH together could significantly explain the variance in Hb levels, after controlling for age and gender ($p<0.001$) in the same way as HCT, MCV and MCH together could explain ($p<0.001$).

Hemoglobinand hematocrits can be determined both manually and using autoanalyzers. Inaccuracies inherent to Hb estimations result from dilution, apart from cloudy sample owing to inadequate RBC lysis, increased leucocyte count, hyperlipidemia or hyperproteinemia. Likewise, sources of inaccuracies for determination of hematocrit are incorrect amounts of anticoagulants, inappropriate sample mixing, inadequate centrifugation apart from the lock in of plasma in the red cell column. To this end, auto-analyzers compute HCT by straight measurements of RBC number and volume. Notwithstanding, such approach can be problematic in patients with polycythemia or atypical plasma osmotic pressures.Despite being practical in assessment of anemia in most patients, Hb and HCT are swayed by certain significant limitations. As these parameters point towards an altered volume of plasma rather than the mass of RBCs, they can potentially create confusion in the diagnosis of anemia in condition like pregnancy or dehydration. Additionally, increase in these parameters may be spurious in individuals inhabiting at high altitudes or those with a right to left cardiac shunt. Variation in the levels of hemoglobin may also be associated with its altered ability to bind and release oxygen. Similarly, using Hb concentration or HCT to indicate anemia can also pose problems in cases with acute blood loss, as immediately following loss of blood, the levels of these parameters are normal due to vasoconstriction and require some time to accurately depict the condition. The RBC count, in this context, is the least valuable parameter. Apart from these, changes in posture can also have significant bearings on the measurement of Hb concentration and HCT. It has been found that with recliningposture, HCT tumbles by 7% (4-10) % in an hour; probably due to changes in the volume of plasma with hydrostatic transfer of fluid amid the circulation and extravascular compartments, as in the lower limbs[7].

Use of automated RBC counters has significantly improved the accuracy of counting the RBCs. The RBCs are counted together with the WBCs and thus can suffer from inaccuracies in cases of marked leukocytosis. A parameter very useful in classifying the anemias, MCV can be measured directly with automated instruments or calculated indirectly using RBC count and Hematocrit values.Spuriously high MCV can be seen in situations such as agglutination of cells, osmotic engorgement of RBCs as in severe hyperglycemia (glucose >600 mg/dL)[7].

A measure of average hemoglobin content per RBC and a reflection of hemoglobin mass, MCH can be calculated manually or by automated methods. This parameter symbolizes anemia such as iron deficiency anemia which develops consequent to compromised synthesis of hemoglobin and thus culminating in reduced mass of Hb per RBC. Specious upsurge of MCH is concomitant to leukocytosis and increased turbidity of plasma as in hyperlipidemia. Turbid samples can be centrifuged to rectify the MCV values. The average concentration of hemoglobin in a given red cell volume, MCHC represents the ratio of hemoglobin mass to the volume of RBCs. MCHC is swayed by the factors with significant bearings on hematocrit and hemoglobin, such as plasma trapping, abnormal RBCs, hyperlipidemia or leukocytosis. The obvious demerit of HCHC (like MCV and MCH) is its inability to sufficiently characterize the blood samples with mixed populations of RBCs which clearly warrants examination of the blood smears apart from the RBC histograms. While MCV is tremendously useful in classification of anemias, MCH and MCHC values remain stable for a give specimen over time and are used in laboratory quality control[7].

The present study suffers from a number of limitations apart from those incurred in the measurements of each parameter. Firstly, we didn't categorize the cases as to different types of anemia based on clinical and laboratory findings. Using Hb concentration can only define anemia. Such approach has failed to take into account the variations in different hematological parameters in different types of anemia. This could have been circumvented by properly classifying this disorder. The other limitation is related to the sample size which may be insufficient to properly asses the relationships as done in the study. As our study was the hospital based study, the lack of representativeness is also a major setback.

5. Conclusion

Notwithstanding, the findings of our study can still serve as a foundation for more future studies that can be planned in the setting of the general population with large sample size. Moreover, it can serve to add to the evidence as to the prevalence of anemia in the hospitalized patients, in general. The variation in the occurrence of anemia in different ethnic backgrounds can also serve as a valuable tool in decision making in clinical as well as research back drops.

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