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Spectrum of Haemoglobinopathies Among HPLC-Positive Paediatric Cases from Tea Garden Tribal Communities at a Tertiary Care Centre in Upper Assam

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ABSTRACT
Haemoglobinopathies are a critical genetic disorder of tea garden tribal communities of northeast India that tends to emerge during childhood. Nevertheless, information on the clinical and haematological profile of these children is limited in paediatric population of upper Assam. To characterize spectrum, haematology data, high-performance liquid chromatography (HPLC) pattern, and ethnic profiling of haemoglobinopathies in infected paediatric patients. This descriptive hospital study was carried out in Jorhat Medical College and Hospital during December 2023–October 2024. Out of the 500 paediatric patients screened by HPLC for suspected haemoglobinopathy, 120 HPLC positive cases were included in the study. Haemoglobin variants were identified using the Bio-Rad D-10 system, and anaemia severity was evaluated using World Health Organization (WHO) (2011) criteria. Most frequently encountered haemoglobinopathies were HbE (Haemoglobin E) related diseases (HbE disease 29.2 %, HbE trait 18.3 %), followed by β-thalassaemia trait (23.3 %) and then by sickle cell disorders. Moderate to severe anaemia (93.3 %) comprised a majority of the patient population. Severe anaemia was particularly prevalent in sickle cell disease (SCD). HPLC fraction patterns matched typical diagnostic profiles. HbE- related haemoglobinopathies were the predominant presentation in this cohort, with distinct clinical and haematological patterns across disease types. HPLC remains a valuable diagnostic tool, which together with targeted screening and genetic counselling may be a helpful intervention in this ethnic group.
Keywords: *haemoglobinopathy, HbE disease, sickle cell disease, β-thalassaemia, HPLC, paediatric, tea garden tribal*

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INTRODUCTION

Haemoglobinopathies comprise a large sub-group of inherited disorders that impair haemoglobin synthesis. India has one of the world's most concentrated tribal populations and within communities haemoglobinopathy and β-thalassaemia represent serious health complications [1,2]. The genes for sickle haemoglobin (HbS), haemoglobin E (HbE), and β-thalassaemia are unevenly divided among various groups of tribes. Consequent to the common consanguinity and endogamy (caste and geographical), some sub-populations carry remarkably high carrier rates within them, rendering these disorders both a major public health problem and genetic one [1,3].

Tea garden tribal people in Assam are a demographically different group. They migrated generations ago from central Indian states such as Madhya Pradesh, Bihar, Odisha, and Andhra Pradesh to work as tea-leaf pickers. These communities have since permanently settled in the tea estates [4,5]. HbE is the most commonly reported haemoglobin variant in northeastern India. Yet HbS and β-thalassaemia also occur in different proportions depending on the tribal groups that live in this part of India [5,6].

High-performance liquid chromatography (HPLC) remains the standard clinical method for identifying and measuring haemoglobin variants [7]. Several studies have reported haemoglobinopathies in adult or mixed-age populations from Assam [5,6], but data regarding paediatric patients from tea garden tribal communities is limited compared to the population at focus. Thus, this study aimed to describe the spectrum, haematological profile, HPLC fraction distributions, and ethnic distribution of haemoglobinopathies among paediatric patients from these communities who had HPLC-confirmed haemoglobinopathy in a tertiary care centre located in upper Assam.

MATERIAL AND METHODS

This hospital-based descriptive study was performed in the Department of Pathology of Jorhat Medical College and Hospital (JMCH), Jorhat, Assam during December 2023 to October 2024.

Ethical clearance to conduct the study was duly granted by the Institutional Ethics Committee (reference: SMEJ/JMCH/MEU/841/Pt-2/2011/5009, 23 November 2023) and participant wise written informed consent was obtained from the parents or legal guardians.

All patients included in this study were children (aged 2-13 years) of Tea Garden tribal ethnicity and hailed from different tea estates located in Jorhat and surrounding districts of upper Assam; no cases outside of this community were included.

