International Journal of Medical and Pharmaceutical Research

Online ISSN-2958-3683 | Print ISSN-2958-3675
Frequency: Bi-Monthly
Available online on: https://ijmpr.in/

Original Article

Iron Overload and Household Economic Burden Among Children and Young Adults On Regular Blood Transfusion at A Tertiary Care Hospital in A Tribal District of Eastern Gujarat: A Cross-Sectional Study

Yasheshkumar Ramanuj[1], Vidhi Shah[2], Arpita Rajgor[3], Shobhana Dangi[4], Sanjay Kumar[5], Zainab Cyclewala[6]

[1,3] Resident Doctor, Department of Community Medicine, Zydus Medical College and Hospital, At Post Nimnaliya, Dahod, Gujarat, India.
[2] Assistant Professor, Department of Community Medicine, Zydus Medical College and Hospital, At Post Nimnaliya, Dahod, Gujarat, India.
[4] Associate Professor, Department of Community Medicine, Zydus Medical College and Hospital, At Post Nimnaliya, Dahod, Gujarat, India.
[5] Professor, Department of Community Medicine, Zydus Medical College and Hospital, At Post Nimnaliya, Dahod, Gujarat, India.
[6] MBBS Student, Department of Community Medicine, Zydus Medical College and Hospital, At Post Nimnaliya, Dahod, Gujarat, India.

Corresponding Author:

Shobhana Dangi

Associate Professor, Department of Community Medicine, Zydus Medical College and Hospital, At Post Nimnaliya, Dahod, Gujarat, India.

Received: 04-06-2026
Accepted: 08-07-2026
Available online: 20-07-2026

ABSTRACT

Background: Haemoglobinopathies are inherited autosomal recessive disorders highly prevalent in the tribal belts of western India. Transfusion-dependent patients require lifelong transfusion, causing progressive iron overload. Data on the iron burden of such patients from tribal eastern Gujarat are scarce.
Objectives: To describe the clinico-social and economic profile of regularly transfused patients with haemoglobinopathies and to estimate the prevalence of transfusion-related iron overload.
Materials and Methods: A cross-sectional study was conducted at a tertiary care teaching hospital in Dahod, eastern Gujarat. Patients admitted for transfusion for a haemoglobinopathy were assessed using a predesigned questionnaire covering demographic, socio-economic, clinical and laboratory variables. Spearman rank correlation and the Mann-Whitney U test were used for exploratory associations (two-sided $p<0.05$).
Results: Thirty-eight patients were analysed (21 male, 17 female); mean age 9.5 ± 5.6 years, with 29 (76.3%) under 13 years. Median age at first transfusion was 6 months and median transfusion frequency 18 per year. Mean serum ferritin was 1,824.7 ± 805.4 ng/mL (n=18); 15 of 18 (83.3%) exceeded 1,000 ng/mL and 4 of 18 (22.2%) exceeded 2,500 ng/mL. In exploratory analysis, ferritin correlated with annual transfusion frequency ($\rho=0.52$, $p=0.032$) and age ($\rho=0.53$, $p=0.023$). Mean haemoglobin was 6.8 ± 2.0 g/dL, with 10 of 19 (52.6%) below 7 g/dL. Five of 24 families (20.8%) spent more than 10% of annual income on therapy.
Conclusion: Iron overload was present in most patients tested. Low haemoglobin suggests symptom-driven rather than scheduled transfusion. Despite nominally free blood, one in five families incurred catastrophic health expenditure.

Keywords: *Thalassaemia; Iron overload; Serum ferritin; Catastrophic health expenditure; Tribal health; Gujarat.*

INTRODUCTION

The haemoglobinopathies are a group of inherited, autosomal recessive disorders characterised by qualitative or quantitative abnormalities of the globin chains of haemoglobin (Old, 1996). They are distributed predominantly across

historically malarious regions of the world (El-Hazmi, 1987), a pattern attributed to the survival advantage that carriage of a variant β-globin chain confers against *Plasmodium falciparum* infection (Pasvol, 2010).

