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Original Research Article

Correlation Between Blood Types and Hemoglobin Status Among Rural Inhabitants of west Bengal Region

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Abstract:

Background: Anemia is a major health issue in rural India, particularly among women. While numerous factors are associated with anemia, the potential role of genetic markers like ABO blood groups in contributing to hemoglobin (Hb) variation is not well researched, especially among rural groups.

Objective: To study the ABO blood-group types in relation to hemoglobin status among adults living in rural Bihar and to provide gender-specific anemia prevalence estimation.

Methodology: Cross-sectional survey of 90 adults aged 18-32 years from rural West Bengal. Capillary blood was collected by sterile finger-prick method. ABO and Rh blood grouping was done by slide agglutination and hemoglobin estimation by Sahli's method. Statistical analysis was done by SPSS v26 with the $p < 0.05$ cut-off.

Results: 64 (71.1%) of the 90 patients were non-anemic (Hb ≥10 g/dL) and 26 (28.9%) were anemic. Females (48.6%) were considerably more anemic than males (16.4%) ($\chi^2 = 52.8$, $p < 0.0001$). There was no statistically significant association between ABO blood group and hemoglobin ($\chi^2 = 6.0$, $p = 0.17$), although O+ was most frequent among non-anemics.

Conclusion: Gender was also a significant predictor of anemia, and females were more impacted. No statistically significant correlation between ABO blood groups and hemoglobin was observed. Gender-specific interventions are recommended to prevent anemia in rural West Bengal.

Keywords: Anemia, Blood Group, Gender Difference, Hematology, Hemoglobin, Rural West Bengal.

Introduction

Blood is a specialized connective tissue with a complete and fixed identity. Blood is a vital component of maintaining homeostasis, carrying oxygen and nutrients, and promoting immune reactions. Blood is also a medium of coordination among different body cells and organs and is responsible for keeping the internal environment in accordance with alterations in the external environment [1]. Blood transfusion is an unavoidable process with the advancement of modern medicine, particularly in trauma treatment, surgery, and hematological disorder management [2].

Blood contains an incredibly large number of antigens on the surface of red blood cells, with well over 30 common and hundreds of rare antigens reported. The antigens vary in their immunogenicity and clinical significance. Of these, the ABO and Rh blood group systems are clinically significant due to high immune systems and their ability to cause immune responses, particularly in blood transfusion and pregnancy. The ABO system categorizes individuals into four main blood groups: A, B, AB, and O, based on the presence or absence of particular antigens. Group A contains A antigens, group B contains B antigens, group AB contains both, and group O lacks either of the two antigens. The Rh system, most significantly the RhD antigen, further subdivides the blood into Rh-positive (presence of RhD) or Rh-negative (lack of RhD) [3].

Blood group antigens are not limited to transfusion medicine. Literature correlations of risk to certain diseases, such as duodenal ulcers, diabetes mellitus, urinary tract infection, and hemolytic disease of the newborn, have been reported. The possible correlation of ABO blood group and hematologic indices, particularly hemoglobin (Hb) level, is a relatively unstudied area, especially among rural communities with limited access to healthcare and diagnostics.

Anemia, a hemoglobin value below the age and sex corresponding to normal, is a public health problem in the world. According to WHO, approximately 1.62 billion individuals, or 24.8% of the world

population, are anemic [4]. The burden is disproportionately high in developing countries like India and even higher in rural India, where socioeconomic and nutritional determinants are the principal causes of its persistence. WHO defines anemia as Hb <130 g/L in men, <120 g/L in non-pregnant women, and <110 g/L in pregnant women. Anemia is a major cause of maternal and perinatal death in India and accounts for about 20% of such deaths in low-resource settings [5].

It has multifactorial etiology that involves nutritional deficiencies (iron, folate, vitamin B12), chronic illness, parasitic infections, and genetic disorders. In adolescents and women of reproductive age, iron deficiency is the most prevalent cause. This is especially problematic, since anemia is the cause of compromised physical and mental development, reduced work capacity, and adverse pregnancy outcomes [6]. While oral iron supplementation is a safe and common therapy, it is only to be used in the case of diagnosed iron deficiency, since unnecessary supplementation may lead to side effects such as nausea, vomiting, constipation, and worsening of underlying gastrointestinal diseases such as ulcers. In addition, long-term iron supplementation has been associated with elevated oxidative stress and even increasing the risk of cardiovascular diseases [7,8],.