A total of 500 consecutive cases matching this profile were screened during the study period. Of those, 120 (24.0%) were found to be positive for HPLC confirmed haemoglobinopathy, which finally constituted our study cohort. The number of patients screened (n = 500) was arrived at pragmatically, based on the consecutive paediatric cases fulfilling the inclusion criteria (cases in the age group 2-13 years, belonging to the tea garden tribal communities, underwent HPLC testing) during the study window. This approach ensured that all eligible cases were enrolled and that there was adequate representation of HPLC-positive cases for meaningful descriptive analysis.

Children younger than 2 years were excluded as physiologically high fetal haemoglobin (HbF) in infancy could potentially impede the HPLC-derived interpretation of haemoglobin variant patterns, as well as mask or mimic specific diagnostic fractions [8,9].

Demographic data (age, sex, self-reported ethnicity) and laboratory data were collected on a structured proforma. A complete blood count (CBC) was determined on an automated haematology analyser (Sysmex XN-550, Sysmex Corporation, Japan). Haemoglobin variant analysis was carried out using Bio-Rad D-10 HPLC in accordance with the manufacturer's instructions [7]. HPLC fractions that were documented included HbA, HbA2 (which include HbE ,as HbE co-elutes with HbA2 in the Bio-Rad D-10 system), HbF(fetal hemoglobin) and HbS (sickle hemoglobin).

Anaemia was graded using WHO (2011) age-specific haemoglobin threshold values [10]: for children aged 6–59 months — severe (<7.0 g/dL), moderate (7.0–9.9 g/dL), mild (10.0–10.9 g/dL), normal (≥11.0 g/dL); for those aged 5–11 years — severe (<8.0 g/dL), moderate (8.0–10.9 g/dL), mild (11.0–11.4 g/dL), normal (≥11.5 g/dL); and for children aged 12–14 years — severe (<8.0 g/dL), moderate (8.0–10.9 g/dL), mild (11.0–11.9 g/dL), normal (≥12.0 g/dL).

It should also be mentioned that the 500 screened patients were drawn from a pre-selected subset of paediatric hospital attenders who were referred for HPLC due to a clinical suspicion for haemoglobinopathy or for the evaluation of anaemia; therefore, such cohort is subject to selection and referral bias and cannot be used as a benchmark against which measures of the rest of the community or general paediatric population are to be inferred. The 120 HPLC-confirmed cases comprise the HPLC-positive subset of this already chosen group, and the proportions reported here represent the case mix across confirmed cases for this centre and not the prevalence at the community level. Descriptive statistics (frequency, percentage, mean ± standard deviation) were used for data analysis.

RESULTS

Among 500 paediatric patients from tea garden tribal communities who were screened by HPLC during the study period, 120 (24.0%) were found to have some form of haemoglobinopathy and formed the cohort for the study. The boys came in slightly more: 64 males (53.3%) and 56 females (46.7%) with a male-to-female ratio of 1.14:1. Ages were from 2 to 13 years (M=7.0 ± 3.6 y). The highest proportion was found in 2–5-year-olds (51, 42.5%), which was followed by 6-10 years-old group (42, 35.0%) and those aged 11-13 (27, 22.5%) respectively.

The distribution of haemoglobinopathies between ethnic groups is shown in Table 1. All 120 cases belonged to a tea garden tribal community and eleven ethnic groups were identified. The Tanti community had the most (33, 27.5%), followed by Orang (19, 15.8%), Lohar (17, 14.2%), Munda (16, 13.3%) and Bhumij (13, 10.8%). In this group, in the Munda (10/16) and Lohar (7/17) communities, HbE disease was more prevalent, while sickle cell disease was more frequent among the Orang (6/19) and Tanti (9/33). β-Thalassaemia trait was most common among Bhumij group (7/13).

