AMERICAN JOURNAL OF BIOLOGY AND NATURAL SCIENCES
https://biojournals.us/index.php/AJBNS
ISSN: 2997-7185

Article

The Prevalence of Thalassemia Among Residents of Baghdad: An Epidemiological Survey

Shatha Ramadhan Zaidan*[1]

1. Department of Microbiology, Alkindy College of Medicinem University of Baghdad, Iraq
*Correspondence: shatha.r@kmc.uobaghdad.edu.iq

Abstract: Context: Thalassemia is a lifelong blood disease that needs to be treated with regular blood transfusion and iron chelation drugs. Aims: To explore the epidemiology of thalassemia in Baghdad and interventions that are administered. Setting and Design: It is a cross-sectional study that was done at the center of treating thalassemia in Rusafa side of Baghdad in Iran. The sample size was 206, which was involved in the research course in October, 2024 to January, 2025. Methods and Material: Demographics were also obtained of all respondents as well as information about their form of thalassemia, treatments received, adherence to, and type and longevity of treatment. The respondents were 55.8% women, and 44.2% men; the average age of the respondents was 16.88 years (SD ± 8.69). Statistical test employed: Data were analysed with the help of IBM SPSS v28. The continuous variables are given as the mean with SD; categorical variables as the number with percentages. Chi-square tests employed group comparisons ($p < 0.05$ was taken to be statistically significant). Results: There were more proportions of severely elevated iron in males (47.3% vs. 25.2% of females), and females depended on family funding more to acquire treatment (30.4% vs. 5.5% of males). Hospitals were the center of care delivery, and no participants were treated in other places but the hospitals. Pharmaceutical stores were cited as having medications that are always in stock with 99.0% of the participants, but delays were reported occasionally by 3.4% of the respondents. Conclusions: To maximize results on people with thalassemia, gender-specific issues should be considered, practices of monitoring should be enhanced, and access to care should be a consistent phenomenon. PGT-IVF should be considered as an intervention mechanism to particular cases.

Keywords: Thalassemia, Beta major, Alpha, Exjade.

Citation: Zaidan S.R. The Prevalence of Thalassemia Among Residents of Baghdad: An Epidemiological Survey. American Journal of Biology and Natural Sciences 2026, 3(11), 61-69.

Received: 10th Aug 2026
Revised: 11th Sep 2026
Accepted: 20th Oct 2026
Published: 16th Nov 2026

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Introduction

Thalassemia is a family of inherited blood disorders which involves a deficiency or lack of synthesis of one or more globin chains that make up hemoglobin, an oxygen-binding protein in red blood cells.[1] This interference in hemoglobin synthesis causes persistent anemia, inefficient erythropoiesis and chain reaction of physiological complications which may severely affect the quality of life of a person. Thalassemia is most common in areas that were traditionally malaria-prone, including the Mediterranean, Middle East, South Asia, and Southeast Asia, because thalassemia trait provides a selective advantage in the area against intense malaria.[2] Thalassemia is still a significant

social issue in the medical science world with millions of people either having the disease or possessing the genetic mutations that cause it.

The genetic basis of thalassemia lies in mutations affecting the genes that encode the alpha (α) and beta (β) globin chains of hemoglobin. Massachusetts Medical Society explains that adults possess tetrameric proteins known as hemoglobin A (HbA) where two α chains and two β chains unite but β chains differentiate from α chains. The location of the alpha-thalassemia genetic material on chromosome 16 at HBA1 and HBA2 genes determines the condition alongside beta-thalassemia which demonstrates mutations at HBB on chromosome 11.[3] Mutations cause unbalanced globin chain synthesis after which developing red blood cells become toxic toward unpaired chains. The combination of inherited mutations and their being mild or severe determines how thalassemia will appear in patients which can lead to either an unnoticed carrier state or an intensive medical condition needing permanent medical treatment.