With the importance of anemia to public health and the probability of interaction between hematological parameters and genetic markers like blood groups, there is a requirement to check potential correlations that can be utilized for early detection of risk and intervention. Though some studies have established statistical correlation between hemoglobin and ABO blood groups, findings have been inconsistent, leading to local variations that are not always accounted for.

With the rural population of West Bengal, where prevalence of anemia and knowledge of distribution of blood groups are also not adequately documented, this correlation is of special interest to explore. Socioeconomic restrictions, inadequate dietary intake, and lack of adequate healthcare facilities add to the challenges, rendering the population at risk for anemia as well as its complications. Therefore, through a critical examination of the relationship between ABO blood group phenotypes and hemoglobin, useful information regarding disease susceptibility patterns and utilized in formulating public health policy of the local population can be derived.

The current research is an attempt to investigate this possible relationship between ABO blood group categories and hemoglobin in a rural population in West Bengal. En route, we hope to advance the knowledge regarding whether certain blood group categories predispose individuals to anemia or, on the other hand, have protective attributes in as far as hematological condition is concerned. These findings could be of enormous significance in screening programs, preventive medical interventions, and resource planning in rural health planning.

Methodology

Study Design: This was a prospective, observational, cross-sectional study aimed at exploring the relationship between adult hemoglobin levels and ABO blood types in a rural community.

Study Area: The study was conducted in the Department of Physiology, Gouri Devi Institute of Medical Sciences, Durgapur, West Bengal, India. Participants were selected from the surrounding rural areas of West Bengal

Study Duration: The study was conducted over a period of one year.

Sample Size: A total of 90 adult participants, including both males and females, were enrolled in the study.

Sample Collection: Capillary blood samples were collected using a finger prick method under aseptic conditions. Blood samples were used for:

- ABO and Rh blood grouping using the glass slide method with commercially available antisera A, B, and D.
- Hemoglobin estimation by Sahli's method, a manual technique based on acid hematin color matching.

Inclusion Criteria

- Adults aged 18 to 32 years.
- Individuals who provided written informed consent.
- Individuals without known hematological disorders or chronic illnesses.

Exclusion Criteria

- Individuals are unwilling to participate or provide consent.
- Individuals with known blood disorders (e.g., thalassemia, sickle cell anemia).
- Participants on iron supplements or medications affecting hemoglobin levels.
- Pregnant or lactating women.

Procedure: Patients who fulfilled the inclusion criteria were recruited after giving informed consent. Each subject was subjected to an innocuous and simple finger prick under aseptic precautions to obtain capillary blood. Blood grouping was done by the slide agglutination technique with the help of anti-A, anti-B, and anti-D sera to identify ABO and Rh blood groups. Hemoglobin estimation was carried out using Sahli's method, wherein hemoglobin was converted to acid hematin by the addition of hydrochloric acid. The color produced matched with that of a standard to estimate hemoglobin concentration.

All the tests were conducted under regular laboratory conditions and in strict aseptic procedures so that the safety of the participants and accuracy of the results could be ensured.

Statistical Analysis: "Data were determined into Microsoft Excel and subsequently analyzed with the Statistical Package for the Social Sciences (SPSS) version 26. Descriptive statistics like the mean and standard deviation were obtained for hemoglobin levels for various ABO blood groups. For finding associations, Chi-square tests were utilized for categorical data, and one-way ANOVA was utilized to find average hemoglobin levels between various blood groups. A p-value of less than 0.05 was deemed statistically significant."

Result

Table 1 indicates the distribution of haemoglobin (Hb) status in 90 adults as non-anaemic or anaemic. Out of the adults, most 64 (71.1%), of them had Hb ≥10 g/dL and were therefore non-anaemic. On the other hand, 26 adults (28.9%) had Hb <10 g/dL and were therefore anaemic. From this, we can observe that while anaemia exists, most of the sample population has a haemoglobin level above anaemia.

