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Incidence of Sickle Cell Anaemia and Thalassaemia in Central India

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ABSTRACT

Haemoglobinopathies are group of diseases characterized by abnormalities both quantitative and qualitative in the synthesis of haemoglobin. Haemoglobinopathies consist of sickle cell anaemia (SCA), thalassaemia (β^T) and variant haemoglobins. In India, they are responsible for the largest number of genetic disorders and hence are of great public health hazardous. In India major concerned haemoglobinopathic disorders are sickle cell anaemia and β-thalassaemia. Of the several abnormal haemoglobin molecules, four which are widely prevalent in India include: HbS, Hbβ^T, HbE and HbD. Examination of 6463 individuals showed high incidences for haemoglobin variants, HbS and Hbβ^T in different ethnic groups, the frequency being varies from 0% - 20% and 0% - 9% respectively. The frequency of HbS in Brahmins is 4.17%, in Kalar 5.41%, in Rajput 2.04%, in Muslims 3.73% in Maratha 2.08% in Bania 9.09% while in Teli it is 3.65%. Among the Scheduled castes and Nomadic tribal groups HbS ranges from 1% - 12%; in backward caste categories it varies from 3% - 16%; while in Scheduled tribes it ranges from 0% - 20%. The high magnitude of sickle cell trait has been noticed in the Pardhan (20.31%) followed by the Marar (16.10%), the Dhiwar (11.90%), the Gond (11.89%), the Mahar (11.81%) and the Bania (9.90%). A considerable high frequency (9.27%) of β-thalassaemia has been observed among the Sindhi population. Sporadic occurrence of Hbβ^T and HbD among other communities suggested the gradual spread of the genes into the region. The present findings in 11 communities with the thalassaemia syndrome suggest that the β-thalassaemia is accompanied by raised level of HbA_2. Unusual greater mean RBC and WBC suggest the high concentration of hypochromic microcytosis in anaemia. The mean MCV and MCH in Hbβ^T and HbD are much lower than the normal ranges compared to HbS. The mean MCHC is much lower in Hbβ^T, HbDD and HbS than the normal range. The cumulative gene frequency of haemoglobinopathies in India is 4.2%. With a population of over 1 billion and a birth rate of 28 per 1000, there are over 42 million carriers and over 12,000 infants are born each year with a major and clinical significant haemoglobinopathy. Out of these, clinically significant sickle cell anaemia and β-thalassaemic disorders account for almost equal numbers.

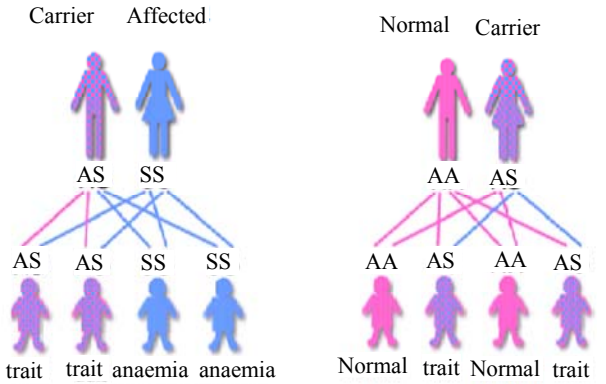
Keywords: Haemoglobinopathies; Sickle Cell Anaemia; Thalassaemia; Central India; Prevention; Management

1. Introduction

The haemoglobinopathies-sickle cell anaemia, thalassaemia and other abnormal haemoglobins contribute to genetic diseases and imbalance health profile of a nation in general and Vidarbha region in particular. The haemoglobinopathies are a group of inherited conditions that result in the synthesis of either a globins chain with an abnormal structure or reduced synthesis of a globins chain with normal structure leading to chain imbalance. The inherited disorders of haemoglobin are prevalent largely in tropical countries including India. The inherited genetic diseases of haemoglobin are controlled by a single gene that transmits from parents to offspring from one generation to another affecting millions of people throughout the world. Sickle cell anaemia (SCA) and thalassaemia (β^T) are such genetic disorders caused by point mutation, which are of major concern from the point of view of public health policy. Haemoglobin, a component of red blood cells, carries oxygen from the lungs to different body organs and tissues and brings carbon dioxide back to the lungs.