Having said that, a number of the other ethnic subgroups — Kurmi, Chick Baraik, Gorai, Ghatowar, and Guwala (n ≤ 6) — had numbers too small for reliable inference. Accordingly, proportions derived for these groups should be interpreted with caution.

The age-wise distribution of haemoglobinopathies is shown in Table 2 and Figure 1. The high prevalence rate (14 per 24 or 58.3%) of SCD cases in the youth group (2-5 years) indicated the earlier clinical presentation [2]. In contrast, β-thalassaemia trait was more evenly distributed amongst all the age groups.

The overall percent of haemoglobinopathy types is also shown in Table 3 and Figure 2. HbE-related diseases formed almost half the whole group: 47.5% (57 of 120) of all confirmed cases were because of HbE disease and HbE trait. β-Thalassaemia trait was the next most frequent diagnosis (28, 23.3%), followed by SCD (24, 20.0%) and sickle cell trait (11, 9.2%).

Anaemia was graded based on WHO (2011), age specific criteria [10]; the assessment results are described in Table 4 and Figure 3. The general load of anaemia was large: 51 of 120 cases - 42.5% were severe anaemic and 61 (50.8%) moderate anaemic. Therefore, 93.3% of our sample lay within the moderate- to moderate-to-severe range.

Severe anaemia was predominantly observed in patients with disease states — in SCD patients, 18 out of 24 (75.0%) were severely anaemic, and in HbE disease, this was 27 out of 35 (77.1%). On the contrary, not a single patient with β-thalassaemia trait or sickle cell trait had severe anaemia, highlighting the expected clinical distinction between disease and carrier states. Among those HbE trait carriers, 6/22 (27.3%) were severely anaemic, an observation that presumably is more likely due to concurrent iron deficiency anaemia, prevalent in this population [11], than the heterozygous HbE state. The high prevalence of moderate to severe anaemia in this cohort is expected of a hospital-based study which is naturally enriched for symptomatic disease.

Described are the mean haematological parameters by diagnosis group in Table 5. Patients with sickle cell disease (SCD) exhibited the lowest mean haemoglobin level (6.1 ± 1.5 g/dL), closely followed by those with HbE disease (6.4 ± 1.4 g/dL). In contrast, individuals with sickle cell trait and β-thalassaemia trait demonstrated relatively higher mean haemoglobin values (9.9 ± 1.1 g/dL and 9.6 ± 0.9 g/dL, respectively). The overlap in red cell indices (MCV, MCH, and MCHC) across groups is likely due to the potential confounders of concurrent iron deficiency seen in this population, which may obscure disease-specific haematological distinctions [11].

HPLC fraction analysis demonstrated the appearance of characteristic haemoglobin patterns of the respective diagnostic categories (Table 6). In HbE disease, the HbA2/E (HbA2/HbE fraction combined) fraction was markedly increased (80.2 ± 2.4%) with a small fraction of HbA (3.7 ± 0.9%), a pattern consistent with the profile of HbE disease [7,8]. As anticipated, the HbE trait had a less significant elevation in the HbA2/E (26.9 ± 4.6%) accompanied by preserved HbA fraction (60.5 ± 6.4%).

β-Thalassaemia trait showed elevated HbA2 (5.5 ± 0.73%) and HbA was the main phenotype with the range of 88.5 ± 2.6% [8,9]. In the SCD group, HbS was dominant (74.8 ± 6.7%) and HbF was notably elevated (18.1 ± 6.3%), while sickle cell trait carriers displayed an lower HbS (32.2 ± 7.9%) with HbA remaining the predominant fraction (56.8 ± 2.35%).

Table 1: Distribution of haemoglobinopathies among HPLC-confirmed cases in different ethnic groups. Values are n (% within ethnic group).

