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PREVALENCE AND DISTRIBUTION OF HEMOGLOBINOPATHIES IN SOUTHERN ODISHA: A COMPARATIVE PERSPECTIVE WITH NATIONAL AND GLOBAL TRENDS

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ABSTRACT
Hemoglobinopathies are genetic blood disorders caused by alterations in the globin genes that affect either the structure or production of hemoglobin. Structural abnormalities result in abnormal hemoglobin variants, whereas reduced or absent globin chain synthesis leads to thalassemia. Deletions in the α-globin genes cause α-thalassemia whereas mutations in the β-globin gene are cause β-thalassemia. Alterations in the amino acid sequence of the α- or β-globin chains may also produce structurally defective hemoglobin, leading to various hemoglobinopathies. The global prevalence of these disorders has increased due to migration from endemic regions, making hemoglobinopathies an important public health concern in India. Early detection and awareness are essential for effective disease management and prevention. Individuals with suspected hemoglobin disorders are initially evaluated through clinical history and routine hematological investigations, followed by confirmatory tests such as hemoglobin electrophoresis, high-performance liquid chromatography, and mass spectrometry. Recent advances in molecular diagnostics, particularly massively parallel sequencing (next-generation sequencing), have improved the accuracy of detecting thalassemia and other hemoglobinopathies. In addition, genetic screening and prenatal diagnosis play a crucial role in reducing the birth of affected children and preventing pregnancy-related complications. In the present study, data of 1368 hemoglobinopathy patients from different districts of Southern Odisha like Ganjam, Gajapati, Rayagada and Kandhamal were collected and analyzed. Among them, 917 cases were identified as sickle cell positive and 451 as thalassemia positive. This study aims to evaluate the current burden of hemoglobinopathies in Southern Odisha and compare the findings with national and global trends.

KEYWORDS: Hemoglobinopathy, genetic disease, thalassemia, sickle cell anaemia, Southern Odisha

INTRODUCTION

Haemocytes are the remarkable type of blood cell called red blood corpuscles, hamates, and erythrocytes. Cells are the most common type of blood cell, having a nucleated cell found in the blood [1]. A vital role is played by red blood cells in sustaining living creatures' lives by delivering oxygen to peripheral tissues. It binds oxygen along with carrying oxygen and transports it to every cell of the body, and Hemoglobin molecules carry out the delivery system in the cytoplasm of RBCs [2, 3]. A hem molecule that binds up with oxygen is found inside a hemoglobin molecule, which is supported by the globin polypeptide chains (2α and 2β) [4, 5]. The quantitative balance and structural stability of the globin chains are the most significant processes for the hemoglobin molecules and red blood cells [6, 7]. When the genes have encoded imperfections i.e. in the form of variation in the globin chains (For α-globin, HBA and β-globin, HBB), which reflected in abnormal changes in the structure of globin moiety, which leads to pernicious anaemia [8, 9]. In humans, Hemoglobinopathy disorders are generated by abnormal changes leading to synthesizing a non-functional blend of protein, resulting in a significant variance in globin chains moiety, among which thalassemia is one of the most common forms. Like that other types of Hemoglobinopathy such as sickle cell diseases are due to abnormalities in globin chains i.e., synthesis of pathogenic variants which result in structural change [10, 11].

Magnitude of the burden in India

The β thalassemias and sickle cell disorders gives the important health load in Odisha, India. The mean prevalence of β thalassemia transporters is 3-4 % which translates to 35 to 45 million carriers in our multi-ethnic and culturally and linguistically diverse population of 1.21 billion people which also includes around 8% of tribal groups according to the Census of India 2011. Several ethnic groups have a much higher prevalence (4-17%) [3,4].

β-thalassemia and sickle cell disorders constitute a significant health burden in Odisha, India. The average prevalence of β-thalassemia carriers in India is estimated at 3–4%, representing approximately 35 to 45 million carriers within the country's multi-ethnic, culturally diverse, and linguistically heterogeneous population of 1.21 billion people. According to the Census of India 2011, tribal groups account for around 8% of the population. The prevalence of β-thalassemia varies

considerably among different ethnic communities, with certain groups exhibiting markedly higher frequencies ranging from 4–17% [3, 4].

