

*Index*

# A BIOSOCIAL STUDY ON $\beta$ -THALASSAEMIA

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## CHAPTER-I

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### INTRODUCTION

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On a world wide basis hereditary forms of anemia are immensely common and affected persons are numbered in millions. Such hereditary disorders may be looked into on two levels: (1) biological level, and (2) familial or societal level. On biological level one should look into various types of manifestations of such diseases and their genetic consequences. On familial/societal level one has to look into the cost of maintaining such patients, psychological impact on the patients themselves and their parents, contributions of the patients to the society in terms of academics, workload, etc. The main purpose of such study should be to find out the types of welfare measures that could be taken for the patients and also to see how the social load could be reduced in the society.

Tyler et al. (1982, 1983) have found out how the families of the patients with Huntington's chorea (a genetic disorder) suffer from tremendous economic hardship to meet the expenses for treatment of those patients and also the patients themselves suffer from various types of disruption in family as well as in conjugal life. They have also

observed that there are other types of problems for such patients, e.g., employment opportunities, social adjustments, etc. Finally, they are of the opinion that the community as a whole is bound to suffer for such patients from social and economic points of view, if no suitable social measures are taken to rehabilitate those patients in proper and reasonable manner.

In the present study we shall consider only thalassaemia ( $\beta$ -thalassaemia). The thalassaemias are a group of inherited disorders of haemoglobin synthesis with varying severity, characterised by reduced rate of production of one or more of the globin chains of haemoglobin. This leads to imbalanced globin chain synthesis and to precipitation of the globin chains which are produced in excess. The major defects in red-cell maturation and survival, which characterise thalassaemia, are the direct result of the deleterious effects of the precipitated globin chains. It is now believed that it is one of the most common single gene disorders in the world. It produces a massive public health problem in many countries. It is true that it occurs in particularly high frequency in a broad belt, stretching from the Mediterranean through the Middle East, Indian subcontinent, Burma, and South-East Asia (Weatherall, 1983).

Ingram and Stretton (1959) have suggested that there are two main types of thalassaemia - (1)  $\alpha$ -thalassaemia -

occurring due to reduced rate of  $\alpha$ -chain synthesis and (2)  $\beta$ -thalassaemia - resulting from defective production of  $\beta$  chains. This suggestion of Ingram and Stretton (1959) has fully been confirmed by many subsequent studies on the rate of globin chain production.

If the gene is inherited from one of the parents the person will be in a heterozygous state with reference to the thalassaemia gene. In such a case of heterozygous state various terms like thalassaemia trait, thalassaemia minor, thalassaemia minima or Cooley's trait are used to express the underlying genetic heterozygosity. Generally the people in heterozygous state, i.e., with thalassaemia trait, are more or less in perfect health condition, though there can be mild to moderate anemia, slight elevation of HbA<sub>2</sub> (2.5 to 5 per cent), presence of small amount of HbF (if not all) and slight reduction in erythrocyte count. So in such cases, the clinical symptoms are usually nil or minimal (Chatterjea, 1965).

Sometimes the thalassaemia genes may be inherited from both parents, and the person will be genetically homozygote with reference to the thalassaemic gene. Such condition is known as thalassaemia major or Cooley's anemia in which the clinical manifestations are quite severe (Chatterjea, 1965).

Besides these two conditions, some individuals are found to have a thalassaemia gene, along with an abnormal

haemoglobin gene, which they inherit one from one parent and the other from the other parent. Such persons, possessing two dissimilar haemoglobinopathic genes, are said to be in "double heterozygote" state. In such case of a double heterozygote state (like HbS-thalassaemia, HbE-thalassaemia, etc.), the gene for thalassaemia interacts with the gene of relevant abnormal haemoglobin. such conditions lead to an enhanced production of abnormal haemoglobin, and thereby producing varying degrees of severe clinical disorder. In any case, in both homozygote and double-heterozygote states the thalassaemia patients suffer from severe anemia and many other haematological problems (Chatterjea, 1965; Weatherall, 1975).

#### **Clinical Picture of $\alpha$ - and $\beta$ -Thalassaemia**

The main cause for  $\alpha$ -thalassaemia is due to gene deletion when there is a possibility of losing from 1 to 4  $\alpha$ -genes, four abnormal conditions are found. The loss of a single  $\alpha$ -gene does not cause any pathological condition. In a foetus this deficiency of  $\alpha$ -chain leads to the production of an excess of  $\tau$ -chain, which forms  $\tau_4$  tetramer or Hb Barts. Around 2 to 3 per cent of haemoglobin is of this form. The condition is known as  $\alpha$ -thalassaemia-2. When two  $\alpha$ -genes are missing, it leads to a condition known as  $\alpha$ -thalassaemia-1; and at birth 5 per cent of haemoglobin is Hb Barts. The