Ethnic group	HbE disease	HbE Trait	SCD	SC Trait	β-Thal Trait	Total	%
Tanti	8 (24.2)	7 (21.2)	9 (27.3)	4 (12.1)	5 (15.2)	33	27.5
Orang	2 (10.5)	4 (21.1)	6 (31.6)	1 (5.3)	6 (31.6)	19	15.8
Lohar	7 (41.2)	2 (11.8)	2 (11.8)	0 (0)	6 (35.3)	17	14.2
Munda	10 (62.5)	4 (25.0)	2 (12.5)	0 (0)	0 (0)	16	13.3
Bhumij	2 (15.4)	0 (0)	3 (23.1)	1 (7.7)	7 (53.8)	13	10.8
Chawra	2 (28.6)	3 (42.9)	0 (0)	1 (14.3)	1 (14.3)	7	5.8
Kurmi	1 (16.7)	1 (16.7)	2 (33.3)	1 (16.7)	1 (16.7)	6	5.0
Chick Baraik	2 (66.7)	0 (0)	0 (0)	1 (33.3)	0 (0)	3	2.5
Gorai	0 (0)	0 (0)	0 (0)	1 (33.3)	2 (66.7)	3	2.5
Ghatowar	1 (50.0)	1 (50.0)	0 (0)	0 (0)	0 (0)	2	1.7
Guwala	0 (0)	0 (0)	0 (0)	1 (100)	0 (0)	1	0.8
Total	35 (29.2)	22 (18.3)	24 (20.0)	11 (9.2)	28 (23.3)	120	100

SCD = sickle cell disease; SC Trait = sickle cell trait; β-Thal Trait = β-thalassaemia trait. Percentages are shown within brackets.

Table 2: Distribution of haemoglobinopathies by age group.

Age group	HbE disease	HbE Trait	SCD	SC Trait	β-Thal Trait	Total
2–5 yrs	16	9	14	4	8	51
6–10 yrs	13	7	5	5	12	42
11–13 yrs	6	6	5	2	8	27
Total	35	22	24	11	28	120

Table 3: Frequency of haemoglobinopathies among HPLC-confirmed cases (n = 120).

Diagnosis	**Number (n)**	**Percentage (%)**
HbE disease	35	29.2
HbE Trait	22	18.3
Sickle Cell Disease (HbSS)	24	20.0
Sickle Cell Trait (HbAS)	11	9.2
β-Thalassaemia Trait	28	23.3
Total	120	100

Table 4: Distribution of anaemia severity by haemoglobinopathy type, graded by WHO (2011) age-specific criteria.

Diagnosis	**Severe n(%)**	**Moderate n(%)**	**Mild n(%)**	**Normal n(%)**	**Total**
HbE disease	27 (77.1)	8 (22.9)	0 (0)	0 (0)	35
HbE Trait	6 (27.3)	12 (54.5)	4 (18.2)	0 (0)	22
SCD	18 (75.0)	6 (25.0)	0 (0)	0 (0)	24
SC Trait	0 (0)	8 (72.7)	2 (18.2)	1 (9.1)	11
β-Thal Trait	0 (0)	27 (96.4)	1 (3.6)	0 (0)	28
Total	51 (42.5)	61 (50.8)	7 (5.8)	1 (0.8)	120

Severe: <7.0 g/dL (6–59 months) or <8.0 g/dL (5–14 years); Moderate: 7.0–9.9 g/dL (6–59 months) or 8.0–10.9 g/dL (5–14 years); Mild and Normal: age-specific thresholds as per WHO (2011) [10].

Table 5: Haematological parameters across disease groups (mean ± SD).

