Journal of Carcinogenesis
Covering Genesis to Therapeutics

Journal of Carcinogenesis, ISSN: 1477-3163
2025; Vol 24: Issue 7s, https://carcinogenesis.com/

Genetic Mosaic: ABO & Rh Blood Group Distribution in a multi-ethnic Medical College Cohort" – a cross sectional study

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ABSTRACT

Background: Study of blood group distribution is not only of importance in the field of transfusion medicine, but also serves as a valuable tool in understanding population genetics, anthropology, and ethnic diversity as well as to understand the incidence and prevalence of non-communicable and communicable diseases as well as rare diseases occurrence and propensity in a particular population cohort. The pattern of ABO and Rh blood groups varies across regions, communities, and ethnic groups, offering insight into the genetic mosaic of populations. In the present study, an attempt has been made to evaluate the ethnic variation of ABO blood groups among first-year MBBS students of P. A. Sangma International Medical College. The unique diversity of this student cohort provides an opportunity to explore the genetic and ethnic heterogeneity represented within this institution. Moreover, this type of study was not done before involving the tribes in the state of Meghalaya.

Aim: To identify the distribution of blood groups among first-year MBBS students of P. A. Sangma International Medical College, Meghalaya, and to analyse their variation across different ethnic backgrounds.

Materials and Methods: ABO & Rh Blood groups of the students were found out using slide agglutination method using commercially available antisera. The weight of the students was measured by digital weighing machine and height measured by stadiometer.

Results: The majority of students had O positive (34.97%), B positive (31.29%), and A positive (22.70%) blood groups; 61.96% were female and 43.56% belonged to tribal communities. Mean age was 20.8 years, average BMI 24.16, and most followed a mixed diet. Distinct blood group patterns were observed among different tribes with predominance of O positive and A positive amongst Khasi tribes and B Positive in Garo tribes with O positive in Galo tribes and O Positive and A positive in Ao tribes.

Discussion: This study reveals predominance of O+ and B+ blood groups and marked tribal/non-tribal variation among MBBS students, highlighting the region's ethnic diversity and supporting transfusion services, genetic, and public health planning.

Conclusion: O and B groups were most common, Rh positivity prevailed, and unique ethnic and gender-linked differences highlight regional genetic influences.

Keywords: *Ethnic tribes, Khasi, Garo, Adi, Ao, Galo, ABO & Rh blood group*

How to Cite: Dr. Arijit Mazumdar, Dr. Neeha Kalita, Dr. Firuz Khan, Dr. Ahsanul Habib, (2025) Genetic Mosaic: ABO & Rh Blood Group Distribution in a multi-ethnic Medical College Cohort" – a cross sectional study, *Journal of Carcinogenesis*, *Vol.24, No.7s*, 903-915

1. INTRODUCTION

The determination of blood group systems holds critical importance in medical science, particularly in the context of blood transfusion, organ transplantation, various surgical interventions, and medico-legal investigations. Accurate identification of an individual's blood group is essential, as incompatibility in transfusion leads to serious haemolytic reactions that may be life-threatening.[1] The classification of human blood into four major phenotypes—A, B, AB, and O—under the ABO system is based on the presence or absence of specific agglutinogens (antigens) on the membrane of red blood cells (RBCs).

This fundamental principle was first established by Karl Landsteiner in 1901, when he demonstrated the reciprocal relationship between antigens present on erythrocytes and naturally occurring antibodies (agglutinins) in the plasma.[2]

In addition to the ABO system, the Rhesus (Rh) blood group system represents another clinically significant determinant in transfusion practices. The Rh system encompasses multiple antigens, the most important of which are C, c, D, d, E, and e. Among these, the D antigen is of paramount clinical relevance, and its presence or absence defines the Rh phenotype. Individuals carrying the D antigen are termed Rh-positive, while its absence constitutes the Rh-negative phenotype. The Rh system was jointly defined in 1941 by Landsteiner and Weiner, establishing two fundamental phenotypic groups—Rh-positive and Rh-negative—within the human population.

The combined understanding of the ABO and Rh systems has profoundly shaped modern transfusion medicine, ensuring compatibility and safety in clinical transfusion and transplantation practices. Furthermore, knowledge of the population frequency distribution of these blood groups is indispensable for planning efficient blood banking services, maintaining transfusion safety, and addressing regional or ethnic variations. Such data not only enhance medical preparedness but also contribute significantly to the study of population genetics, anthropological diversity, and epidemiological trends across various ethnic groups.[3]

The distribution of blood groups within a population exhibits significant ethnic and geographical variation, which has important implications for both clinical medicine and public health. Determination of ABO and Rh blood groups serves not only as a vital prerequisite for preventing mismatched transfusions in clinical practice but also as a valuable tool for anthropological and genetic studies.[4] Variability in the prevalence of ABO and Rh phenotypes across populations highlights the role of ethnicity, race, geography, and even tribal affiliations in shaping these distributions.