situation is associated with minor blood abnormalities in later life. "When only two  $\alpha$ -loci are present they may be on the same chromosome, i.e., the Homologue has lost both  $\alpha$ -loci, or they may be on different chromosomes - the so called homozygous situation - in which a single gene has been deleted from each chromosome. This 'homozygous state' tends to characterise the situation in African and Mediterranean countries, and the heterozygous one in Asia (Harrison, 1988). When the synthesis of  $\alpha$ -chains is defective, the haemoglobin produced is made up of four  $\beta$ -chains, known as HbH ( $\beta_4$ ) or of four  $\tau$ -chains, known as Hb Bart's ( $\tau_4$ ). Individuals with such types of haemoglobin suffer from severe anemia (Poirier et al., 1994). An unusual form of the condition occurs in some children with mental retardation and an acquired form has been reported in patients with preleukemia and other myeloproliferative disorders. But the patients with HbH disease have variable degree of anemia and splenomegaly. Haemoglobin values range between 7 and 10 g/dl and the red cells show marked hypochromia and variation in shape and size. A complete absence of  $\alpha$ -loci leads to a condition, known as hydrops foetalis. It is fatal in pre-natal development. In such case no  $\alpha$ -chains are produced at all but the production of  $\tau$ -chain continues for longer than normal. This, however, is insufficient for post natal existence (Harrison, 1988).

$\beta$ -thalassaemia is characterised by persistent synthesis of  $\alpha$ -chains beyond the neo-natal period, which results in a variable elevation of foetal haemoglobin (HbF). The  $\beta$ -thalassaemia can broadly be classified into  $\beta^0$ -thalassaemia, in which no globin chains are synthesized at all, and  $\beta^+$ -thalassaemia, in which there is a reduced rate of  $\beta$ -chain production. These conditions are very heterogeneous, both at molecular and phenotypic levels. The  $\beta^+$ -thalassaemia can be further sub-classified at a descriptive level into the severe Mediterranean form and the milder Negro form (Weatherall, 1983).

There is also another well defined sub-group of both  $\beta^0$  and  $\beta^+$ -thalassaemia, in which the HbA<sub>2</sub> level is normal in heterozygotes. Finally, there are some rarer forms of thalassaemia which have only been found in single families or populations (Weatherall, 1983).

Usually the homozygous state for  $\beta^0$ -thalassaemia or the severe forms of  $\beta^+$ -thalassaemia or the compound heterozygous states for  $\beta^0$  and severe  $\beta^+$ -thalassaemia are associated with transfusion-dependent anemia from early in life. However, some patients run a much milder course and the term thalassaemia intermedia is used to describe this condition (Weatherall, 1983).

Weatherall (1975) has very succinctly summarised the thalassaemia syndromes, which are as follows:

**Table 1.1**  
**The Thalassaemia Syndromes\*\*\***

Type of Thalassaemia	Homozygous State	Heterozygous State
$\beta$ -thalassaemia (with haemoglobin A production)	Severe anaemia; high level of haemoglobin F	Increased level of haemoglobin A <sub>2</sub>
$\beta$ -thalassaemia (with no haemoglobin A production)	Severe anaemic; haemoglobin consists of F and A <sub>2</sub> only	As above
$\beta$ -thalassaemia (with no haemoglobin A production)	Moderate anaemia; haemoglobin consists of F and A <sub>2</sub> only	Increased level of haemoglobin A <sub>2</sub> and high levels of haemoglobin F (5-15% range)
$\beta$ - $\delta$ -thalassaemia	Severe anaemia; haemoglobin consists of F only	Haemoglobin F in 5-20% range; normal levels of haemoglobin A <sub>2</sub>
Haemoglobin Lepore thalassaemia	Severe anaemia; haemoglobin consists of Lepore and F	Normal levels of haemoglobin A <sub>2</sub> ; haemoglobins F and Lepore present
$\beta$ -thalassaemia with $\beta$ -chain	Clinical severity depends on level of haemoglobin A, and proportion of haemoglobin A is produced. Most important are S thalassaemia, C thalassaemia and E thalassaemia.	
$\alpha$ -thalassaemia 1**	Death in utero; haemoglobin consists mainly of Bart's	Difficult to detect in adults; haemoglobin Bart's in 5-10% range in infancy
$\alpha$ -thalassaemia 2**	Not yet recognised	Not detectable in adults; slight elevation of haemoglobin Bart's in infancy
Haemoglobin H disease	-	Probably heterozygous for for thalassaemia 1 and 2 or haemoglobin; Constant Spring
$\alpha$ -thalassaemia 1 and 2 with haemoglobin E	-	Severe anaemia; haemoglobins Bart's, F, E and A present
$\delta$ -Thalassaemia	-	Reduced haemoglobin A <sub>2</sub> levels
Thalassaemia-like states	Normal levels of haemoglobin A <sub>2</sub> and F, with clinical picture of thalassaemia	

\* Probably a distinct form of  $\beta$ -thalassaemia with more haemoglobin F synthesis than in typical  $\beta$ -thalassaemia.

\*\* May represent different genetic disorders in different populations.

\*\*\* Adopted from Weatherall (1975).

### Characteristics of $\beta$ -thalassaemia

Basu (1974), while discussing about the characteristics of  $\beta$ -thalassaemia, has made the following observations:

1) In case of severe anemia frequent blood transfusions are needed and often it turns to be fatal in early childhood.