Parameter	**HbE disease (n=35)**	**HbE Trait (n=22)**	**SCD (n=24)**	**SC Trait (n=11)**	**β-Thal Trait (n=28)**
Hb (g/dL)	6.4 ± 1.4	9.1 ± 1.5	6.1 ± 1.5	9.9 ± 1.1	9.6 ± 0.9
HCT (%)	29.2 ± 5.2	28.5 ± 6.6	29.5 ± 6.2	30.0 ± 4.5	31.3 ± 6.3
MCV (fL)	71.7 ± 11.6	69.7 ± 13.1	71.7 ± 12.2	67.8 ± 8.7	75.5 ± 8.8
MCH (pg)	22.0 ± 4.1	22.0 ± 3.9	22.2 ± 3.4	22.1 ± 4.0	20.8 ± 4.3
MCHC (g/dL)	31.0 ± 2.2	32.3 ± 2.0	31.4 ± 1.6	31.3 ± 2.6	30.6 ± 2.5

Iron studies were not performed. Inferential comparison of red cell indices was not undertaken as concurrent iron deficiency cannot be excluded. Values should be interpreted with caution.

Table 6: HPLC fraction analysis by haemoglobinopathy type (mean ± SD). On the Bio-Rad D-10, HbE co-elutes with HbA2; the HbA2/E column represents the combined fraction.

Condition	HbA (%)	HbA2/E (%)	HbF (%)	HbS (%)
HbE Trait	60.5 ± 6.4	26.9 ± 4.6	1.09 ± 1.1	—
HbE disease	3.7 ± 0.9	80.2 ± 2.4	3.92 ± 1.3	—
β-Thalassaemia Trait	88.5 ± 2.6	5.5 ± 0.73	1.09 ± 0.8	—
Sickle Cell Trait	56.8 ± 2.35	2.8 ± 0.5	2.3 ± 0.7	32.2 ± 7.9
Sickle Cell Disease	<1	3.4 ± 0.5	18.1 ± 6.3	74.8 ± 6.7

HbA2/E = combined HbA2 and HbE fraction on Bio-Rad D-10 HPLC. In β-thalassaemia trait, the A2/E fraction represents HbA2 alone. — = not applicable.