Globally, an estimated 450,000 infants are born each year with a haemoglobinopathy, of whom approximately 85.9% have sickle cell disease and 9.7% have β-thalassaemia; roughly 80% of these births occur in low- and middle-income countries (Modell & Darlison, 2008; Weatherall, 2011). In India, sickle cell disease and β-thalassaemia are the two commonest haemoglobinopathies (Modell & Petrou, 1983; Verma et al., 2012), and the burden falls disproportionately on tribal populations of the western and central states, including Gujarat, Madhya Pradesh and Rajasthan. In a screening programme covering 317,539 individuals across Gujarat, sickle cell trait was documented in 11.37% of those from tribal areas compared with 1.1% from non-tribal areas (Patel et al., 2012).

Patients with transfusion-dependent disease require regular red cell transfusion from early childhood for survival. Each unit of transfused blood delivers iron that the body has no active mechanism to excrete, so repeated transfusion inevitably produces progressive iron loading of the myocardium, liver and endocrine organs. Iron chelation therapy, guided by periodic monitoring of serum ferritin, is therefore as fundamental to survival as the transfusion itself; contemporary guidance recommends intensifying chelation as ferritin rises above approximately 1,000 ng/mL, and identifies sustained concentrations above 2,500 ng/mL as carrying substantially elevated cardiac risk (Farmakis et al., 2022).

The clinico-social context in which this care is delivered materially shapes its success. In a study of 297 patients with congenital haemolytic anaemia at a tertiary hospital in Kolkata, Chattopadhyay et al. (2012) found HbE-β thalassaemia to be the commonest diagnosis (41.1%), followed by β-thalassaemia (23.6%), and reported a mean age at presentation below 17 years; low educational attainment and poverty were associated with poor awareness and delayed health-seeking behaviour. Within Gujarat, Bhalodiya et al. (2023) reported a progressive rise in mean serum ferritin with advancing age among 100 regularly transfused children with β-thalassaemia major, reaching 2,387 µg/L in the 11–18 year age group.

Dahod is a predominantly tribal district of eastern Gujarat situated on the Gujarat–Madhya Pradesh border. Published data on the profile and iron burden of transfusion-dependent patients from this region are scarce. The present study was undertaken to describe the demographic, clinico-social and economic characteristics of patients admitted for blood transfusion at a tertiary care hospital serving this population, and to quantify the magnitude of transfusion-related iron overload among them.

MATERIALS AND METHODS

Study design and setting

A cross-sectional, observational study was conducted in the Department of Community Medicine of a tertiary care teaching hospital attached to a medical college in Dahod district, eastern Gujarat, India, over a six-month period from March 2023 to August 2023.

Participants

All consecutive patients admitted to the Thalassaemia Ward for scheduled blood transfusion during the study period were included.

Exclusion Criteria:

- *Patients transfused for a non-haemoglobinopathy indication*
- *Those declining consent.*

Sample size

Universal sampling was adopted, wherein all eligible patients admitted during the study period were enrolled.

Data collection

Data were collected using a predesigned, pretested questionnaire. A detailed history was taken covering demographic details, education, parental occupation, household size and income, annual expenditure on therapy and related costs, age at first transfusion, duration and annual frequency of transfusion, parental consanguinity and its degree, family screening, and family history. General and systemic examination was performed. Laboratory investigations, including complete blood count and serum ferritin, were recorded from hospital records where available.

Haemoglobin was recorded at admission, before the transfusion was administered.

Statistical analysis

Continuous variables are presented as mean ± standard deviation and median with range or interquartile range; categorical variables are presented as frequencies and percentages calculated on the number of records in which the variable was actually documented, with that denominator stated in every instance. Associations were explored using Spearman rank

correlation and the Mann-Whitney U test. A two-sided p value below 0.05 was considered statistically significant. Analyses were performed using Epi Info 7.

Ethical considerations

The study was approved by the Institutional Ethics Committee of Zydus Medical College and Hospital, Dahod (86/2022). Written informed consent was obtained from the parent or legal guardian of every participant below 18 years of age, with assent from the child where applicable, and directly from participants aged 18 years and above. Confidentiality of patient identifiers was maintained throughout.

