ORIGINAL RESEARCH

Hemoglobinopathies in adults and cord blood analysis for neonatal screening with special reference to Alpha Thalassemia - A pilot study from central India

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ABSTRACT

Objectives: Haemoglobinopathy is a genetic disorder characterized by the characterised by the generation of haemoglobin that is structurally flawed or by a problem with the globin chains that are produced from it. Thalassaemia syndromes are a combination of structural abnormality of haemoglobin with reduction in haemoglobin chains and are widely seen all over India mostly in tribal population. Haemoglobinopathies is thereby recognized as a major global health problem, as these conditions produce major morbidity and mortality problems in the community. Therefore, every country has introduced in its health program, the screening of population for these genetic conditions. Despite substantial research on haemoglobins at the molecular, biochemical, and haematological levels, diagnosing diseases involving them remains difficult. Early identification and characterisation of hemoglobinopathies are crucial for providing couples and families with the necessary counselling in order to prevent serious haematological repercussions. Therefore, a study was planned to screen the population in and around the region of Ujjain as there is a tribal belt found in that population. Material and Methods: In the present study, 100 cord blood & and 55 patients samples received between December 2010 to January 2011 were analysed for various haemoglobinopathies. All the samples were collected from patients admitted to R.D.Gardi Medical College – Ujjain. Under the direction of knowledgeable staff there, midwives collected umbilical cord blood samples. Blood was drawn into a vacutainer tube containing EDTA after clamping. Hb analysis was done by Drabkins method. Other haematological parameters were analysed by automated cell counter (ERMA INC, PME 210).Results: 100 cord blood samples were taken out of which 3 cases (3%) showed Barts hemoglobin. Concluding the presence of α-thalassaemia. 55 patients samples subjected to electrophoresis showed 18 cases with hemoglobinopathy. β-Thalassaemia major was observed in 9%, β-thalassaemia minor in10%, sickle cell trait in 7.2%, and HbD in3.6% . One case of sickle cell thalassaemia (1.8%) was seen. The overall incidence of hemoglobinopathy was observed in 13.5% of patients sample. One case of sickle cell disorder showed high HbF. Conclusion: Our sample size was small and selective hence it does not reflect a true incidence. Larger studies are needed to assess a true incidence of hemoglobinopathies. Incidence of hemoglobinopathies from this region is sparse. It is suggested that hemoglobinopathy clinics should be started so that systematic evaluation of these cases can be instituted. This will also help in screening the parents and children. Such clinics can offer marriage counselling and prenatal diagnosis.

BACKGROUND

In India's central area, hereditary haemoglobin (Hb) anomalies are rather prevalent. Due to the high rates of illness, mortality, and miscarriage among the underprivileged, disadvantaged, and vulnerable communities, they constitute a public health issue.

INTRODUCTION

The word "hemoglobinopathy" refers to inherited genetic disorders of haemoglobin synthesis that are defined by the production of haemoglobin that is structurally defective haemoglobin or defect in its production of globin chains. The haemoglobinopathies are broadly divided into two categories. The first group are the thalassaemias (including alpha and beta variants), which result from decreased production of one of the globin chains. The second group are the haemoglobin variants which are caused by mutations leading to the production of abnormal forms of globin chains such as HbS, HbE , HbC, HbD and others. The association of thalassaemias with other structural abnormal haemoglobins (double heterozygosity) is not uncommon and therefore shows wide variation of clinical picture ranging from asymptomatic to severe hemolytic picture. In India, such a heterozygosity between Thalassaemia and haemoglobin S and E is commonly seen. It has been estimated that about 1.5% of the global population (80 to 90 million people) are carriers of beta-thalassemia, with about 60,000 symptomatic individuals born annually, the great majority in the developing world.[1] Various studies have shown that frequency of Thalassaemia gene in India varies between 0-18% with average of nearly 4% with the present population , it is estimated that there are at least 40 million people who are carriers of this gene.10,000 infants with thalassaemia major are born there each year, accounting for 10% of all births worldwide[2,3]. One out of every eight carriers of thalassemia in the world lives in India[4]. The average prevalence of haemoglobin S (Hb S) is in India is 4.3%.[5] Despite substantial research on haemoglobins at the molecular, biochemical, and haematological levels, diagnosing diseases involving them remains difficult. In order to properly counsel couples and families who may be at risk of serious haematological effects, early detection and characterisation of the haemoglobinopathies are crucial. Before cord blood stem cells are donated to cord blood banks or as part of a neonatal screening programme for hemoglobinopathies, blood from the umbilical cord (cord blood) is now tested. Identification of sickle cell disorders is the primary goal of a neonatal hemoglobinopathies screening programme because research has shown that early diagnosis if combined with immunisation, the implementation of infection prevention, and parental education, reduces childhood mortality.[6,7]

