Genetic diversity of hemoglobinopathies, G6PD deficiency, and ABO and Rhesus blood groups in two isolates of a primitive Kharia Tribe in Sundargarh District of Northwestern Orissa, India

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Abstract Tribal communities constitute about 8.2% of the total population of India. Their health needs are even larger than elsewhere in India; this study investigates the genetic diversity in relation to hemoglobinopathies, G6PD deficiency and, ABO and Rhesus (D) blood groups in two sects, i.e. Dudh (converted Christian) and Dhelki (Hinduised) Kharia, a primitive tribe in Sundargarh district of Orissa in Central-Eastern India. A randomized screening of 767 Kharia tribals (377 males and 390 females) belonging to all age groups and both sexes was done. Laboratory analysis was carried out following the standard methodology and techniques. Contrasting differences were observed in the frequency of hematological genetic disorders such as β -thalassemia, sickle cell, hemoglobin E, G6PD deficiency, ABO and Rhesus (D) blood groups between the two subgroups. Dudh Kharia had no hemoglobin variant allele other than the high prevalence of β -thalassemia trait (8.1%), whereas, their counterpart Dhelki Kharia had the high prevalence of sickle cell allele (12.4%), hemoglobin E allele (3.2%), and β -thalassemia allele (4.0%). Frequency distribution of hemoglobin variants between Dudh and Dhelki Kharia tribe was statistically highly significant ($p < 0.001$). High G6PD deficiency was detected 19.2% and 30.7% in Dudh Kharia and Dhelki

Kharia, respectively ($p < 0.001$), the average being 24.4% in Kharia tribe. Kharia tribes show a trend for replacement of sickle cell gene with G6PD-deficiency gene as the clinical manifestations of G6PD deficiency are mild (do not result in a complete loss of enzyme activity) against the sickle cell disease with high morbidity and mortality. Rhesus (D)-negative blood group was 1.1% in Dudh Kharia and absent in Dhelki Kharia ($p < 0.05$). This study showed genetic isolation of the two sects of Kharia tribe. Antimalarial drugs administration needs to be done with caution. Hematological disorders pose a major health challenge having multifaceted implications in public health genetics.

Keywords Genetic isolates · Dhelki Kharia · Dudh Kharia · Hemoglobin variants · G6PD deficiency · India

Introduction

About a half of the indigenous people of the world live in India. The scheduled tribes constituted about 8.2% (67.8 million) of the Indian population according to 2001 census and are the descendants of the aboriginal communities in India (Bhasin and Walter 2001). There are 635 scheduled tribes and subtribes including 75 communities who have been designated as ‘primitive’ based on pre-agricultural level of technology, low level of literacy, stagnant or diminishing population size, relative seclusion (isolation) from the main stream of the population, economical and educational backwardness, extreme poverty, dwelling in remote inaccessible hilly terrains, maintenance of constant touch with the natural environment, and unaffected by the developmental process undergoing in India. The health status of any autochthonous community is influenced by the interplay of several factors such as socio-cultural,

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demographic, economic, educational, and political and health consciousness of the people. The common beliefs, traditional customs, myths, practices related to health, and disease in turn influence the health-seeking behavior (Balgir 2004).

The state of Orissa, the most picturesque state in Central-Eastern India, occupies a unique position in the tribal map of India having the largest number of scheduled tribe communities (62), unevenly distributed in forest and hilly areas including 13 primitive tribes with a population of over 8.15 million constituting 24.3% of the population of the state as per 2001 Census. The tribal panorama presents a kaleidoscopic mosaic in Orissa with various ethnic, linguistic, cultural, religious, moral values, traditions, folklore styles, food habits, and genetic strands maintaining at various levels of development—social, cultural, and economic life. They are mainly dependent on hunting, food gathering and shifting cultivation. They are not a homogeneous mass and cannot be lumped together for assessing their health needs, challenges, and problems in Orissa as they live in varied habitat and ecological niches (Balgir 2000).

Historical evidence has revealed that originally about 150–200 years ago before the British colonization in India, both Dudh and Dhelki Kharia tribes belonged only to one ethnic stock (Sinha 1987). Subsequently, they were bifurcated into two sects based on their religious proselytisation. It would be relevant and interesting to the international research community to study such tribes of other countries for knowing how the religious conversion and metamorphosed traditional socio-cultural and mating practices bring about diversified changes in the genetic structure of a community, leading to genetic diversity. In view of the above health scenario and limited genetic studies available on the tribal communities in India, this study presents the genetic diversity in relation to hemoglobinopathies, G6PD deficiency, and ABO and Rhesus (D) blood groups in two isolates of Kharia tribe, namely, Dudh (Converted Christian) and Dhelki (Hinduised) Kharia primitive tribe in Sundargarh district of Northwestern Orissa, India. This genetic diversity is discussed in relation to the history of the population structure and the consequences for future health care.