RESULTS

Demographic and socio-economic profile

Thirty-eight patients were analysed, of whom 21 (55.3%) were male and 17 (44.7%) female, giving a male-to-female ratio of 1.24. The mean age was 9.5 ± 5.6 years (median 10, range 2–25 years) and 29 patients (76.3%) were below 13 years of age, with three patients aged above 18 years. Of the 34 patients whose residence was recorded, 14 were from Dahod itself, while some travelled from neighbouring Madhya Pradesh (Jhabua, Meghnagar, Thandla) or Rajasthan (Banswara).

Households were large and economically constrained. The median monthly family income was ₹10,000 (IQR ₹7,000–15,000) supporting a median of six members (range 2–15). Parental occupation was manual labour, farming or petty business in 23 of 26 (88.5%) records in which it was documented. Demographic and socio-economic characteristics are summarised in Table 1.

Table 1: Demographic and socio-economic characteristics (N = 38)

Variable	Category	n (%) or value
Age (years)	Mean ± SD	9.5 ± 5.6
	Median (range)	10 (2–25)
Age group	0–5 years	12 (31.6%)
	6–12 years	17 (44.7%)
	13–18 years	6 (15.8%)
	>18 years	3 (7.9%)
Sex	Male	21 (55.3%)
	Female	17 (44.7%)
	M:F ratio	1.24
Education (n=25)	Primary	12 (48.0%)
	Junior KG	4 (16.0%)
	Illiterate	3 (12.0%)
	Secondary	3 (12.0%)
	Anganwadi	2 (8.0%)
	Graduate	1 (4.0%)
Parental occupation (n=26)	Labour	9 (34.6%)
	Business	7 (26.9%)
	Farmer	7 (26.9%)
	Vegetable vendor / Teacher / Housework	1 each (3.8% each)
Blood group (n=23)	O positive	9 (39.1%)
	B positive	7 (30.4%)
	A positive	3 (13.0%)
	AB positive	2 (8.7%)

Variable	Category	n (%) or value
	O negative	2 (8.7%)
Monthly family income (₹) (n=26)	Median (IQR)	10,000 (7,000–15,000)
Household size (n=37)	Median (range)	6 (2–15)
Annual therapy cost (₹) (n=24)	Median (range)	3,800 (1,000–60,000)
Cost as % of annual income (n=24)	Median (maximum)	3.9% (50.0%)
Catastrophic expenditure (>10% of annual income) (n=24)	Yes	**5 (20.8%)**

SD = standard deviation; IQR = interquartile range. Percentages are calculated on the number of records in which the variable was documented, shown in parentheses beside each variable..

Family history and transfusion profile

Parental consanguinity was reported by 8 of 27 respondents (29.6%), and where the degree was specified, it was third degree in five and second degree in two. Family screening had reportedly been undertaken in 23 of 27 (85.2%).

The median age at first transfusion was 6 months (IQR 0.50–1.50 years), and 15 of 26 patients (57.7%) had received their first transfusion within the first year of life. The median duration on transfusion was 10.5 years (range 1–20) and the median transfusion frequency was 18 per year (IQR 13–24, range 10–48). These findings are presented in Table 2.

Table 2: Family history, consanguinity and transfusion profile

Variable	Category / Statistic	Value	n recorded
Parental consanguinity	Yes	8 (29.6%)	27
	No	19 (70.4%)	27
Degree of consanguinity	Third degree	5 (71.4%)	7
	Second degree	2 (28.6%)	7
Family screening done	Yes	23 (85.2%)	27
	No	4 (14.8%)	27
Age at first transfusion (years)	Median (IQR)	0.50 (0.50–1.50)	26
First transfusion before age 1 year	n (%)	**15 (57.7%)**	26
Duration on transfusion (years)	Median (range)	10.5 (1–20)	26
Transfusions per year	Median (IQR)	18 (13–24)	26
	Range	10–48	26

IQR = interquartile range.