Globally, numerous studies have demonstrated that the frequencies of ABO and Rh blood groups differ markedly across regions and ethnic groups. For instance, blood group O is highly prevalent among certain indigenous populations, while group B shows greater representation in Asian populations.[5] Similarly, the proportion of Rh-negative individuals is significantly higher among Europeans compared to Asian and African populations. These variations are believed to be influenced by evolutionary pressures, migration patterns, genetic drift, and selective advantages conferred by specific blood group antigens in relation to infectious diseases.

Although individual blood group antigens remain stable throughout life, distribution patterns within populations may shift over time due to demographic transitions, intermarriages, and migration across geographical boundaries. As a result, the study of blood group frequency provides valuable insight into population genetics, human adaptability, and ethnic lineage.[6]

In addition to their anthropological significance, understanding the ethnic and regional variations of blood groups plays a crucial role in strengthening transfusion services and health system preparedness.[7] Reliable data on blood group distribution ensures an adequate and representative blood bank inventory, thereby reducing the risk of shortages in critical situations.

The present study was undertaken to determine the frequency distribution of ABO and Rh blood groups among first-year MBBS students of P. A. Sangma International Medical College & Hospital, Ri Bhoi, Meghalaya, with particular emphasis on highlighting differences across caste and ethnic backgrounds represented in this diverse student cohort.

2. MATERIALS & METHODS

The study was conducted in Department of Physiology, P A Sangma International Medical College & Hospital, Ri Bhoi, Meghalaya from 22nd Dec 2024 to 16th March 2025. Prior ethical approval from Institutional ethical committee was taken. The type of study was cross sectional. 163 students of First Professional MBBS studying in PIMC in the age group of 19-25 years of either gender were included in the study. Sample size was calculated using Raosoft sample[12] size calculator for 163 students, with a confidence level of 95%, a margin of error of 5%, and an assumed population proportion of 50%, the required sample size was 115

- Population size: 163
- Confidence level: 95%
- Margin of error: 5%
- Population proportion: 50%
- Recommended sample size: 115

This sample size ensured that the study findings were statistically reliable for the given population and parameters. After obtaining consent from the students, 1ml of venous blood was collected by venepuncture from antecubital vein in cubital fossa from non-dominant hand using aseptic and antiseptic precautions in Haematology laboratory of the Department of Physiology PIMC. Prior to collection of blood detailed history about their age, address, tribe, socioeconomic status, any addiction, any chronic illness, food habits were taken. After that their weight was taken using a digital weighing machine and height estimated in centimeters using stadiometer. Accordingly, BMI was calculated using the standard formula of

BMI and graded as per Indian BMI standards. Blood group of the students were found out by glass slide method using standard kits with commercially available antiserum [14]. A blood grouping procedure was performed by preparing a saline suspension of red blood cells from a finger prick collected under aseptic conditions. One millilitre of normal saline was taken in a test tube and a drop of blood was added and mixed thoroughly to prepare the cell suspension. On three clean glass slides, a drop of each antiserum—Anti-A, Anti-B, and Anti-D—was dispensed separately. An equal volume of the cell suspension was added to each antiserum, ensuring no direct contact during application. They were mixed using separate applicators and allowed to settle for 10 minutes. The mixtures were gently rocked and observed for agglutination after ten minutes, followed by microscopic confirmation using low power magnification. The blood groups so obtained was entered in MS Excel alongwith the height, weight and BMI was calculated using MS Excel software.

3. RESULTS

The data collected after experimentally obtaining ABO &Rh Blood groups of the First Professional MBBS students of P A Sangma International Medical College & Hospital which is a private Medical College with students from across India and predominantly from its native state Meghalaya, were entered and analysed using various statistical formulas in MS Excel software. On analysis it was found that out of the 163 students 62 were males and 101 were of female gender. There was no student of third gender.

Gender	Number of students	Percentage
Males	62	38.03%
Females	101	61.96%

Table1: Distribution of students as per gender

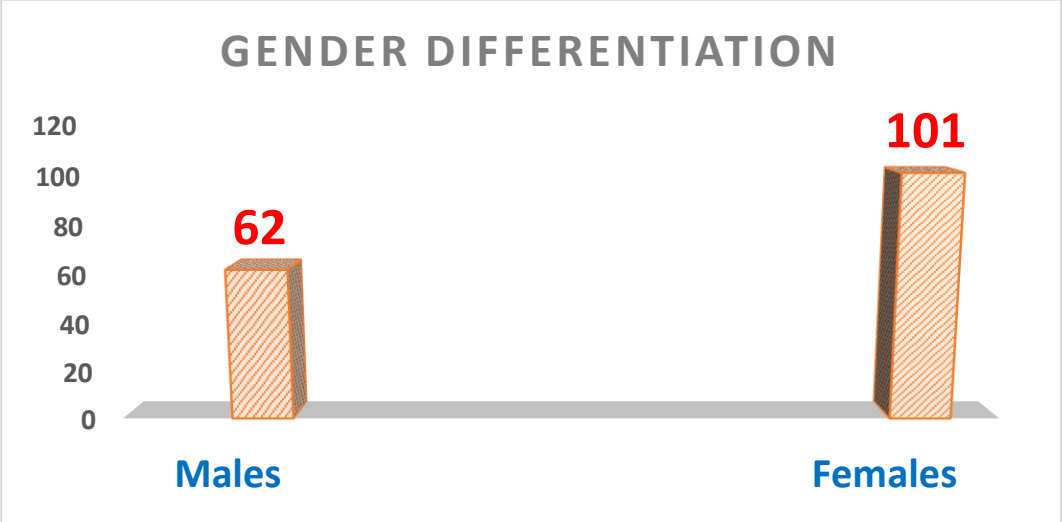


Fig:1 Bar Diagram depicting gender differentiation

When the blood group of the students of First professional were analyzed it was found that out of the 163 students there were 92 students who

