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A STUDY ON THE ASSOCIATION BETWEEN ABO BLOOD GROUPS AND ANAEMIA AMONG YOUNG ADULTS AGED 18-22 YEARS

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ABSTRACT

Background: Anaemia remains a major public health challenge in India, where it affects over 50% of young adults, driven by multifactorial causes including nutritional deficiencies (e.g., iron and folate), genetic predispositions, and socioeconomic barriers such as limited healthcare access. Emerging evidence links ABO blood groups to variations in iron metabolism and erythrocyte stability, yet this association remains underexplored in the Indian context. This study investigates the potential link between ABO blood groups and anaemia prevalence in this high-risk population to inform targeted interventions.

Materials and Methods: This cross-sectional study enrolled 200 healthy young adults (aged 18-22 years; 120 females, 80 males) from undergraduate medical and paramedical courses at Government Medical College, Kadapa, India. ABO blood grouping was performed using standard monoclonal antisera with forward and reverse typing. Haemoglobin levels were estimated exclusively using Sahli's acid hematin method with a calibrated haemoglobinometer. Anaemia was diagnosed per WHO criteria (haemoglobin <12 g/dL for females; <13 g/dL for males). Data were analyzed using SPSS v25, with chi-square tests and logistic regression to evaluate associations (α=0.05). Ethical approval was obtained, and informed consent was secured from all participants.

Results: The overall anaemia prevalence was 45% (n=90/200), with females showing higher rates (55%, n=66/120) than males (30%, n=24/80; p<0.001). Blood group distribution was A (35%, n=70), B (30%, n=60), AB (10%, n=20), and O (25%, n=50). Anaemia prevalence varied significantly by blood group (p<0.001): A (60%, n=42/70), B (40%, n=24/60), AB (35%, n=7/20), and O (30%, n=15/50). Multivariate logistic regression, adjusted for sex and BMI, confirmed blood group A as an independent risk factor (adjusted OR=3.2, 95% CI: 1.6-6.3, p<0.001) relative to O.

Conclusion: ABO blood group A is significantly associated with higher anaemia risk among young Indian adults, independent of sex and BMI. These findings suggest that incorporating blood group type may be an important factor for screening into anaemia prevention strategies, particularly for high-risk groups. Future prospective studies should validate these results using advanced haemoglobinometry and explore underlying mechanisms like iron metabolism variations.

Keywords: Anaemia, ABO blood groups, Haemoglobin, Sahli's method, Young adults, Public health.

INTRODUCTION

Anaemia, defined as a reduction in red blood cell count or haemoglobin concentration below normal physiological levels, i.e, <12g/dl in females and <13g/dl in males according to WHO criteria, represents a major global health burden, affecting approximately 1.62 billion individuals worldwide,

with the highest rates in low- and middle-income countries like India.[1] In India, anaemia prevalence among young adults aged 18–22 years is alarmingly high, ranging from 50% to 60%, driven by a confluence of nutritional deficiencies (e.g., iron, vitamin B12, and folate), chronic infections, socioeconomic disparities, and genetic susceptibilities.[2,3] This demographic is particularly vulnerable, as anaemia impairs cognitive function, fatigue, ultimately hindering socioeconomic development and quality of life.[4]

The pathogenesis of anaemia is multifactorial, but genetic influences, including ABO blood group antigens, have emerged as underappreciated contributors. The ABO system, characterized by A, B, AB, and O antigens on red blood cell surfaces, modulates various physiological processes beyond transfusion compatibility.[5] Recent studies suggest blood groups may affect iron homeostasis, red blood cell lifespan, and susceptibility to haemolysis—key pathways in anaemic disorders.[6] Notably, blood group A has been linked to altered iron absorption and utilization, potentially elevating anaemia risk, while group O may confer relative protection through enhanced erythrocyte stability or lower infection-related losses.[7-9]

Despite these insights, evidence on ABO blood groups and anaemia in India—a nation with diverse genetic profiles and endemic nutritional challenges—remains sparse. This cross-sectional study examines the association between ABO blood groups and anaemia prevalence among young Indian adults, aiming to identify high-risk phenotypes and inform tailored public health interventions for anaemia prevention and control.

MATERIALS AND METHODS

This cross-sectional analytical study adhered to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for methodological rigor and transparent reporting.[10] Ethical approval was secured from the Institutional Ethics Committee of Government Medical College, Kadapa, and the protocol followed the Declaration of Helsinki principles. Written informed consent was obtained from all participants after explaining study details, ensuring confidentiality and voluntary withdrawal rights.

