Protocol for the cost-effectiveness of parenteral iron and oral iron therapy for first-line management of anaemia among pregnant women in a natural programme setting in Gujarat

Somen Saha,1 Bharat Desai,1 Manish Fancy,2 Tapasvi Puwar,1 Deepak Saxena,1 Komal Shah,1 Apurvakumar Pandya1

ABSTRACT

Introduction Maternal anaemia is a major public health issue in India. The government of India recommends parenteral iron to manage moderate and severe grades of anaemia. In contrast to its clinical efficacy, the cost-effectiveness of intravenous iron sucrose and ferric carboxymaltose is not yet established in Indian context. This article illustrates the protocol of health technology assessment to evaluate the cost-effectiveness of intravenous therapy on the improvement of haemoglobin concentration over oral therapy.

Methods and analysis The study will be carried out in two districts of Gujarat state. The study participants will be selected by a proportionate sampling method from the rural, tribal, desert and coastal region of the districts. Data will be collected over 1 year on key outcome indicators using a mixed-method approach. Key informant interviews will be conducted, and cost data will be gathered to perform cost-effectiveness analysis.

Ethics and dissemination This study is approved by the Technical Appraisal Committee of Health Technology Assessment India, Department of Health Research and Institutional Ethics Committee of the Indian Institute of Public Health, Gandhinagar.

INTRODUCTION

Maternal anaemia is a major public health issue in India. Specifically, iron-deficiency anaemia (IDA) during pregnancy is a significant public health concern as it is associated with perinatal mortality, preterm birth, neonatal low-birth-weight, and maternal mortality and morbidity. Furthermore, in Gujarat, iron deficiency is higher (65%) among anaemic women. Conventionally, the first line of treatment for IDA in pregnant women is oral iron (OI) therapy. Nevertheless, OI therapy is associated with numerous side effects, chiefly constipation, vomiting and epigastric discomfort. Therefore, compliance with this mode of treatment is a major concern.

Evidence reveals that OI is not sufficient for the treatment of moderate and severe IDA detected during the late stage of pregnancy.

Of all the parenteral iron preparations available, intravenous administration has emerged as an effective alternative to OI therapy in pregnant women. Apart from its quick absorption, intravenous mode is also known to impart a lesser incidence of hypersensitive reactions. Additionally, intravenous iron sucrose (IVIS) has been reported to be safe and effective during pregnancy. Recently, ferric carboxy maltose (FCM) is also considered as an effective treatment for IDA during pregnancy and the postpartum periods. Table 1 shows national guidelines for IDA treatment among pregnant women.

Prime Minister’s Overarching Scheme for Holistic Nourishment Campaign (POSHAN Abhiyaan) was launched in March 2018 in India to reduce the burden of anaemia. Complying with the overarching objective of POSHAN Abhiyaan, the Anaemia Mukt Bharat (Anaemia-Free India) strategy was
designed to achieve the ambitious target of 50% reduction of anaemia among women of reproductive age by 2025. To fulfill this target, digital methods for testing of anaemia among women of reproductive age by (Hb <10 g/dL) are being supplied by the government, and hence it is being used instead of 60 mg FCM, ferric carboxymaltose; I-NIPI, Intensified National Iron Plus Initiative; IVIS, intravenous iron sucrose; OI, oral iron.

Sample size
From an earlier study, the 0.75 g/dL change in Hb between these two groups is considered to calculate the sample size. Thus, by considering α error 5% and the power of the study as 95%, the estimated sample size was 26 per group. By assuming a loss-to-follow-up of 20%, the expected sample size comes to 32. Thus, a total of 64 patients (32 in each group) will be selected from the Devbhoomi Dwarka district. Considering the demography of Banaskantha and patients’ higher enrolment, we decided to take 100 patients in each group. Hence, a total of 200 patients will be selected for the Banaskantha district study. Injection (inj.) FCM has not yet started in Banaskantha and Devbhoomi Dwarka districts. Therefore, the inclusion of a third group (inj. FCM) will depend on the availability and coverage of inj. FCM in the respective districts. We expect to enrol 396 patients in the study from October 2020 to achieve the expected sample size.