Laboratory and anthropometric findings

Mean haemoglobin was 6.8 ± 2.0 g/dL (median 6.9, range 2.5–10.9) and mean corpuscular volume was 70.5 ± 6.6 fL. Mean body mass index among the 12 patients in whom it could be reliably calculated was 18.5 ± 3.7 kg/m². Laboratory and anthropometric findings are shown in Table 3.

Table 3: Laboratory and anthropometric findings

Parameter	Mean ± SD	Median (range)	n recorded
Haemoglobin (g/dL)	6.8 ± 2.0	6.9 (2.5–10.9)	19
Mean corpuscular volume (fL)	70.5 ± 6.6	72.1 (51.4–79.8)	19
Mean corpuscular haemoglobin (pg)	23.3 ± 2.3	23.3 (19.1–28.2)	18
Platelet count (×10³/µL)	244.9 ± 124.3	280.5 (57–494)	18

Parameter	Mean ± SD	Median (range)	n recorded
Serum ferritin (ng/mL)	**1,824.7 ± 805.4**	**1,646.4 (616.8–3,532)**	18
Body mass index (kg/m²)	18.5 ± 3.7	17.8 (12.8–25.4)	12
Pulse (beats/min)	104.5 ± 15.5	102.0 (81–128)	19

SD = standard deviation. Denominators differ between parameters because laboratory data were not available for all patients; see section 4.5.

Iron overload

Among the 18 patients in whom serum ferritin was measured, the mean concentration was 1,824.7 ± 805.4 ng/mL (median 1,646.4, range 616.8–3,532). Fifteen of 18 (83.3%) exceeded 1,000 ng/mL and 4 of 18 (22.2%) exceeded 2,500 ng/mL. Ten of 19 patients (52.6%) had a haemoglobin below 7 g/dL. Key thresholds are summarised in Table 4.

Table 4: Distribution of serum ferritin and key clinical thresholds

Finding	n / total	%
Serum ferritin >1,000 ng/mL	**15 / 18**	**83.3%**
Serum ferritin >2,500 ng/mL	**4 / 18**	**22.2%**
Serum ferritin 1,000–2,500 ng/mL	11 / 18	61.1%
Serum ferritin <1,000 ng/mL	3 / 18	16.7%
Haemoglobin <7 g/dL	10 / 19	52.6%

Exploratory associations

Serum ferritin correlated positively and significantly with annual transfusion frequency (ρ=0.52, p=0.032) and with age (ρ=0.53, p=0.023). No significant association was demonstrated between ferritin and family income, or between ferritin and parental consanguinity. These analyses are shown in Table 5 and are exploratory only.

Table 5: Exploratory associations with serum ferritin

Comparison	Test	Statistic	p value
Ferritin vs transfusions per year (n=17)	Spearman	**ρ = 0.52**	**0.032**
Ferritin vs age (n=18)	Spearman	**ρ = 0.53**	**0.023**
Ferritin vs monthly family income (n=18)	Spearman	ρ = 0.29	0.242
Ferritin: consanguineous vs non-consanguineous (5 vs 13)	Mann-Whitney U	U = 32.5	1.000

These analyses involve 17 to 18 patients and are uncorrected for multiple comparisons. They were not pre-specified and are reported as hypothesis-generating rather than confirmatory.

DISCUSSION

This study describes 38 children and young adults receiving regular blood transfusion at a tertiary care hospital serving a tribal population in eastern Gujarat. Three findings merit emphasis.

Iron overload

Iron overload was near-universal among patients in whom it was measured. Serum ferritin exceeded 1,000 ng/mL in 83.3% and 2,500 ng/mL in 22.2%, and rose with both age and annual transfusion frequency. This gradient is the expected signature of transfusional iron accumulating faster than chelation can remove it. Contemporary guidance regards chelation, guided by serial ferritin monitoring, as inseparable from transfusion itself in transfusion-dependent thalassaemia (Farmakis et al., 2022). The direction of these findings is consistent with the age-related rise in ferritin reported among transfused children elsewhere in Gujarat by Bhalodiya et al. (2023). The present data cannot distinguish whether the shortfall arises from chelator supply, affordability, adherence, or absent monitoring, and identifying which of these predominates is the natural next enquiry in this population.