Table 1: Distribution of haemoglobin in adults with and without anemia

Hb	Frequency	Percentage
≥10	64	71.1
<10	26	28.9
Total	**90**	**100**

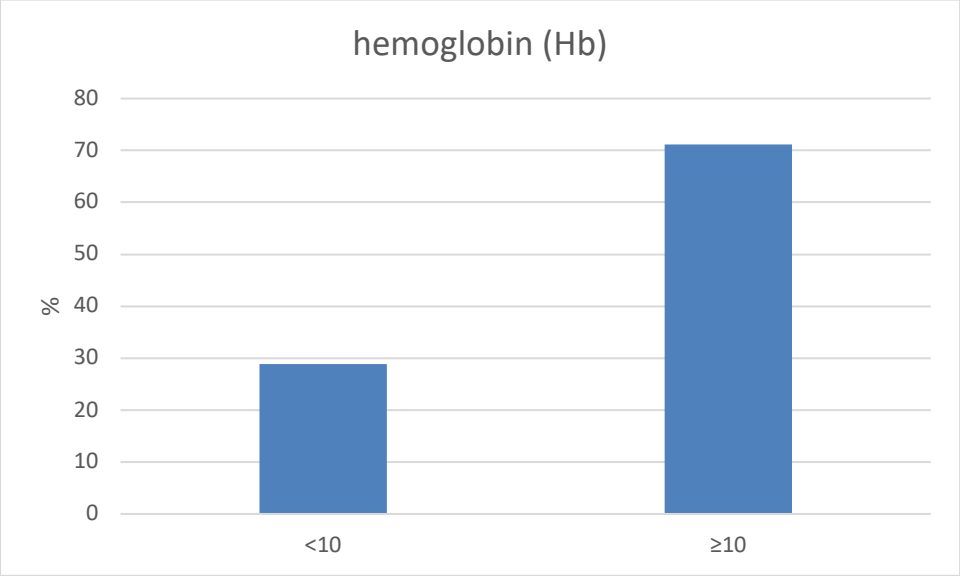

Figure 1: Heamoglobin distribution in with & without anemia adults

Table 2 indicates anaemia status of men and women by haemoglobin (Hb) status. Among 55 men, 46 (83.6%) were Hb ≥10 g/dL, and 9 (16.4%) were anaemic with Hb <10 g/dL. Conversely, among 35 women, 18 (51.4%) were Hb ≥10 g/dL, whereas a whopping 17 (48.6%) were anaemic. This indicates that anaemia happens much more often in women than men in the study population.

Table 2: Male and female anemia status

Sex	Hb ≥10	Hb <10	Total
Male	46	9	55
Female	18	17	35
Total	**64**	**26**	**90**

($\chi^2 = 52.8$, $p < 0.0001$)

Table 3 shows blood group prevalence among adults who were non-anaemic (Hb ≥10) and anaemic (Hb <10). The most common blood group found was O positive, with 25 non-anaemic and 8 anaemic participants out of 33. Blood group B positive had 16 non-anaemic and 10 anaemic participants out of 26 participants. Other blood groups, such as B negative, AB positive, AB negative, A positive, and A negative, were represented by lower participant numbers with various anaemia statuses. The statistical test ($\chi^2 = 6.0$, $p = 0.17$) shows no significant association

between blood type and anaemia status within this sample.

Table 3: Different blood group status in persons with and without anemia

Blood group	Hb ≥10	Hb <10	Total
O +ve	25	8	33
B +ve	16	10	26
B -ve	2	1	3
AB -ve	0	1	1
AB +ve	2	2	4
A -ve	1	0	1
A +ve	18	3	21
Total	**64**	**26**	**90**

($\chi^2 = 6.0$, $p = 0.17$)