MATERIALS AND METHODS

In the present prospective study, 100 cord blood & and 55 patients samples received between within 1 year were collected and questionnaire and patient records were used to collect data from mothers regarding infants and their gestational ages. Premature babies were those born after less than thirty eight weeks of gestation. Blood was drawn into vials containing EDTA. Prior to haemoglobin electrophoresis, the Itano and Pauling method was used for sickling test which was further modified by Sergeant.[8] Electrophoresis on cellulose acetate paper with alkaline buffer was carried out. Umbilical cord blood was drawn into a vacutainer tube containing EDTA. Hb analysis was done by Drabkins method. Other haematological parameters were analysed by automated cell counter (ERMA INC, PME 210). After collection of blood, Complete blood count, Peripheral blood smear examination, Reticulocyte count , Sickling test, Hb Electrophoresis were performed.

Inclusion criteria- primarily the ones who visited or admitted for the work up of anaemia and jaundice, whose peripheral smear shows features of haemolysis and patients with increased reticulocyte count.

Investigations Performed: Complete blood count including peripheral smear examination, Reticulocyte count, Sickling test, Hb Electrophoresis (if needed)

RESULTS

In the present study, the overall incidence of haemoglobinopathy was 13.5%. 20 males & 35 Females were screened for haemoglobinopathies. 8 males & 10 Females were found to possess abnormal haemoglobins. Incidence in males was found to be 40% & incidence in Females was found to be 28.5%. This indicates that incidence of haemoglobinopathies was much more in males than females. In 55 cases studied, incidence of thalassaemia was found to be 20 % it was 25 % in males & 17% in females. In 55 cases studied, total incidence of Sickle cell trait was found to be 7.2%. The incidence was found to be higher in Females. Incidence of sickle cell trait was found to be 5 % in males & 8.5 % in females.

2 cases out of 55 were found to have haemoglobin D with 1 case each in males and females. Alpha-thalassaemia (α -thal) was found in 3% of Cord blood samples in the present study and was most prevalent in ages between 10 to 12 years.

DISCUSSION

The present study was aimed at finding the occurrence of hemoglobinopathy, specially the incidence of alpha thalassaemia, in new born children on cord blood samples employing Cellulose Acetate Electrophoresis method. The reports on alpha (α) thalassaemia incidence are sparse in Indian literature including Madhya Pradesh. Simultaneously, patients samples received for hemoglobin electrophoresis from various wards of R. D. Gardi Medical College, Ujjain, during the period were analyzed and discussed. The overall frequency of α -Thalassaemia gene in India varies between 0-18% with overall of 4% (Table II). Our study carried out on 100 cord blood samples shows an incidence of 3% which is comparable to the overall average incidence in India. The first report on testing cord blood for sickle cell anaemia was published in 1972. The main drawback of using this kind of sample is undoubtedly the possibility of maternal blood contamination[9], which increases the likelihood of a

false-negative result when determining the illness phenotype. In 1994, a study comparing the use of liquid and dried blood for the screening of newborn hemoglobinopathy was published. The following benefits of using cord blood samples should be taken into account the good quality and stability of the sample[10] regardless of the technique utilised, degraded Hb components are frequently present when dried blood spots are examined, and extensive knowledge is necessary for the interpretation of different profiles separately; the outcome is made accessible fairly soon after birth.

The cord blood-based Brussels neonatal screening programme was done to enable maternity personnel to receive results and confirmatory samples from suspected children of haemoglobinopathies before the infants are sent to their respective home[11]. The primary objectives of screening for haemoglobinopathies are to identify newborns with sickle cell disease in order to undertake preventive medical therapies and to identify minor haemoglobinopathies in order to provide genetic counselling. The cord blood samples that are meant for the cord blood blank must also be checked for sickle cell diseases and thalassemia in addition to the newborn screening for hemoglobinopathies. The use of HPLC, IEF, or CE is advised by the standard cord blood banking quality control methods. The screening procedure for hemoglobinopathies must be able to distinguish between heterozygous and homozygous forms of Hb A, Hb A2, Hb S, and Hb C. Bahrain study shows an incidence of 24% of α-thalassaemia which is higher in Arabs[12].