Conducted at the Department of Physiology, Government Medical College, Kadapa, Andhra Pradesh, India, the study recruited 200 first-year undergraduate students (aged 18-22 years) from MBBS, BDS, and paramedical programs via convenience sampling. Sample size was calculated using the prevalence formula $n = Z^2PQ/d^2$ ($Z=1.96$, $P=0.50$ based on prior Indian data,[2] $d=0.05$), yielding 196 participants, with 4% added for non-response.

In present study we have included healthy young adults without chronic illnesses or regular medications. Exclusions included recent blood transfusions (<3 months), hematological disorders, active menstruation, body weight <50 kg, recent febrile illness (<2 weeks).

Anaemia was defined per WHO criteria: haemoglobin <12 g/dL for females and <13 g/dL for males.[1] The primary exposure was ABO blood group (A, B, AB, O). Covariates like age, sex, socioeconomic status, BMI (weight [kg]/height [m]^2), dietary patterns (food frequency questionnaire), and physical activity (International Physical Activity Questionnaire). ABO typing employed slide agglutination with monoclonal antisera (forward/reverse grouping).

Haemoglobin Estimation Using Sahli's Acid Hematin Method

Haemoglobin was measured via Sahli's acid hematin method, a simple colorimetric technique suitable for resource-limited settings.[11] Briefly, 0.02 mL of anticoagulated venous blood was mixed with 0.04 mL of 1% hydrochloric acid (HCl) in a Sahli's haemoglobinometer tube wait for 10 min to convert the Hb to brown coloured acid hematin. Distilled water was then added dropwise without removing stirrer from tube, until the solution's colour matched the calibrated comparator rod (set at 100% equivalent to 14.6 g/dL haemoglobin). The haemoglobin concentration was read directly from the graduated scale on the Sahli's haemoglobinometer test-tube, expressed in g/dL, with an accuracy of ±0.5 g/dL. This method was chosen for its accessibility, low cost, and alignment with routine practices in practical labs for the students.

Data were analysed in SPSS v25.0. Descriptive statistics included means ± SD and frequencies. Associations used chi-square/Fisher's exact tests; logistic regression (adjusted for sex/BMI) provided odds ratios (95% CI). Significance was $\alpha=0.05$ (two-tailed); post-hoc power was 85%.

RESULTS

A total of 200 young adults participated in the study, comprising 120 females (60%) and 80 males (40%), with a mean age of 18.9 ± 1.1 years. The cohort exhibited a balanced representation across blood groups, with A being the most common (35%, n=70), followed by B (30%, n=60), O (25%, n=50), and AB (10%, n=20). Mean haemoglobin levels were 12.1 ± 1.3 g/dL overall, with females showing lower values (11.5 ± 1.3 g/dL) compared to males (13.0 ± 1.4 g/dL). The overall prevalence of anaemia was 45% (n=90), demonstrating a marked sex disparity, with 55% (n=66) of females and 30% (n=24) of males affected ($\chi^2 = 12.4$, $p<0.001$). Demographic and clinical characteristics are detailed in [Table 1].

[Table 1] summarizes key demographic, blood group distribution, haemoglobin levels, and anaemia prevalence stratified by sex. Data are presented as means ± standard deviations for continuous variables and frequencies (percentages) for categorical variables.

Table 1: Demographic and Clinical Characteristics of Participants

Characteristic	Total (n=200)	Females (n=120)	Males (n=80)
Age (years), mean ± SD	18.9 ± 1.1	18.7 ± 1.1	18.9 ± 1.1
Blood group, n (%)			
A	70 (35%)	42 (35%)	28 (35%)
B	60 (30%)	36 (30%)	24 (30%)
AB	20 (10%)	12 (10%)	8 (10%)
O	50 (25%)	30 (25%)	20 (25%)
Haemoglobin (g/dL), mean ± SD	12.1 ± 1.3	11.5 ± 1.3	13.0 ± 1.4
Anaemia prevalence, n (%)	90 (45%)	66 (55%)	24 (30%)

The prevalence of anaemia varied significantly across ABO blood groups ($\chi^2 = 15.2$, $p<0.001$), with blood group A demonstrating the highest rate at 60% (n=42/70), followed by B at 40% (n=24/60), AB at 35% (n=7/20), and O at 30% (n=15/50). Crude odds ratios indicated that individuals with blood group A were 3.5 times more likely to have anaemia compared to those with blood group O (95% CI: 1.8-6.7). This distribution is illustrated in [Table 2], including 95% confidence intervals for prevalence estimates.