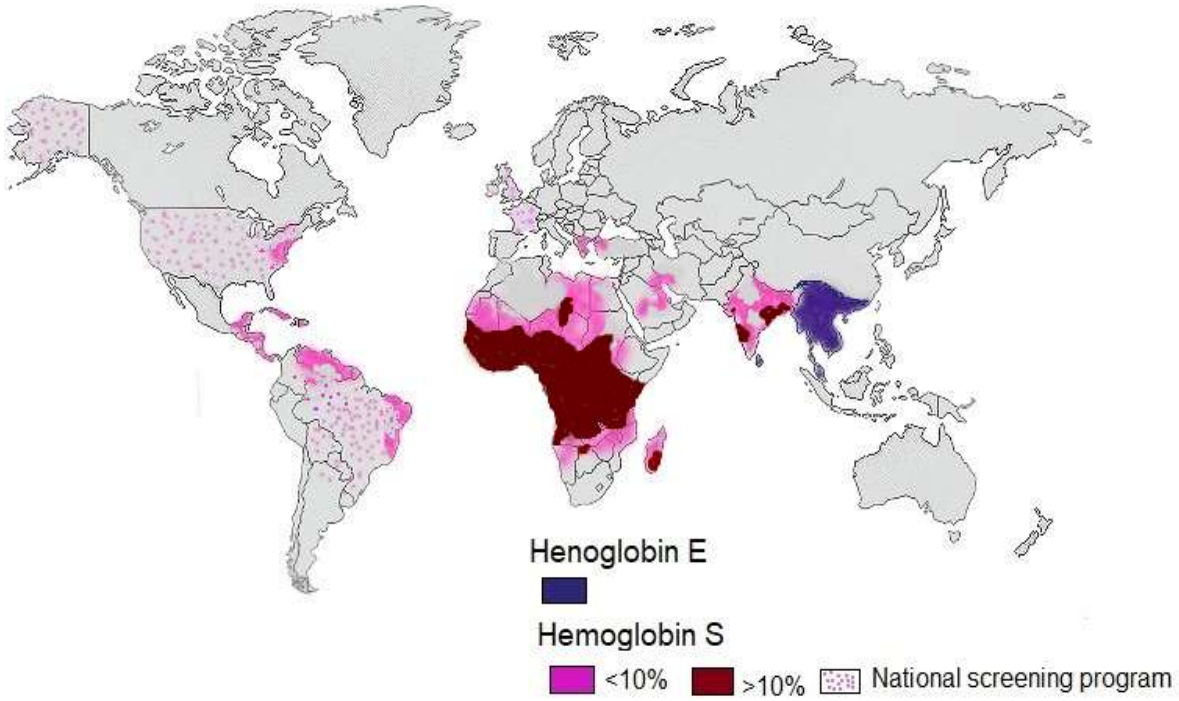

Figure 1. Global distribution of Hemoglin trait

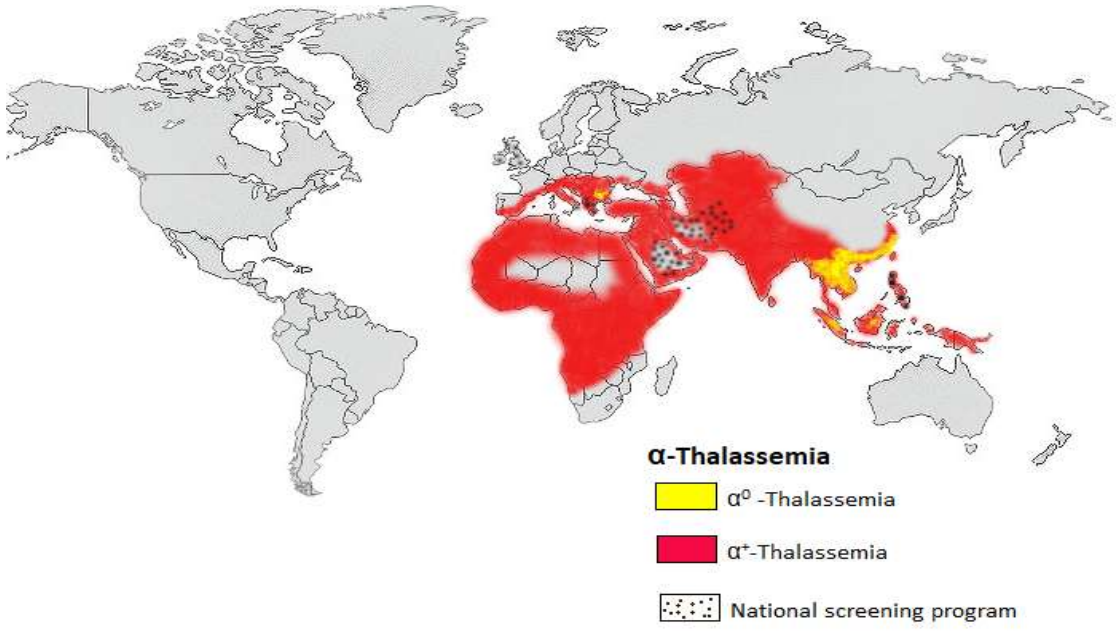

Figure 2. Distribution of global α-Thalassemia

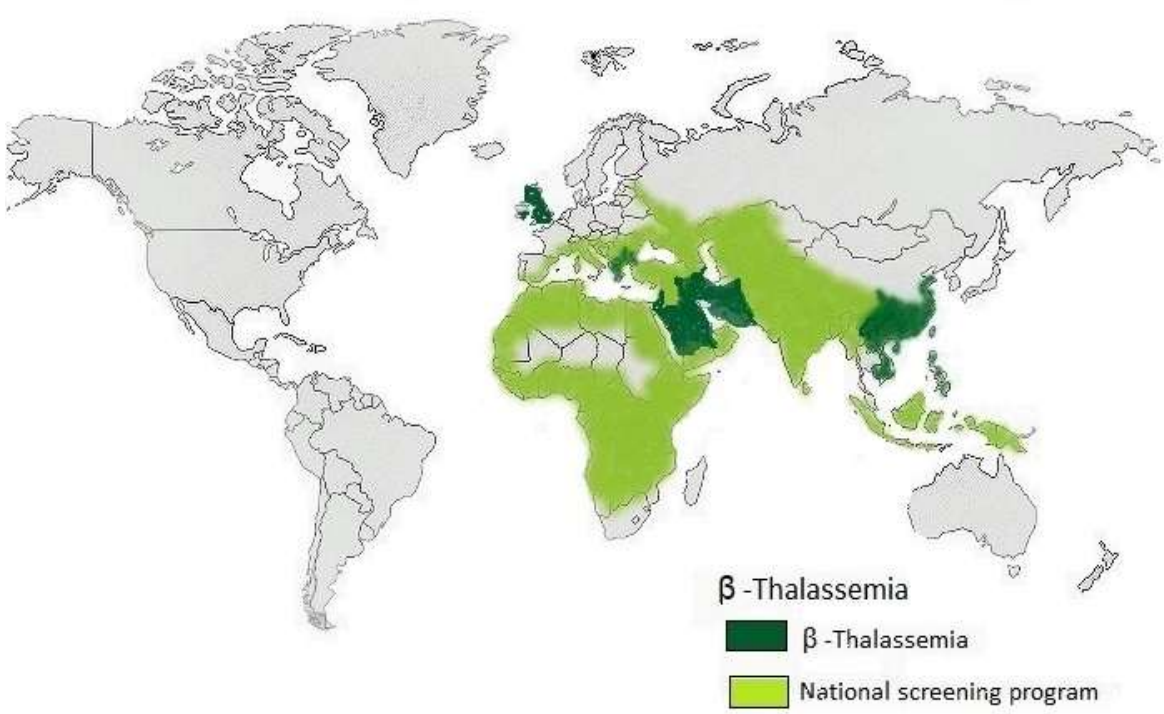

Figure 3. Distribution of global β-Thalassemia

The Hemoglobinopathy disease diagnosis in anaemic patients begins with family history background, phenotypic identification and relevant laboratory test etc. By establishing genetic confirmation harmful variant genes are diagnosed [12, 13]. In traditional sequence analysis it has been very difficult to diagnosis the genetic heterogeneity of the disease and the mutations of the genetic makeup [14]. Recently, by using the novel tool of molecular technologies large deletion/duplication mutations can be assessed and by massively parallel sequencing facilitated with multiple gene panel tests and also by using detailed molecular diagnosis examination of genetic haemolytic anaemia in patients which reflected in better conception of the genomic identity of the disease [12, 15, 16].This review focused on the range of hemoglobinopathy disorders in Southern Odisha and the development of analytical techniques such as molecular genetic testing, prenatal diagnosis, screening tests, and data exchange from other regions of the state.

The major programs or initiatives are taken by the Central/State Government/ abroad countries to controlling/reducing the thalassemia patients in Odisha and India also. The programmes like (1) Thalassemia Bal Sewa Yojana (TBSY): The Thalassemia Bal Sewa Yojana (TBSY) is a government-supported initiative that provides financial assistance of up to 1 million currency to eligible patients for undergoing bone marrow transplantation. (2) Thalassemia screening and counselling centre for mass papulations or symptomatic patients: The Indian Red Cross Society (IRCS) that aims to avoid the birth of children with hemoglobinopathies. (3) Premarital screening for parents who has parental evidence for thalassemia symptoms: Compulsory premarital screening for sickle cell and thalassemia in Saudi Arabia to reduce at-risk marriages. (4) High school level screening for stopping the thalassemia in country: A program in Montreal, Canada that screens and informs students about carriers of thalassemia or Tay Sachs disease. (5) Weekly Iron and Folic Acid Supplementation Programme: The Ministry of Health and Family Welfare execute this programme to facilitate the door-to-door distribution of folic acid and iron supplements among the normal population and thalassemia patients. (6) Rashtriya Arogya Nidhi Scheme: A program by the Ministry of Health and Family Welfare for specific for patients with thalassemia. (7) Mass communication and media: Awareness regarding thalassemia can be promoted by incorporating educational messages into school textbooks and integrating thalassemia-related information into school health and adolescent health programmes. (8) Counselling of healthy patients as well as thalassemia symptomatic patients: Institutionalizing counselling for thalassemia during antenatal care, postnatal care, and in blood banks.

The major strategies for control of thalassemia in India as well as Odisha needs (1) Awareness programmes for population at large papulations, school students, college students, pregnant women, through educating health professionals or trained health workers (2) Prenatal diagnostic facilities should be established at central and state-level primary health centers across different regions of the country to improve access to early diagnosis and appropriate management of inherited hemoglobin disorders. (3) Day Care Centers with sufficient equipment with medicines for managing existing patients with thalassemia (4) Genetic counselling and prenatal diagnosis. 5). Establishing affordable stem cell transplantation facilities across the country to make this treatment accessible to more patients. (6) The combined efforts of the parent–patient societies, NGOs, corporate organizations, Central and State Governments can help to reduce the burden of hemoglobinopathies in India. (7) The National Health Mission, under the Ministry of Health and Family Welfare, has recently prepared guidelines for implementing such a national programme with the support of experts from across the country [64].