Subjects and methods

This study was a part of a major project undertaken on the ‘Intervention for hereditary common hematological disorders among the major tribals of Sundargarh district of Orissa’ carried out during the period from January 2000 to December 2004 with the financial support from the Ministry of Health and Family Welfare, Government of India through the Indian Council of Medical Research

(ICMR), New Delhi, at Regional Medical Research Centre (ICMR), Bhubaneswar, Orissa in Central–Eastern part of India. Ethical approval was obtained from the Human Ethical Committee, Regional Medical Research Centre (ICMR), Bhubaneswar, Orissa, India.

Geographical location

The district of Sundargarh is situated in the northwestern part of the state of Orissa in Central-Eastern region of India. This district is a bordering district surrounded by two states, namely, Jharkhand in the north and Chhattisgarh in the west. The Keonjhar district of Orissa is in the East, and Jharsuguda, Sambalpur, and Deogarh districts of Orissa are located in the Southern part of it. This study was carried out in Sundargarh district of Orissa.

Background of Kharia tribe

Traditionally, Kharia tribe is a hunting and food gathering community, practicing shifting cultivation, and following the tribal endogamy. The tribe, although originally belonged to one ethnic stock, but now divided into three social groups, namely, the Hill Kharia (Pahari or Paudi), Dudh (Pure) Kharia (converted Christian), and Dhelki (Late Comer) Kharia (Hinduised), and are distinguished from each other on the basis of three grades of primitive culture in the state of Orissa (Balgir 2005a). The Hill Kharia, the primitive and backward section, represents the hunting and food gathering stage of economic life along with the practice of primitive culture and rudimentary shifting cultivation. The Dhelki Kharia section represents the more advanced culture with habit of plow cultivation and food production. The Dudh Kharia people have the most advanced culture, which equates them with other nontribal population of the region. The Dudh Kharias have embraced Christianity about one and half century ago, whereas, the Dhelki Kharias are Hinduised group. The latter group preponders over the other two groups in population size. The inter-group marriages are not taking place at all. Reproductively and genetically, they are completely isolated from each other. The Hill Kharias who reside in Mayurbhanj district of Orissa were not studied. The scatter and distribution of these tribes in particular locality is shown in the Adivasi Atlas of Orissa (Sinha 1987).

Sampling procedure

The present study adopted a randomized sampling procedure for each subgroup of tribe living in entirely different

eco-niches by selecting exclusive villages from each cluster of Kharia tribe in three blocks, namely, Balisankara (Dhelki Kharia); Bargaon and Subdega (Dudh Kharia). From each cluster of villages, two villages were randomly selected to cover the approximate sample size of 1,000 persons. Screening for hemoglobinopathies, β -thalassemia syndrome, G6PD deficiency, and ABO and Rhesus (D) blood groups was carried out irrespective of the age, sex, and individual morbidity (susceptibility) pattern. A total number of 767 Kharia tribals (377 males and 390 females) of which 345 Dhelki Kharia (181 males and 164 females) and 422 Dudh Kharia (196 males and 226 females) belonging to all age groups, were studied from Sundargarh district of Orissa.

Blood collection

About 2–3-ml intravenous blood samples were collected by disposable syringes and needles from each individual using ethylene diamine tetra acetic acid (EDTA) as anticoagulant after obtaining the informed/written consent in the presence of a doctor and community leaders. On request, the local Primary Health Centre (PHC) doctor recorded all the signs and symptoms related to hemoglobinopathies after clinical examination on the pre-designed proforma. Other ailments were treated/referred to local health facilities. Blood samples so collected were transported to the laboratory at Bhubaneswar under ice-cold conditions within 24 h of collection. Laboratory investigations were carried out following the standard procedures after cross-checking for quality control from time to time. Hematological parameters were studied by using an automated Blood Cell Counter (Model: MS4 Melet Schloesing Laboratories, Cergy-Pontoise Cedex, France).