were non-tribal (56.44%) whereas 71 (43.56%) students were tribes of different communities from all the north-eastern states of India except

Assam[8]. The overall distribution of the different blood groups (ABO&Rh) is depicted below in a tabular form and bar diagram.

Blood group(ABO & Rh)	No. of students
O+	57
B+	51
A+	37
AB+	12
O-	2
B-	3
A-	1
AB-	0
Total	163

Table 2: Depicting distribution of blood groups (ABO & Rh) of the students

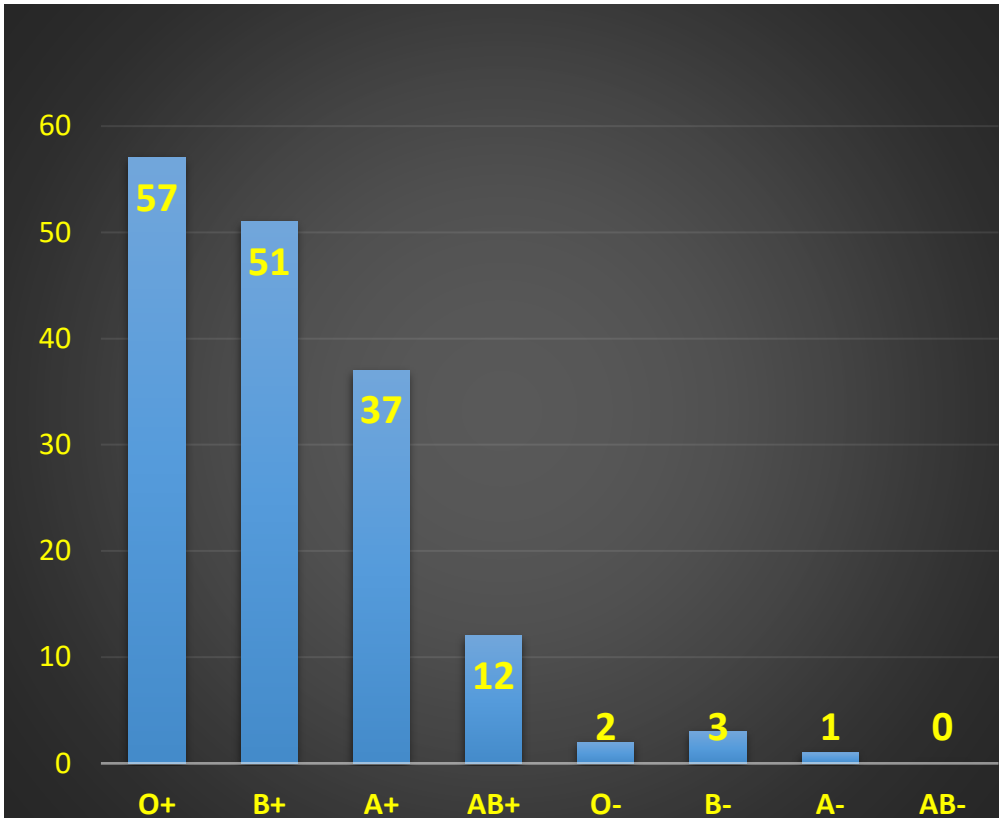


Fig2: Bar diagram depicting the blood group (ABO & Rh) of the participants

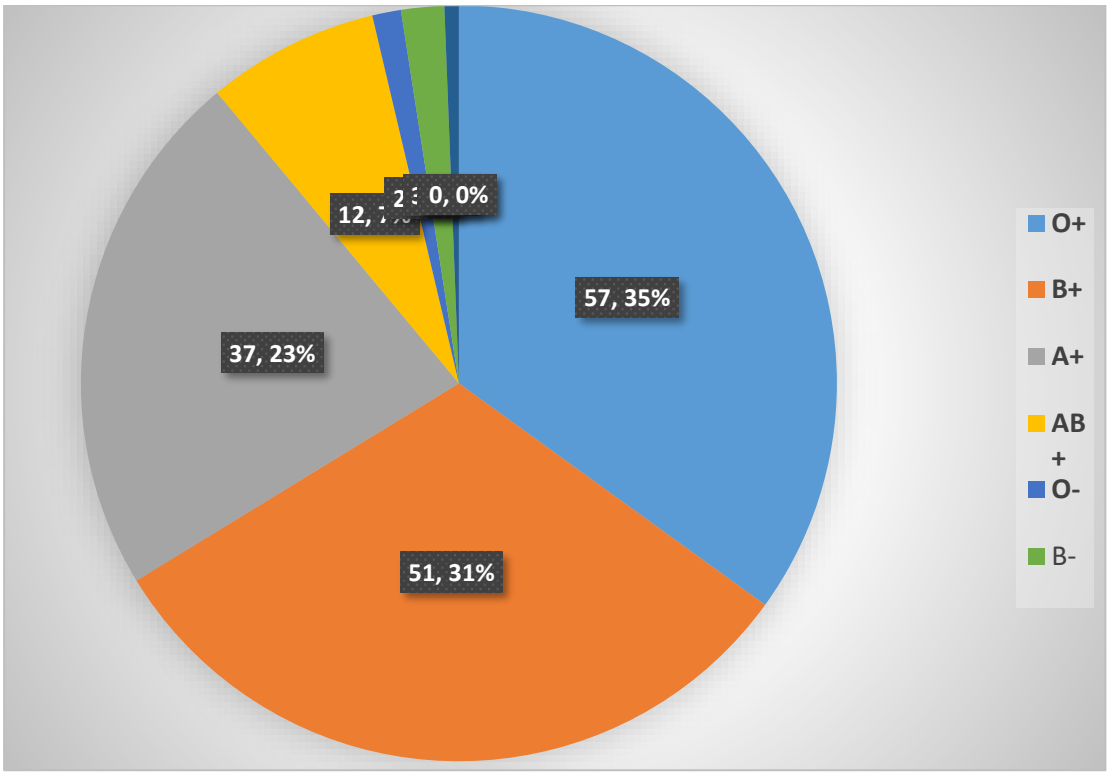
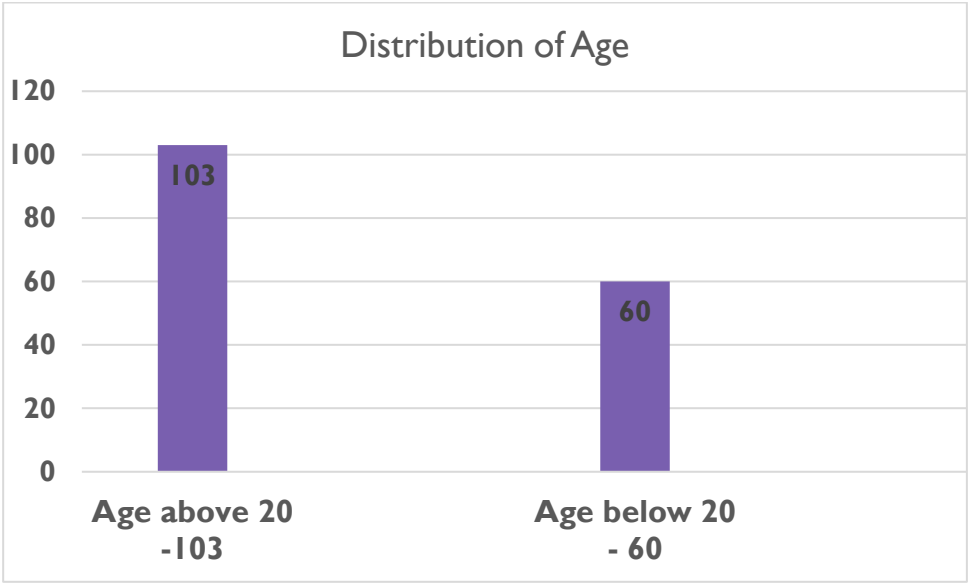
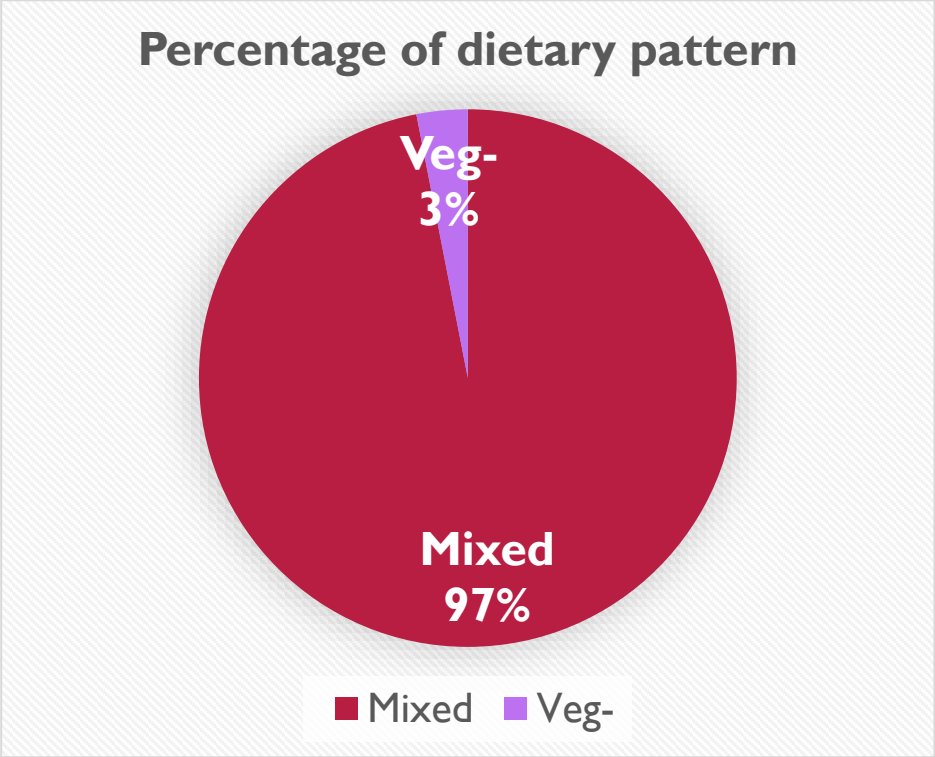


