EVALUATION OF HAEMOGLOBINOPATHIES IN BALANGIR DISTRICT OF WESTERN ODISHA- A HOSPITAL BASED STUDY FROM A TERTIARY HEALTH CARE CENTER

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ABSTRACT

Background: Hemoglobinopathies are genetic disorders related to Haemoglobin. Haemoglobinopathies in Odisha is a significant public health concern, particularly among tribal population. Western region of Odisha has a good tribal population and significant studies regarding the prevalence and burden of haemoglobinopathy in this area is sparse.

Objective: To Determine different spectrums of abnormal haemoglobin, in the patients attending Pathology department, sent from various clinical department of Bhima Bhoi Medical College and Hospital.

Material and Methods: This observational study was carried out in the Department of Pathology of Bhima Bhoi Medical College and Hospital, Balangir, Odisha, from August 30, 2024 to 31th May 2026. 2ml of EDTA blood sent by other department for evaluation of haemoglobinopathy. CBC, sickling test slide, peripheral blood smear were performed for every case and Haemoglobin patterns were analyzed by Chromatogram Interpretation Ready Reckoner, ß Thalassemia Mode, HLC-723G8 (TOSOH INDIA PVT. LTD).

Result: A total of 1678 patients were studied, out of which 723 patients were detected with abnormal Haemoglobin. Sickle cell trait was found to be most common, followed by was Sickle cell homozygous cases.

Conclusion: The higher prevalence of haemoglobinopathy in our study is attributed to the advanced diagnostic tools and selective sampling of clinically doubtful cases sent to our department for study. Public awareness, Proper Anti-natal care and genetic counselling will definitely help community in decreasing the disease burden.

Keywords: Haemoglobinopathies, Sickle Cell Trait, Sickle Cell Homozygous, Genetic Counselling.

INTRODUCTION

Hemoglobinopathies refer to a group of genetic disorders caused by either due to structural or production defect of hemoglobin [(1)]. Haemoglobinopathies in Odisha is a significant public health concern, particularly among tribal populations [(2)]. As per the 2011 census, the tribal population comprises of 8.5% of the total Indian population. Sixty-two types of Tribal Groups are present in Odisha, of which 21.1% belongs to Balangir District only[(3)]. Haemoglobinopathies are nowadays not confined to Tribal areas, due to urbanisation and migration.

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Hemoglobin disorders are the most common single-gene disorder worldwide, with an estimated global prevalence of 7%[(4)]. Each year, 300,000 to 500,000 children are born with significant hemoglobin disorders worldwide[(4)]. India carries a substantial share of the global burden, with a prevalence of 4.2%[(5)]. Beta thalassemia affects 3-4% of the Indian population[(3)]. Sickle cell anaemia is more prevalent among tribal populations in central, southern, and western India, while HbE is more common in the northeastern states [(4,6)]. Sickle cell anaemia and thalassemia are the most prevalent hemoglobinopathies in India.

A carrier state usually doesn't cause any symptom but the Homozygous states are symptomatic and needs medical care. Being aware of abnormal haemoglobin status is very important to improve the health condition and early prevention of complications. Western part of Odisha has a good tribal population and significant studies about the prevalence of haemoglobinopathies in this area is few. This study is carried out in Tertiary health care

centre, located in remote area, to fill the gap regarding the haemoglobinopathy spectrum in these areas.

Haemoglobinopathies are preventable disease, as it is genetically transmitted. Early diagnosis, counselling and treatment are the keys to a healthy and productive life. National Sickle Cell Anemia Elimination Mission (NSCEM)**,** was recently launched by the Hon'ble Prime Minister of India at Shahdol, MP. It combines both screening & awareness strategies to ensure early detection and treatment and aims at eliminating it by 2047 [(7)]. There are less number of studies regarding the prevalence and burden of haemoglobinopathy in this western part of Odisha, hence our study will help in reducing the gap. Proper counselling of the patient and their family members, particularly among young adults helps to create awareness about avoiding marriages between two heterozygous individuals. This will play a great role in decreasing the overall burden of disease in future.