The highest incidence of Alpha thalassaemia was reported to be 71% from Behrampur and 42% from Jeypur (South Orissa) and 11% from north Andhra Pradesh[13,14] .This high incidence compared to our study is due to geographical variation and genetic inheritance in the population. In our study, the sample size is small and we studied the hospital population which may not represent the community as a whole. There are no studies to suggest that Ujjain population is a high risk population for haemoglobinopathies. Larger studies are needed to find out the incidence in Ujjain. We observed an incidence of β-thalassaemia in 20% out of 55 samples studied. The incidence of thalassaemia Major was 9.2% and beta thalassaemia trait was 10%. Our findings are comparable to the observed values of 11.5 % reported in studies of Munshi et.al[15] (2008). In another study by [16]Mutua, B. Sowayi in Kenya in 2022, the homozygous β-thalassemia was similarly low with prevalence of 3.6% . In 2019, Ray GK[17], Jena RK in Odisaa 54.06% were positive Beta Thalassemia, while in another study by [18]Narang V, Jain A, in 2022 in Punjab region the β-thalassemia major was found to be (1.8%) and 72.2% of the females had the Beta-thalassemia trait after HbD Punjab trait (17.8%), the HbQ India trait (2.9%), the -thalassemia major (1.8%), and two cases (1.2%) each of the HbS trait, the HbD Iran trait, and the compound heterozygous of HbD Punjab and thalassemia. In a 2022 study by Kumar A, Gupta DK, and Saluja S in a tertiary care hospital, found that amongst all the genotypes, thalassemia (15%) were the most common type.[19] In a 2019 study by PriyaranjanChattopadhyay, SoumyaKundu from West Bengal discovered that aberrant haemoglobin fraction was 13.69% [20]

The most prevalent abnormal haemoglobin which contributed to 8.34% of cases, was thalassemia trait. Sickle cell disease heterozygosity (2.22%) being the second most prevalent one.[21] In 10,745 (50.2%) of the 21,371 anaemic patients, hemoglobinopathies were found. HbS gene was present in 52.48% of cases, betathalassemia was found in 54.06%, and HbE hemoglobinopathies were present in 9.19% of cases. In our centre, a fairly high percentage of cases (50.2%) had hemoglobinopathy. In a study by Ray GK, Jena RK in 2019 in Odissa, these two hemoglobinopathies—various forms of thalassemia and sickle cell hemoglobinopathies were the most prevalent (54.06% and 52.48%, respectively). In a study from Gujrat (Patel et.al 2009) reported an incidence of 7.48% of thalassemia major[22], which is comparable with our study. It may be that Ujjain and Gujrat belong to same geographical area. Sharma et.al[23](1963) found that 80 cases of thalassaemia major in Mumbai region with regional distribution of Maharashtrian (21), Gujraties (35), Uttar Pradesh (8), Sindhis (12), Goaneses (9), Bangalis (1). Present study shows the incidence of 10% of β-thalassaemia trait. Ganeshguru et.al[24](1987) in a study observed high frequencies of beta-thalassaemia trait (4.6% cases in Libyan Arab Jamahiriya, 4.49% cases in Tunisia, 1-3% in Lebanon, Algeria, Morocco and 3% among ethnic Arabs). It is common in Italy, Greece and Cyprus (Angastiniotis et.al 2006)[25]. Balgir (2006) in an analysis of 1015 cases of Central-East coast of India observed 18.2% incidence of thalassaemia trait[26]. In a study in 2009 (Balgir) reported an incidence of 20.5% in population of Jabalpur. Our study shows a lower incidence of 10%. This could be because of the smaller number of cases and selective cases included in the study. Nishi Madan (2010) also observed a lower incidence of 4.05% of β-thalassaemia trait on 5682 samples studied in Mumbai[27,28]. A similar incidence of 5.8% to 9.2% was observed in a study of school children of north west Delhi. VaniChandrashekar and MamtaSoni[29] (2011) observed a high incidence of β-thalassaemia trait (37.9%) from South India (Table 2). There is a selective resistance of heterozygotes in endemic malarial regions which is contributory to the maintenance of high incidence in these areas. Study by Priyaranjan Chattopadhyay, Soumya Kundu in 2019 in West Bengal 13.69% revealed abnormal hemoglobin fractions while the most common being β Thalassem8.35%[30].In another study by Narang V, Jain A in 2022 in Punjab, 72.2% of the females were found to be associated with β-thalassemia trait[31].In the present study we observed an incidence of 7.2% of Sickle Cell Trait. Sickle cell trait

(AS) is widely observed all over India and in different casts and tribes. Lehman & Cutbush (1952) demonstrated the presence of sickle cell trait among the aboriginal tribes (the Pre-Dravidian) found in Nilgiri hills in South India.[32]An incidence of 14.3% of sickle cell trait has been described by Calro (1946) in African Negros. Hb s is distributed in equatorial Africa in a broad zone extending from coast to coast. Highest incidence occurs in the eastern parts of continent where 40-50% members of some tribes are affected, having a prevalence ranging from 10-20%. Prevalence found to be 25% in southern Turkey, Saudi Arabia, Israeli and Mediterranean region (weatherall 2005).