### Table 1: I-NIPI operational guidelines for management of iron deficiency anaemia among pregnant women

<table>
<thead>
<tr>
<th>Anaemia Level</th>
<th>Guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>For mild (10–10.9 g/dL) and moderate (7–9.9 g/dL) anaemia</td>
<td>Two tablets of iron and folic acid tablet, that is, OI (60 mg* elemental iron and 500 μg folic acid) daily, orally given by the health provider during the antenatal care (ANC) contact. Parenteral iron therapy (IVIS or FCM) may be considered the first line of management in pregnant women who are detected to be anaemic late in pregnancy or compliance is likely to be low (high chance of loss to follow-up).</td>
</tr>
<tr>
<td>For severe (5–6.9 g/dL) anaemia</td>
<td>The treatment will be done using IVIS or FCM by the medical officer. Immediate hospitalisation is recommended in the third trimester of pregnancy at a health facility where round-the-clock specialist care is available.</td>
</tr>
</tbody>
</table>

Source: I-NIPI guideline (MoHFW, GOI 2018). *100 mg elemental iron is being supplied by the government, and hence it is being used instead of 60 mg FCM, ferric carboxymaltose; I-NIPI, Intensified National Iron Plus Initiative; IVIS, intravenous iron sucrose; OI, oral iron.

### Table 2: Key statistics of Banaskantha and Devbhoomi Dwarka districts based on 2019–2020 information

<table>
<thead>
<tr>
<th>Estimated numbers</th>
<th>Banaskantha</th>
<th>Devbhoomi Dwarka</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total pregnancy registered</td>
<td>40067</td>
<td>7015</td>
</tr>
<tr>
<td>Total anaemic pregnant women</td>
<td>19858</td>
<td>4213</td>
</tr>
<tr>
<td>Pregnant women with moderate anaemia (study cohort)</td>
<td>13276</td>
<td>1363</td>
</tr>
<tr>
<td>Pregnant women with severe anaemia (study cohort)</td>
<td>6582</td>
<td>32</td>
</tr>
</tbody>
</table>

Source: Records maintained by District Health Team for the year (April 2019–March 2020).
Study procedures
The study will be conducted in a natural programme setting of the primary health centres (PHCs). The blocks will be selected by proportionate sampling method from the four regions of the district, that is, rural, tribal, desert and coastal regions, based on the previous year’s registered pregnancy. The PHCs will be selected randomly from the proportionately selected blocks. Patients with moderate anaemia who are exclusively on OI supplements will be recruited as the control population. Women will be asked to bring back empty packs and be asked about the intake of tablets and the stools’ colour to ensure consumption of the tablets. Patients indicated for IVIS or FCM by the medical officer will be taken under the intervention arm. Iron requirements will be calculated using modified Ganzoni’s formula as follow.16

\[
\text{Iron requirement (mg)} = \text{Total iron deficit (mg)} = \text{Body weight (kg)} \times (\text{target Hb} - \text{actual Hb}) \times 0.24 + \text{storage iron (500) [mg]}
\]

At the baseline, information regarding sociodemographic profile, obstetric history, preintervention assessment (includes height, weight and Hb) and history of intervention will be recorded. All pregnant women will be followed up to 6 weeks following delivery. Hb levels will be measured at the end of each month after baseline and at the 42nd day of the postnatal period. Hb estimation will be carried out by a digital haemoglobinometer (HemoCue Hb 201 System recommended by the Ministry of Health and Family Welfare).13 through a laboratory technician available at the facility before treatment and during each follow-up visit. Figure 1 presents a summary of the study plan.