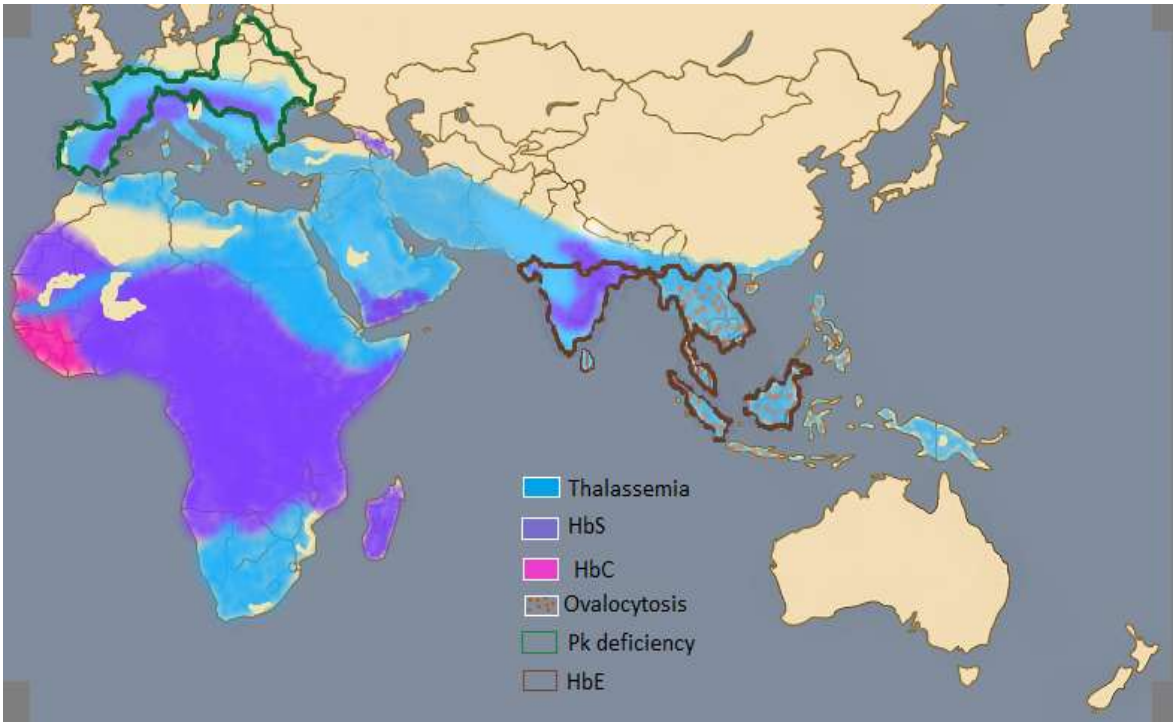

Figure 4. Distributions and variations of global Hemoglobinopathy

Global burden of Hemoglobin disorders

Thalassemia and other structural variations of Hemoglobin are included in the category of hereditary Hemoglobinopathies. According to estimates, in each year about 300,000 kids with acute Hemoglobinopathy are born; as per worldwide scenario they are single gene diseases i.e. autosomal recessive inheritances that are most common [11, 17]. Because consanguineous marriages are common in many nations, natural selection and an epidemiological shift have combined to produce their high frequency of Hemoglobin abnormalities [18, 19]. The prevalence of all hemoglobinopathies varies greatly throughout nations, even within short travel distances. Around 270 million peoples are the carriers of sickle cell anemia and/or thalassemia (WHO 1994). Around 1% of couples have a high risk of Hemoglobinopathy and the majority of them have minimal one affected child. The impacted children typically pass away from chronic illnesses in their early years [17, 18]. Studies have indicated that children under the age of five account for at least 3.4% of all pediatric mortality. A significant risk of Hemoglobinopathy is thought to have affected 24 nations, including China and India. The country estimates that 13% of the rapid recent spread of Hemoglobin disorders is associated with migration, i.e., in northern and western Europe, affected conceptions are now more common than in southern Europe. Hemoglobin disease impact around 2.7 out of every 1000 conceptions, 2.55 out of every 1000 affected births, and Globally, approximately 1% of couples are at risk of having children affected by the disorder. In children under five years old, hemoglobin abnormalities are associated with 3.4% global mortality and 6.4% in Africa [19, 20, 21]. The majority of countries have reduced their statistics because of genetic counselling and Hemoglobinopathy screening; these services ought to be fundamental components of health care systems, and much more effort has to be done to offer a reliable estimate of their actual frequency.

Hemoglobinopathy scenario in India

The two most prevalent conditions are structural Hemoglobin variations and thalassemia. With a population of 1300 million, India is predicted to have 100,000 cases of new thalassemia syndrome annually, 150,000 patients with sickle cell illness, and 100,000 individuals with thalassemia disease [18, 19, 20]. The Indian population has a wide variety of Hemoglobin variations, many of which go unrecognized because of a lack of curiosity. Sickle cell disorders and β-thalassemia syndrome are highly widely distributed in India. In our 1.21 billion strong population, which is culturally, linguistically, and multi-ethnically diversified, the β-thalassemia carriers approximate average number is 3-4%, or 35 to 45 million. The 2011 Census of India shows that 8% or so of the country's population is made up of tribal communities [21, 22, 23, 24]. Based mostly on patient reports from West Bengal and surrounding areas, research has been conducted on β-thalassemia (9.62%), HbE/β-thalassemia (3.67%), HbE trait (4.92%),chronic fatal Hb (1.9%)and other Hemoglobinopathies that are comparatively uncommon (<1%). The distribution of HbE gene average frequency of is approximately 10.9% in the Indian population.[23, 24].A practicable option to control the threat of chronic Hemoglobin disorder is to educate the people through different types of awareness programmed, magnify the screening techniques in all the states with micro mapping which flourish the satisfactory services for the prenatal diagnosis and genetic counselling in different public sectors, institutions, government and non-governmental organization. It is a great challenge for our country by reaching all rural regions for identification of Hemoglobinopathy of HbS and Hb where almost 70% of the population resides with abnormal genetic disorder. Different Strategies are taken into consideration by different agencies to control Hemoglobin disorders, it comprises:

a) Educating the general public, expectant mothers, high school and college students.
b) Offering facilities for prenatal diagnosis tools around the nation.
c) Establishing day care centres to oversee and manage patients with hemoglobinopathy who are already ill.
d) Emerging, reasonably priced stem cell transplant centers for individuals with hemoglobinopathy around the nation.