For the first time the presence of Sickle cell gene (HbS) in India was detected in Irula boy in Nilgiri hills in 1952 [1]. This deleterious gene was later on found in many parts of the country. Linus Pualing and his co-workers in 1950 obtained abnormal haemoglobin by electrophoresis in which the proteins with the same molecular weight but different charges migrate at different rates. J. Ingram in 1957 obtained the molecular change in the haemoglobin molecule of sickle cell anaemia.

Pattern of Inheritance



At present about 5 percents of the world's population are carriers of a potentially pathological haemoglobin gene (heterozygote condition). Every year about 300,000 infants worldwide are born with thalassaemia syndrome (30 percents) and sickle cell anaemia (70 percents). Globally, the percentage of carriers of thalassaemia is greater than that of carriers of SCA, but because of the high frequency of the sickle cell gene in certain regions the number of affected birth is higher than with thalassaemia. While the general incidence of β-thalassaemia trait and sickle cell haemoglobinopathy varies between 3 and 17 percents and 1 and 44 percents respectively, because of high consanguinity and caste and area endogamy some communities show high incidence making the disease a major public and genetic health problem in India [2,3]. Earlier reports show a very high frequency of sickle cell trait (> 20 percents) among the Mahar, Kurmi, Panka, Otkar, Pardhan, Pawara, Bhil etc. [4-20]. β-thalassaemia is a major monogenic single gene disorder resulting from a reduced or absent synthesis of β-globin chain. This mutant gene is common in communities like, Sindhi, Parsee and Lohana and different ethnic groups of Punjabi, Bengali, Gujarati etc. [21-24]. There are five haplotypes which are responsible for SCA namely, Senegal, Bantu, Benin, Asian and Camroon across the world.

2. Material and Method

A systematic mass screening camps were carried out in various schools and at the community level during which 6463 individuals comprising 3468 males and 2995 females from four districts of Vidarbha region were screened for haemoglobin S and haemoglobin β^T using solutions of qualitative solubility test and NESTROFT respectively. **Figure 1(a)** shows the area from where the data have been collected. Necessary consents as prerequisite were obtained from individuals before subjecting them to the tests. 20 µl blood samples were drawn from finger prick for each test and mixed thoroughly with solutions. Result for haemoglobin S variant was noted down after 3 minutes while for haemoglobin β-variant it was taken after about 20 - 25 minutes. The sample with turbidity and opaque was considered positive for sickle cell and thalassaemia [25]. 2 ml intravenous blood sample was drawn in B.D. vacutainer and brought to the DNA lab at CRC, Nagpur for further analysis. Haematological indices were measured using calibrated ERMA particle counter.

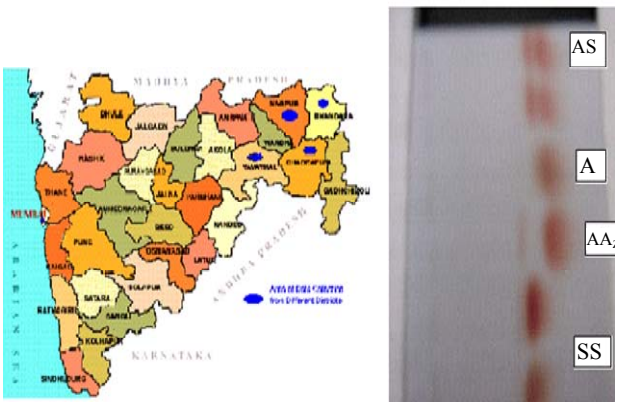
Laboratory investigations were carried out following standard procedure as described by Dacie and Lewis [25]. All the samples were subjected to haemoglobin electrophoresis using cellulose acetate membrane in alkaline TEB buffer at pH 8.9 for pattern confirmation. The known samples (control) of HbS and Hbβ^T along with present samples were run for electrophoresis. A_2 fraction of adult haemoglobin was estimated by elution method of 413 nm using spectrophotometer as well as HPCL. **Figure 1(b)** shows the mobility of pattern for different haemoglobin variants. A value of more than 3.5 percents for A2 was considered as the cut off point for determination of β-thalassaemia trait. Foetal haemoglobin was estimated by the method of Betke *et al*. [26].

Only male samples were subjected to for G_6PD deficiency status by florescent spottest [27].