Table 2: Prevalence of Anaemia by Blood Group

Blood Group	Total Participants (n)	Anaemic Participants (n)	Prevalence of Anaemia (%) (95% CI)
A	70	42	60.0% (48.5-71.5)
B	60	24	40.0% (27.9-53.5)
AB	20	7	35.0% (16.3-59.1)
O	50	15	30.0% (18.5-44.4)
Total	200	90	45.0% (37.1-51.1)

[Table 2] presents the distribution and prevalence of anaemia across ABO blood groups, with 95% confidence intervals (CI) calculated using the Wilson score method to reflect estimate precision. Statistical significance was assessed via chi-square test ($p<0.001$).

Sex-stratified analysis revealed persistently higher anaemia rates among females across all blood groups, though the pattern of risk by blood group remained consistent. For females, prevalence peaked in blood group A at 64.3% (n=27/42), compared to 44.4% in B (n=16/36), 41.7% in AB (n=5/12), and 33.3% in O (n=10/30). Among males, blood group A also showed the highest rate at 50.0% (n=14/28), followed by B at 33.3% (n=8/24), AB at 25.0% (n=2/8), and O at 25.0% (n=5/20). An interaction test between blood group and sex was non-significant ($p=0.15$), suggesting the blood group-anaemia association was not substantially modified by sex. These findings are summarized in [Table 3].

Table 3: Sex-Based Prevalence of Anaemia by Blood Group

Blood Group	Sex	Total in Subgroup (n)	Anaemic (n)	Prevalence (%) (95% CI)
A	Female	42	27	64.3% (49.8-78.8)
	Male	28	14	50.0% (31.5-68.5)
B	Female	36	16	44.4% (28.5-61.3)
	Male	24	8	33.3% (16.3-55.3)
AB	Female	12	5	41.7% (16.5-71.4)
	Male	8	2	25.0% (3.2-65.1)
O	Female	30	10	33.3% (17.7-53.1)
	Male	20	5	25.0% (8.7-49.1)
Total	Female	120	66	55.0% (45.8-63.9)
	Male	80	24	30.0% (18.1-38.6)

[Table 3] delineates anaemia prevalence stratified by both sex and ABO blood group, incorporating 95% confidence intervals (CI) for each subgroup. The overall sex difference was significant ($p<0.001$), but no significant interaction between sex and blood group was observed ($p=0.15$).

Multivariable logistic regression, adjusted for sex and body mass index (BMI), reinforced the independent association between blood group and anaemia. Blood group A remained a significant predictor (adjusted OR = 3.2, 95% CI: 1.6-6.3, $p<0.001$) relative to blood group O, while no substantial confounding by sex or BMI was evident (adjusted OR for female sex = 2.8, 95% CI: 1.5-5.2, $p=0.001$). These models explained 28% of the variance in anaemia status (Nagelkerke $R^2 = 0.28$), highlighting the combined influence of genetic and demographic factors.

DISCUSSION

This cross-sectional study among 200 young Indian adults aged 18-22 years revealed a significant association between ABO blood group and anaemia prevalence, with blood group A exhibiting the highest risk (60%), followed by B (40%), AB (35%), and O (30%) ($p<0.001$). The overall anaemia prevalence of 45% aligns closely with national estimates for this demographic in India, where rates range from 50% to 60%,[2,3] though slightly lower than the 55-65% reported in broader adolescent cohorts, possibly attributable to the relatively privileged educational setting of our participants.[4] The pronounced sex-based disparity—55% in females versus 30% in males ($p<0.001$)—mirrors

global and Indian patterns, primarily driven by physiological factors such as menstrual blood loss and lower baseline iron stores in females.[1-12] Notably, the independent association of blood group A with anaemia (adjusted OR=3.2, 95% CI: 1.6-6.3) persisted after controlling for sex and BMI, underscoring a potential genetic modifier in anaemia susceptibility.

The elevated anaemia risk in blood group A observed here corroborates findings from non-Indian cohorts, particularly those implicating ABO antigens in iron dysregulation and haemolytic processes. For instance, Eze et al,[7] reported a higher prevalence of iron deficiency anaemia among blood group A individuals in a Nigerian population (OR=2.8, $p<0.05$), attributing this to A-antigen-mediated alterations in duodenal iron absorption via interactions with ferroportin and hepcidin pathways. Similarly, a recent Ghanaian study on malaria-associated anaemia found blood group A associated with 16- to 17.8-fold increased odds of severe anaemia compared to group O,[13,14] likely due to enhanced rosetting of parasitized erythrocytes in group A, exacerbating haemolysis and iron loss. These parallels suggest a conserved mechanistic role for ABO antigens in anaemia pathogenesis across diverse genetic ancestries, potentially amplified in malaria-endemic regions like sub-Saharan Africa and parts of India.