MATERIALS & METHOD

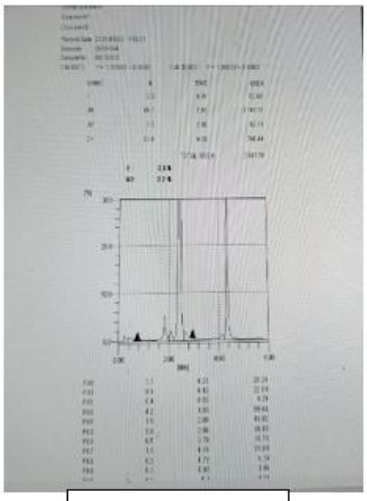
This observational study was carried out in the Department of Pathology of Bhima Bhoi Medical College and Hospital, Balangir, Odisha. Inclusion criteria: This study includes all the patients from August 30, 2024 to May 31, 2025; whose 2 ml of EDTA blood was sent to the department for evaluation of haemoglobinopathy. The complete blood count analysis was performed by using the XN-1000 auto-analyzer (Sysmex Cobe Japan). For every patient a peripheral blood smear was prepared and a sickling slide was done by using freshly prepared 2% sodium metabisulphite. The abnormal hemoglobin fraction was analyzed by Chromatogram Interpretation Ready Reckoner, ß Thalassemia Mode, HLC-723G8 (TOSOH INDIA PVT. LTD). Different hemoglobins were eluted at different retention times. HbF, HbA, HbA2, HbD, HbS and HbC elute at mean retention times of 0.70 min, 2.35 min, 3.00 min, 4.00 min, 4.50 min, and 5.00 min, respectively. Different hemoglobinopathies were diagnosed by considering clinical findings, blood transfusion history, complete blood count (CBC) findings, sickling test (slide method) and HPLC results.

RESULT

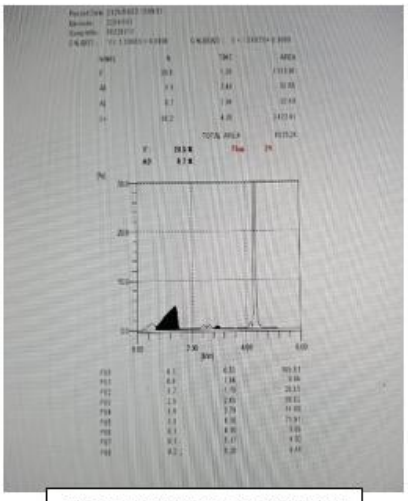
A total of 1,678 patients were referred to the Department of Pathology between August 30, 2024 and May 31, 2026 from various Departments. These patients were Screened for various hemoglobinopathies by doing CBC, peripheral blood smear, sickling test and HPLC. Of the 1,678 patients, 723 (43.09%) presented with an abnormal hemoglobin pattern. Table 1 outlines the spectrum of hemoglobinopathies identified in this study. The most common hemoglobinopathy detected was sickle cell trait (372 cases; 22.17%), followed by sickle cell anaemia homozygous (269 cases; 16.03%). In total, sickle cell disorders compromised 38.20% of the studied cases. Other diagnosed cases included beta-thalassemia trait (35 cases; 2.09%) and beta-thalassemia major (8 cases; 0.48%). Consequently, patients with a thalassemia disorder accounted for 2.57% of the total studied cases. Cases of compound heterozygous HbS-beta-thalassemia constituted 1.49% (25 cases) of our study population. A few other compound heterozygous cases were also detected, including HbS-HbD Punjab (7 cases; 0.42%).

Table1. Spectrum of Haemoglobinopathy detected

Serial no.	Type of Haemoglobinopathy	No. of cases	% of cases
1.	Sickle cell trait	372	22.17%
2.	Beta thalassemia trait	35	2.09%
3.	HbE trait	2	0.12%
4.	HPFH trait	2	0.12%
5.	HbJ Trait	2	0.12%
6.	Alpha thalassemia trait	1	0.06%
7.	Sickle cell homozygous	269	16.03%
8.	Beta thalassemia major	8	0.48%
9.	Compound heterozygous for HbS & Beta thalassemia	25	1.49%
10.	Compound heterozygous for HbS & HbD punjab	7	0.42%
11.	Total cases	723/1678	43.09%