3. Results

Total samples of 6463 individuals have been screened for sickle cell anaemia and thalassaemia with the qualitative solubility test and NESTROFT respectively. Out of which 374 (5.78 percents) and 145 (2.24 percents) individuals were shown to be positive for HbS for Hbβ^T respectively.

Table 1 portrays the frequency for HbS and Hbβ^T varies from 0.16 - 33.33 percents and 0.72 - 9.27 percents respectively. A very high frequency of HbS is recorded among the Pardeshi (25 percents) followed by the Pardhan (20.31 percents). A moderate frequency has been seen among the Dhiwar and the Bania (9.09 per-



(a) (b)

Figure 1. (a) Map of Maharashtra showing study area; (b) Position of Hb variants.

Table 1. Profile of Haemoglobinopathies in Vidarbha region of Maharashtra.

Community	No.	HbAA		HbAS		HbSS		β-thal		HbAD		HbDD	HbF
		M	F	No.	%	No.	%	No.	%	No.	%	No.	No.
Mahar	1651	751	699	195	11.81	8	0.48	-	-	-	-	-	4
Kunbi	185	77	99	9	4.86	-	-	-	-	-	-	-	-
Teli	329	177	140	12	3.65	-	-	-	-	-	-	-	-
Halba	139	86	49	2	1.44	-	-	1	0.72	1	0.72	-	-
Gond	230	103	99	27	11.74	-	-	1	0.43	-	-	-	-
Gowari	55	29	22	4	7.27	-	-	-	-	-	-	-	-
Marar/Mali	118	40	59	19	16.10	-	-	-	-	-	-	-	-
Bawane kunbi	23	11	11	1	4.35	-	-	-	-	-	-	-	-
Maratha kunbi	48	17	30	1	2.08	-	-	-	-	-	-	-	-
Dange kunbi	18	8	9	1	5.56	-	-	-	-	-	-	-	-
Kalar	111	56	49	6	5.41	-	-	-	-	-	-	-	-
Brahmin	144	89	49	6	4.17	-	-	-	-	-	-	-	-
Tirale kunbi	134	75	52	6	4.48	-	-	1	0.75	-	-	-	-
Khaire kunbi	246	94	129	23	9.35	-	-	-	-	-	-	-	-
Zade kunbi	13	7	5	1	7.69	-	-	-	-	-	-	-	-
Chambhar	54	28	25	1	1.85	-	-	-	-	-	-	-	-
Dhangar	43	25	17	1	2.33	-	-	1	2.33	-	-	-	1
Dhiwar	55	24	26	5	9.09	-	-	-	-	-	-	-	-
Pardhan	64	22	28	13	20.31	1	1.56	-	-	-	-	-	1
Kohali	37	16	20	1	2.70	-	-	-	-	-	-	-	-
Bania	11	8	2	1	9.09	-	-	-	-	-	-	-	-
Banjara	17	10	4	1	5.88	1	5.88	1	5.88	-	-	-	-
Muslim	161	117	38	6	3.73	-	-	-	-	-	-	-	-
Mehetar	62	29	32	1	1.61	-	-	-	-	-	-	-	-
Madgi	40	21	15	4	10.0	-	-	-	-	-	-	-	-
Dhobi	43	24	15	2	4.65	-	-	2	4.65	-	-	-	-
Rajput	49	28	18	1	2.04	-	-	1	2.04	-	-	1	-
Powar	113	57	52	2	1.77	-	-	4	3.54	-	-	-	2
Sutar	30	14	16	-	-	-	-	-	-	-	-	-	-
Lohar	59	26	32	1	1.69	-	-	-	-	-	-	-	-
Dhanoje kunbi	2	-	2	-	-	-	-	-	-	-	-	-	-
Lewa kunbi	4	1	3	-	-	-	-	-	-	-	-	-	-
Lonare kunbi	3	2	1	-	-	-	-	-	-	-	-	-	-
Katia	2	-	1	1	50.0	-	-	-	-	-	-	-	-
Navi	17	12	5	-	-	-	-	-	-	-	-	-	-