Figure 1: Distribution of Hemoglobinopathies by age group

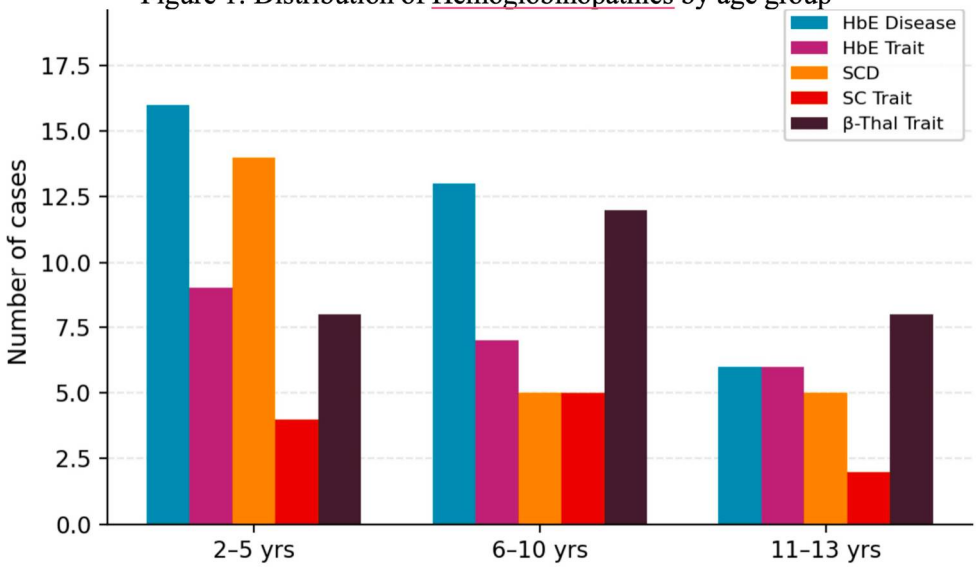


Figure 2: Frequency of haemoglobinopathies among HPLC-confirmed cases

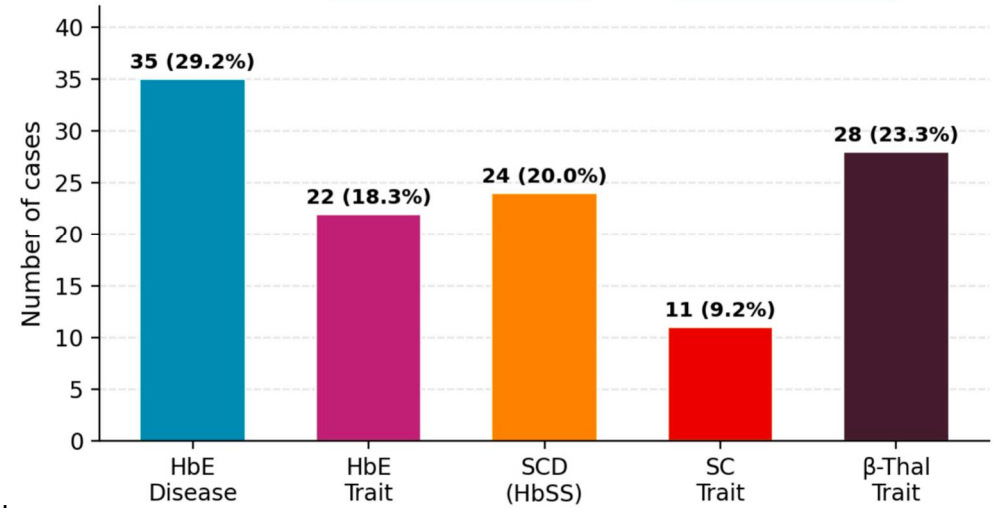
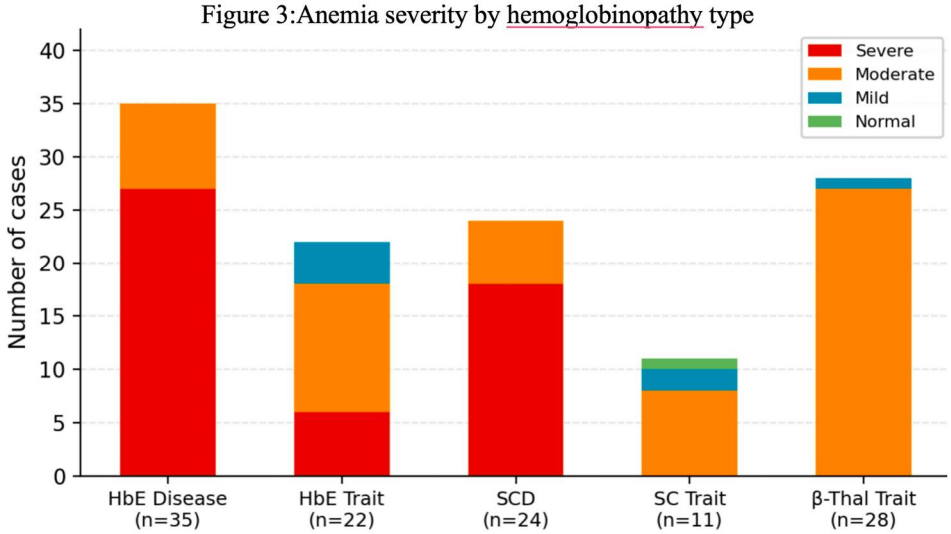


Figure 3:Anemia severity by hemoglobinopathy type



DISCUSSION

This study attempts to describe the spectrum of haemoglobinopathies among HPLC-confirmed paediatric cases drawn from tea garden tribal communities. A total of 500 paediatric patients (aged 2–13 years,

belonged to Tea garden tribal communities and underwent HPLC testing) were consecutively screened during the study period. Among them, 120 cases (24.0%) were identified as HPLC-positive and constituted the study cohort.