2) Red cells of varying size and distorted forms (poikilocytes) and target cells are present.

3) Foetal haemoglobin (HbF) level rises to 50 to 90 per cent.

4) The percentage of haemoglobin A<sub>2</sub> is variable. The HbA<sub>2</sub> level is elevated in the parents of the persons with thalassaemia major.

5) Erythrocyte count is generally reduced (1,000,000 to 3,000,000 cells for Cmm) and the serum iron concentration is found to be higher than normal.

6) The stained blood shows a marked hypochromia and many of these cells show only a thin rim of haemoglobin.

7) Physical growth is usually retarded.

8) Marked pallor, patchy skin pigmentation, chronic leg ulcers and abdominal distentions are often observed.

9) Bones of cranial vault are thickened and changes in facial bones give some characteristic appearance known as Mongoloid faces.

10) Bone pain and recurring bouts of fever occur from an early age.

11) Progressive splenomegaly is found early and affected individuals fail to gain weight normally and become anemic.

### **Diagnosis of $\beta$ -thalassaemia**

The diagnosis of  $\beta$ -thalassaemia major is usually possible from the clinical and haematological data as well as from family studies. For all suspected individuals electrophoresis tests are performed to determine the level of haemoglobin F and  $A_2$  in both patients and parents. The high  $A_2$   $\beta$ -thalassaemia homozygosity can be diagnosed, if both parents are found to have increased haemoglobin  $A_2$  level and the patient also shows an increase in haemoglobin F, usually in excess of 20 per cent of the total haemoglobin. Electrophoretic studies on the parents will also indicate whether the patient is truly homozygous for high  $A_2$   $\beta$ -thalassaemia or heterozygous for high  $A_2$   $\beta$ -thalassaemia and one of the  $\beta$ -thalassaemic variants (Basu, 1994). The recent evidences indicate that  $\beta$ -thalassaemia heterozygotes may be distinguished from normal infants by age of 3 months, and with certainty by age of 6 months. The  $HbA_2$  level becomes elevated above the normal adult level by about 3 months and is clearly distinguishable from normal by 6 months. An

elevated level of HbF is also a useful indicator for the presence of a  $\beta$ -thalassaemia gene since it seems to be significantly higher than in normal infants, at least upto the age of 1 year (Weatherall, 1983).  $\beta$ -thalassaemia major can be distinguished from severe iron-deficiency anemia by more severe changes in erythrocytes in former disease by presence of large amounts of HbF, raised serum iron level and increased iron content of bone-marrow in thalassaemia major (Basu, 1994).

Diagnosis

#### **Growth and Development of $\beta$ -thalassaemic Patients**

Krogan Garn (1952) is of the opinion that height and weight are the two body dimensions which are generally taken as good indicators of physical growth. As a matter of fact, human physical growth is influenced by many factors, including genetic constitution (Mills, 1937; Meredith, 1941; Garn, 1952; Greulich, 1957).

The clinical pictures of the thalassaemic children have first been described by Cooley et al. (1927). The patients usually appear to be small for their age. But Smith et al. (1955) have pointed out that physical growth of the thalassaemic persons seems to be normal upto 8 or 10 years of age and then retardation in rate of physical growth starts and final stature becomes shorter than average.

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Sarkar et al. (1984) have made a study on stature and weight in relation to some haemoglobin genotypes in a Bengali-speaking population of Calcutta. They have observed that haemoglobin genotypes do not have any influence on stature and weight in adult population. They have further observed that the heterozygotes (comprising Hb $\beta$ E or  $\beta$ T gene) enjoy no advantage in physique over the haemozygotes, which may be due to relaxation of selective pressure. In a significant study on 50 individuals (both sexes), all having diagnosed as suffering from  $\beta$ -thalassaemia major, aged between 2 years 10 months and 28 years 5 months, Johnston and Krogman (1964) have made the following observations:

"1. Children with Cooley's anemia have their growth patterns altered in two ways; a retardation in their normal growth expectation and a retardation in their rates of growth.

2. The retardation in growth rate would indicate a much later expectation for any growth-time-linked event. The expression of the event itself; when it occurs, would be a function of the damage due to the prolonged anemia.

3. With the extension of the growth period, and with the success in prolonging life expectancy, it could be concluded that a curve of growth similar to the normal, but not quite reaching normal values, would emerge for children so affected.

4. Cephalofacial manifestations of orthodontic significance seems to be concentrated mainly in maxillary alveolar bone and in the palate as well."

The pathogenesis of growth retardation in thalassaemic patients is complex and incompletely understood. However, the National Thalassaemic Bulletin (1995) indicates the following factors, which may be responsible for affecting growth:

- 1) Chronic anemia
- 2) Endocrine disease
- 3) Chronic liver disease
- 4) Iron overload
- 5) Zinc deficiency
- 6) Desferal toxicity

#### **Distribution of Thalassaemia**

During recent years there have been some reviews depicting the geographical distribution of thalassaemia. No other haemoglobinopathic genetic disorder is known to be as widely distributed as thalassaemia till today.