Thalassemia is a disease that manifests in forms of varying degrees of severity when presented in patients. Thalassemia minor patients will remain asymptomatic despite the presence of mild anemia due to this disease. Thalassemia intermedia patients require regular but infrequent blood transfusion to treat their moderate anemia state but Cooley anemia and thalassemia major patients must receive consistent early childhood blood transfusion because of severe anemia.[4] Individuals with thalassemia experience severe health issues due to recurrent blood transfusion owing to iron overload and these complications lead to splenomegaly along with bone abnormalities as well as growth retardation and endocrine malfunctioning. The untreated overload of iron is a significant threat since the extra amount of the metal is deposited in other body parts such as the heart and liver and the endocrine glands, making developing a risk of organ failure leading to early death. [5]

The burden of thalassemia is astounding in the world since it is estimated that 7% of the global population carries at least one thalassemia gene mutation.[6] Thalassemia is an urgent public health concern in some high-endemic areas like Cyprus, Greece, and some areas in India where frequencies of the carriers are above 10%. Economic and social effects of managing thalassemia are also extremely high, especially in countries with low and middle income where access to high-end medical care and facilities might be restricted. An example is that lifelong transfusion and iron chelation therapy cost a big burden to health systems and families, which in most cases leads to differences in care and outcomes.[7] Moreover, one should not also disregard psychosocial implications of being affected with thalassemia where in most cases patients are struggling with stigma, poor quality of life as well as lack of confidence in their future.

Scientists have managed to conduct research on genetic as well as molecular factors that cause thalassemia that have presented new diagnostic tests and improved treatment options. The studies concerning molecular diagnostics have allowed researchers to detect specific mutations resulting in thalassemia thereby developing more effective screening and prenatal certainty examinations.[8] The future of the disease treatment has improving chances with the help of promising therapeutic procedures such as gene therapy using the help of stem cell transplantation. The area in which gene therapy has the most potential is the fact that as of now, it has been shown that defective globin genes can be treated via CRISPR/Cas9, in conjunction with other gene-editing methods.[9] The new findings imply why institutions should allocate continuous financial resources and research sponsorship to healthcare systems of thalassemia.

This research aims at exploring the occurrence of thalassemia in Iraq, most frequently occurring genetic mutations, and the influence of consanguinity as a risk factor. The data that was gathered were analyzed using the cross-sectional design and collected using structured questionnaires, complete blood count (CBC) tests, and statistical analysis with the help of Excel and SPSS V.28. The proposed study will help in building the existing understanding of thalassemia in Iraq and informing efforts to enhance patient outcomes by combining the current knowledge on the topic with new research. The study aims also to highlight the importance of prevention and community health in minimizing the burden of thalassemia in the world. The prevalence of thalassemia can be reduced through carrier screening, genetic counseling, and awareness activity to enable the affected individuals and families to make well-informed choices regarding their health.

Methodology

Research Design

The research design that was used in this study was cross-sectional and descriptive in nature to investigate the demographic, clinical and social features of individuals living with thalassemia. The researchers were interested in evaluating the adherence to the treatment, accessibility, and satisfaction along with determining the possible differences on gender and other variables.

Key inclusion criteria were:

- Thalassemia (Alpha or Beta Minor or Major) Diagnosis.
- Visit to the hospitals regularly to receive treatment.
- The desire to engage in the study and to give the informed consent.

Exclusion criteria included:

- Response bias on important variables in the data.

Data Collection:

A structured questionnaire was used to collect the data through interviewing the respondents in the process of visiting the hospital normally. The areas that were covered by the questionnaire included:

- **Demographic Information:** Age, gender, level of education and employment status and place of residence.
- **Clinical Characteristics:** Red blood cell (RBC) count, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and the existing levels of iron.
- **Treatment Practices:** Blood transfusion, use of medication, use of iron testing and treatment compliance with chelation therapy.
- **Social and Economic Factors:** Treatment funding, access to medication and contentment with treatment.

Subsequent analysis was made in an Excel spreadsheet all the data were entered. The missing values have been addressed based on the existing rules and the user-defined missing values were treated as missing during statistical analyses.

Statistical Analysis:

To be accurate and reliable, data were evaluated using SPSS software V.28. Means, standard deviations, frequencies, and percentages were used to describe the characteristics of participants using descriptive statistics. The inferential statistics were conducted to find the significant associations and differences between the groups. The statistically significant P-value was set to P-value < 0.05.

Results and discussion

Demographic study

The analysis was conducted on 206 participants (55.8% females and 44.2% males). The average age of the participants is 16.88 ± 8.7 SD, with 1-42 years range, represented in Table (1).