Two qualifications apply to this gradient. First, the association was observed with annual transfusion frequency rather than with cumulative transfusion burden, which would require the product of frequency and duration; the present analysis therefore describes the intensity of current transfusion rather than lifetime iron input. Second, age and transfusion frequency are not independent of one another in a cohort transfused from infancy, so the two correlations should be read as one

finding rather than two. Both associations were exploratory, uncorrected for multiple comparisons and derived from 17 to 18 observations, and require confirmation in a larger series.

Haemoglobin and transfusion adequacy

The mean haemoglobin of 6.8 g/dL, with more than half of patients below 7 g/dL, lies well beneath the pre-transfusion target of approximately 9–10.5 g/dL recommended for a regular hypertransfusion regimen (Farmakis et al., 2022). If these values represent pre-transfusion concentrations, the pattern is consistent with transfusion being triggered by symptoms rather than delivered on schedule. Chronic under-transfusion permits compensatory marrow expansion with consequent skeletal deformity and growth impairment.

Household economic burden

Although blood is nominally provided free of charge within the public system, 5 of 24 families (20.8%) spent more than 10% of annual household income on therapy and associated costs, one family spending half of its annual income. Expenditure exceeding this threshold is widely used to define catastrophic health expenditure (Xu et al., 2003). In a cohort with a median monthly income of ₹10,000, this is a health-systems finding that a purely clinical account would overlook, and it is compounded by the tri-state catchment observed here: families travelling from Madhya Pradesh and Rajasthan incur travel and subsistence costs at every transfusion cycle. Out-of-pocket spending on chelating drugs and transport, rather than the cost of blood, is the plausible driver and warrants direct measurement.

Comparison with other Indian series

The demographic profile of this cohort accords with previous Indian work. Chattopadhyay et al. (2012) reported a mean age at presentation below 17 years and identified low educational status and poverty as barriers to health-seeking among patients with congenital haemolytic anaemia; the present cohort is consistent on all three counts, being overwhelmingly paediatric, poorly educated and economically marginal. Parental consanguinity in 29.6% is consistent with the recessive inheritance of these disorders and reinforces the case for premarital and extended-family screening in this district. It must be emphasised, however, that the absence of diagnostic subtyping in the present study precludes any comparison of the distribution of haemoglobinopathies with that reported by Chattopadhyay et al. (2012) or with other Indian series.

Limitations

Several limitations qualify these findings. Chelation status was not recorded, so the observed iron burden cannot be attributed to any specific failure of prescription, supply or adherence. Diagnostic subtyping by high-performance liquid chromatography was not performed, so the specific haemoglobinopathies represented in the cohort are unknown.

Serum ferritin was available for only 18 of 38 patients (47.4%), because testing was constrained by cost. This missingness is unlikely to be random, and it may bias the estimate in either direction: if testing was concentrated among families able to afford it, those patients may also have been better able to afford chelation, and the true prevalence of iron overload in the full cohort would be higher than 83.3%; conversely, if testing was prompted by clinical concern, the estimate would be inflated. The prevalence reported here should therefore be interpreted as applying to the tested subgroup rather than to the cohort as a whole.

The study was single-centre and hospital-based, and this hospital serves a limited tribal catchment. The findings describe patients who reach tertiary care and cannot be generalised to the community, in which both the most severely affected and the entirely untreated are likely to be under-represented. Body mass index was calculable in only 12 patients and was not converted to age- and sex-specific z-scores, so no inference about nutritional status is drawn here. Finally, the small number of observations underlying the exploratory analyses limits the precision of all reported associations.