There are mainly two areas, where prevalence of thalassaemia disease is very high, though it is found in all parts of the world. These two focal areas are as follows:

- 1) Mediterranean countries including Italy, Sicily, Sardina, Greece, Cyprus, Turkey and parts of North Africa.

2) South-eastern countries including India, Burma, Thailand and Indonesia (Chatterjea, 1965).

Regarding the distribution of this genetic disorder Chatterjea (1965) has mentioned that  $\beta$ -thalassaemia has been reported in China, the Phillipines, Australia, New Guinea and various parts of Africa and the West Indies. He has further mentioned that some isolated instances of  $\beta$ -thalassaemia have been detected from almost every country and in many racial groups.

In India instances of  $\beta$ -thalassaemia have been reported since 1938 from different parts of the country. But  $\beta$ -thalassaemia cases have been studied mainly from the pathological point of view. Basu (1994) has very recently tried to compile all data on  $\beta$ -thalassaemia, so far published on Indian populations. The first instance of  $\beta$ -thalassaemia in India was recorded in a two years old Bengali boy (Mukherjee, 1938). In Bengal the frequency of  $\beta$ -thalassaemia gene has been estimated to be present to the extent of 3.7 per cent among the Bengali Hindus (Chatterjea et al., 1957). Some cases of homozygous  $\beta$ -thalassaemia have also been reported in Bengal (Chatterjea et al., 1957) as well as in Gujarat (Sanghvi et al., 1958; Sukumaran et al., 1959, 1960). Choubisa (1985) has reported that the frequency of  $\beta$ -thalassaemia trait varies from 1.05 per cent in the Mochi to 3.12 per cent in the Ganchha among the scheduled caste

populations of Rajasthan. Gupta and Tiwary (1993) have reported that in Jabalpur (Madhya Pradesh)  $\beta$ -thalassaemia is common in all categories of population, i.e., scheduled castes, backward classes and forward communities and also present in lower frequency among the scheduled tribes. Sharma et al. (1971) have found the presence of  $\beta$ -thalassaemia among the Lohana, Gaud Saraswat and Chitrapur Saraswat in Gujarat. Sukumaran and Haveli (1978), cited by Basu (1994), have found  $\beta$ -thalassaemia among the Warli, Dhodia and Kokana in varying frequencies. Sukumaran (1975), while reviewing abnormal haemoglobins in India, has discussed about the prevalence of  $\beta$ -thalassaemia in various populations of Bombay. In north-eastern states of India a very few studies have so far been carried out. Das and Deka (1980) have compiled the existing data and have shown that the frequency of  $\beta$ -thalassaemia gene is about 2.8 per cent among the Assamese of lower Assam and 0.8 per cent among the Ahom and 1.4 per cent among the Khasis of Meghalaya. The  $\beta$ -thalassaemia trait has been reported in different parts of U.P., Maharashtra, Karnataka, Andhra Pradesh, Kerala, Orissa and Goa (Basu, 1994). However, our purpose is not certainly to show the exhaustive distribution of thalassaemia in India, but to focus the point that  $\beta$ -thalassaemia is found all over the country, though its concentration is more in eastern sector, particularly in West Bengal.

## Treatment of $\beta$ -thalassaemia

The treatment for homozygous  $\beta$ -thalassaemia consists of monthly transfusions and iron chelation therapy and bone marrow transplantation.

Iron overload is a major clinical problem in this group of disorders, particularly in  $\beta$ -thalassaemia. In severe homozygous form of  $\beta$ -thalassaemia. ( $\beta$ -thalassaemia major) the affected children require regular blood transfusions.

Since iron losses in man are not significantly increased in response to iron overload, a large excess of iron storage steadily accumulates with progressive damage to the liver, endocrine glands, etc. Death from cardiac iron loading usually occurs at the end of the second decade of life (Pippard, 1983).

An excessive dietary iron absorption contributes to iron overload in the patients with  $\beta$ -thalassaemia major particularly if their blood transfusion regimens do not maintain haemoglobin level sufficient to suppress their own erythropoiesis. Increased absorption from the gastro-intestinal tract provides the main route for iron loading in patients with  $\beta$ -thalassaemia intermedia. These patients have clinical features dominated by chronic anemia and extreme erythroid hyperplasia, but in spite of their not requiring regular blood transfusion they may eventually develop iron overload

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associated with liver cirrhosis and multiple endocrine deficiencies. However, there are great individual variations in the rate of iron loading, and at present there is no simple way to predict which patient with  $\beta$ -thalassaemia intermedia will develop potentially fatal iron overload by the middle of life. It is clear that iron loading occurs at predictable rate in the patients with transfusion-dependent thalassaemia. So a careful individual assessment of the degree and rate of iron loading is therefore essential to remove iron overload (Pippard, 1983).