Table 1. Demographic characteristics of the participants

Variable		Frequency	Percent, %
Gender	Male	91	44.2
	Female	115	55.8
Education	Elementary	57	27.7
	Primary	3	1.5
	High school	67	32.5
	University	33	16.0
	Postgraduate	16	7.8
	Other	30	14.6
Employment	Unemployed	183	88.8
	Employed	15	7.3
	Freelancer	5	2.4
	Retired	3	1.5

Types of Thalassemia and therapy plans

The type of thalassemia that prevailed was Thalassemia Beta Major with 156 patients (75.7%) diagnosed. The further details are illustrated in Table (2).

Table 2. Frequency of affected participants according to the type of Thalassemia

Variable		Frequency	Percent, %
Type of Thalassemia	Thalassemia Beta Major	156	75.7
	Thalassemia Minor	50	24.3
Duration of Medication Use, Years	1-4	126	61.2
	4-6	40	19.4
	6-8	22	10.7
	8-10	18	8.7
Hemoglobin Levels Before Transfusion, mg/dL	<7	98	47.6
	7-8	51	24.8
	8-9	50	24.3
	9-10	7	3.4

Iron levels and testing

The analysis revealed variations in iron levels among patients tested and different time intervals to test their iron level. Surprisingly, heart iron testing remains uncommon among patients with thalassemia, as shown in Table (3). Patient registers indicate a high adherence to treatment plans at 99.5%, with medication availability at 99.0%. The public health authority in Iraq participated in treating 80.6% of patients, while 19.4% of patients treated themselves or by their families.

Table 3. Iron levels and adherence to heart iron testing

Variable		Frequency	Percent, %
Current Iron Levels, ng/mL	500-1000	50	24.2
	1000-2000	84	40.8
	2000-4000	72	35.0
Frequency of Iron Testing	Every month	15	7.3
	Every 2 months	32	15.5
	Every 3 months	42	20.4
	Every 6 months	114	55.3
Frequency of Heart Iron Testing	Never	3	1.5
	Rarely	32	15.5
	Never	174	84.5
Mainly Used Drugs	Deferasirox (Exjade)	91	44.2
	Deferoxamine	115	55.8

Discussion

The study population is 55.8% females (n = 115) and 44.2% males (n = 91), which represents a slightly stronger representation of females. The mean age is 16.88 years (±8.692 SD), females were slightly older (17.28 years) than males (16.38 years). The age is between 1- 42 years with majority of the participants being adolescents or young adults. A majority (27.7% and 32.5%) of the participants had either elementary or high school education with A smaller proportion displayed university (16.0%) or postgraduate education (7.8%). Females were more likely to have higher education levels (e.g., university or postgraduate level) than males significantly (P = 0.005). As well, the overwhelming majority (88.8%) were not working and only 7.3% were working, and 2.4% freelancers. Such results would necessitate the establishment of equal access to affordable drugs and interventions, especially to low-income families. Another study by Taher et al. in Lebanon[10] also indicated gender-specific differences in the management of thalassemia with the females showing greater compliance with the chelation therapy than the males. Likewise, Kumar et al. in India[11] emphasized on high amounts of

iron overload in men, which they explained by physiological circumstances, like excessive body mass and reduced compliance to chelation treatment. These findings are compatible with the fact that higher iron overload of males was found in our study and may be explained by increased non-adherence to chelation therapy or by physiological variations in iron metabolism. Moreover, the cultural norms can have an impact on access to education amongst females and this might enhance health literacy and management of chronic diseases such as thalassemia.