Laboratory investigations

The sickling test was performed on red cells by using freshly prepared 2% sodium metabisulphite solution as reducing agent (Dacie and Lewis 1991). The routine hemoglobin electrophoresis was carried out on cellulose acetate membrane (CAM) in Tris-EDTA-Borate buffer at pH 8.6 and quantification of A_2 fraction of hemoglobin by elution method (Weatherall 1983). A value of more than 3.5% of A_2 hemoglobin was taken as cut-off point for determining the β -thalassemia trait. Estimation of fetal hemoglobin was done as described by Weatherall (1983). Confirmation for the presence of hemoglobin E was done as described elsewhere (Balgir 2003; Balgir et al. 2003). Family studies were carried out to confirm the diagnosis, wherever it was felt necessary.

G6PD enzyme deficiency was primarily detected by using dichlorophenol indophenol dye as described by Bernstein (1962). G6PD activity in females depends on the proportion of normal to deficient cells. In most of the cases, the normal activity varies from 20% to 80%. However, a few heterozygotes (about 1%) may have almost only normal or almost only G6PD-deficient cells. The present study has not at all encountered any such ambiguity; therefore, there were either 60–80% normal cells or deficient cells in all cases. Subsequent confirmation was done by following the Beutler et al. (1979) and WHO procedures (1967) in case any doubt arose for the detection of G6PD deficiency. The typing of ABO and Rhesus (D) blood groups was done as per the instructions of the manufacturer (Tulip Diagnostics Private Limited, Panaji, Goa) in India.

Data obtained were analyzed and statistically tested applying Chi-square test and Student *t* test for the difference, if any between the variables studied and subtribe variations; and the significance indicated in the text.

Results

Table 1 presents the village-wise distribution of hemoglobinopathies, thalassemia syndrome, G6PD deficiency, and Rhesus (D) negative among the subgroups of Kharia tribe of Sundargarh district in Orissa. The frequency of β -thalassemia trait was significantly higher ($p < 0.001$) in Latagaon (Bargaon Block) village (11.4%) than in Ranpur (Subdega Block) village (3.0%) in Dudh Kharia tribe. Similarly, Rhesus (D)-negative blood group phenotype was very low in Latagaon (2.0%), whereas, it was absent in Ranpur village. The frequency of G6PD deficiency was although higher in Ranpur village (24.0%) than in Latagaon (16.1%), but the difference was statistically not significant.

On the other hand, the frequency of β -thalassemia trait was higher in Chandnimal village (8.2%) than in Sarbahal village (1.7%) of Balishankara Block, and the difference was statistically significant ($p < 0.05$) in Dhelki Kharia tribe (Table 1). The frequency of sickle cell disorders (trait and disease) was significantly higher ($p < 0.05$) in Sarbahal (15.1%) than in Chandnimal (7.4%) village. Similarly, the frequency of G6PD deficiency was significantly higher ($p < 0.01$) in Sarbahal village (36.7%) than in Chandnimal village (19.7%) in Dhelki Kharia Tribe.

The frequency of β -thalassemia trait was double in Dudh Kharia (8.1%) than in Dhelki Kharia (4.0%) which was statistically significant ($p < 0.05$) with an overall frequency being 6.2% in Kharia tribes. It was surprising to know that none of the Dudh Kharia had any other hemoglobin variant other than the high prevalence of β -thalassemia trait (8.1%). No case of thalassemia major or thalassemia

Table 1 Distribution of hemoglobinopathies, thalassemia syndrome, G6PD deficiency, and Rhesus (D) negative among the subgroups of Kharia tribe in Sundargarh district of Orissa, India