The distribution of HbS varies between 0-18.5% in North Eastern Zone, 0-33% in Western Zone, 2.5-44.5% in central Zone and 1-40% in southern Zone. Our results are comparable to the observed incidence between 0-33% in Western Zone. Mandot and Khurana (2009) observed the prevalence of 8.4% in Garasia tribe of Rajasthan, which is similar to our observation[33]. (Table 5)

A low prevalence was observed in a study on 428 cases in Gujrat 2.8% (Patel et al 2009)[34]. This study similar to our study where cases received for electrophoresis investigation were included. They used Bio-Rad HPLC method. We observed elevated levels of Hb F in 1 case of sickle cell disorder. High levels of Hb F are commonly seen in both sickle cell disease and sickle cell trait. This is probably linked to the mutation in β8 gene. In a study by Das and Kar[35] (1995) on 603 samples, observed the mean HbF value between 1-15%.The prevalence of homozygous sickle cell disease (SCD) was discovered to be 18.2% in Mutua, B., Sowayi in Western Kenya in 2022, along with prevalence of sickle cell disease Hb and foetal Hb (SCD+HbF), 8.1% in n = 20, and sickle cell disease Hb with -thalassemia (SCD+-Thal), 25.1% in n = 62. While sickle cell trait (Hb AS) with foetal Hb (SCT+HbF) had the lowest proportions of 0.8% (n = 2), 41.7% (n = 103) of the people had sickle cell trait (SCT) haemoglobin (HbAS) with -thalassemia (SCT+ thalassemia) had proportions of 2.4% (n = 6). With proportions of 3.6%, homozygous -thalassemia had a similar low prevalence [30]Heterozygous sickle cell disease (2.22%) was found out to be second most common abnormality as found by PriyaranjanChattopadhyay, SoumyaKundu in 2019 in their West Bengal study. Ray GK, Jena RK in 2019 in Odissa found in their study, HbS gene in 52.48% cases and HbE hemoglobinopathies in 9.19% cases [17] .In a 2022 study by Kumar A, Gupta DK, and Saluja S in a tertiary care hospital, the HbS hemoglobinopathy was (7%)[36] Narang V, Jain A in Punjab in 2022 found two cases (1.2%) each of HbS trait [18].The profile of hemoglobinopathy was as follows: HbS gene in 52.48% cases, betathalassemia in 54.06% and HbE hemoglobinopathies in 9.19% cases. Ena RK and Ray GK[17] in their study at a tertiary Care Hospital in Odisha Made a new discovery regarding the spectrum of hemoglobinopathies with a cut-off value of HbA2 of >4.0%, thalassaemia trait was found in the majority of cases, or 62 (56.3%), while thalassaemia major/intermedia was found in 11 (10%). In our study we observed 2 cases (3.6%) of Hb D trait. Sickling was negative in these 2 cases. In various studies the incidence of HbD varies between 0.2% to 4.0% (Balgir R S, 1996, 2006 &2009, Nishi Madan,2010) [27,28]. Narang V, Jain A in Punjab in 2022 found two cases (1.2%) each of HbS trait, HbD Iran trait, and compound heterozygous of HbD Punjab and β-thalassaemia, whereas HbE trait, compound heterozygous of HbQ and β-thalassemia, compound heterozygous of HbJ-variant and β-thalassemia had one case each (0.6%)[18]. Raper (1949) reported higher incidence in females. We observed almost equal incidence in males and females 23.8% and 25.8% in females. Our sample size is very small to come to a conclusion. Our study showed presence of anaemia in 90% of cases of hemoglobinopathy. This is due to samples received were suspected of hemoglobinopathy. Most of them showed microcytic hypochromic blood picture. All the cases of Alpha thalassaemia showed Low MCV, MCH and MCHC values. Reciprocal genetic illnesses continue to dominate the general spectrum of disease in societies where consanguineous marriage is frequently practised [37]. The practise of communal endogamy reduces population diversity because the same normal or abnormal genes combine to reproduce without any alteration in DNA recombination within the community. Inbreeding is also a result of endogamy and consanguineous marriages. Consequently, recessively inherited harmful genetic characteristics like homozygous sickle cell disease, homozygous haemoglobin E sickness, or -thalassemia major are becoming more homozygous (homozygosis). As a result, the population's or the parents' fitness declines. Inbreeding occurs as a result of societies' custom of marrying for convenience within a radius of less than 40 km from their place of origin, which also promotes homozygosity of the faulty genes. According to the results of the current study, carrier parents of these illnesses have disastrous outcomes. Double heterozygosity is rarely found of -thalassemia with Hb S and Hb E but if found can have severe clinical signs, which may indicate genetic admixture or migration. Hb E/-thalassemia co-occurrence in several areas suggests that these anomalies, along with other hemoglobinopathies, are common in Madhya Pradesh and place a significant hereditary burden on those in need in central India.