Table 1. β-Thalassemia in Different Indian Communities [22, 23, 24, 25]

Communities		Prevalence of β-thalassemia
Lohanas,Vellalas, Sindhis, Bhanushalis		8-17%
Jaths, Aroras, Khatris		6-10%
Banias,Patels,Prajapatis, Mayavanshis,Jains		6-8%
Menons, Fakirs, Shiyas		5-7%
Vasava, Gamit, Kokana tribes, Chaudhryfrom Gujarat		12-15
Mahars, Neobuddhists		4-6%
Mandols, Kayastha,		5-9%

This work aims in India is to explores different strategies in which State and Central Governments, Corporate houses, NGOs, can work together to make the scenario successful and permanently diminish the stress of Hemoglobinopathy., Recently with the assistance of numerous specialists a number of guidelines around the nation has been released by the National Health Mission and Ministry of Health and Family Welfare. Varied districts have varied distributions of β-thalassemia carriers: Maharashtra (1-6%) and Gujarat (0-9.5%) [22, 23, 26]. Every year, the estimated number of children expected to be born with β-thalassemia major was also calculated for each district in these two states. In Gujrat, the homozygosis rate per 1000 births was 0.39 and in Maharashrra it was 0.28, [22, 23, 24, 25]. The frequency of HbS carriers differs considerably among various population groups, ranging from 5 to 35%, with the highest occurrence mainly reported among Scheduled Castes, Scheduled Tribes and Other Backward Classes. In India, eastern regions and the north-eastern carry the frequency of HbE carriers varies from 3 to over 50%. [22, 25, 27]. However, the other caste populations of the coastal regions of north-eastern India, the scenarios of the HbE trait were found in Odisha and West Bengal; these reports were reported previously (Balgir 2004, 2005) [22, 26, 27]. In north-eastern India and West Bengal, the HbE characteristic is commonly seen in both tribal and nontribal groups (Balgir 1995, 2003). In South Gujarat the widespread presence of SCT and βTT trait was 4.4% and 1.3%, respectively [22, 27, 29]. Furthermore, Uttar Pradesh had the highest prevalence of β-thalassemia, a Hemoglobinopathy illness. Balgir's study on the spectrum of hemoglobinopathies in Odisha, conducted between 1994 and 2003, provided important insights into the distribution of these disorders. In particular, West Bengal is recognized as an endemic region for hemoglobin E. Therefore, it makes sense to suggest that gene flow from these regions is what ultimately causes it to occur in Orissa [29, 30, 31].

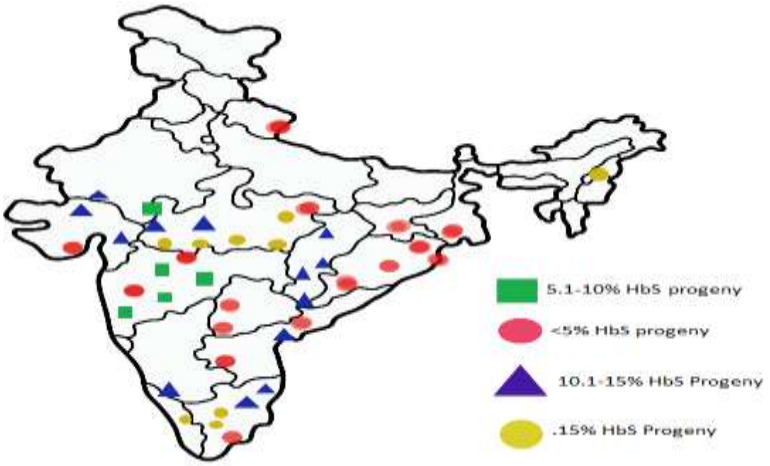

Figure 5. Sickle cell gene in tribal population of different Indian State

About 300,000 to 400,000 babies are thought to be born each year with a severe Hemoglobin defect. The most common single gene diseases with an autosomal recessive inheritance are thalassemia and structural variations of hemoglobin. The thalassemia is a dangerous illness that affects most newborn; about 30,000 of them have significant cases has been reported in middle- and low-income countries. Sickle cell diseases and Thalassemia and the severe health risk in India [29, 30, 31, 32]. According to the 2011 Census of India, among the 1.21 billion country's population the average prevalence of thalassemia carriers was estimated to be 3–4% or 35–45 million. India has approximately a heterogenous population with considerable linguistic and cultural diversity, including about 8% tribal populations [22, 34, 35, 36]. Small-scale studies

conducted in specific geographical areas have reported that β-thalassemia carrier frequencies are not evenly distributed across the country however the carrier frequencies ranging from 1–6% in Maharashtra and 0–9.5% in Gujarat. [35, 36, 37].
In these two states, for every district each year the estimated number of newborns expected to develop β-thalassemia major was also calculated. The annual homozygosity rate per birth was 0.39 in Gujarat and 0.28 in Maharashtra. HbE is mainly prevalent in the north-eastern and eastern regions, where its carrier frequency ranges from 3 to over 50%, in contrast the HbS carrier frequencies show greater variation and mainly reported among Scheduled Tribes, Scheduled Castes and Other Backward Classes respectively with 5 to 35% across a variety of groups [36, 37, 38]. These hemoglobin variants often occur together with β-thalassemia, particularly in regions where both conditions are commonly found. In this enormous country, estimates indicate that there would be approximately100,000 individuals with β thalassemia syndrome and 150,000 cases of sickle cell disease approximately [35, 37, 38, 39]. Though, the specific numbers are unknown due to the deficiency of patient national registers. It has been estimated that, out of every 365 days, 32,400 kids with a significant hemoglobin problem will be born, or 27 million births in the country of India [39,40]. Just a small percentage of India's 10,000–12,000 thalassaemic newborns receive the necessary care, mostly in urban regions; however, the Bharat Regime has included sickle cell and thalassemia patients concerns and management of the patients in the 365 days plan [41, 42]. Two million packed red blood cells are thought to be required for the country's thalassemia sufferers to receive transfusions. Improved care for β thalassemia primary patients, who are primarily found in Republic of India's cities, can lead to a better quality of life by providing frequent, reliable blood transfusions and adequate iron chelation [43, 44]. Yet, multidisciplinary care becomes necessary as they aged. Blood is currently given free of cost to the patients with hemoglobinopathies and in many states the iron chelators are gradually made available as well, despite the fact that testing, processing, and leucodepletion still come with a lot of additional expenditures [45, 46]. As an outcome the majority of patients do not receive the best care. The only method for relieving β-thalassemia major sufferer remains is to allogeneic stem cell transplantation in the patient's body.

Present Hemoglobinopathy scenario in Odisha

More than 70% of people in Odisha had one or more Hb mutations, such as abnormalities in the HbE gene (2.2%), β-thal gene (22.0%), the HbS gene (23.7%), etc. [47, 48]. It is estimated that approximately around 3,000 to 4,000 babies are born each year with severe forms of these illnesses. In the coastal state of Odisha, It was also reported that the population of tribal pregnant women appearing urban hospitals accounts were 13.5% of the population, which is disturbingly high. The prevalence of Hb mutations was generally highest (76.4%) in the population of general caste, approximately 14.9% in scheduled caste, and 8.7% in scheduled tribe [49, 50, 51]. It has been determined from urban hospitals in coastal Odisha that pregnant women with frequencies around 5.6% of β-thalassemia trait and sickle cell trait, 1.1% of Hemoglobin E trait, and 0.6% of each sickle cell-E-disease respectively [52]. For the first time, the homozygous and heterozygous forms of the HbE allele were found among the Delki Kharia tribe in the Sundergarh area of Odisha. The state's eastern coastal regions, namely the Balasore and Bhadrak districts, are frequently the site of Hb E infections [53, 54].
In comparison to the control group and sickle cell trait, patients compound heterozygotes for both alleles or homozygous for β-thalassemia had considerably lower Hb level and higher level of HbF, HbA2, and reticulocyte counts. Approximately 70% of individuals with significant β-thalassemia had less than 7.0 g/dL of total hemoglobin level, In contrast, about 10% of the patients with sickle cell disease had levels below this value. [55, 56, 57]. High amounts of Hb-F were found in both sickle cell disease patients and sickle cell trait cases. According to historical accounts, people from various regions migrated into the state's eastern, northern, and western corridors. For instance, Brahmin migrants from Uttar Pradesh brought an aberrant β-thalassemia gene to the northern waves; Hemoglobin E was brought by migrants from West Bengal and Assam; and people with sickle cell gene were brought to Orissa by migrants from Gondwana land in the eastern waves. The Division of Human Genetics at the Regional Medical Research Centre (ICMR), Bhubaneswar, collected 1,015 cases of anaemia from various medical colleges, hospitals, and hospitals throughout the several districts of Orissa between 1994 and 2003 [58, 59].