The findings indicate that most participants are Thalassemia Beta Major subtype (75.7%, n=156) and the Thalassemia Minor is 24.3% (n=50). Beta thalassemia trait is also common as evidenced in research studies carried out in the neighbouring nations. But the same prevalence does not occur in other parts of the world[12] which could be because of sociodemographic variations between societies in which beta thalassemia is usually transmitted in families. Further, majority 61.2% of the participants said that they have been on thalassemia medication 1-4 years with 19.4% having been on medication 4-6 years and 19.4% FOR 6-10 years. These results are suggesting that there is a high prevalence of severe thalassemia among the population. Almost half of the respondents 47.6% had a hemoglobin level of less than 7mg/dL with 24.8% having 7-8mg/dL. The percentage of participants with high iron levels (>1000 ng/mL) is high (75.8%), whereas the percentage of participants with low iron levels (500-1000 ng/mL) is quite low (24.3%), which implies that the iron chelation therapy needs to be enhanced in adherence and monitored more frequently. Cappellini et al. in Italy[13] have given similar trends, and have reported that a long-lasting treatment with chelation therapy led to lower and yet high levels of iron. Also, Porter[14] emphasised the importance of transfusion thresholds in iron overload management that keeping haemoglobin level above 9 mg/dL can decrease iron transfusion and consequent iron buildup. The increased rate of severe iron overload in the case could be due to the inability to remain with chelation therapy adherence over time or the difficulties in obtaining drugs on a regular basis. Individualized intervention, including individual dose schedules and more frequent monitoring, would help eliminate these risks. The proportions of patients with severely elevated iron levels (2000-4000 ng/mL) were higher in participants who were on medication for ≥ 6 years or more (n = 35, 48.6%) than in those who were on medication between 1-4 years (n = 37, 29.4%). Such high heart iron level can be explained by ignorance of testing the level of iron in the heart where 84.5% of the participants never tested their iron in the heart whereas the remaining participants (15.5%) never tested their iron in the heart that shows a serious gap in preventive measures of cardiac complications. The high levels of adherence are also in line with those of Vichinsky[15] in the United States, where the structured healthcare systems and patient education programs showed a positive effect on adherence. The poor use of heart iron tests that was witnessed in this study is however inconsistent with recommendations by Pennell[16] who urged the need to undertake regular cardiac iron tests to avoid complications. The absence of heart iron screening among the population can be due to poor knowledge of patients and healthcare providers as well as access to resources in state hospitals. These gaps could be improved with specific programs of education and intervention in policy. There was a significant difference ($p < 0.001$) in proportions of severely elevated iron levels (2000 -4000 ng/mL) with males having higher proportions and requiring specific measures to meet their needs. Conversely, majority (55.3%) of the respondents checked their iron levels after every 6 months as compared to others (15.5%) who checked their iron levels after every 2 months, with (1.5%) not checking the levels of their iron at all. Routine heart iron testing should be introduced because of the frequent iron level tests to avoid complications. A majority of the participants are using government funding to treat them highlighting the need to support them through public health.

The fact that regular blood transfusion and regular medication use are high points to the fact that the patients are very well adhering to the treatment regime, but it also needs to be mentioned that the complications such as iron overload must be monitored constantly, and patients should be educated about the dangers of iron overload and the necessity of following the regime of chelation treatment. The primary drug is deferoxamine (55.8%), and the other Deferasirox (Exjade) (44.2%). The self-reported compliance with taking the medications and access to medications were great, 99.5% and 99% respectively. Public health authorities also helped in supplying medications free (80.6%) with no delays reported in receiving medications and only 19.4% of patients relied on their families or paid themselves.

Males were more probable to depend on government funding than females ($P < 0.001$). All subjects were treated in the public hospitals that stresses on the need to have a long-term public health support to the treatment of thalassemia. Although compliance with medication and blood transfusion is reasonable, sealing the loopholes in heart iron testing and early diagnosis may enhance the course of outcomes.

Iraq has 19 centres that supply medications of Thalassemia to approximately 19000 patients.[17] Moreover, it is mandatory to conduct premarital tests, such as testing MCV and MCH where the couples who are at risk are then asked to undergo additional counselling and to explain the complications.[18][19][20] This implies that a person should be defective in the copying of two copies of the gene (one of each parent) in order to develop Thalassemia Beta Major. Besides, Families with a history of multiple affectsive members are likely to have both parents carriers. The carriers (people with a single damaged copy) generally have Thalassemia Minor and may be asymptomatic or they may have a mild case. When both parents are carriers, then there is the likelihood of 25% of an affected child (Thalassemia Beta Major), 50% of a carrier child (Thalassemia Minor) and, 25% of an unaffected child. With carrier parents that are only one, the child is unable to develop Thalassemia Beta Major but has a 50% probability of carrying. To prevent this in such instances, the recommended approach of having child that is free of Thalassemia is Preimplantation Genetic Testing (PGT-IVF) that entails screening the embryos and selecting via beta thalassemia trait (heterozygous, β/β^{+} or β/β^{0}) since there is no unaffected embryo in such a situation[21] In other instances where one of the parents is affected, then unaffected embryos can be chosen by PGT-IVF. Though, in the worst scenario where both parents have beta major thalassemia, the only solution that can be used to eliminate affected child will be through donor gametes which is not an option in an Iraqi society because of religion issues. Consequently, education is essential in terms of inheritance patterns of Thalassemia to prevent them.[22][23]