Fig 4: Bar diagram depicting the age wise distribution of the participants

On looking into the age dynamics of the students the highest age was 25 years and the youngest was 19 years. The average age of the students was 20.8 years with standard deviation of the age of the students were 1.08.



On enquiring about the dietary status of the students 158 students preferred mixed dietary pattern of non-vegetarian and occasional vegetarian diet whereas 05 students were purely vegetarian.



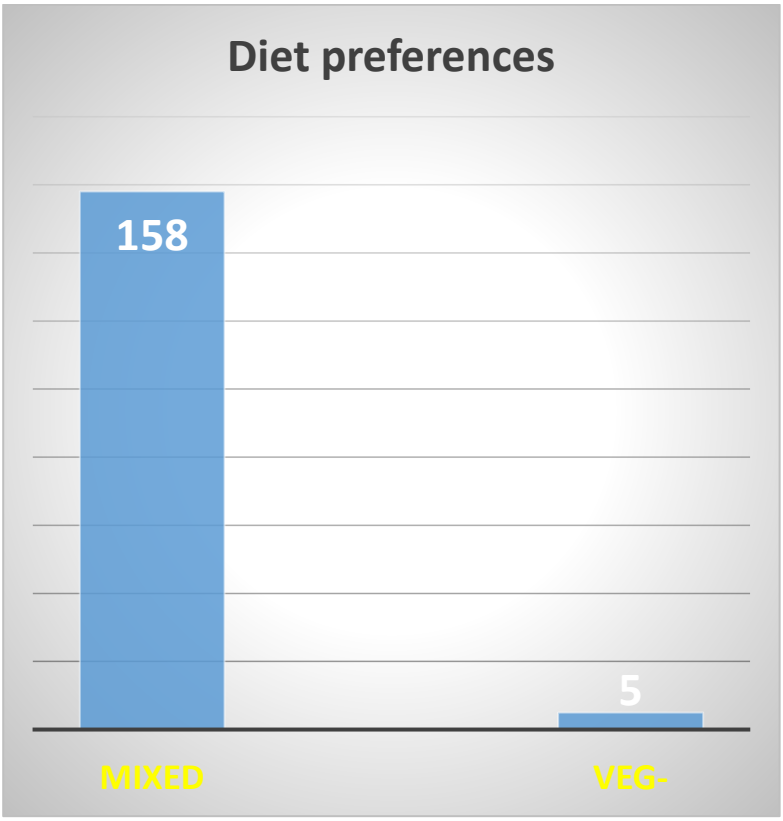


Fig 5: Pie diagram depicting the percentages of dietary choices of the subjects

Fig 6: Bar diagram depicting the dietary patterns of the participants

The height and weight of the students were taken by digital weighing machine and stadiometer. The average height of the students was 160.2699 cms whereas the standard deviation amongst the height of different students measured in cms was 8.30. The average weight of the students was 62 Kgs with a standard deviation of 9.60. The body mass index (BMI) average was 24.16 with a standard deviation of 3. The highest BMI was 31.6 while the lowest BMI was 15.8 depicting that there was obese, underweight and averagely build students. (As per Indian BMI standards)

Build	Number of students
overweight	56
Obese	2
Underweight	4
Normal	101

Table 3: Depicting the build of the participants (as per BMI)