The observed positivity rate should therefore be interpreted as the diagnostic yield of HPLC in a clinically selected hospital population, rather than as a population-level prevalence estimate. HbE-related disorders were the most commonly encountered, accounting for 47.5% of cases, followed by β-thalassaemia trait (23.3%) and sickle cell disease (20.0%).

Laboratory data on HPLC-negative patients were beyond the scope of this study. The observed yield of 24% nevertheless supports the role of accessible HPLC-based diagnostic services in the evaluation of symptomatic paediatric patients in this region.

When placed alongside other Indian hospital-based studies, the 24% positivity rate in our cohort sits on the lower end. Mondal and colleagues [12], working at Assam Medical College and Hospital in Dibrugarh, reported haemoglobinopathies by HPLC in 72 of 206 children (35.0%) who had been referred specifically for chronic anaemia. That higher yield likely reflects a more stringent patient selection — their study was restricted to children with established chronic anaemia, whereas ours cast a wider net by including any child referred on suspicion of haemoglobinopathy or anaemia, which inevitably brings in milder presentations and a larger proportion of HPLC-negative results. In the much larger series by Baruah et al. [5], who studied 9000 mixed-age patients from upper Assam referred expressly for haemoglobin variant analysis, the overall positivity rate was approximately 59.1% — but that cohort essentially represented a pure referral-laboratory population with a much higher pre-test probability. Taken together, these comparisons underscore how strongly HPLC positivity rates are shaped by case-selection criteria, referral patterns, and the demographics of the population being screened [5,12].

That HbE disorders predominated in our cohort is entirely consistent with what has been published from northeast India. Baruah et al. [5] identified HbE as the most frequently encountered variant in this geographic belt, and Fucharoen and Weatherall [13] have drawn attention to the broader epidemiological significance of HbE across the Asia–Pacific corridor. The proportion of SCD among our confirmed cases (20.0%) was somewhat lower than reports from tribal belt studies in central India, where SCD can account for 25–30% of cases [1,2]; this difference probably mirrors the geographic preponderance of HbE in upper Assam.

Teli et al. [6] studied 1,204 adult tribal tea garden workers in Assam and found β-thalassaemia trait (8.64%) and sickle cell trait (4.9%) to be the most common haemoglobinopathies. Although their community-based adult cohort and our hospital-based paediatric cohort — made up entirely of children from these same tea garden tribal communities — differ in design, taken together these findings suggest a substantial burden of haemoglobinopathies in this population, with broadly consistent patterns across different age groups and study settings.

Within our cohort, HbE disease clustered more noticeably among the Munda community and SCD among the Orang and Tanti groups. Such patterns are in line with the founder effects and endogamy that have been described across Indian tribal populations [1,2]. However, several ethnic subgroups had very small sample sizes ($n \leq 6$), and the corresponding within-group proportions should be interpreted with caution. Larger community-based studies would be needed before any conclusions about ethnic-specific patterns can be drawn with confidence.

Anaemia was graded using WHO (2011) age-specific haemoglobin thresholds [10], with 93.3% of the cohort classified as having moderate or severe anaemia, reflecting the symptomatic nature of this hospital-based population. Among the SCD patients, three-quarters (18 of 24) had severe anaemia, while among HbE disease cases the figure was even higher at 77.1%. Trait states, by contrast, clustered in the moderate-to-mild range. This clear separation between disease and trait states along the severity axis is well recognised, though it is worth reiterating that HPLC-based characterisation remains indispensable for definitive diagnosis [7,8]. The observation that 58.3% of SCD cases fell in the 2–5 year age bracket is noteworthy and may point to early clinical presentation in this population [2].