SICKLE CELL TRAIT



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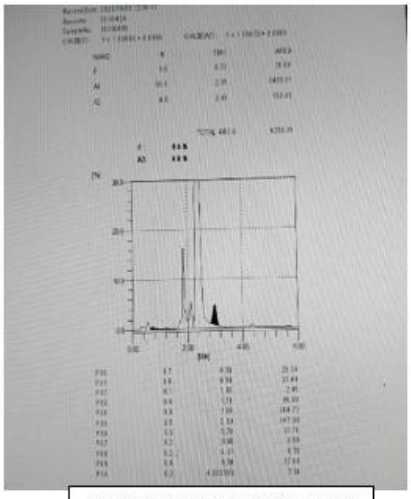

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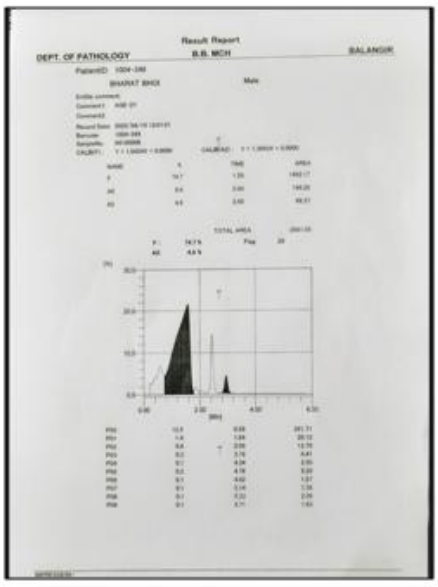

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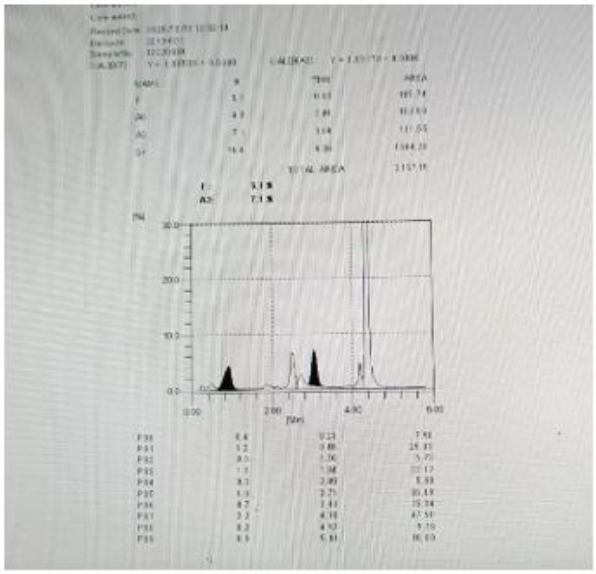
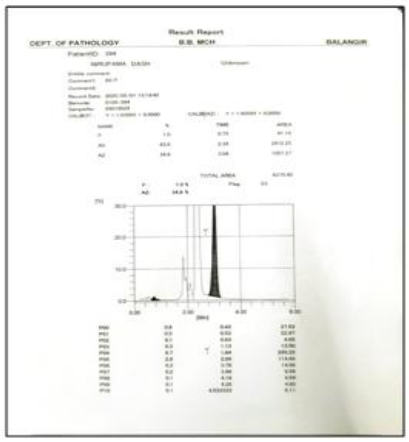
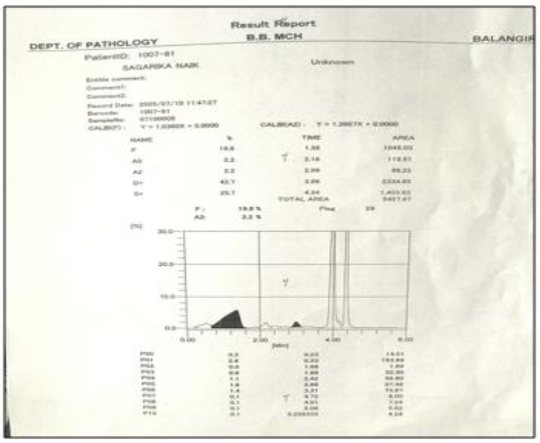