#### **Treatment of Iron Overload in Thalassaemia**

Iron chelation therapy, along with regular blood transfusion, is essential for normal growth and development of the  $\beta$ -thalassaemia patients. So iron chelation therapy should be introduced as soon as possible to prevent organ damage due to iron overload. Iron chelation is being achieved by desferrioxamine (DF, Desferal). DF needs to be injected subcutaneously over 8 hours daily with the help of a portable electronic pump which costs around Rs.20,000 to Rs.25,000, besides Rs.4500 for desferal (National Thalassaemic Bulletin, 1995). The drug was not widely used until the demonstration that prolonged infusions produced much greater urinary iron excretion than equal dose given by intramuscular bolus injection. With this form of therapy it is now possible to

obtain negative iron balance even in very young transfusion-dependent thalassaemic children (Pippard, 1983).

However, this form of therapy is available to less than 10 per cent of the patients, primarily due to its high cost. In India only less than 3 per cent of the thalassaemia patients can receive some DF. Several side effects have been observed on regular DF therapy. In view of its high cost, decreasing compliance and cumulative toxicity, efforts were made over the last 30 years to develop an effective and safe oral iron chelator (National Thalassaemia Bulletin, 1995).

Recently a new capsule Deferiprone/kelfer has been evaluated in 17 countries at 32 centres. In India after an extensive trial on about 200 affected children in Bombay, Calcutta, Delhi, and Chandigarh got the best response. Iron excretion by Deferiprone depends on the dose, frequency of administration and ferritin level. Deferiprone has been used in 2 to 4 divided dose of 50 to 100 mg/day. In this dose it excretes 10 to 20 mg of iron in iron overload individuals and only 1 to 2 mg of iron in normal persons. Overall deferiprone has been found to be effective in excreting iron and in this dose it is able to deplete iron store. It mobilises iron from saturated transferrin liver and other compartments containing excess of iron. The patients with HbF/ $\beta$ -thalassaemia achieve negative iron balance faster on the same dosage schedule. Long term administration helps bringing the

serum ferritin level within the normal range. India is the only country in the world, where multicentric study at four centres, on over 225 cases, have been conducted to determine the effectiveness and safety of deferiprone in the multitransfused thalassaemia children (National Thalassaemia Bulletin, 1995).

### **Bone Marrow Transplantation**

Bone marrow transplantation offers complete cure as defective erythroid stem cells are replaced by normal erythroid precursor cells. However, transplantation can be administered in those cases where HLA compatible donors can be found. The transplantation has to be performed early before the child becomes overly iron immunized by transfusions. But even under ideal circumstances bone marrow transplantation is currently associated with about 25 per cent mortality (Kan, 1986). The cost of bone marrow transplantation varies from Rs.3.5 lakhs to Rs.6.0 lakhs, depending on complications of post transplantation. It is reasonable to expect the following results from bone marrow transplantation in thalassaemia:

- i) 60 per cent complete cure with good quality of life.
- ii) 20 per cent relapse of thalassaemia.

iii) 20 per cent death due to transplant related complications (National Thalassaemia Bulletin, 1993).

But repeated packed cell transfusions continue to remain the main pillar of treatment. Haemoglobin level has to be maintained near normal level and all efforts are to be made to ensure that haemoglobin level does not fall below 10 gm/dl. Washed red cells minimise the blood transfusion reactions. Leucocyte filters should be used, if thalassaemic children develop blood transfusion reaction repeatedly (National Thalassaemia Bulletin, 1993).

### **Polymorphism**

It may be pointed out that of all haemoglobinopathies thalassaemia accounts for the highest infant mortality rate in this country. Chatterjea (1968), while discussing about haemoglobinopathy in Bengal, has pointed out that  $\beta$ -thalassaemia, either in homozygous form or in combination with HbE-appears to be the commonest form of haemoglobinopathy and in fact the incidence of HbE  $\beta$ -thalassaemia has been much higher than that of homozygous  $\beta$ -thalassaemia since the latter is more severe than the former, and many homozygotes die too early.

Now the question arises how gene frequency is being maintained in a population in spite of continued loss of genes through early deaths of homozygotes. This cannot be

explained on the basis of any highly exaggerated mutation rate. Such loss of genes are supposed to be counter-balanced by some biological advantages enjoyed by the heterozygotes against baneful influences of malarial parasites (and perhaps other infections, iron-deficiency and some other environmental stresses). This illustrates the concept of balanced polymorphism (Chatterjea, 1968). In one study (Bhattacharya et al., 1982) it is postulated by examining overall reproductive performance (taking fertility and infant mortality together) that the heterozygotes will eventually suffer from a selective disadvantage in a place like Calcutta, where malaria was claimed to have been eradicated about three decades ago. But with changing situation at present and with reemergence of malignant malaria (often reported in newspapers) it is urgently felt that we shall have to review and reassess the whole situation (Ghosh, 1996).

As it is well known that the persons with thalassaemia disease, i.e., in homozygous states, generally do not survive upto the reproductive age. But now with advancement of medical technology, many of the thalassaemia patients, particularly in urban areas, survive beyond 30/35 years of age (Ghosh, 1996). So with the help of modern medical treatments the expectancy of life of such patients has become significantly greater than what it was even in the middle of

the present century. Consequently, such improved chance of survival of the patients with thalassaemia disease has created a series of social and biological problems, which are critical and relevant for future biological and social evolutions. However, such problems do not occur in the populations of simple cultures, living in remote rural areas. The reason is that they hardly get any opportunity to take the advantage of improved medical facilities since they just cannot afford such huge expenses. Consequently, such deleterious genes are steadily removed from populations through the process of natural selection (Ghosh, 1996).