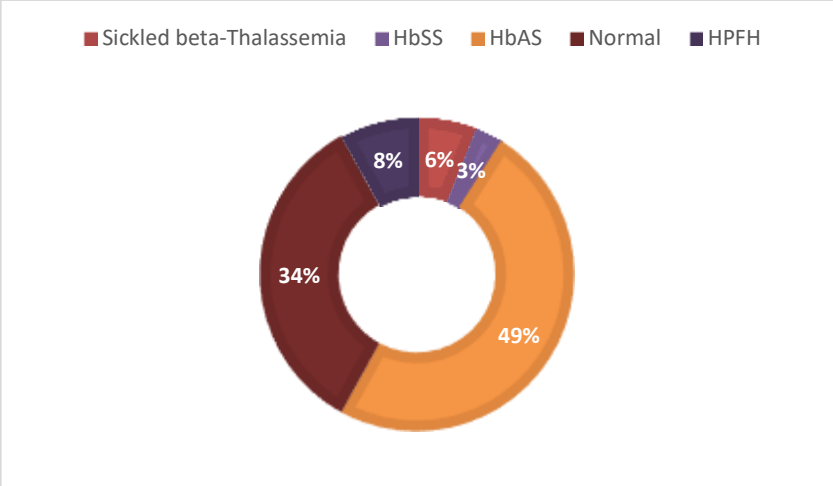

Figure 6. Hemoglobin thalassemia patient's data analysis in Odisha, India

Research from various regions in Odisha has shown that symptomatic cases (23%) predominate over asymptomatic cases (1.7%), indicating a higher prevalence of hemoglobinopathy in patients [58, 59].
The majority of cases of hemoglobinopathy are found in the following district like Anugul, Nayagarh, Khurda, Cuttack, Jajpur, Phulbani, Dhenkanal, Keonjhar, Mayurbhanj, Ganjam, and other districts etc. This can be attributed to the heterogeneous population of Orissa, which is distributed across the state and includes general castes, scheduled castes and tribes from the South-Western and Coastal regions, as well as carriers of almost all major hemoglobinopathies. For instance, the Chasa and Khandyat castes were found to have hemoglobin D, but the Khandyat and Brahmin castes were found to carry hemoglobin E [60, 61].
An extensive and useful database on the range of hemoglobinopathy in the state is provided by the current study. Numerous Hemoglobin variants that are common in the population indicate that Odisha's major public health issues is population is genetically diverse, with a wide range of genetic heritages, among other factors.

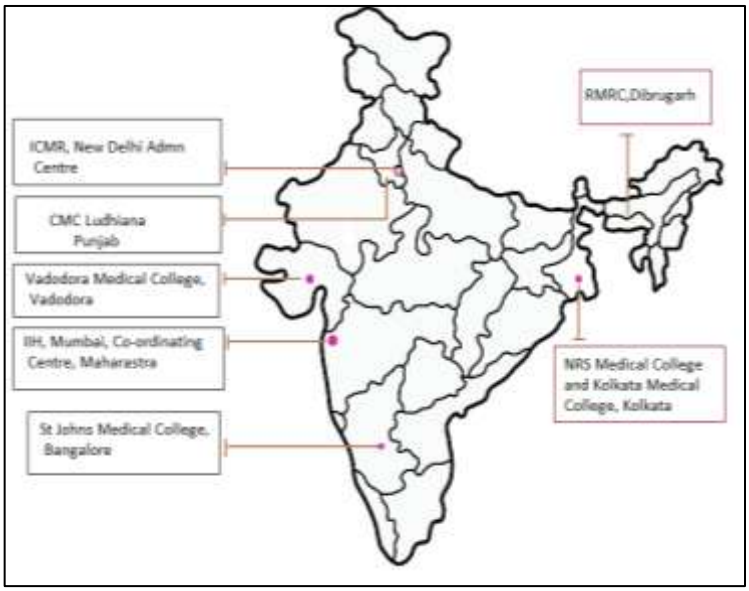

Figure 7. Locations of the co-ordinating and the investigating centres

In Odisha, 43%, 38 %, 15% and 4% of thalassemia patients are seen in 3-5 years, 6-10 years, 11-14 years, and more than 14 years respectively. Among the all patients 63% are literate as well as 37% are illiterate. The 73% of family are belongs to APL and 27% are BPL. It has been reported that the highest proportion of β-thalassemia cases, found to be 49%, in northern Odisha, particularly in the coastal districts of Cuttack, Jajpur, Kendrapara, Bhadrakh, and Balasore. This was followed by 33% of cases from the coastal districts of southern Odisha, including Khurdha, Puri, and Ganjam. The remaining 18% of cases were reported from western Odisha. [62].

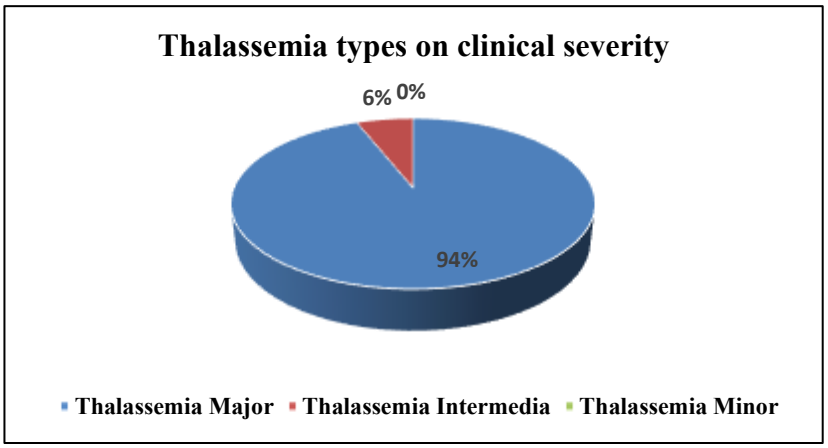

Figure 8. Thalassemia types on clinical severity of patients in Odisha, India

All over the Thalassemia types, Thalassemia major is 94%, Thalassemia Intermedia is 6%, Thalassemia Minor is 0 %. The symptomatic alternation and severity of patients enforces to come in hospitals as well as moderately seen in thalassemia intermedia but in case of thalassemia minors the cases are very less even zero due to very less symptoms of the patients. May be thalassemia minor patients are very less due lack of or tolerable symptoms in the patients. In other sides lack of common methods for detection of thalassemia minors [65].

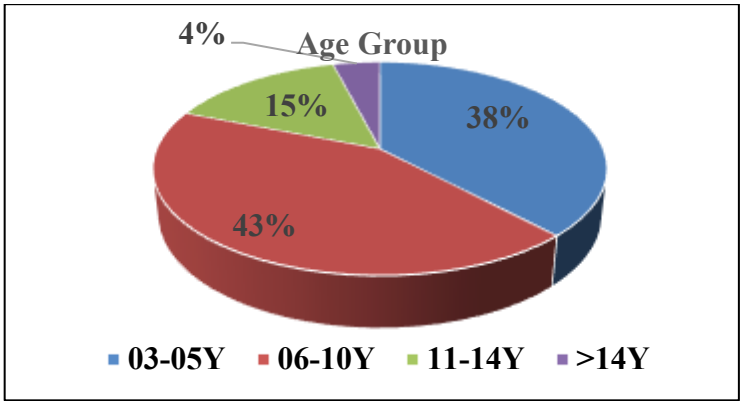

Figure 9. Different age group of thalassemia patients in Odisha

In the present study, patients aged 6–10 years constituted the largest proportion (43%), followed by those in the 3–5-year age group (38%), 11–14-year age group (15%), and those above 14 years (4%). Patients in the 6–10-year age group showed the highest prevalence across all types of thalassemia, educational backgrounds, genders, and income groups in Odisha. Overall, male patients accounted for 61% of the study population, whereas female patients represented 39% [66].