Continued

Sikh	40	25	11	-	-	-	-	1	2.5	3	7.5	-	-
Kumbhar	16	7	9	-	-	-	-	-	-	-	-	-	-
Beldar	21	13	8	-	-	-	-	-	-	-	-	-	-
Bengali	12	9	3	-	-	-	-	-	-	-	-	-	-
Marwadi	12	10	2	-	-	-	-	-	-	-	-	-	-
Sindhi	1241	549	562	2	0.16	-	-	115	9.27	9	0.73	4	-
Shimpi	12	8	3	-	8.33	-	-	-	-	-	-	-	-
Telugu	21	15	1	4.76	-	-	-	-	-	-	-	-	-
Matang	3	1	2	-	-	-	-	-	-	-	-	-	-
Pardeshi	4	1	2	1	25.0	-	-	-	-	-	-	-	-
Christan	28	22	6	-	-	-	-	-	-	-	-	-	-
Bais	6	2	2	2	33.33	-	-	-	-	-	-	-	-
Yadav	39	31	8	-	-	-	-	-	-	-	-	-	-
Kahar	8	6	2	-	-	-	-	-	-	-	-	-	-
Gujarati	13	6	7	-	-	-	-	-	-	-	-	-	-
Walmiki	4	1	3	-	-	-	-	-	-	-	-	-	-
Bhoyar	2	2	-	-	-	-	-	-	-	-	-	-	-
Burud	3	3	1	-	-	-	-	-	-	-	-	-	-
Khatik	7	4	3	-	-	-	-	-	-	-	-	-	-
Satnami	3	3	-	-	-	-	-	-	-	-	-	-	-
Nepali	3	3	-	-	-	-	-	-	-	-	-	-	-
Others	482	297	185	-	-	-	-	-	-	-	-	-	-
Total	6463	3192	2755	362		10		128	-	13	-	5	8

cents each), the Gond (11.74 percents each), the Mahar (11.81 percents), the Shimpi (8.33 percents), the Zade kunbi(7.69 percents), the Madgi (7.5 percents) and the Gowari (7.27 percents). An appreciable frequency of HbS has seen among the Banjara (5.88 percents), the Khaire kunbi (9.35 percents), the Dange kunbi (5.56 percents), the Kalar (5.41 percents), the Kunbi (4.86 percents), the Telugu (4.76 percents), the Tirale kunbi (4.48 percents), the Bawane kunbi (4.35 percents), the Brahmin (4.17 percents), the Muslim (3.73 percents) and the Teli (3.65 percents). However, in some of the sub-group and castes no abnormality of any Hb variant is seen. Since these cases represent the local population structure, they reflect the magnitude and vulnerability of the haemoglobinopathy in the population and the region (**Figure 2**). Most of the cases of haemoglobinopathy, in general are detected when they come forward casually find their status.

From the spectrum of haemoglobinopathies it has been observed that the sickle cell trait is the most common haemoglobinopathy (5.6 percents) followed by β-thalassaemia carrier (2.01 percents), sickle cell disease (0.15 percents) HbD trait (0.19 percents), HbD homozygous (0.08 percents) and HbSFβ^T (0.12 percents) were encountered.

The present study shows a moderate frequency of β-thalassaemia (9.27 percents) among the Sindhi. Sporadic occurrence of β-thalassaemia has also been found among other Hindu caste population in Vidarbha region (**Figure 3**). However, a very high frequency (8 - 17 percents) of the gene Hbβ^T has been reported among the Sindhi population of Nagpur [13,23].

The mean of all the haemotological parameters showed significantly lower levels and increased level of fetal haemoglobin (HbF) and A_2. The percent of A_2 ranges from 3.52 - 16.52. The mean WBC in SCT shows higher than the mean values for β-thalassaemia minor, HbAD and HbDD. The mean RBC of SCT shows lesser