But the situation in urban area is quite different from that in rural areas. All modern medical facilities are available in urban areas, and the people try their best to avail themselves of such opportunities even if these are very expensive. So in modern societies the individuals with such genetic disorder not only survive and enter into reproductive age-group but also have started contributing such deleterious genes to next generation. Consequently, genetic load in the population is steadily increasing and concomitantly social load increases too in such societies. In this context, Roberts (1975) says: "In modern human society deleterious genes assume an importance beyond that which they confer on the life of the individual himself. They present a far wider range of problems than survival and reproduction imply,

problems not only of treatment often expensive and long continued but also of day to day care and maintenance".

In a study in Calcutta (Das et al., 1983), it is observed that the reproductive fitness of the homozygous  $\beta$ -thalassaemia persons is around 0.03, which means that it has increased from 0 per cent to 3 per cent. It means that the rate of segregation of thalassaemia gene has increased to a great extent in view of the fact that previously the segregation of such genes used to take place only through heterozygotes and now homozygotes as well as heterozygotes are passing such thalassaemia genes to the next generation. Consequently, the frequency of thalassaemia gene has steadily been increasing in every generation. It is not only coming through some fresh mutations but also accumulating through higher rate of segregation. Chatterjea et al. in 1957 reported that the frequency of thalassaemia gene among the Bengalees was around 3 per cent, but is now reported by S. Majumder that about 10 per cent of the Bengalees carry thalassaemia gene (*The Statesman*, Calcutta, dated 14.2.94). It means that the frequency of thalassaemia gene has steadily been increasing over last 40 years. In some reported item published in *The Sunday Observer* (New Delhi, Bombay, dated February 6, 1994), that about 4 per cent of Indian population carries thalassaemia trait, 5000 thalassaemia children are born every year in India and 30 million carriers will

continue to pass on this dreadful disorder to their children. According to Dr. Dilip Bhattacharya, the founder of Thalassaemia Society of India in Calcutta there has been an increase of 50 per cent in the number of thalassaemia cases in the last 10 years and every year there is an addition of 250 patients to the thalassaemia society of India (*The Statesman*, Calcutta, dated 14.2.94).

Such limited information proves to what extent the genetic quality of the population, especially in the eastern part of the country, where this genetic disease is very much prevalent in higher frequency, is deteriorating, and thereby to what extent biological load is increasing in Indian population and it is well known that if genetic load (i.e., biological) increases, social load is concomitantly bound to increase in the population. It in turn certainly tells upon both physical and social health of the population.

So in order to understand the physical and social health of a population a combination of demographic, biological and socio-cultural approach is needed. However, so far no serious in depth study has been done, excepting a few isolated surveys from biological point of view. But the use of only one of these approaches is bound to result in partial understanding of the situation. The disease may be a biological one but it does have some social implications on the population. Similarly some social factors may be directly

responsible for passing of a particular disease from one generation to another. With this view in mind we intend to take up a study on bio-social aspects of  $\beta$ -thalassaemia from in and around Calcutta with the following objectives:

1) To determine the physiological symptoms of  $\beta$ -thalassaemic individuals;

2) To find out the rate of physical growth of the thalassaemic patients (upto 20 years);

3) To assess socio-economic and psychological pressures on the parents and the patients themselves;

4) To understand ability of the patients to learn (e.g. education) to work in terms of physical and/or intellectual output, and to attend to social activities;

5) To find out mode of treatment and average cost;

6) Finally, to suggest what type of comprehensive social measures should be taken for such genetically handicapped people and what type of economic reliefs may be given to the parents of such patients.

With this small introduction we shall present our findings in subsequent chapters.

## CHAPTER VI

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### SUMMARY

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#### MAJOR FINDINGS:

##### Biological Aspects

1) Symptoms: The symptoms before detection of thalassaemia show that 17.87 per cent of all males and 19.08 per cent of all females had only fever and 16.03 per cent of females and 12.77 per cent of males suffered from fever and loss of appetite. 19.08 per cent of females and 14.89 per cent of males had fever with vomiting tendency and loss of appetite. About 20 per cent of males and 12.21 per cent of females suffered from fever with cold and cough, loss of appetite. 19.08 per cent of females and 14.47 per cent of males suffered from fever with vomiting tendency, loss of appetite, besides anaemic condition.

2) Out of 380 thalassaemic patients, 174 (45.79 per cent) were detected before one year of age. In case of 171 (45 per cent) individuals it was detected by five years of age. It means 90.79 per cent of all the patients it was diagnosed before five years of age.

3) It is found that the majority (i.e. 40.26 per cent) of the patients visit hospital twice in a month. It is

seen that the patients aged 6 to 10 years, visit hospitals much more regularly.