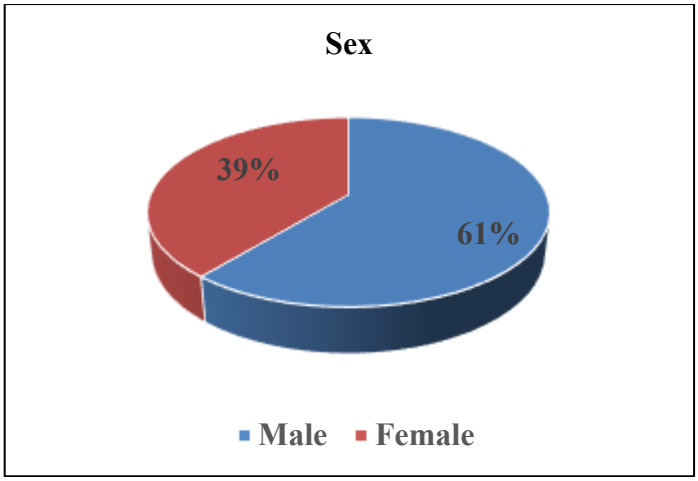

Figure 10. Sex of thalassemia patients in Odisha

In all sex papulations males (61 %) are more prevalent in compare to female (39 %) with respect to all type of thalassemia, education, gender and in all type income groups seen in Odisha. The other factors are also affecting the thalassemia percentage in Odisha [66].

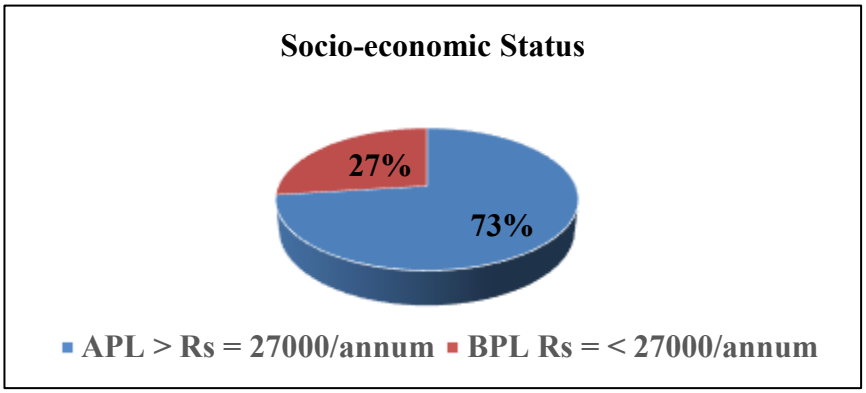

Figure 11. Socio -economic status of thalassemia patients in Odisha

In compare to BPL and APL categories with respect to all type of criterions, BPL groups are more affected in compare to APL groups. The BPL categories members are suffering from thalassemia due to lack of awareness about thalassemia disease, lack of family counselling, no avoidance of carrier marriage, family protective measures should be permissible for avoidance of chine break of thalassemia diseases [67].

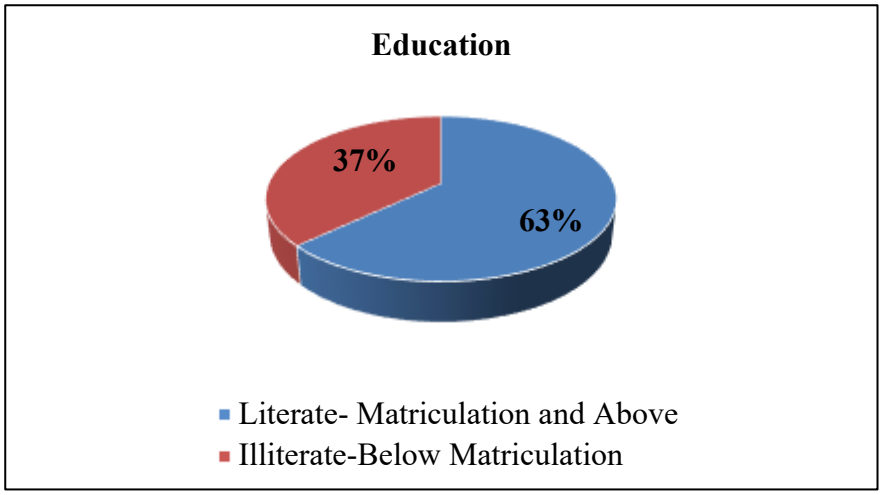

Figure 12. Education qualification of thalassemia patients in Odisha

Education is most important parameters in compare to other parameters and prevent spreading the thalassemia also depend the qualification of patients in Odisha. The previous discussion had important factors like age groups, living status, educations, geographical distributions, gender, etc [67].

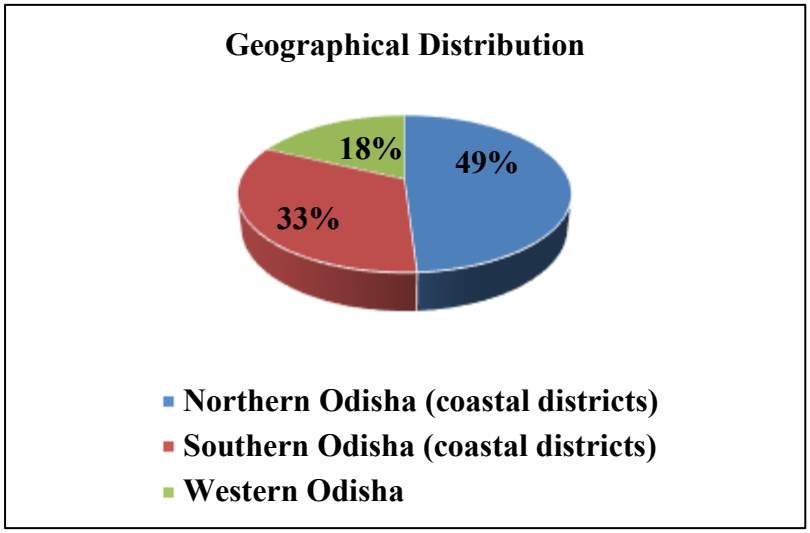

Figure 13. Geographical distribution of thalassemia patients in Odisha.

The geographical regions have some important role spreading of thalassemia, the percentage like 49%, 33%, 18% in Northern, Southern, and Western Odisha respectively. There is no scientific justification of regional distributions of thalassemia but education is the important factor for prevention of thalassemia in Odisha.

The hepato-spleenomegally was seen in 15% and 90% cases respectively. There was clinical jaundice in 20% followed by 7% cases showed growth retardation. Blood transfusion requirement was observed in 90% cases as 1-2 units per month. The coming to the hematological findings the mean hemoglobin was 5.4 ± 1.8 ranges 3gm % to 8gm % followed by reticulocyte count 4 ± 1.8 ranges 1%-7 %, Serum bilirubin mg/dl 3.41± 1.83 ranges 0.8 to 5.8 and LDH units per liter (U/L) 549 ± 116.98 ranges 150-730. Similarly, the mean HbF % was 83.58 ± 9.30 ranges (70.2 to 94) which is markedly increased followed by HbA2 (%) 2.63 ±1.09 ranges (1.1% to 4.3%) and HbA 1.51 ± 0.32 ranges (0 to 2.1%) suggestive of beta thalassemia [62].