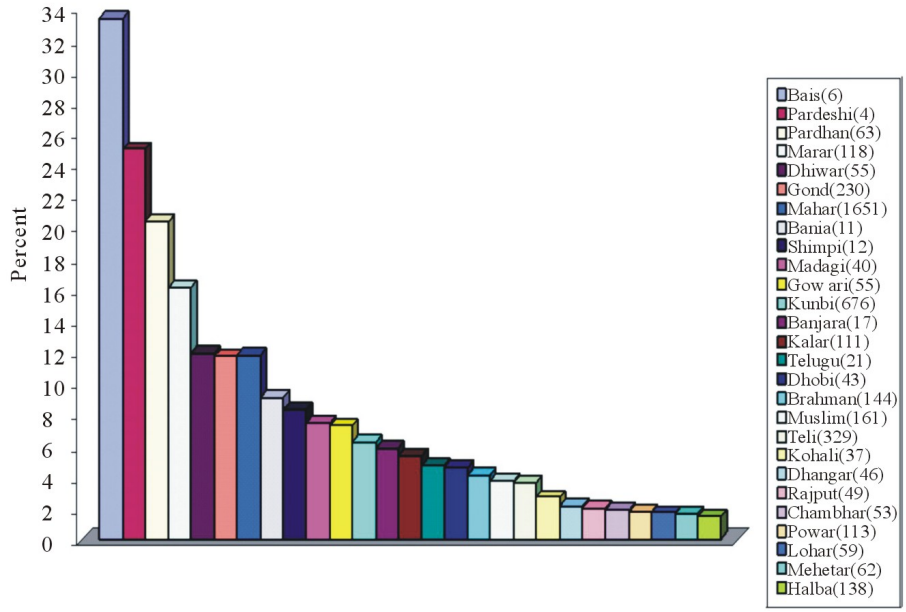


Figure 2. Community-wise frequency distribution of SCT in Vidarbha.

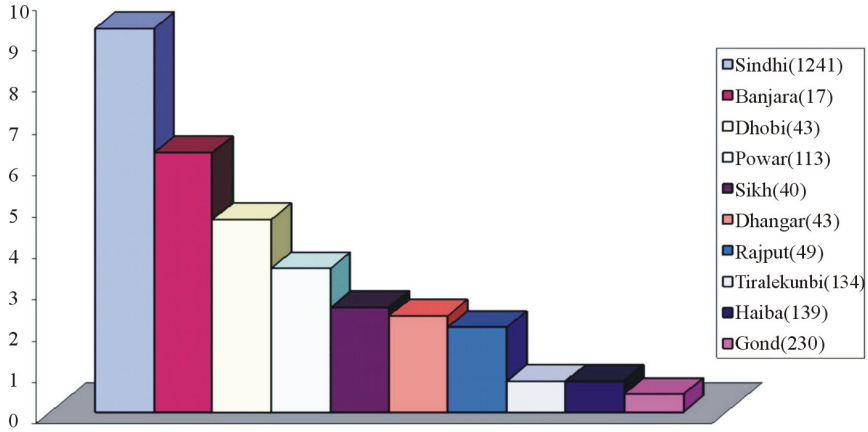


Figure 3. Community-wise frequency distribution of *β*-thalassaemia in Vidarbha region.

value than the mean for *β*-thalassaemia minor and HbDD. The mean values of Hb, MCV, MCH and MCHC among SCT of both male and female shows higher frequencies than their *β*-thalassaemia minor counterparts (**Figures 4 & 5**). However, the mean of all the above-mentioned haemotological parameters has been found much below than their normal ranges. The red cell count is relatively higher in relation to the haemoglobin and MCH in *β*-thalassaemia minor.

Evidently the HbS gene is prevalent in general castes like Brahman, Rajput, Kalar, Bania and Sindhi. Balgir [28] reported a very high frequency of *β*-thalassaemia in Khandayat, Brahmin and the Karan and HbS is no exception in these populations. Sinha *et al*. [29] reported the presence of HbS and Hbβ^T among the Bramin and Muslim. The present findings are in conformity with the above cited findings. Bhasin *et al*. [30] argued that the findings of HbS and Hbβ^T reported earlier elsewhere in India where the haemoglobinopathy is stated to be confined only in Scheduled tribes and Scheduled castes and that the general castes are not affected. This hypothetical assumptions lead to a major controversy in the field of haemoglobinopathies as the genetic disorders are of public health concerned rather than any ethnic specific.

It is apparent that the HbS gene has spread all over the region irrespective of caste or community. *β*-thalassaemia once it was stated to be confined to the Sindhi and Sikh, who migrated from Sindh region of Pakistan, has been detected in other communities. It is interesting to know that in all 11 communities among whom the *β*-thalassaemia has been found, were interviewed and said that no inter-caste marriages were taken place at least for