4) Regarding health condition before and after transfusions it is found that out of 380 thalassaemic patients 136 individuals had serious health problems before transfusion and 244 individuals had no such serious problem. So far as the health status after transfusion is concerned, 62.63 per cent of all thalassaemic patients felt an improvement in their health condition and 37.37 per cent had not found any difference in their health status.

5) It has been found that the mean age at onset of menarche among the girls with  $\beta$ -thalassaemia major is  $13.82 \pm 0.49$  years, and that in the girls with  $\beta$ -thalassaemia trait is  $12.63 \pm 0.12$  years and for the normal girl it is found to be  $13.21 \pm 0.04$  years. It shows that the onset of menstruation is delayed in case of the homozygous  $\beta$ -thalassaemia girls.

6) Mean total haemoglobin level before transfusion shows:

<u>Age group</u>	<u>Male</u>	<u>Female</u>
Upto 5 years	$7.54 \pm 0.27$ g/dl	$8.31 \pm 0.23$ g/dl
6-10 years	$8.34 \pm 0.99$ g/dl	$7.58 \pm 0.20$ g/dl
11-15 years	$7.08 \pm 0.22$ g/dl	$6.94 \pm 0.37$ g/dl
16-20 years	$7.51 \pm 0.68$ g/dl	$6.61 \pm 0.37$ g/dl

t shows that the mean total haemoglobin is much lower in the  $\beta$ -thalassaemia patients than that in normal persons recommended by the WHO (1968).

7) The mean total haemoglobin level after transfusion shows:

<u>Age group</u>	<u>Male</u>	<u>Female</u>
Upto 5 years	10.44 $\pm$ 0.38 g/dl	10.87 $\pm$ 0.40 g/dl
6-10 years	9.45 $\pm$ 0.26 g/dl	10.06 $\pm$ 0.27 g/dl
11-15 years	9.26 $\pm$ 0.30 g/dl	9.29 $\pm$ 0.45 g/dl
16-20 years	8.65 $\pm$ 0.41 g/dl	8.80 $\pm$ 0.46 g/dl

t shows that even after having repeated transfusions the total haemoglobin level in the  $\beta$ -thalassaemic patients male or female, never reached the recommended level.

8) Performance of splenectomy shows:

<u>Age group</u>	<u>Male</u>			<u>Female</u>		
	No	Yes	%	No	Yes	%
Upto 5 years	48	3	6.25	30	2	6.67
6-10 years	61	12	19.67	38	10	26.32
11-15 years	31	16	51.61	14	4	28.57
16-20 years	6	2	33.33	6	3	50.00

t shows that as age advances, more and more thalassaemic patients had to undergo splenectomy.

Altogether 13 anthropometric measurements including 5 skinfold thickness have been taken on 380 (245 males and 135

females)  $\beta$ -thalassaemic patients and 364 (236 males and 128 females) normal individuals aged between 3 and 20 years.

9) In all measurements it is found that the rate of growth in the  $\beta$ -thalassaemic patients is significantly lower than that in normal individuals, excepting in bicondylar femur diameter, where the thalassaemic patients are having higher value than the control sample.

10) It is found that the rate of increment in physical growth of the thalassaemic patients (boys and girls) is lower than that in the normal individuals, though there are a few exceptions.

11) It is found that physical growth of the thalassaemic patients is retarded upto 15 years of age and thereafter though the rate of increment in physical measurements improves, the thalassaemic patients never catch up the normal individuals in physical growth.

12) In the present study we have described the mode of treatments of  $\beta$ -thalassaemia major. It is found that the average cost of treatment of thalassaemia patients comes around Rs.5445/-. It is seen that majority of the thalassaemic patients in the present sample just cannot afford so much money for treatment. Consequently most of them are not having full course of treatment.

## Social Aspects

13) It is seen that out of 380 thalassaemic patients, 245 (64.47 per cent) are males and 135 (35.53 per cent) are females. It is also seen that most of the thalassaemic patients, either male or female belong to the age group 6-10 years. It has also been noticed that with advancement of age, particularly after 15 years, there is a decrease in the frequency of thalassaemia patients.

14) The distribution of the thalassaemic patients by religion/caste shows that it is more or less equally prevalent among all castes and religious groups.

15) The reproductive history of the mothers of the thalassaemic patients shows that the mean number of live births is highest (3.32 per cent) among the Muslims, followed by the Hindu Mahisya (2.71 per cent). It is also found that the mean number of surviving children is the highest among the Muslim ( $2.84 \pm 0.33$ ) and the lowest ( $1.60 \pm 0.22$ ) among the Christian. The present study shows that the frequency of dead children varies between  $0.16 \pm 0.12$  in the Sadgope and  $0.52 \pm 0.12$  in the Muslim. A very high frequency of abortions has been noticed in the study, which varies from 7.96 per cent to 22.33 per cent among the mothers of the thalassaemic children.

16) It is seen that nearly 52.31 per cent of all thalassaemic patients belong to the first birth order. It has

also been observed that there is an inverse relationship between the occurrence of the thalassaemia and number of birth order. It shows that as the number of birth order increases, the probability of birth of a baby with thalassaemia decreases.