Another study in Odisha, out of total patients 51.4% are being male as well as 48.6% female. 40.3% are belong to 5-10 years age group and 32.4% are 1-5years of age group. O +VE blood group are being most predominant i.e, 35.3% subsequent B +VE is 27.7%, A +VE is 21.6%, AB +VE is 12.9%, O -VE is1.4%, B -VE is 0.7%, A -VE is 0.4% blood groups respectively.

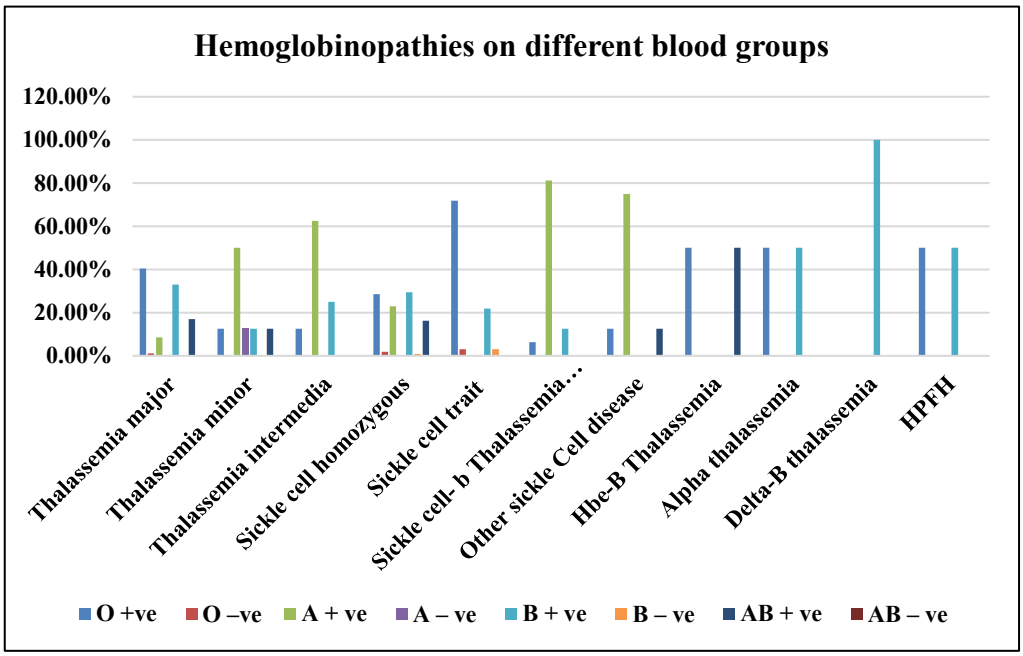

Figure 14. Hemoglobinopathy distributions among different blood groups of thalassemia patients in Odisha

The patients typically 34.9% belong to lower middle class of socioeconomic status 23.7% of lower, 21.6% of upper middle, 15.5% of upper lower and 4.3% upper classes [63].
In this investigation, among the β thalassemia major patients, O+ VE is 40.4% is the height percentage of blood group is recorded followed by B +VE is 33%, AB +VE is 16.2%, A +VE is 8.1% and O – VE is 1% blood groups [63].

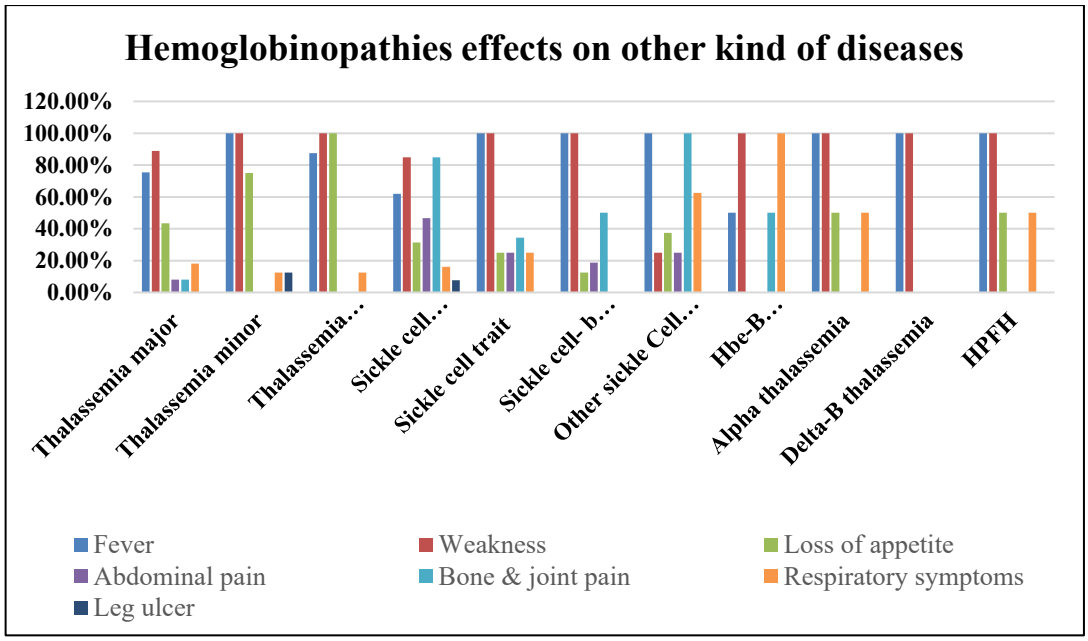

Figure 15. Effects of Hemoglobinopathies on other kind of diseases in thalassemia patients in Odisha

Here the population of hemoglobinopathies, Sickle cell homozygous is most prevalent i.e, 37.8% followed by β Thalassemia major (35.6%), Sickle cell trait (11.5%), Sickle β thalassemia syndrome (5.7%), β Thalassemia minor (2.9%), β Thalassemia intermedia (2.9%), Other sickle cell disease (2.9%), HbE-β thalassemia (0.7%)., α- thalassemia (0.7%), hereditary persistence of fetal hemoglobin (0.7%), δ-β thalassemia (0.4%). The difference of proportions of hemoglobinopathies among male and female is found to be statistically significantly different. In our study group female are more affected in Thalassemia intermedia (75%), sickle cell trait (71.9%), Sickle cell homozygous (59) patients whereas males are more affected in β Thalassemia major (67.7%), β Thalassemia minor (62.5%), δ-β Thalassemia (100%) & HPFH (100%) & other sickle cell disease (100%) patients. Males & females are equally affected in Sickle thalassemia syndrome, HbE-β Thalassemia & Alpha Thalassemia patients [63]. Out of total patients, 27.3 % patients had history of consanguinity of marriage of parents, 74.8% patients had history of blood transfusion before presenting to us & 25.9% patients had positive history of sibling affected with hemoglobinpathies. Weakness (84.2%) was the chief complain of most of the patients followed by fever (77%), bone & joint pain (43.9%), loss appetite (36.7%), abdominal pain (23%), respiratory symptoms (18.7%) and leg ulcer (2.9%). Anemia (97.1%) was the most common clinical finding in our study population

followed by splenomegaly (94.2%), hepatomegaly (91.4%), hemolytic facies (46%), jaundice (43.2%), chest signs (31.7%), other signs (31.7%), hand foot syndrome (29.5%), oedema (11.5%) & CNS signs (5.8%). Most of the patients were found to have multiple clinical signs. The Mean Hb was found to be 5.61 gm% with SD of 1.21. 35.3% cases of our study group had pre transfusion Hb range of 5.1-6 gm% followed by 23.7% in 4.1-5 gm% range, 15.1% in 6.1-7 gm% range, 13% in 7.1-8 gm% range, 8.6% in 3.1-4 gm% range & 4.3% in 8.1-9 gm% range [63].