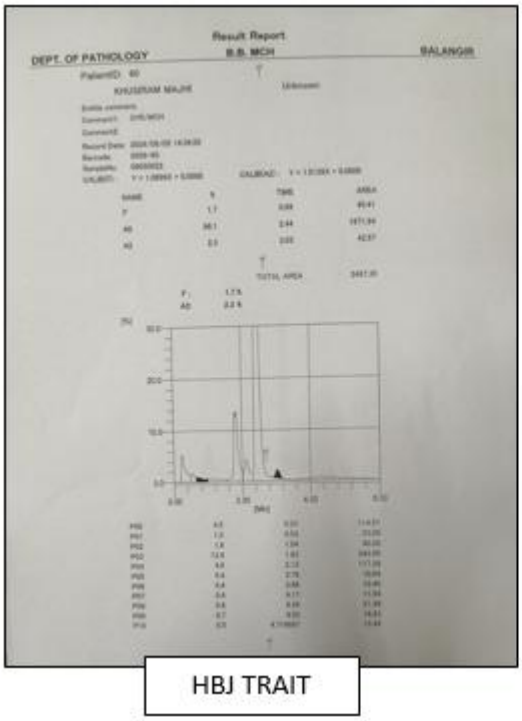
COMPOUND HETEROZYGOUS HBS-BETA THALASSEMIA

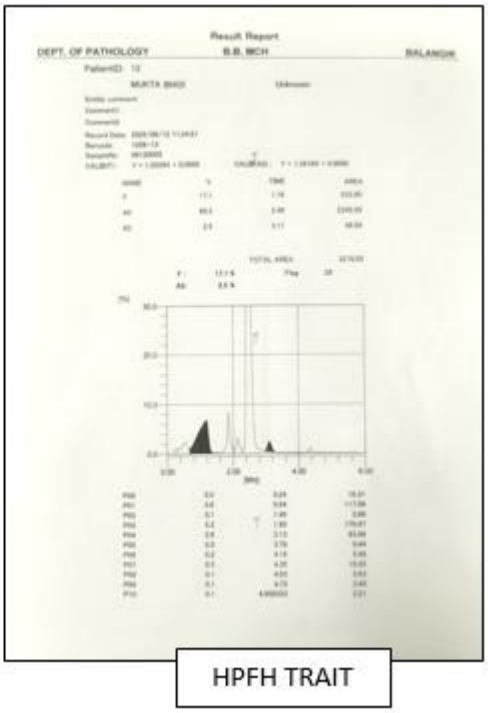


HBE TRAIT



COMPOUND HETEROZYGOUS HBS-HBD PUNJAB





In the present study, female participants slightly outnumbered male participants, as shown in Table 2. The study enrolled 797 male and 881 female participants, yielding a male-to-female (M:F ratio = 1:1.1). The prevalence of hemoglobinopathies was significantly higher in male participants than in female participants. Furthermore, homozygous conditions were more frequently observed in males than in females.

Table 2- Haemoglobinopathies in Different Sex

Sex	Total no. of cases	Homozygous	Heterozygous	Compound heterozygous	Total of haemoglobinoathies
Male	797	190	198	17	405
Female	881	87	216	15	318

The age of the study population ranged from 2 months to 80 years. Hemoglobinopathies were most prevalent in the 11–20 years age group, followed by the <10 years. (Table 3).

Table 3- Occurrence Different Haemoglobinopathy as Per Age

Age in years	No. of cases
<10	181
11-20	219
21-30	175
31-40	85
41-50	38
51-60	17
61-70	3
71-80	5

Complete blood count (CBC) and HPLC parameters for patients with various sickle cell disorders are summarized in Table 4. Patients with sickle cell trait exhibited a mean hemoglobin level of 10.86 ± 2.5 g/dL, with HbA and HbS levels averaging 54.59 ± 4.7% and 29.29 ± 4.7%, respectively. While the majority of these patients presented with normal fetal hemoglobin (HbF) levels, elevated HbF (>5%) was observed in 12% of the cases. Overall, HbF values ranged widely from 0.3% to 32%.

Patients with homozygous sickle cell disease (HbSS) exhibited a mean hemoglobin level of 8.11 ± 2.01 g/dL. High-performance liquid chromatography (HPLC) analysis revealed mean fractions of 19.17 ± 6.6% for HbF, 3.86 ± 7.27% for

HbA, and 65.45 ± 8.5% for HbS. 7% cases had HbF>25%.