Diagnostic categories	Village	Dudh Kharia						Dhelki Kharia						All Kharia	
		Latagaon		Ranpur		Total		Sarbahal		Chandnimal		Total			
		N=255		N=167		N=422		N=223		N=122		N=345		N=767	
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
β -thalassemia trait	Male	12	4.7	1	0.6	13	3.1	1	0.4	5	4.1	6	1.7	19	2.5
	Female	17	6.7	4	2.4	21	5.0	3	1.3	5	4.1	8	2.3	29	3.8
	Total	29	11.4	5	3.0	34	8.1	4	1.7	10	8.2	14	4.0	48	6.2
Sickle cell trait	Male	0	0.0	0	0.0	0	0.0	21	9.4	4	3.3	25	7.2	25	3.3
	Female	0	0.0	0	0.0	0	0.0	11	4.9	5	4.1	16	4.6	16	2.1
	Total	0	0.0	0	0.0	0	0.0	32	14.3	9	7.4	41	11.8	41	5.4
Sickle cell disease	Male	0	0.0	0	0.0	0	0.0	1	0.4	0	0.0	1	0.3	1	0.1
	Female	0	0.0	0	0.0	0	0.0	1	0.4	0	0.0	1	0.3	1	0.1
	Total	0	0.0	0	0.0	0	0.0	2	0.8	0	0.0	2	0.6	2	0.2
Hemoglobin E trait	Male	0	0.0	0	0.0	0	0.0	4	1.8	2	1.6	6	1.7	6	0.8
	Female	0	0.0	0	0.0	0	0.0	3	1.3	1	0.8	4	1.2	4	0.5
	Total	0	0.0	0	0.0	0	0.0	7	3.1	3	2.4	10	2.9	10	1.3
Hemoglobin E disease	Male	0	0.0	0	0.0	0	0.0	1	0.4	0	0.0	1	0.3	1	0.1
	Female	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
	Total	0	0.0	0	0.0	0	0.0	1	0.4	0	0.0	1	0.3	1	0.1
G6PD deficiency	Male	17	6.7	19	11.4	36	8.5	44	19.7	11	9.0	55	15.9	91	11.9
	Female	24	9.4	21	12.6	45	10.7	38	17.0	13	10.7	51	14.8	96	12.5
	Total	41	16.1	40	24.0	81	19.2	82	36.7	24	19.7	106	30.7	187	24.4
Rhesus(D) negative	Male	1	0.4	0	0.0	1	0.2	0	0.0	0	0.0	0	0.0	1	0.1
	Female	4	1.6	0	0.0	4	0.9	0	0.0	0	0.0	0	0.0	4	0.5
	Total	5	2.0	0	0.0	5	1.1	0	0.0	0	0.0	0	0.0	5	0.6

intermedia was encountered in the Kharia tribes. Abnormal hemoglobin D and hereditary persistence of fetal hemoglobin could not also be detected in Kharia tribes. Sickle cell disorders (in trait and disease form) were detected in high frequency (12.4%) and hemoglobin E (in trait and disease form) in low frequency (3.2%) in Dhelki Kharia tribe only. The G6PD deficiency was 19.2% and 30.7%, respectively in Dudh and Dhelki Kharia tribe ($p < 0.001$) with an average of 24.4% in Kharia tribes. Rhesus (D)-negative blood group was detected in low frequency (1.1%) in Dudh Kharia only ($p < 0.05$). The hemoglobin variants distribution between Dudh and Dhelki Kharia tribe was statistically highly significant ($p < 0.001$).

A comparative account of hematological indices of different diagnostic categories of hemoglobin disorders in Kharia tribes is given in Table 2. The homozygous sickle cell disease and hemoglobin E disease cases showed comparatively lower values of hematological indices than that of heterozygous cases such as sickle cell trait, hemoglobin E trait, and β -thalassemia trait in Kharia tribes of Orissa (Table 2). As compared to the hematological

disorders, the distribution of ABO blood groups is very similar in Kharia tribes of Sundargarh district in Orissa. However, the frequency of blood-group B preponders over A in all the subgroups except Dudh Kharia of Ranpur village of Subdega Block in Sundargarh (Table 3).

Discussion

The main conclusion is that there are large differences in the frequencies of hemoglobinopathies, β -thalassemia, G6PD deficiency, and Rhesus (D) blood group, while the ABO blood group distribution is quite similar. ABO blood groups represent more ancient variability that has not been modified by chance or recent heterozygote advantages. The most outstanding finding of this comparative study is the high prevalence of both inherited erythrocytic hemoglobin disorders and G6PD deficiency affecting the genetic structure, health profile, and quality of life of primitive Kharia tribe in Northwestern Orissa. The overall elevated frequency of different hemoglobin variants (13.3%) in

Table 2 Hematological indices and estimation of Hb A₂, Hb F, and Hb S/D in different diagnostic categories in Kharia Tribe (sexes combined) of Sundargarh district of Orissa, India