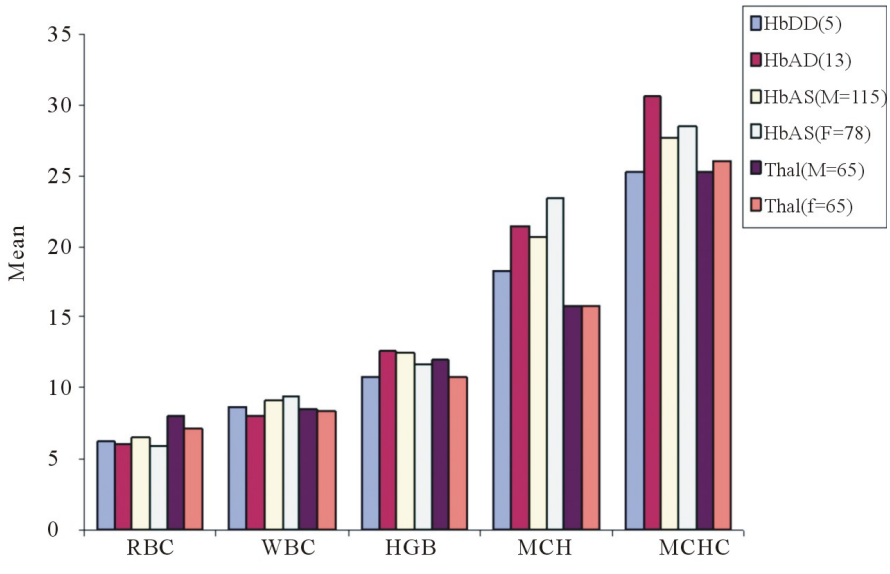


Figure 4. Distribution of mean of cell morphology.

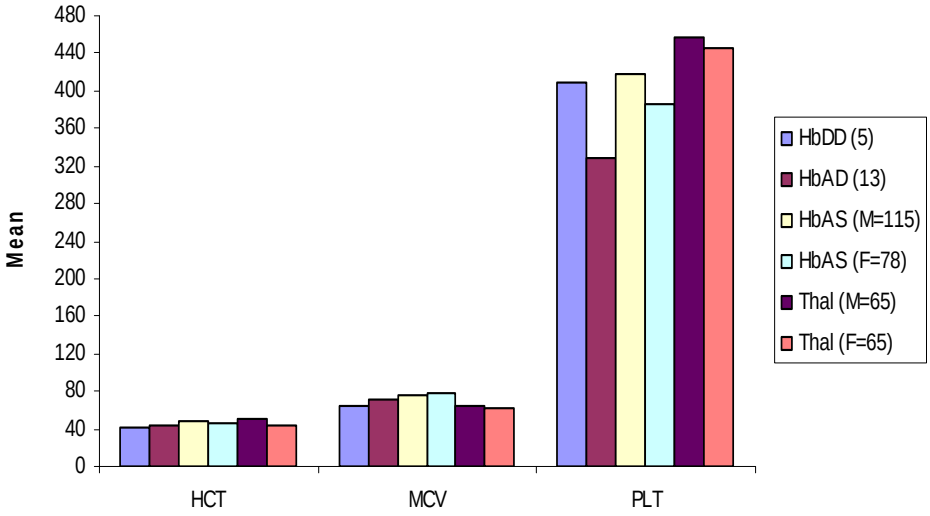


Figure 5. Distribution of mean of cell morphology.

3 - 4 generations except 2 - 3 cases of the Sindhi. The presence of HbD^{Punjab} gene among the Sindhi, Punjabi, Halba and the Rajput and absence in other communities is a clear indication that there is no spread of HbD^{Punjab} in the region.

Ironically, the majority of the cases (50.26 percents) of SCT have been found under childhood period (up to 15 yrs) followed by a reproductive age group (16 - 45 yrs; 46.63 percents). While the individuals of HbAD (68.75 percents) and β-thalassaemia carrier (53.12 percents) shows higher frequency of reproductive age. Only a few cases have been detected for HbS and $Hb\beta^{T}$ variants after reproductive age.

G6PD deficiency has been 10.94 percents among the β-thalassaemia (Sindhi population) and shows a significant association with thalassaemia whereas it was completely absent in sickle cell anaemia.

4. Discussion

The sickle cell anaemia and thalassaemia are the most severe form of genetic disorders and hence are of great importance to be dealt with from public health point of view in India. These two forms of haemoglobin variants prevalent at higher magnitude pose a great threat to population imbalance. Therefore, these inherited abnormalities of haemoglobin synthesis are the most serious public health problem in central India in particular and in

India in general reflecting the genetic heterogeneity of the population.