Regarding red blood cell (RBC) morphology, the majority of patients with sickle cell disorders exhibited a normocytic, normochromic pattern, though a good number of cases also presented with microcytic, hypochromic RBC.

Table 4: HPLC & CBC Parameters in Sickle Cell Disease

Diagnosis	Hb(g/dl)	HbF%	HbA%	HbA2 %	HbS	MCV(fl)	MCH(pg)	MCHC(g/dl)
Normal	11-16	1-2	95-98	1.5-3.5	-	76-96	27-32	30-35
Sickle cell trait	10.86±2.51	2.13±3.5	54.59±4.68	2.74±0.57	29.29±4.74	73.07±9.57	23.47±3.63	31.53±2.09
Sickle cell homozygous	8.11±2.01	19.17±6.63	3.86±7.27	2.1±0.9	65.44±8.5	79.5±12.08	25.66±4.55	32.09±2.13

Beta-thalassemia trait was diagnosed in 35 patients, all of whom exhibited an elevated HbA2 level (5.32 ± 0.63%). Haemoglobin concentrations were either normal or slightly decreased, with a mean value of 11.66 ± 1.62 g/dL. Complete blood count (CBC) parameters were characteristically microcytic and hypochromic.

The age range of patients with beta-thalassemia major was 11 months to 6 years. All patients presented with severe anaemia, characterized by a haemoglobin level of <5 g/dL. The mean fetal haemoglobin (HbF) level was predominantly 70 ± 15%. Complete blood count (CBC) analysis revealed marked microcytic, hypochromic RBCs accompanied by prominent anisopoikilocytosis.

DISCUSSION

Haemoglobinopathies are the most common Autosomal Recessive type of genetic disorder worldwide [8]. The global burden of hemoglobinopathies represents a major public health concern, largely driven by their diverse clinical manifestations and the requirement for regular blood transfusions in severe cases. The burden of these inherited disorders of haemoglobin is significantly high in western part of Odisha. Our study included 1,678 patients, among whom 723 were diagnosed with various hemoglobinopathies. The prevalence of the disease detected in our study was 43.09%. Prior studies have reported variable detection rates depending on the target population (Table 5); for instance, Balgir et al 2005; 44.2% [9] Sarojini et al 2017;37.26% [10], Debi et al.2018 reported a prevalence of 59.2% [11], while Gopal et al.2018 [12] and Pramita et al 2021[13], reported a prevalence of 50.2% and 59.2% respectively. The burden of hemoglobinopathies appears high, because all the above data comes from Institution-based studies. They are subject to selection bias, as the enrolled study populations primarily consist of clinically suspected cases of haemoglobinopathy.

Table 5: Comparison of Prevalence of Haemoglobinopathies in Various Studies

	Studies	Prevalence
1.	Balgir et al (2005)	44.2%
2.	Sarojini et al (2017)	37.26%
3.	Debi et al (2018)	59.5%
4.	Gopal et al (2018)	50.2%
5.	Pramita et al (2021)	59.2%

A distinct Demographic distribution was noted, which was characterized by high prevalence of haemoglobinopathies in age group 11-20 years, followed by <10 years. Increase diagnosis among aldolescent age group may be due to progression of the disease ie. anaemia, vaso-occlusive crisis etc, further physical exertion may trigger vaso-occlusive crisis [16]. In the present study, the mean hemoglobin level among patients with sickle cell trait (SCT) was 10.86 ± 2.51 g/dL. This finding closely aligns with the mean values reported by Aishwarya et al. (11.27±0.81 g/dL) and Priyanka et al. (10.07 ± 2.47 g/dL). Additionally, our study demonstrated a Mean corpuscular volume (MCV) of 73.09 ± 9.57 fl. Sickle cell trait typically presents with normal erythrocyte indices, the observed microcytic hypochromic profile in these patients is likely attributable to a concurrent iron deficiency anaemia, which is highly prevalent in India [10,17,18]. Also, in Sickle cell trait patient, HbF was found in the range of 0.2-34%, The high level of HbF was due to young age ie 2month of child [19]. Homozygous Sickle cell