Valuing of health outcomes
Health-related quality of life will be assessed using the EuroQol-5 Dimensions-5 Levels (EQ-5D-5L) tool at baseline and during each follow-up visit. Five domains, namely, mobility, self-care, usual activities, pain and discomfort, and anxiety and depression, will be assessed on five-level scores ranging from 1 to 5, with 1 being the worst and 5 the best. The response on the EQ-5D-5L will be converted into a single index value to derive quality-adjusted life-year (QALY). The key clinical outcome will be assessed by a mean increase in Hb level.

Measuring the cost of care
The per beneficiary cost of therapy will be estimated from a societal perspective. Cost under various heads such as cost of therapy, consumables, healthcare resources (shared human resource, beds, etc), out-of-pocket expenses and wage loss will be collected from financial records and field interviews. Cost of therapy by OI, IVIS and FCM will be obtained from both government rate contracts and local bulk procurement as the case be. Details of consumables, including materials and supplies issued, consumed, quantity used per test and price per unit, will be collected from the respective facility. Financial and administrative records, including procurement and consumables records, will be reviewed. Healthcare facility-related costs such as time and bed occupied during IVIS or FCM administration will be calculated, whereas research costs such as costs associated with additional testing of sampled cases using digital haemoglobinometer will be excluded from the analysis. Out-of-pocket expenditure in terms of travelling cost and wage loss (of a patient and accompanying person) due to referral or follow-up will be gathered from field records. The costs will be presented as average values across interventions, viz—OI, IVIS or FCM.

Data storage and security
Data will be stored in encrypted and password-protected computer system at the institution. Hard copy of the records will be stored in a locked cupboard in a secure location at the institute. Access to records and study data will be restricted to study personnel. Study data will be de-identified and will be stored separately from the data.

Patient and public involvement
There was no patient or public involvement in the design and planning of the study.

PLAN OF ANALYSES
The primary analysis will be reported as per ‘intention to treat’ to assess the clinical effectiveness and avoid potential bias due to the exclusion of patients. In contrast, the secondary analysis will be carried out as per ‘per protocol’ analysis to identify a treatment effect under optimal conditions. The primary outcome measure will be the mean change in Hb level from baseline. Besides, secondary outcome measures will include target Hb achievement (>11 g/dL), the incidence of treatment failure including change of therapy for side effects, maternal mortality due to postpartum haemorrhage (PPH), pregnancy-related complications due to PPH, preterm birth, low-birth-weight neonates, maternal weight gain, early neonatal mortality and requirement of blood units during delivery. The analysis will be adjusted for protein-energy malnutrition, gestation, compliance to treatment, socioeconomical background, parity and blood loss during delivery. Findings will be subgrouped according to population (urban/rural/tribal/coastal), baseline Hb levels, trimester of pregnancy, grades of compliance, duration and treatment dose. Further subgroup analysis will be employed within the intervention arm to understand the dose–response and mean change in Hb.

Cost-effectiveness analysis
The cost-effectiveness analysis (CEA) per QALY gained will be undertaken by estimating the programme


Iron requirement (mg) = Total iron deficit (mg) = Body weight (kg) × (target Hb - actual Hb) [g/dl] × 0.24 + storage iron (500) [mg]

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Cost from societal perspective
- Cost of administering IVIS
- Cost of administering FCM
- Time spend by health workers including bed occupancy
- Transportation cost

Establishment of Cohort of pregnant females from Banaskantha and Devbhoomi Dwarka Districts

Total ANC registered in 6 months (Banaskantha: 40667 Devbhoomi Dwarka: 7015)

Pregnant women with moderate/severe anaemia
Banaskantha: 1958 Devbhoomi Dwarka: 1395