The earlier researchers have shown a complete absence of gene HbS in Muslims [31-34]. On the contrary to this, the present findings show the presence of gene HbS among the Muslim (3.73 percents) and is in agreement with earlier findings [28,29]. A very high frequency among the Pardhan was reported [9,11,12,35]. The present findings are in agreement with the findings [4] where they had reported a very high frequency of HbS among the Mahar and the Kunbi. Sickle cell is prevalent in Maharashtra, Madya Pradesh, Orissa, Andhra Pradesh, Gujarat, Tamil Nadu, Karnataka, Kerala and Uttar Pradesh [36]. The HbS gene is prevalent among the general caste including Brahmins and is in conformity with the findings reported [28,29].

The presence of the deleterious gene HbS in some groups and the complete absence in some groups indicates that the independent mutation might have taken place during early life of human being. It is evident from the literature that the several ethnic groups with varied genetic elements have been assimilated into the mainstream, resulting in population diversity with the passage of time [37]. This situation leads to the parallel divergence of sub groups of the same community that the one group with the deleterious gene emerged while another group of the same ethnic elements evolved unaffected during the course of time. Initially the mutation might have originated at first and gradually reached a high frequency in these populations. Sometime migration may also one of the reasons to carry mutant allele into other population, which ultimately reached a high frequency. The subdivision of the population of India by geographic, linguistic, religious caste and other barriers has resulted in the existence and perpetuation of thousands of distinct highly inbred communities [38]. This remarkable genetic heterogeneity is a distinctive feature of the Indian population accounts for uneven and variable distribution of the haemoglobinopathies [39]. Diffusion of HbS mutation from the Middle East region to India by Arab or Muslim expansion was proposed by Livingstone [40]. In most cases, HbS mutation in the Middle East and in India shares a common haplotype but the high prevalence of HbS among the tribal and scheduled caste populations of India and its relatively less among the Muslims does not convince the suggestion.

A considerable high level of HbF in few cases of sickle cell patient and β-thalassaemia carrier provides a protective mechanism in ameliorating the quality of life. A few incidences of splenomegaly have been observed in sickle cell patient, HbSβ^T and β-thalassaemia major. The persistence splenomegaly was greater in HbSFβ^T patients probably related to the raised HbF level found in Indian. Higgs *et al*. [41] reported a significantly greater persistence of splenomegaly in Jamaican. The effect of α-thalassaemia is not large enough to be noticeable in Indian populations [42] but this test was not done in the present study.

The spread of Hbβ gene in the region is due to gene flow or migration of people from north-west pre-independent India ie, Sindh region of Pakistan. It is evident from the present findings that the β haemoglobin is in abundance in endemic form in the present population from where they had spread to other part of the central India.

It is interesting to note that rapid proliferations of abnormal haemoglobins S and Hbβ^T in central India is due to castes and area endogamy and lack of medical facilities. These many aspects are the root causes for increaseing complexions of SCD and β-thalassaemia in central India.

The HbSβ-thalassaemia patients had more severe disease with lower Hb level, MCV and MCH than their counterparts having HbSS. The red cell count was relatively higher among HbSβ patients in relation of the haemoglobin and MCH in carriers of the thalassaemia may be due to production of extra microcytes. In the present study the detection of HbAD (5 percents) in the Sikh is in agreement with the earlier reports [21,24,43].

5. Conclusions

Haemoglobinopathies are the most common monogenic disorder affecting the millions of population worldwide. The geographical distribution of HbS and Hbβ^T variants in India is not uniform as the prevalence varies from 2 - 22 percent and 1 - 15 percent respectively in different region of the country. In central India the incidence of β-thalassaemia has been mainly attributed to its high prevalence in the migrant population of Sindhi origin. Screening of healthy population is required to determine the carrier rates and gene frequencies in this region. Because of the complications associated with haemoglobinopathies and frequent health crisis these genetic disorders are becoming a growing health care problem in all regions of the developing country. The urgent attention and need of the hour is to launch community based mass screening programme at large level to target the high risk population so that implementation and monitoring can be done to reduce the prevalence of haemoglobinopathies in the country.