Anaemia Patients presented with a mean hemoglobin (Hb) level of 8.11±2.01 g/dL, which aligns closely with the values of 8.32±0.21 g/dL and 7.2±1.3 g/dL reported by Aishwarya et al. and Gopal et al., respectively. However to our surprise about 2% of Homozygous sickle cell patients had no clinical symptoms with normal haemoglobin level and detected incidentally during screening. Our study exhibited a mean HbS concentration of 65.44%, satisfying the standard diagnostic threshold for sickle cell anemia ie. HbS > 50%. Additionally, a substantial proportion of patients demonstrated elevated fetal hemoglobin HbF> 25%, a phenotype likely driven by the high prevalence of the Saudi Arabian/Indian HbS gene haplotype [20,21]. This elevated HbF level serves a protective role by inhibiting HbS polymerization, thereby mitigating clinical severity and reducing the frequency of vaso-occlusive crises [20,22].

The third most prevalent hemoglobinopathy identified in this cohort was the beta-thalassemia trait, accounting for 35 cases (2.09%). This prevalence is notably lower than the rates reported in previous literature, such as studies by Balgir et al. (18.2%) [9], Debi et al. (6.8%) [11], and Haimanti et al. (4.18%) [2]. In this study, a hemoglobin A2 (HbA2) quantification between 4% and 9% was established as the diagnostic threshold for the beta-thalassemia trait, while values ranging from 3.5% to 4.0% were classified as borderline. Due to overlapping hematological profiles—characterized by microcytic, hypochromic red blood cell indices, iron deficiency anemia (IDA) presents as the primary differential diagnosis for the beta-thalassemia trait. Consequently, patients presenting with borderline HbA2 levels were evaluated in conjunction with their peripheral blood smears. Those exhibiting microcytic hypochromic anaemia alongside marked anisopoikilocytosis were advised to undergo iron supplementation therapy followed by a repeat evaluation to confirm the diagnosis[23].

In the present study, the prevalence of beta-thalassemia major was 0.48% (8 cases), which is in concordance with the findings of Haimati et al. (0.44%). These patients presented with severe anemia, and their peripheral blood smears revealed microcytic, hypochromic RBCs with marked anisopoikilocytosis and the presence of nucleated red blood cells (NRBCs)

In the present study, the prevalence of sickle beta-thalassemia was 1.49% (25 cases), which is significantly lower than the rates reported by Sadaf et al. (23%) and Gopal et al. (14.99%). All patients presented with anemia, exhibiting a mean hemoglobin level of 8.48±0.93 g/dL. High-performance liquid chromatography (HPLC) analysis revealed a predominant HbS window (70.83±5.74%) along with an elevated HbA2 level (5.81±0.69%).

Another hemoglobinopathy that elutes in the HbA2 window is HbE. In the present study, two cases (0.12%) of HbE were identified; these were incidental findings in asymptomatic antenatal women who attended the Hospital for routine health checkups [24].

In the present study, two cases (0.12%) of hereditary persistence of fetal hemoglobin (HPFH) trait were identified. Both patients exhibited a normal hematological profile. This finding aligns with a few studies conducted in western Odisha that have also reported the presence of HPFH [25,26].

In the present study, two cases (0.21%) of HbJ heterozygosity were identified. Both cases were clinically silent and eluted in the P3 window. In addition to HbJ, the P3 window also represents degraded blood sample [27]. The heterozygous state is typically either clinically silent or produces only mild symptoms. However, consanguineous marriage (or intermarriage) between carriers can lead to compound heterozygosity, which often results in moderate to severe clinical manifestations. In the present study, we identified compound heterozygosity of the HbS gene with beta-thalassemia (25 cases;1.49%), HbD-Punjab(7cases; 0.42%) [12,28,29].

CONCLUSION

The present Study identifies Sickle cell trait (22.17%), is the most common haemoglobinopathy, followed by Sickle cell homozygous (16.03%). The higher prevalence of haemoglobinopathy is attributed to the advanced diagnostic tools and selective bias of clinically suspected cases. Compound heterozygous conditions typically present with more severe clinical manifestations than the heterozygous state. Consequently, premarital and prenatal counselling is essential to reduce the prevalence of these compound heterozygous states. To achieve this effectively, widespread community participation and awareness are required

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