Diagnosis	Hb g/dl mean/SD	RBC X10 ⁶ /μl mean/SD	HCT% mean/SD	MCV fl mean/SD	MCH Pg mean/SD	MCHC g/dl mean/SD	WBC X10 ³ /μl mean/SD	Hb A ₂ % mean/SD	Hb F% mean/SD	Hb S% mean/SD
SCT (N=42)	11.3±2.2	5.8±1.1	41.5±9.0	72.2±5.5	19.7±0.1	26.8±1.7	7.0±4.6	2.5±0.6	1.4±0.9	21.4±3.7
SCD (N=2)	10.2±1.6	5.0±1.2	34.3±4.5	68.2±4.5	20.2±0.3	29.7±2.6	6.2±2.3	2.1±0.6	15.7±5.7	–
Hb AE (N=10)	10.8±1.6	5.1±0.5	35.8±5.9	69.4±8.2	19.8±1.6	27.5±1.1	8.1±2.2	31.1±4.2	0.6±0.2	–
Hb EE (N=1)	9.1	5.2	34.0	65.0	17.4	26.7	6.4	98.2	0.9	–
β-Thal.T (N=48)	10.9±1.7	5.3±0.5	39.6±2.7	75.4±5.2	20.6±2.2	27.9±1.6	6.9±1.9	4.7±0.7	0.7±0.3	–
Normal control (N=1419)	11.0±1.6	5.1±0.7	39.3±5.4	77.1±7.8	21.6±2.9	28.0±2.2	6.2±2.4	2.3±0.5	1.4±0.6	–

SCT sickle cell trait, SCD sickle cell disease, HbAE hemoglobin E trait, HbEE hemoglobin E disease, β-Thal.T beta-thalassemia trait, HbAA adult hemoglobin

Kharia tribe might be significantly contributing to the high morbidity and mortality in the vulnerable people. The practice of marital and territorial endogamy further complicates the segregation of abnormal genes in a hyper-malaria-endemic district of Sundargarh in Orissa. This may also lead to consanguinity (inbreeding), resulting in homozygosity of the recessively inherited defective alleles (homozygous sickle cell disease, hemoglobin E disease, or combination of both variants and aberrant heterosis with G6PD deficiency) in the vulnerable tribal communities of Orissa.

Sickle cell disorders (trait and disease) and β-thalassemia trait are the most frequently encountered hemoglobinopathies in Kharia tribes (Table 1). The frequency (5.6%) of sickle cell disorders (trait and disease) as well as the prevalence of β-thalassemia trait (6.2%) was quite high in Kharia tribes. A remarkable difference observed between the two groups was the absence of hemoglobin variants except β-thalassemia trait in Dudh Kharia tribe. This finding indicates the isolation of two tribal sects with the passage of time, originally having a common ethnic stock about one to two centuries ago. Dudh Kharias had embraced Christianity, whereas, the Dhelki Kharia tribals had come under the umbrella of Hinduism from traditional worshiping of tribal gods and deities. The

marriage between these two sects is now prohibited. These two sects of Kharia tribe show the evolutionary trend of the founder effect and/or genetic drift as reported among other populations (Balgir and Sharma 1988). These findings get further support from our earlier studies (Balgir et al. 2003; Balgir 2005a) conducted on this community.

Hemoglobin E allele was detected in heterozygous and homozygous form in Delki Kharia tribe for the first time in Sundargarh district of Orissa. However, the cases of hemoglobin E had earlier been reported in other caste populations in the coastal region of Orissa, West Bengal, and North Eastern part of India (Balgir 2004, 2005b). The presence of hemoglobin E among the Delki Kharia tribe suggests the admixture with other tribes and/or nontribal populations of West Bengal or North Eastern India among whom this trait is quite frequently observed (Balgir 1995, 2003). However, tracing of the history of these affected cases and our verbal queries about any biological interaction with the populations of the above-mentioned states did not confirm the migrations or admixture with the populations of North Eastern India.

At population level, it is evident from the present study that the frequency of G6PD deficiency (30.7%) is higher than the combined different hemoglobin variants (13.3%) in

Table 3 Distribution of ABO and Rhesus (D) blood groups in subgroups of Kharia tribes of Sundargarh district in Orissa, India

Name of village/tribe	A		B		AB		O		Total		Rh (D) negative	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Sarbahal (Dhelki Kharia)	64	28.8	76	34.2	39	17.6	43	19.4	222	100.0	1	0.5
Chandnimal (Dhelki Kharia)	32	26.4	39	32.2	10	8.3	40	33.1	121	100.0	1	0.8
Total Dhelki Kharia	96	28.0	115	33.5	49	14.3	83	24.2	343	100.0	2	0.6
Latagaon (Dudh Kharia)	60	27.0	70	31.5	27	12.2	65	29.3	222	100.0	5	2.3
Ranpur (Dudh Kharia)	52	31.1	43	25.7	18	10.8	54	32.3	167	100.0	2	1.2
Total Dudh Kharia	112	28.8	113	29.0	45	11.6	119	30.6	389	100.0	7	1.8
Kharia Tribes	208	28.4	228	31.1	94	12.8	202	27.6	732	100.0	9	1.2