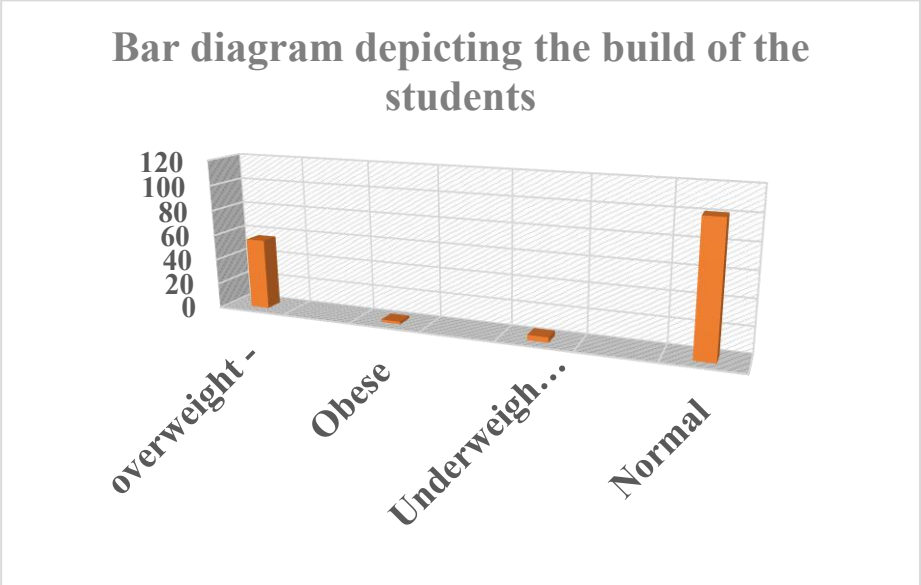


Fig 7: Bar diagram depicting the build of the students (as per BMI)

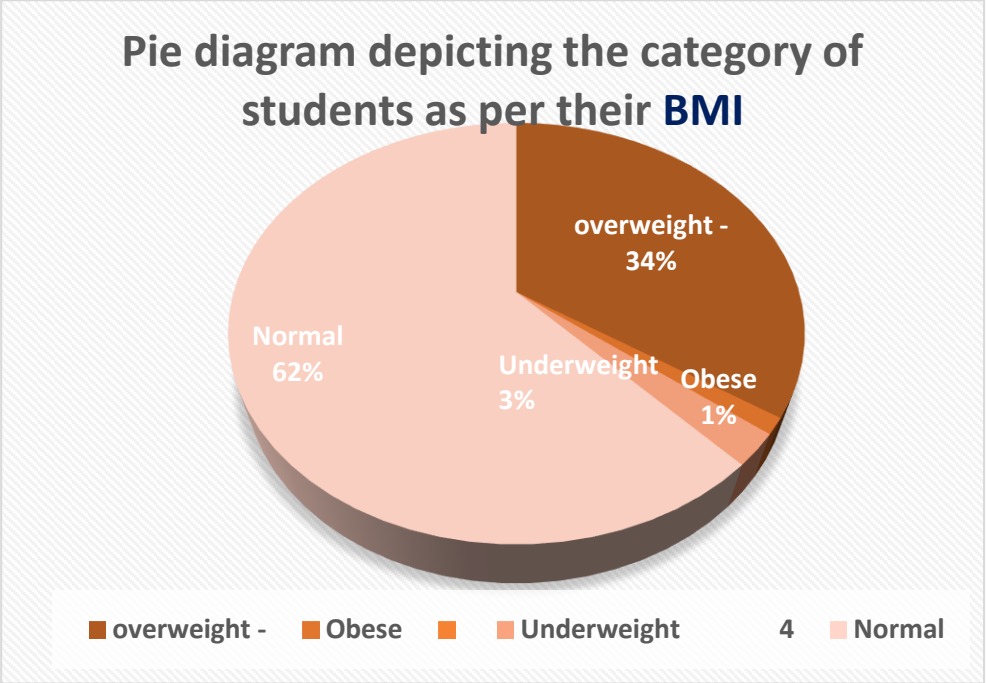


Fig: 8 Pie diagram depicting the build of the students as per BMI

When we differentiated the blood groups of the students as per their tribes (71 students) of all the north eastern states except Assam and analysed their pattern of distribution it was found that O positive and A positive blood groups were equally common amongst Khasi tribes which was about 31.7% each. Next common was B positive which was about 26.82%. AB positive blood group was about 7.31% while A negative was one case of 2.43%.

Amongst Garo tribes which had 15 students in total B positive is the most common blood group which consisted of 53.33% of the total population studied. O positive was next at 20% followed by A positive (13.33%), AB positive (6.66%) and B negative (6.66%). In Jaintia tribes A positive blood group, B positive blood group and O positive blood group were equal with 33.33% each. In Ao tribes of Nagaland, 50% were found to be O positive and 50% were found to be A positive. In Galo tribes of Arunachal Pradesh 100% were found to be O positive. In Adi tribes of Arunachal Pradesh 66.66% were found to be O positive and 33.33%were found to be B positive. In Chakhesang tribe of Nagaland A positive was common & similarly A positive was common in Manipuri (Meitei) tribe.

The male and female distribution and percentages are elicited in a tabular form below. On evaluating the table, it is seen that in Khasi females O positive is more common (92.3%) followed by B positive, A positive, AB positive and A negative respectively. The Khasi males were found to have predominantly B positive and A positive (23.36%) each followed by O positive and AB positive.

In Garo females, B positive was the predominant blood group found (62.5%) whereas in males also B positive was found to be predominant (37.5%). Amongst Jaintia population studied in this study O positive, A positive and B positive were found to be equally distributed (33.33%). In Ao tribes O positive and A positive were found to be equally present. In Galo tribes of Arunachal Pradesh, O positive was the predominant blood group in both females and males of 66.66% and 33.33% respectively. Amongst Adi tribes' O positive and A positive were found out. In Chakhesang and Manipuri(Meitei) tribes A positive was the predominant blood group.