CONCLUSION

100 cord blood samples and 55 patients samples were screened for hemoglobinopathies by cellulose acetate method. Of the 55 patients samples 20 were males and 35 were females. A fully automated electrophoresis equipment of (GeniouS) manufactured by, InterLabsrl (Italy)).was used to separate various hemoglobins.

Detailed patients history as per proforma was taken. Of the 100 cord blood samples 3 cases (3%) showed Barts hemoglobin. Concluding the presence of α-thalassaemia.55 patients samples subjected to electrophoresis showed 18 cases with hemoglobinopathy. β-Thalassaemia major was observed in 9%, β-thalassaemia minor in10%, sickle cell trait in 7.2%, and HbD in3.6%1 case of sickle cell thalassaemia (1.8%) was seen. The over all incidence of hemoglobinopathy was observed in 13.5% of patients sample.1 case of sickle cell disorder showed high HbF. We have tabulated and discussed the occurance(incidence) of various hemoglobinopathies in our study. Our sample size was small and selective hence it does not reflect a true incidence. Larger studies are needed to assess a true incidence of hemoglobinopathies. Incidence of hemoglobinopathies from this region is sparse. It is suggested that hemoglobinopathy clinics should be started so that systematic evaluation of these cases can be instituted. This will also help in screening the parents and children. Such clinics can offer marriage counselling and prenatal diagnosis. The effects of community genetics, endogamy, and consanguineous marriages on neonatal and infant health are significant factors in the debilitating illnesses sickle cell disease and -thalassemia syndrome.

Table 1: Distribution of haemoglobinopathies in Males & Females.

Gender	Total no of persons	No. of persons with haemoglobino-pathies	No. of persons without haemoglobino-pathies	Incidence of persons with haemoglobino-pathies	Incidence of persons without Haemoglobino-pathies
Both Males & Females	55	18	37	33%	67%
Males	20	8	12	40.00%	60.00%
Fem Ales	35	10	25	28.50%	71.40%

The table reveals distribution of haemoglobinopathies in Males & Females. In the present study, 20 males & 35 Females were screened for haemoglobinopathies. 8 males & 10 Females were found to possess abnormal haemoglobins. Incidence in males was found to be 40% & incidence in Females was found to be 28.5%. This indicates that incidence of haemoglobinopathies was much more in males than females.

Table 2: Incidence of Thalassaemia

Gender	Total no of cases	No. of Thalassaemia cases	Incidence
Both Males & Females	55	11	20%
Males	20	5	25%
Females	35	6	17%

In 55 cases studied, incidence of thalassaemia was found to be 20 % it was 25 % in males & 17% in females.

Table 3: Incidence of sickle cell trait

Gender	Total no of cases	No. of sickle cell trait cases	Incidence
Both Males & Females	55	4	7%
Males	20	1	5.00%
Females	35	3	8.50%

In 55 cases studied, total incidence was found to be 7.2%. The incidence was found to be higher in Females. Incidence of sickle cell trait was found to be 5 % in males & 8.5 % in females.

Table 4: Incidence of Hb D trait

Gender	Total no of cases	No. of Hb D trait case	Incidence
Both Males & Females	55	2	4%
Males	20	1	5%
Females	35	1	3%

2 cases out of 55 were found to have haemoglobin D with 1 case each in males and females.