Pregnant women with no/mild anaemia
Banaskantha: 20299 Devbhoomi Dwarka: 2802

Intervention group

Inj. FCM given
Banaskantha: 100 Devbhoomi Dwarka: 32

Inj. Iron sucrose given
Banaskantha: 100 Devbhoomi Dwarka: 32

Ol (tab. IFA) given
Banaskantha: 100 Devbhoomi Dwarka: 32

Control Group

Indicators to be assessed in both groups
- Primary outcome: Change in mean haemoglobin level from baseline
- Secondary outcomes: Target haemoglobin achievement (>11 g/dL), Compliance to the treatment, highest haemoglobin level (Hb level just before delivery), incidence of treatment failure, change of therapy for side effects, incidence of maternal mortality due to anaemia related complications, incidence of pregnancy related complications, pre-term birth, low-birth weight neonates, maternal weight gain, early neonatal mortality, requirement of blood units during delivery
- Cost from limited societal perspective

Planned subgroup analysis
- According to population: Urban/Rural/Tribal
- Effect of intervention according to the baseline haemoglobin levels
- Effect of intervention at different trimesters of pregnancy
- Effect of intervention within various grades of compliance
- Effect of intervention according to duration and dose of treatment

Figure 1  Summary of the study design to compare the cost-effectiveness of the IVIS and FCM therapy among pregnant women with IDA. FCM, ferric carboxymaltose; Hb, haemoglobin; IDA, iron-deficiency anaemia; inj. injection; IVIS, intravenous iron sucrose.

implementation cost from the health system and societal perspective. The incremental cost-effectiveness ratio (ICER) will be calculated by combining costs and outcomes. The CEA results will be expressed in cost per patient achieving target Hb across the approaches (Ol, IVIS and FCM) and cost per unit change in mean Hb level after 6 weeks of delivery compliance rate.

The cost-effectiveness model will be cross-verified using subgroup analysis, where the population will be grouped according to landscape classification (urban/rural/tribal/coastal), baseline Hb level, trimester of pregnancy and compliance. One-way sensitivity analysis will be carried out by varying model parameters to estimate joint uncertainty in all parameters. A tornado chart will be presented using ICER values to depict changes in selected variables that influence the results.

DISCUSSION

It is evidenced that with an increase in each 1 g/dL mean Hb level, the risk of maternal mortality falls by 25%.\textsuperscript{17} Evidence indicates that the Hb level in the range between 5 g/dL and 12 g/dL is significantly associated with reducing maternal mortality.\textsuperscript{18} Therefore,
an aggressive approach for treating moderate and severe anaemia among pregnant women is justified. One therapy is indicated in a patient diagnosed with moderate anaemia in pregnancy unless the patient presents late in pregnancy or those whose compliance is likely to be low (high chance of loss-to-follow up). In these patients, parenteral iron therapy is indicated. A systematic review conducted by Qassim et al in 2018 concluded that different intravenous iron preparations (FMC/iron polymaltose/iron sucrose) were similar in terms of safety and efficacy. They documented that cost and convenience of administration mainly influence the selection of specific parenteral iron preparation. However, evidence on the effect of parenteral iron therapy on improvements in critical maternal or perinatal outcomes lacked in the available literature. Unfortunately, no studies from Indian settings had performed comprehensive cost (including cost incurred by health system) evaluation of oral and parenteral iron therapy. One cost-included in a natural programme setting using a health system perspective. Therefore, it has a huge scope of generating evidence for policy-makers.

ETHICS AND DISSEMINATION

Technical approval has been obtained from the Technical Appraisal Committee of the Department of Health Research and the Indian Institute of Public Health Gandhinagar’s institutional ethics committee (TRC-IEC No: 11/2019-20). A manuscript with the results of the primary study will be published in a peer-reviewed journal.

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Contributors SS: conceptualised and designed the study; BD: drafted the protocol; AP: aided manuscript writing, review and editing. DS, TP, MF and KS: reviewed the content of the protocol and edited the manuscript. All authors read and approved the manuscript.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not required.

Provenance and peer review Not commissioned; externally peer reviewed.

REFERENCES

18. Kant S. Do we have a magic bullet to treat moderate and severe anaemia in pregnant women? Indian J Public Health 2019;63:165–70.