Tribes	Blood group	Gender	Number	Total	Percentage
Khasi (41 students)	O+	Male	1	13	7.69
		Female	12		92.3
	B+	Male	3	11	27.27
		Female	8		72.72
	A+	Male	3	13	27.08
		Female	10		76.92
	AB+	Male	1	3	33.33
		Female	2		66.66
	A-	Male	0	1	0
		Female	1		100
Garo (15 students)	O+	Male	1	3	33.33
		Female	2		66.66
	B+	Male	3	8	37.5
		Female	5		62.5
	A+	Male	0	2	0
		Female	2		100
	AB+	Male	0	1	0
		Female	1		100
	B-	Male	0	1	0
		Female	1		100
Jaintia (3 students)	O+	Male	0	1	0
		Female	1		100
Jaintia (3 students)	B+	Male	1	1	100
		Female	0		0
	A+	Male	0	1	0
		Female	1		100
Ao (4 students)	O+	Male	1	2	50
		Female	1		50
	A+	Male	1	2	50
		Female	1		50
Galo (3 students)	O+	Male	1	3	33.33
		Female	2		66.66

Adi (3 students)	**O+**	**Male**	**0**	**2**	**0**
		Female	**2**		**100**
	B+	**Male**	**0**	**1**	**0**
		Female	**1**		**100**
Chakhesang (1 student)	**A+**	**Male**	**1**	**1**	**100**
		Female	**0**		**0**
Manipuri(Meitei) (1 student)	**A+**	**Male**	**0**	**1**	**0**
		Female	**1**		**100**

Table 4: Table depicting the male & female distribution of the different tribes as per their ABO & Rh blood groups

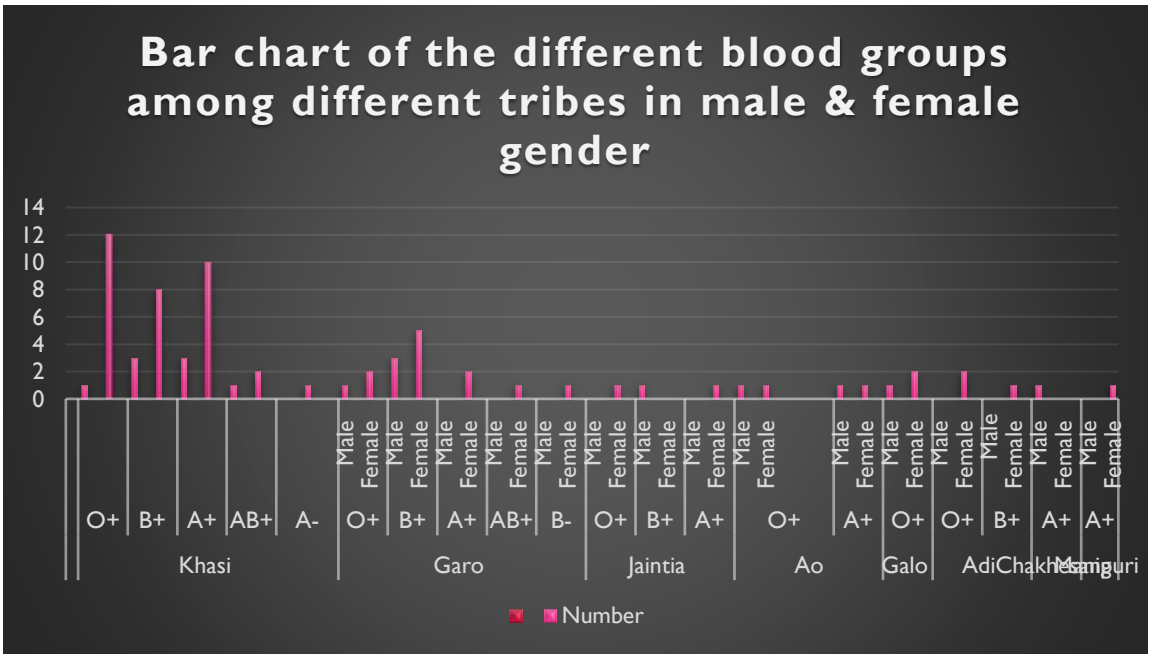


Fig 9: Bar diagram depicting the distribution of ABO & Rh blood groups as per gender and tribe

4. DISCUSSION

This study provides a detailed insight into the ABO and Rh blood group distribution among first-year MBBS students of P. A. Sangma International Medical College & Hospital, with an emphasis on tribal and non-tribal variations as well as associated demographic, anthropometric, and dietary patterns. This research we believe contributes significantly to population genetics, public health planning, and anthropological understanding in a region famous for its ethnic diversity in addition to throwing light on transfusion medicine and propensity of communicable and non-communicable diseases. The gender composition of the batch showed a majority of female students (61.96%) compared to males (38.03%), [9] reflecting evolving trends in medical education enrolment in India. There was no third gender student reflecting on the national medical scenario.