Table 5: Values of Hb in Normal & in cases with haemoglobinopathies in cord blood samples

Type of Persons	Total no. of cases	Range of Hb in group (gm/dl)							
		< 10		10 to 12		12 to 14		> 14	
		No.	%	No.	%	No.	%	No.	%
Normal	97	5	5.15%	34	35.05%	51	52.50%	7	7.20%
Alpha	3	1	33%	2	67%				

Thalassemia									

Alpha Thalassaemia was found to be most prevalent in ages between 10 to 12.

Table 6: **Haemoglobin % & red cell morphologies in 3 cases of Hb Bar'ts**

Cases	Hb % (gm/dl)	Red Cell morphologies
A	9	Microcytic Hypochromic
B	9.3	Microcytic Hypochromic
C	10.6	Microcytic Hypochromic

All the cases of alpha thalassemia were observed to have Microcytic Hypochromic red cell morphologies.

Table 7: Comparative incidence of β-thalassaemia trait, β-thalassaemia major and Sickle cell trait.

Author	Year	Place	No. samples	Method	Beta-Thal trait	Thal-Major	Sicklcell Trait
Mishra et.al	1991	India		Cellulose acetate	8.0%	--	-
Balgir R.S	2006	India	1015	Cellulose acetate	18.2%	5.3%	29.3%
Balgir R.S.	2009	India	508	Cellulose acetate	20.5%	-	-
Saxena e t al	2009	India	113	HPLC on cordblood	28.3%	11.5%	-
Madan et al.	2010	India	5682	Cellulose acetate	4.05%	-	-
Munshi et al	2008	Andhra Pradesh, India	1592	HPLC	21.7%	7%	-
Kukreja et al.	2011	Malaysia	112	--	16.3%		
Chandra Shekar et al.	2011	India	37.9%	South India	37.9%	-	-
Present study	2011	India	55	Cellulose acetate	10%	9%	7.2%
Priyaranjan Chattopadhya	2019	India	903	HPLC	-	8.35%	-
Kumar A, Gupta DK and Saluja S	2022	India	100	Molecular genetics	15%	-	-
Mutua.B Sowayi	2022	Kisumu, Kenya	247	HPLC	3.65%		
Narang V. & Jain A	2022	Punjab, India	2509	HPLC	72.2%	1.8%	-
Shaikha salim	2008	Bahrain	-	-	-	-	13.3%
Madot and Khurana	2009	Rajasthan, India	-	-	-	-	8.4%
Gulbis B.	2009	Andhra Pradesh, India	195783	IEF	-	0.0038%	0.0065%
Patel J etal	2011	Gujrat,India	425	HPLC	-	7.48%	-
Adormo Eli sangela	2005	Brazil	-	Cord Blood	-	-	6.6%

Table 8: Comparative Incidence Of α-Thalassaemia

Author	Year	Place	No.(Cases)	Incidence	Remarks
Nadkarni et al	2007	Bahrain	5503 (Cord blood)	23.2%	Electrophoresis
Mohammed et al	1992	Bahrain	10327Cord blood)	24.3%	Electrophoresis
Fatton ef el	1987	Tuniisia	529(Cord blood)	4.8%	Electrophoresis
Zoria et al	2002	Tunisia	Cord blood	8%	Electrophoresis
Anita et al	1982	Hong Kong	937	5.2%	Electrophoresis
Riylers	2006	UK	Cord blood	0.5- 11.97%	HPLC
Gupta et al	1991	India	200 General population	8.5%	Electrophoresis

Chakraborthi et al	2006	India	-	18% West Bengal 3.9% Arunachal 3.84% Assam	Electrophoresis
Choubisa et al	2000	Rajasthan India	1647 Cord blood1	.88%	Electrophoresis
Labie et al	1989	Orissa India	-	71%&41%	Electrophoresis
Present study	2011	Ujjain India	-	100 Cord blood 3%	Electrophoresis

The overall frequency of α -Thalassaemia gene in India varies between 0-18% with overall of 4% (Table 8). Our study carried out on 100 cord blood samples shows an incidence of 3% which is comparable to the overall average incidence in India. Behrain study shows an incidence of 24% of α-thalassaemia which is higher in Arabs. The highest incidence of Alpha thalassaemia was reported to be 71% from Behrampur and 42% from Jeypur (South Orissa) and 11% from north Andhra Pradesh. This high incidence compared to our study is due to geographical variation and genetic inheritance in the population. In our study, the sample size is small and we studied the hospital population which may not represent the community as a whole. There are no studies to suggest that Ujjain population is a high risk population for haemoglobinopathies.Larger studies are needed to find out the incidence in Ujjain.

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CONFLICTS OF INTEREST
There are no conflicts of interest.

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