Data Collection and Statistical Distribution of Hemoglobinopathy in South Odisha

Out of 1368 patients of hemoglobinopathies 917 cases were found to have sickle cell anemia and 451 cases were thalassemia (table-2). Sickling patients were more in Ganjam, Gajapati, Rayagada than Kandhamal. In Ganjam 48.75% (449) of the total (921) cases were found to have thalassaemia and 51.24% (472) of the total 921 cases were found sickle cell anemia alone. In Gajapati 229 number (16.73%) of sickle cell anemia major cases were reported out of total hemoglobinopathy cases. In Rayagada the sickle cell anemia was a major case where 179 numbers (34.7%) out of 515 patients were positive. In Kandhamal district there were minor cases of sickle cell anemia as 37(94.8%) out of 39 patients and 2 number (5.1%) were found to be thalassaemia.

Table 2. Region Wise Distribution of Hemoglobinopathy Cases in Southern Odisha

REGION WISE DISTRIBUTION OF THALASSAEMIA AND SICKLING PATIENTS IN SOUTHERN ODISHA

	GANJAM						GAJAPATI	RAYAGADA	KANDHAMAL
	Polasara	Buguda	Khalikote	Bhatakumarada	Kodala	Bhanjanagar	Paralakhemundi	Gunupur	Raikia
Thalassemia	2	396	19	22	8	2	0	0	2
Sickling	5	408	3	12	12	32	229	179	37

Age Distribution of Hemoglobinopathy Cases

In Ganjam maximum number patients were within 10 to 20 years of age range which was observed as 198 (21.49%) patients, 5 to 10 years consisted 190 (20.62%) numbers of patients, <5 years also were 102 (11.07%) in numbers, 20 to 30 years of age where 192 (20.84%) cases were found, 205 (22.25%) of patients were in the 30 to 40 years of age, 40 to 50 years consisted 135 (14.65%) cases and 50 to 60 years where 47 (5.5.1%) and >60 years were 11 (1.19%). In Rayagada district <5 years found to be 31 (17.3%) in numbers, 5 to 10 and 10 to 20 years of age group were found to be in equal proportions that is both are in 50 (27.90%) in numbers, which where maximum cases. 20 to 30 years of patients were found to be in 33 (18.4%) numbers and Only 6.7% and 1.1% of cases were above 30 and 40 years of age which are 12, 2 and 1 numbers of patients. In another district Gajapati all the hemoglobinopathy cases taken for study are <5 years as 27 (11.8%) number of patients, 5 to 10 years are 58 (25.3%) numbers of patients, 10 to 20 years are 84 (36.7%) in number which are maximum in Gajapati district and above 20 and 40 years were found to be 36 (16.7%) in numbers. In Kandhamal district unlike other districts this contains minor cases compared to others as 2.9% of hemoglobinopathy cases, <5years of patients are 2 (5.12%) in number, 5 to 10 years were 9 (23.07%),10 to 20 years were 6 (15.38%), 20 to 30 years of age consisted 7 (17.94%), 30 to 40 years of age were 8 (20.51%), 40 to 50 years of patients were 6 (15.38%) and above 50 years of age was only 1 (2.56%). The statistical data of age groups of the patients with respect to sample size has been shown in table 3.

Table 3. Statistical data and level of significance of mean age of patients.

Parameters	RAYAGADA	GAJAPATI	KANDHAMAL	GANJAM
Mean Age Of Patients In Years	14.4	14.6	24.1	26.6
Maximum	50	84	9	341
Minimum	1	6	1	51
Standard Deviation	22.35	31.85	18.73	122.98
Sample Number	179	229	39	921

Sex of Hemoglobinopathy Patients

The sex wise distribution of the hemoglobinopathy cases is presented in Table-4 and Figure-16. More numbers (66-90%) of female patients attended the health centers of all four districts of the southern Odisha state. In Ganjam 60% of the studied patients were female and male were 40%. More numbers (70%) of female patients were from Gajapati region. The tables 4 shows an overall dominance of female patients (sickle cell anemia-75% Thalassaemia-25%) among the studied patients.

Table 4. Sex wise distribution of hemoglobinopathy patients in Southern Odisha

Sex wise distribution of Thalassaemia and Sickle cell disease in Odisha

	MALE (in %)			FEMALE (in %)		
Name of regions	Sickle cell disease	Thalassaemia disease	Total	Sickle cell disease	Thalassaemia disease	Total
Rayagada	41%	_	41%	60%	_	60%
Gajapati	43%	_	43%	58%	_	58%
Ganjam	25%	25%	50%	26%	24%	50%
Kandhamal	37%	2%	39%	62%	_	62%

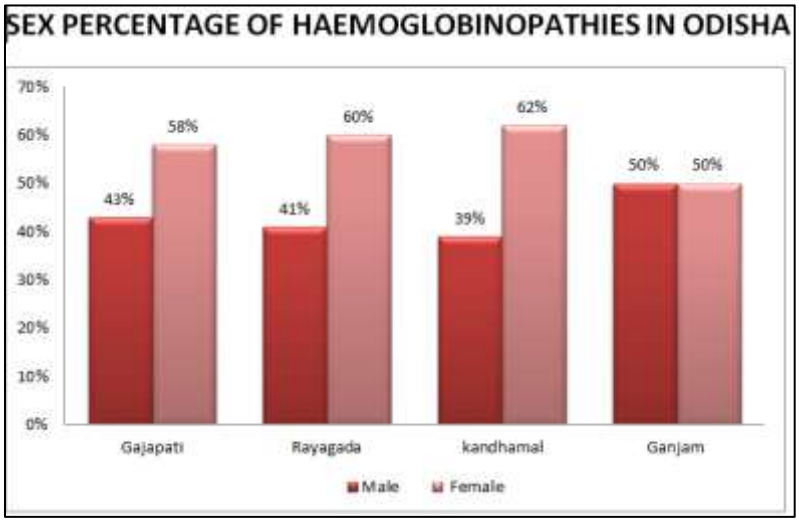

Figure 16. Sex percentage of Hemoglobinopathies in Southern Odisha

The sex wise distribution of hemoglobinopathy cases is depicted in Figure 16. More number of female hemoglobinopathy (sickle cell anemia) cases were reported as 52.26% form all four districts of southern Odisha. The percentage of male cases varied from 40 to 50% and an average of 47.73%.

CONCLUSION

Similarly, further research work on the remarkable field of Hemoglobinopathy provides crucial evidence about the spreading of the Hemoglobin disorders from high-frequency populations in different zone of southern Odisha. Various researchers have contributed the Hemoglobinopathy related diseases across the India and Odisha. In Odisha the research focused on the coastal part but still there should be more attention required for Southern part of Odisha. Very few results have been reported by some researchers about Hemoglobinopathy in Southern Odisha. Although a remarkable study has done on paediatric population of Southern Odisha but the whole Hemoglobinopathy study is required. From our statistical study, we found the burden of hemoglbinopathy of Southern Odisha and further work to be conducted on biochemical and molecular analysis. Hence further research work on the field of Hemoglobinopathy will provide crucial evidence about the dispersal of the Hemoglobin disorders from high-frequency populations in different zone of southern Odisha.

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