Analysis of blood group types among the 163 students revealed O positive as the most prevalent (34.97%), followed by B positive (31.29%), A positive (22.70%), and AB positive (7.36%). Rare Rh-negative types constituted a small but clinically relevant portion of the group, with 3.68% (O-, B-, A-) collectively. These frequencies are closely in line with large-scale

Indian surveys, where O (34.56%) and B (34.10%) generally dominate, especially in Southern and Eastern regions, and Rh negativity remains low at around 5–6%. Comparable studies in Northeast India similarly report high frequencies of O and B groups within tribal and non-tribal cohorts. [10] Study done by B M Das, H Walter in 1987 found that variation in blood group existed in the fair skinned and mongoloid(origin) tribal population of Assam. Another research article by Das Sengupta in 2002 found that Sonowal Kacharis of Assam have prevalence of AB blood group. No such type of study involving other parts of north-eastern states (except Assam) has not been done.[11,12]

A major strength of this study lies in its ethnic breakdown: 56.44% non-tribal and 43.56% tribal students representing diverse communities from North-eastern India (excluding Assam). Among Khasi tribes, O positive and A positive appeared equally frequent (31.7% each), while B positive followed (26.82%). The Garo cohort showed overwhelming dominance of B positive (53.33%), with O positive being the next most frequent (20%), mirroring findings from local studies that highlight regional blood group shifts tied to ancestry and founder effects. Smaller tribal subgroups like Jaintia, Ao, Galo, Adi, Chakhesang, and Manipuri (Meitei) further illuminated unique blood group profiles: O positive and A positive predominated, with some subgroups like Galo and Ao showing exclusive or equal distribution of these types. These intra-regional variations are consistent with previously reported genetic drift and gene flow among tribal populations in Northeast India and reinforce the concept of blood group distribution as a marker of population genetics, migration, and isolation.[14]

Gender-specific analysis of blood group frequency among tribes uncovered further nuances. For instance, in Khasi females, O positive was overwhelmingly common (92.3%), while in males both A and B positive were prominent (23.36%). Similarly, in Garo tribe females, B positive predominated (62.5%), with males exhibiting a lower share of the same group (37.5%). These findings suggest not only genetic influence but possibly social factors affecting intermarriage and family structure, which may deserve further investigation.[15]

The anthropometric assessment confirmed a healthy cohort of students: mean age of the students were 20.8 years, average height 160.27 cm (SD ±8.30), average weight 62 kg (SD± 9.6), and mean BMI 24.16 (SD ±3), with most students falling in the normal BMI category per Indian standards.[16,17] Only 2 students were classified as obese, 4 as underweight, and 56 as overweight, which arguably compares with general population studies. [18] On the dietary pattern data, 158 out of 163 students favoured a varied diet and only 5 adhering to strict vegetarian dietary pattern which reflects traditional food customs prevalent in Meghalaya and Northeast India.[19]

From a transfusion medicine standpoint, knowing the precise frequency and distribution of blood groups at a regional and subpopulation level is essential for effective blood bank inventory management.[20] This study also highlights the probable presence or occurrence of non-communicable and communicable diseases amongst the different tribes and their linkages to different blood groups like gastric ulcer in A blood group people etc.[21]

This study not only the general pan-Indian trends in ABO and Rh group distribution but, more importantly, achieves a fine-grained ethnic analysis,[22] highlighting unique tribal blood group patterns and their implications for medical care, genetics, and public health. It emphasizes the utility of such data for shaping transfusion policy, understanding population structure, and promoting personalized approaches to healthcare in this region.[23] Future research involving larger, multi-institutional cohorts and wider regional representation would further extend the generalizability and scientific value of these findings.[24]

5. CONCLUSION

This study presents a comprehensive analysis of the ABO and Rh blood group frequencies among first-year MBBS students at P. A. Sangma International Medical College & Hospital, with an emphasis on both tribal and non-tribal differences. The findings affirm the predominance of O and B blood groups and Rh positivity, aligning with broader Indian and Northeast regional patterns. The ethnic stratification further elucidates unique intra-regional and gender-linked blood group variations that may reflect genetic diversity, migration, and socio-cultural influences among tribal communities.

6. LIMITATIONS OF THE STUDY

The single-center nature and relatively small sample size may limit the generalizability of the results. Participation was restricted to one academic batch which might not fully represent the broader population's blood group heterogeneity. Furthermore, the cross-sectional design precludes assessment of trends over time. The study also did not exhaustively consider socioeconomic or environmental variables or undertake molecular analyses to further elucidate genetic mechanisms underlying observed patterns. Future research with larger, multicentre samples across different timeframes and the inclusion of molecular and sociodemographic parameters is recommended to enrich understanding and maximize clinical and public health applications.

Conflict of Interest:

The authors declare no conflict of interest with any person or organisation.

Funding: Self-Funding

Acknowledgements: The author deeply acknowledges the students of First Professional MBBS, P A Sangma International Medical College for actively consenting to participate in the study. We are indebted to HOD, Department of Physiology, PIMC, Prof (Dr.) Gayatri Bora for allowing us to carry out the study in the department. We are indeed thankful to our non-teaching staff of the Department of Physiology for actively supporting us to carry out our study.

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