In contrast, Indian studies yield more heterogeneous results, often highlighting blood group B or O as predominant risks, though associations are frequently non-significant. Mishra et al,[12] in a cross-sectional analysis of 150 young medical students using Sahli's method for haemoglobin estimation, documented a 26.7% overall anaemia prevalence, with blood group B showing the highest rate (33.3%), followed by O (22.6%), A (22.2%), and AB (20%; $p=0.80$). This pattern was echoed by an observational study among rural Indian adults, where blood group B was most anaemia-prone (prevalence 35%), succeeded by O, AB, and A.[11,15] Sreelakshmi et al,[13] reported a lower 31.3% prevalence among 99 dental students, with anaemia more frequent in groups B and O than A or AB ($p=0.45$), positing dietary vegetarianism—prevalent in India—as a confounder favoring B-group susceptibility due to regional blood group distributions (B ~30-40% in South Asia). Discrepancies with our findings may stem from methodological variances, such as smaller sample sizes reducing power in prior studies, differences in haemoglobin cutoffs (e.g., <10 g/dL in Mishra et al. versus WHO standards here), or unadjusted confounders like parasitic infections and dietary iron intake, which interact variably with ABO phenotypes.[6,16] Our use of a larger cohort and multivariable adjustment may have unmasked the A-group risk, aligning more with global evidence while highlighting the need for ABO-stratified analyses in Indian public health surveillance.

Mechanistically, the higher anaemia burden in blood group A could involve antigen-induced perturbations in iron metabolism, including reduced transferrin receptor affinity and elevated gastric acidity impairing non-heme iron uptake.[6,13] Additionally, group A individuals exhibit increased susceptibility to Helicobacter pylori colonization—a common anaemia contributor in India—which exacerbates iron malabsorption via hypochlorhydria.[8] Conversely, the relative sparing in group O (30% prevalence) may reflect the absence of A/B antigens, promoting erythrocyte longevity and lower haemolytic propensity, as evidenced by reduced von Willebrand factor levels mitigating microvascular occlusion.[9] The non-significant sex-by-blood group interaction ($p=0.15$) implies that while females bear a disproportionate burden, ABO effects are additive rather than synergistic, warranting universal screening irrespective of sex.

These results carry substantial implications for anaemia control in India, where the condition perpetuates intergenerational cycles of morbidity. Prioritizing blood group A individuals for proactive interventions—such as fortified iron supplementation and deworming—could optimize resource allocation in high-prevalence settings like educational institutions. Integrating ABO typing into routine health check-ups, as recommended by WHO for at-risk groups,[1] may enhance early detection, particularly among young females transitioning to reproductive age.

CONCLUSION

In summary, this study establishes a significant association between ABO blood group A and elevated anaemia risk among young Indian adults, independent of sex and BMI, with an overall prevalence of 45%. These findings extend prior evidence on ABO-mediated iron dysregulation and advocate for blood group-informed screening in anaemia mitigation strategies, potentially reducing the public health burden in resource-constrained contexts.

Limitations: Several limitations temper the generalizability of our findings. The cross-sectional design precludes causal inferences, leaving unclear whether blood group directly precipitates anaemia or proxies unmeasured factors like dietary habits. The convenience sampling from a single medical college introduces selection bias, potentially underrepresenting socioeconomic diversity and rural-urban gradients prevalent in India. Reliance on Sahli's method, while practical, may introduce measurement error (±0.5 g/dL) compared to automated analyzers, particularly at haemoglobin extremes.[11] Residual confounding from unassessed variables—such as detailed menstrual history, parasitic load, or micronutrient status—could influence estimates. Finally, the modest sample size for rarer blood groups (e.g., AB, n=20) limits subgroup precision.

Future Directions: Prospective cohort studies with larger, multicenter samples should validate these

associations, incorporating advanced haemoglobinometry and biomarkers (e.g., serum ferritin, hepcidin) to elucidate mechanisms like ABO-iron interactions. Mechanistic investigations, including genomic analyses of ABO loci and gut microbiome profiling, could clarify causality. Intervention trials targeting blood group A with tailored nutrition (e.g., heme-iron emphasis) would assess efficacy. Community-based research in diverse Indian populations, adjusting for ethnicity and diet, is essential to inform policy, such as ABO-stratified National Anaemia Prophylaxis Programs.

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