The misbelieve/wrong notions that has been deeply rooted in the society is that, the presence of sickle cell gene among the lower castes is due to food habits as the people used to eat the flesh of dead animals during earlier days. Historically, the man used to eat animal flesh and tubers for his survival when he evolved until he learnt to produce food. Each and everybody were solely

dependent upon the nature, sharing a common platform and consumed same thing more or less equally whatever was available during that time. So it is worth mentioning here that every small group of population has something or the other genetic disorder as there is no association between caste or creed and disease. Therefore it is inappropriate to say that SCA is confined to the lower caste and tribal groups. Earlier researchers were mostly confined to tribal groups and hence they did not have any other option but to write about scheduled tribe. From the present study it may be stated that the presence of HbS among higher communities pave the way of transmitting this gene in to lower castes during ancient period as the higher caste people used to sexually exploit socially and economically backward populations. To suppress this fact, there was planned and a thoughtful view of earlier researchers [10,44] who stigmatised the Mahar from central India with the high rate of sickling so that the label of high SCA could remains with them. With the advent of modern technology it has been cleared now that the earlier food habit has nothing to do with the occurrence of sickle cell or thalassaemia in man. Occurrence of deleterious gene HbS and Hbβ^T among the people of different communities is due to alteration at the molecular level in the genetic material (DNA) what is called mutation. Sickle cell anaemia and thalassaemia are the best examples of point mutation as these disorders are caused by a single gene which is transmitted through parents to offspring from generation to generations. And this mutation has taken place independently in different communities in different areas across the world during the course of human evolution.

In present study the presence of HbS gene in almost all castes and communities demonstrate that sickle cell anaemia is no longer confined to specific ethnic groups; instead it is widely distributed in all tribal, scheduled caste, backward and higher caste populations' native to this region. Similarly, sporadic occurrence of Hbβ^T, HbD in the present study suggests the spread of Hbβ^T well beyond the Sindh and Punjab regions to central India. The high magnitude of HbS and β^T appears to contribute significantly to the load of haemoglobinopathies in this region which ultimately going to be a great challenge imbalancing the genetic constitution and threat to these populations in this region. Since many of the sicklers live up to 40 - 42 years with active reproductive life and carriers lead a normal life like healthy ones, they enhance the chance of propagation of deleterious genes of sickle cell anaemia, thalassaemia and other abnormal haemoglobin genes for generations together. It is not unrealistic to state that the presence of HbS, β^T and HbD in hitherto unreported communities from this region is due to of lack of research, under-diagnosis due to suspicion, prevailing bias and prejudices, stigma, complexity, defaming attitude, lack of awareness and absence of diagnostic facilities at prenatal stage.

In Maharashtra, the incidence of Hbβ^T has been mainly attributed to its high prevalence in the migrant population of Sindhi. The sporadic occurrence of Hbβ^T among other communities is the indication of either gradual spread of β-gene due to hybridization or due to independent mutation during the course of evolution which needs further indepth research at the molecular level to decipher the reason.

The most effective approach to tackle the menace of haemoglobinopathies, it is essential to offering genetic counselling, proper health education, sensitization to the individual concern, prenatal diagnosis and selective termination of pregnancy of the affected foetus are the remedial measures for prevention and management of haemoglobinopathies in India to see better tomorrow and healthy nation.

5.1. Prevention

1) Identification of groups at high risk through mass screening at the community level.

2) Carrier couples detected are informed of the genetic risk and advice for prenatal diagnosis.

3) Screening and counselling can lead to a significant reduction in affected births.

4) Strategy for prevention-provision of prenatal diagnosis for risk couple and screening of People of premarital/reproductive age.

5) Genetic counselling is essential to protect the autonomy of the individual. It should be sensitive to the cultural, religious and ethical views of the individual.

5.2. Management

1) Public education, genetics, detection of genetic risk the community, family history and premarital genetic counselling.

2) Nationwide programme for prevention and treatment.

3) A barrier to implementing effective haemoglobinopathy services is lack of awareness about genetic diseases. Improve understanding and awareness at community level.

4) Medical education and training courses should include modules on genetic counselling, the application of genetics to public health and the associated ethical, legal and social issues.

5) Due to lack of sufficient data on the epidemiology of haemoglobinopathies, research and surveillance are important for planning and evaluation of intervention.

6) Heamoglobinopathies are becoming challenging task to introduce genetic approaches to control other chronic

childhood diseases. Before formulating are effective programme, health authorities, health professionals and expert should perceive haemoglobin disorder as a public health problem.

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