Dhelki Kharia tribe. Co-existence of two hematological genetic mutations predominating one (G6PD deficiency) over the other to counter lethal effects of malaria is an interesting one. Both Kharia groups probably show a trend for replacement of sickle cell gene with G6PD deficiency gene. Since the selection favors the mutation with least cost to the population (as the clinical manifestations of G6PD deficiency are mild and do not result in a complete loss of enzyme activity against the sickle cell disease with high morbidity and mortality in the region), it seems that the replacement of the sickle cell allele for G6PD-deficient allele is occurring in Kharia tribe of Orissa. Historical evidence is virtually absent to support that G6PD deficiency in the Kharia community was less frequent in earlier times. However, high morbidity and reproductive wastage in sickle cell disorders (trait and disease) has been reported (Balgir 2007a). G6PD deficiency in the red cells inhibits the malaria parasite survival (Balgir 2006, 2008). This study indicates the possibility of mechanism(s) how selection operates against malaria when two mutations occur in the same geographical region. It seems that natural selection had played a major role initially in favor of the mutations of sickle cell or β -thalassemia, and later on for G6PD deficiency so that they have probably evolved as a protective mechanism against the lethal effects of malaria in this part of the country. This medical aspect is important from an evolutionary biological point of view. These findings are consistent with our previous studies carried out in the state of Orissa in Central-Eastern India (Balgir 2006). It is difficult to say with the present set of data that this replacement is going on, or has ever taken place. Further specific studies on this aspect repeated after 10 years or so may yield some vital clues for understanding the true mechanism of operation of natural selection.

The high occurrence of G6PD deficiency in Kharia tribe has multifaceted biomedical and public health genetics implications. The G6PD deficiency decreases bactericidal activity of neutrophils as a result of which the subject becomes prone to repeated infections leading to high morbidity and mortality. In deficient individuals, the enzyme is also lower than normal in leucocytes, platelets, liver, kidneys, and adrenals. In enteric fever, pneumonia, and hepatitis, G6PD-deficient subjects can react more severely and hemolysis can complicate the course of disease. Apart from important manifestations of oxidative stress causing hemolysis (severe hemolysis after consuming large quantities of soft drinks containing ascorbate) and other complications, its association with hypertension, cardiac disease, diabetes mellitus, drug-induced renal shutdown, preeclampsia, antimalarial therapy, aging process, and infertility has been attributed. Unfortunately, all the above-mentioned diseases are quite common in India and might be exaggerating the outcome of administration of

drugs/treatment in some susceptible cases in vulnerable communities such as the Kharia primitive tribe. G6PD-deficient subjects need to be protected from hemolysis-causing agents and antimalarial drugs administration needs to be done with caution.

Comparatively, the absence or less number of homozygous cases of sickle cell anemia among the Kharia tribe in the present study indicate almost similar conditions in those tribes who are economically worse off with hemoglobin level, poor nutrition and low earning capacity, and poor access to health care facilities. This leads to increased mortality during neonatal, infancy, and early childhood (Kaur et al. 1997; Balgir 1999, 2007a). Inherited hemolytic disorders are not curable and cause high degree of morbidity and mortality in India, thus, need special intervention strategies for prevention and control (Balgir 1999, 2004, 2007b). It is indeed a Herculean task to cater the needs of such a huge population of affected persons with the available advanced curable modern techniques, which are still in infancy stage in India.

Health is a prerequisite for human development and is an essential component for the well-being of mankind. This study gives an insight into the disease prevalence, morbidity pattern, and possible explanation for health status of tribal people. Bringing health awareness through information, education, and communication activities, prenatal diagnosis, timely intervention, and genetic/marriage counseling can prevent many of these genetic and hematological disorders (Balgir 2001, 2007b). Although a tremendous scientific advancement in preventive and curative medicine has taken place, the health care delivery in this area is still poor which needs to be strengthened. It is highly essential to achieve the sustainable health development among the tribal communities of Orissa in particular and in India, in general.

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