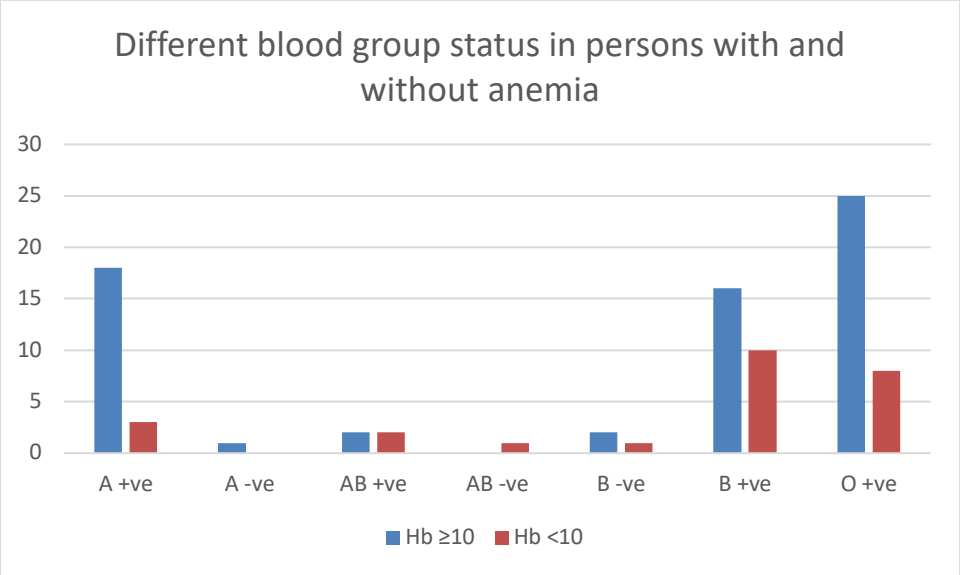

Figure 2: Different blood group status in persons with and without anemia

Discussion

The sample population comprised 90 adult subjects for whom haemoglobin (Hb) was assessed to determine the prevalence of anaemia. The majority of the subjects (71.1%) were non-anaemic with a level of Hb ≥10 g/dL, and 28.9% were anaemic with a level of Hb <10 g/dL. This indicates that while a high proportion of the population is maintaining haemoglobin within a normal range, a proportionate minority is still suffering the consequences of anaemia and thus may need targeted intervention or further investigation into causative factors such as diet, socioeconomic status, or underlying medical conditions.

Ramalingam & Raghavan (2020) [9] also carried out a study in Kanchipuram, Tamil Nadu, and reported a higher frequency of anemia in blood group B, then group A, O, and AB. Our results are in line with these very closely and point towards a regional susceptibility to low hemoglobin levels in individuals belonging to blood group B. The authors propose the hypothesis that genetic determinants related to blood group B could influence iron metabolism or erythropoiesis and thus increase susceptibility to anemia.

Similarly, a cross-sectional survey by Shah and Shah (2021) [10] in pregnant women from rural Himachal Pradesh also found increased anemia in blood group B positive individuals. Their results confirmed the hypothesis that some blood groups have an inbuilt risk of low hemoglobin and emphasized the value of blood-group-based screening and nutrition intervention.

A comparison by gender revealed a division between males and females in the anaemia prevalence. 83.6% of males consisted of Hb ≥10 g/dL, whereas only 16.4% were anaemic. In females, there was a fairly uniform pattern with 51.4% non-anaemic and 48.6% anaemic. Statistical analysis revealed a highly significant correlation between gender and anaemia status ($\chi^2 = 52.8$, $p < 0.0001$), establishing clearly that females have a disproportionate burden. This may be accounted for by a myriad of biological and social causes, e.g., menstrual blood loss, pregnancy, and variation in dietary intake or access to health care. Another study conducted in West Champaran, Bihar, also concluded that in the anemic patients, the most common blood group was B,

which was in close agreement with our observed trends (Bottuman, 2022) [11]. Another study assessing the correlation of ABO blood group and hemoglobin level, patients of blood group B were found to have increased risk of anemia among other groups, i.e., O and A (Pennap et al., 2011) [12]. This regional uniformity among different districts of Bihar implies a possible genetic or physiological relationship warranting further exploration.

When compared to anaemia status, no statistically significant association ($\chi^2 = 6.0$, $p = 0.17$) existed. There were, however, some trends evident. The O+ group had the largest subgroup with more non-anaemic subjects than anaemic subjects. B+ and A+ groups also had more non-anaemic subjects, although the percentage of anaemia in B+ was relatively higher than A+. A few of the less common blood groups like AB– and A– were found in very small numbers, and it may be premature to draw some conclusions for these groups. As no significant association was found, longer-term follow-up and larger samples may make it more evident whether there are subtle associations to be detected.

Research on rural West Bengal by Kumar (2021) [13] also failed to find any notable correlation of hemoglobin levels with ABO blood groups. They found that the prevalence of anemia was higher among the B group, then the O, then the AB, and the A group. This concurs with our result of more non-anemic patients among the O+ group, which is indicative of regional consistency in such patterns.

Conversely, research in West Champaran, Bihar, by Prasad and Kumar (2023) [14] indicated a strong relationship between hemoglobin and the ABO blood groups. They reported that hemoglobin risk was significant among B blood group patients, followed by A, O, and AB groups. Such variation can be attributed to varying sample sizes, populations, or study methodologies employed in the studies.

In general, the findings point to gender as the primary predictor of the prevalence of anaemia, and blood group does not make a contributory factor in the population being studied. The findings may have implications for the adjustment of public health intervention to control and screen anaemia, particularly among women.

Conclusion

The present study investigated the relationship of hemoglobin levels and ABO blood groups in the rural population of West Bengal. The findings presented a statistically significant gender difference as well as hemoglobin status, with the female subjects having a higher percentage of anemia compared to the male subjects. No statistically significant relationship was, however, found between hemoglobin levels and ABO blood groups, meaning that blood group type does not play a significant role in anemia status in this group. These findings suggest the significance of gender in being a more critical factor in anemia prevalence compared to blood group type, thus implying the necessity of differential health interventions, especially in women in rural populations.

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