HPLC fraction analysis yielded patterns that were broadly in keeping with established diagnostic profiles [7,8], though there was some variation that likely reflects underlying genetic heterogeneity. The markedly elevated HbA2/E in HbE disease (80.2%) and the raised HbA2 in β-thalassaemia trait (5.5%) both fall within the expected ranges for the Bio-Rad D-10 system [7,8]. The mean HbF of 18.1% in the SCD group is worth commenting on: elevated fetal haemoglobin is known to exert a protective effect on the clinical severity of SCD [14], and the relatively high HbF in our cohort may partly account for why a quarter of SCD patients presented with moderate rather than severe anaemia. The combination of a comparatively lower HbS fraction with higher HbF also raises the possibility that some compound heterozygous states (such as HbS/β-thalassaemia) may have been included in the SCD group [8,9]. The HbS fraction in sickle cell trait (32.2 ± 7.9%) was consistent with the expected heterozygous carrier state [8]. A small but consistent

amount of HbA detected in cases classified as HbE disease (3.7 ± 0.9%) may point to underlying compound heterozygosity (HbE/β-thalassaemia), a distinction that HPLC alone cannot reliably make [8,13].
Red cell indices (MCV, MCH, MCHC) turned out to be fairly similar across all diagnostic groups, which goes against the textbook expectation that β-thalassaemia trait should show characteristically low MCV and MCH [8]. The most plausible explanation is the confounding effect of concurrent iron deficiency, a condition reported to be widespread among tribal children in this region [11]. Because iron studies were not performed, these indices should be interpreted cautiously.

Limitations

Two layers of selection bias are present in this study design and needs to be acknowledged. The 500 screened patients were themselves a pre-selected hospital cohort — paediatric attendees referred because of a clinical suspicion of haemoglobinopathy or for evaluation of persistent anaemia — and they do not mirror the broader community or general paediatric population. The study cohort of 120 HPLC-confirmed cases represents only the HPLC-positive fraction (24.0%) of this already selected group, which further enriches it for clinically significant and symptomatic disease. The proportions reported here therefore capture the case mix at this referral centre and cannot be extrapolated to community-level prevalence. The sample size was dictated by the number of HPLC-positive cases identified among 500 consecutively sampled patients who met the inclusion criteria.
Iron studies were not performed, preventing distinction between haemoglobinopathy-related and iron deficiency-related red cell changes. Molecular characterisation was not performed; HPLC-based classification on its own cannot distinguish certain compound heterozygous states — for instance, HbE/β-thalassaemia from homozygous HbE, or HbSS from HbS/β^0-thalassaemia [8,9,13]. Larger future studies that incorporate community-based screening, iron status assessment, and molecular-level analysis would go a long way towards filling these gaps.

CONCLUSION

This study, conducted among paediatric patients from tea garden tribal communities, shows high frequency of haemoglobinopathies at a tertiary care centre in upper Assam. HbE-related disorders were seen to be the most frequently observed, which was followed by β-thalassaemia trait and sickle cell disease. About three-quarters of the SCD cases presented with severe anaemia. HPLC fraction patterns were largely consistent with what is expected for each diagnostic category, though some degree of variation present, likely reflecting genetic heterogeneity within these communities. Ethnic clustering of specific haemoglobinopathies was seen across the eleven tea garden tribal groups, although subgroup sizes were small. These findings stress the need for HPLC-based diagnostic facilities along with community level screening programmes, and genetic counselling specifically aimed at the tea garden tribal populations of northeast India.

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Conflicts of interest

The authors declare that they do not have any conflict of interest.

Authors' contribution

All authors meet the authorship criteria as per ICMJE guidelines, having made substantial contributions to the conception and design of the study, data acquisition, analysis and interpretation, drafting or critical revision of the manuscript, and final approval of the version to be submitted.

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Ethical Approval

This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Institute Ethics Committee with reference number:SMEJ/JMCH/MEU/841/Pt-2/2011/5009, dated 23 November 2023.

Informed Consent

Informed written consent was obtained from all participants. Participants were explained that their identity would remain confidential.

Competing Interests
The authors declare that they have no competing interests.

Data Availability
The relevant datasets were included in the manuscript. Raw data can be provided on request.

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