CONCLUSION

Among 38 children and young adults receiving regular blood transfusion at a tertiary care hospital in tribal eastern Gujarat, iron overload was present in 83.3% of those tested and, in exploratory analysis, rose with age and annual transfusion frequency. Together these findings suggest suboptimal control of transfusional iron overload in this population. Haemoglobin was low, suggesting symptom-driven rather than scheduled transfusion. Despite nominally free blood, one in five families incurred catastrophic health expenditure. Routine diagnostic subtyping by high-performance liquid chromatography should be established so that the distribution of haemoglobinopathies in this tribal district can be determined, and premarital and extended-family screening strengthened given the substantial prevalence of parental consanguinity.

Conflict of interest: None.
Ethical approval: Obtained from the Institutional Ethics Committee, Zydus Medical College and Hospital, Dahod.
Informed consent: Written informed consent was obtained from parents or legal guardians of all participants below 18 years, with child assent where applicable, and from participants aged 18 years and above.

Author contributions
Concept and design: Dr. Zainab Cyclewala and Dr. Sanjaykumar
Data acquisition: Dr. Vidhi Shah
Analysis and interpretation: Dr. Yasheshkumar Ramanuj
Drafting: Dr. Shobhana Dangi, Dr. Arpita Rajgor
Critical revision: Dr. Vidhi Shah, Dr. Yasheshkumar Ramanuj
Final approval: All authors

Acknowledgements
The authors thank the blood bank, the participating families and the Thalassaemia Ward staff.

REFERENCES

1. Bhalodiya, V. R., Valiya, L. G., Mehta, N. A., & Padhariya, B. B. (2023). Correlation of serum ferritin level in transfusion-dependant thalassemia major patients: A study at a medical college affiliated hospital in Gujarat region. *International Journal of Contemporary Pediatrics, 10*(3), 330–333. https://doi.org/10.18203/2349-3291.ijcp20230429
2. Chattopadhyay, K., Biswas, R., Bhattacherjee, S., & Bandyopadhyay, R. (2012). An epidemiological study on the clinico-hematological profile of patients with congenital haemolytic anemia in a tertiary care hospital of Kolkata. *Indian Journal of Preventive and Social Medicine, 43*(4), 372–377.
3. El-Hazmi, M. A. (1987). Haemoglobinopathies, thalassaemias and enzymopathies in Saudi Arabia: The present status. *Acta Haematologica, 78*(2–3), 130–134.
4. Farmakis, D., Porter, J., Taher, A., Cappellini, M. D., Angastiniotis, M., & Eleftheriou, A. (2022). 2021 Thalassaemia International Federation guidelines for the management of transfusion-dependent thalassemia. *HemaSphere, 6*(8), e732.
5. Modell, B., & Darlison, M. (2008). Global epidemiology of haemoglobin disorders and derived service indicators. *Bulletin of the World Health Organization, 86*(6), 480–487. https://doi.org/10.2471/BLT.06.036673
6. Modell, B., & Petrou, M. (1983). The problem of the hemoglobinopathies in India. *Indian Journal of Hematology, 1*(5).
7. Old, J. M. (1996). Hemoglobinopathies. In *Molecular diagnosis of genetic diseases* (pp. 169–183). Humana Press.
8. Pasvol, G. (2010). Protective hemoglobinopathies and *Plasmodium falciparum* transmission. *Nature Genetics, 42*(4), 284–285.
9. Patel, A. P., Naik, M. R., Shah, N. M., Sharma, N. P., & Parmar, P. H. (2012). Prevalence of common hemoglobinopathies in Gujarat: An analysis of a large population screening programme. *National Journal of Community Medicine, 3*(1), 112–116.
10. Verma, I. C., Saxena, R., & Kohli, S. (2012). Hemoglobinopathies in India—Clinical and laboratory aspects. *Clinics in Laboratory Medicine, 32*(2), 249–262.
11. Weatherall, D. J. (2011). The challenge of haemoglobinopathies in resource-poor countries. *British Journal of Haematology, 154*(6), 736–744.
12. Xu, K., Evans, D. B., Kawabata, K., Zeramdini, R., Klavus, J., & Murray, C. J. (2003). Household catastrophic health expenditure: A multicountry analysis. *The Lancet, 362*(9378), 111–117.