Alternatively, allogeneic hematopoietic stem cell transplantation (HSCT) is now the only curative therapy to be applied to a child with beta thalassemia major as long as there is an appropriate donor at the age of the patient, below 14 years before he or she has caused harm to the organs.[24][25][26] Optimal results may be obtained when matched sibling is possible (> 90% curative rate) with somewhat less curative rate may be seen when matched unrelated donor is possible (approximately 80% curative rate) whereas, it is lower when haploidentical donor is possible (parent or half-matched sibling) with curative rate of about 75%. The cost of treatment remains a significant issue and should be taken into account by the public health providers.[27][28]

Conclusions

The paper has identified important demographic, clinical and management trends in Thalassemia patients demonstrating a considerable level of gender disparities, disease burden, and monitoring and treatment adherence gaps. In males, iron overload is much higher, presumably because of inadequate compliance with chelation treatment. Beta Thalassemia major is seen in overwhelming majority patients (75.7%), with severe iron overload (75.8% with >1000 ng/mL), which implies the necessity to apply better chelation regimens and regular cardiac iron testing, since only 84.5% of the patients have heart iron testing, Although, there are high rates of compliance with the transfusion and medication (99.5%), long term accumulation of iron is a significant issue especially among males and those on long term medication. The public healthcare system has a significant role in delivering free care (80.6%), however, the personalized interventions, including the personalized dose of chelation, patient education, and compulsory cardiac iron screening are strictly necessary to avoid the life-threatening complications, Screening before marriage and genetic counseling are needed to decrease the prevalence of thalassemia, but the societal and religious backgrounds restrict the possible alternatives such as donor gametes to high-risk couples. In people with this disease, HSCT is the only cure and the outcomes are best in cases of young patients (<14 years old) and matched sibling recipient. Nevertheless, the issues of cost and accessibility are to be considered in order to increase the range of treatment opportunities. Lastly, Preimplantation Genetic Testing-In Vitro Fertilization (PGT-IVF) needs to be established as a systematic national intervention in Thalassemia prevention as a standard reproductive choice of at-risk couples. This evidence-based practice can allow the unaffected embryos

to be selected in respect of cultural and religious belief by means of heterozygous (β/β^+) carrier embryos to be selected in the case of both parents having the disease. To overcome the obstacle in the implementation of programs in conservative populations, the priorities of the public health efforts should be based on free access to PGT-IVF, the development of genetic counseling facilities, and community education.

Declarations

Acknowledgement:

During the preparation of this work the author used deepseek in order to improve the readability and language of the manuscript. After using this tool/service, the author reviewed and edited the content as needed and take full responsibility for the content of the publication.

List of abbreviations:

CBC: complete blood count

CRISPR/Cas9: clustered regularly interspaced short palindromic repeats / CRISPR-associated protein 9

HbA: hemoglobin A

HBA1, HBA2: hemoglobin subunit alpha 1 and 2 genes

HBB: hemoglobin subunit beta gene

HSCT: hematopoietic stem cell transplantation

MCH: mean corpuscular hemoglobin

MCV: mean corpuscular volume

PGT-IVF: preimplantation genetic testing–in vitro fertilization

RBC: red blood cell

SD: standard deviation

SPSS: Statistical Package for the Social Sciences

Funding:

The declares that this study receives no funding

Conflicting interests:

The author declaires no conflict of interest.

Consent for participation:

Written informed consent was obtained from all adult participants (≥18 years) before data collection. For participants under 18 years, written informed consent was obtained from a parent or legal guardian, and the child's verbal assent was also obtained, where age-appropriate. Participants and guardians were informed about the aim of the study, the voluntary nature of participation, and their right to withdraw at any time without any effect on the care they receive. They were also told that the information collected would be kept confidential, used only for research purposes, and reported in anonymized form.

Ethical approval:

Given the observational /non-interventional design of the study, formal ethics approval was not sought.

Author Contribution:

Onr author study.

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