17) Educational achievement of the parents shows that 7.67 per cent are illiterate, whereas 29.32 per cent are graduates. Majority of the parents (45.76 per cent) have had education upto the secondary level.

18) Economic condition of the families with thalassaemia patients shows that 50.74 per cent of the families belong to the lower income group, 26.11 per cent to the middle income group, and 23.15 per cent to the high income group.

19) The frequency of thalassaemia children in relation to economic condition shows that out of 350 thalassaemic children 179 belong to the low income group, 90 belong to the middle income group, and 81 of them to the high income group.

20) It is found that the mean expenditure per month per thalassaemic patient in the low income group is Rs.714.39±35.44. In the middle income groups Rs.1082.33±63.55 and in the high income group Rs.2158.64±80.74. Combining all the patients of three economic groups together, it is found that the average expenditure on treatment of the thalassaemic patients per month is Rs.1143.24±57.43.

21) It is found that\* nearly 95 per cent of all parents, belonging to the low income group, are facing tremendous economic hardship to maintain their thalassaemic children. Even among the parents of the middle income group nearly 67 per cent of them have admitted such economic hardship, whereas nearly 35 per cent of the parents belonging to the high income group have had such economic burden on them for maintenance and treatment of their thalassaemic children. It clearly shows that lower the economic condition of the parent, higher is the economic burden on them.

22) Educational achievement of the thalassaemic children shows that out of 373 patients 2365 (71.67 per cent) have been attending school whereas 108 (28.95 per cent) have not attended any school. It further shows that with advancement of age the frequency of thalassaemic children's going to school decreases.

23) Educational achievement of the thalassaemic patients shows that 20.35 per cent of males and 18.82 per cent of females have been going to the pre-primary schools whereas 51.74 per cent of males and 50.54 per cent of females are in the primary schools. Similarly, 23.84 per cent of males and 29.03 per cent of females are in the secondary level. However, it shows that the thalassaemic patients generally do not go beyond the secondary level, which may be

due to various health problems, faced by them since childhood.

24) Educational performances of the thalassaemic patients show that irrespective of age groups the male thalassaemic patients have been performing more satisfactorily than their female counterparts. It further shows that nearly 50 per cent of all thalassaemic patients just cannot do well in their academic pursuits which may be again due to various health problems.

25) It has been found that nearly 93.75 per cent of the males and 84.96 per cent of the females participate in games. It shows that boys take more part in games than the girls. It has also been found that both boys and girls aged upto 15 years, take more part in games in comparison to those who are above 15 years of age.

26) Physical activities of the thalassaemic patients show that nearly 41.67 per cent of male and 36.09 per cent of female thalassaemic patients are physically active. It further shows that with advancement of age activities of the thalassaemic patients gradually declines.

27) Opinion of the parents regarding marriage of the thalassaemic children shows:

<u>In favour</u>	<u>Against</u>	<u>Undecided</u>	<u>Depends on Children</u>
88(24.11)	140(38.36)	117(32.05)	20(5.48)

28) In the present study it is found that nearly 93 per cent of all parents remain always extremely anxious about the health condition of their diseased children. Only 7 per cent of the parents become anxious at times. However, it shows that nearly 100 per cent of such parents spend their time in anxiety for their thalassaemic children. Consequently, nearly 100 per cent of the parents never allow their thalassaemic children to move freely, though 56 per cent of the parents rarely allow their thalassaemic children some freedom to move alone.

29) It is found that nearly 11 per cent of the parents with thalassaemia children never go out for any pleasure trip. Nearly 9 per cent of them never take their thalassaemic children to visit their relatives or friends and 2 per cent of them never attend any social gatherings along with their thalassaemic children.

We have seen in the present study how recent medical advancement has brought about an improvement in the mode of treatment for the  $\beta$ -thalassaemic patients. Consequently, the average longevity of the  $\beta$ -thalassaemia patients has increased considerably, as a result of which a good number of  $\beta$ -thalassaemic patients not only enter into the reproductive age groups but also they have started contributing the deteriorious genes to the next generation. As a result the genetic load in the population is steadily increasing on the

other hand it is seen that the thalassaemic patients have very little opportunity to contribute to the society. it is well known that society spends a lot for maintenance of such thalassaemic patients. Consequently, it shows that as genetic load increases in the society, social load concomitantly increases. We have made certain suggestions to decrease both genetic load and social load. The suggestions are as follows:

1) The government must come forward to take up the responsibility of all medical treatment for all thalassaemic patients in this country as it is normally expected that any welfare state would do.

2) Alternatively, if the government itself cannot take up this responsibility the government should reimburse the parents the whole amount spent by them for the treatment of their thalassaemic children.

3) The government must introduce immediately a national register for all thalassaemic patients in this country.

4) The government should make all efforts to encourage and motivate people to go for marriage counselling.

5) The government should make a legislation to prevent marriage between two heterozygotes, i.e., those who are the carriers of this deleterious gene and also the legislation should prevent the thalassaemic patients from marrying.

With this idea in future we hope to make a further study on the  $\beta$ -thalassaemic patients and that may help us understand the biological and social implications of this dreaded disease.