Pharaoh Academy

A cost-comparative analysis of intravenous Ferric Carboxymaltose versus Iron Sucrose for the ambulatory treatment of Iron-deficiency Anemia in a major tertiary care hospital in Saudi Arabia

Alzahrani S[1], Almeziny M[1], Narang A[2], Mohamed O[3] Salem Almeziny[4], Abdullah Almeziny[5]

Correspondence:
Mohammed Almeziny
Prince Sultan Military Medical City (PSMMC)
Riyadh, Saudi Arabia
Email: meziny@hotmail.com

1Prince Sultan Military Medical City, Riyadh, Saudi Arabia
2 IQVIA, Gurgaon, India
3 IQVIA, Dubai, DU, United Arab Emirates
4 College of medicine, Almaarefa University, Riyadh, Saudi Arabia.
5College of medicine, Imam Mohammad Ibn Saud Islamic University, Riyadh, Saudi Arabia.

Volume number 1
Issue number 1
Pages 28-35

10.61466/ijcmr1010005

Received: 19.07.2023
Accepted: 19.08.2023
Published: 20.08.2023
0nline: 20.08.2023

Abstract

Background:

The objective of this study was to compare the cost of outpatient ferric carboxymaltose (FCM; Ferinject®) versus Iron sucrose complex (ISC; Ferosac®), two prevalent intravenous iron therapy used in the treatment of iron-deficiency anemia (IDA) in the Kingdom of Saudi Arabia (KSA) from a tertiary care hospital perspective.

Methods:

A retrospective study was performed for all patients who were administered FCM in the outpatient clinical setting at Prince Sultan Military Medical City from January 1, 2019, until December 31, 2019. The descriptive data was analyzed using Microsoft Excel 2019 (Microsoft Corporation, Redmond, WA, USA). The total cost of treatment reflected the cost of drugs, the cost of disposables for each infusion, drug monitoring costs during infusion, the cost of productivity loss, and patient traveling cost.

Result:

Overall, 993 patients with IDA, treated with FCM in 1,688 outpatient visits were recruited in the study. In the outpatient setting, the per annum cost of treatment was SAR 1,434,092.50 with FCM treatment and SAR 1,715,299.70 with ISC treatment, with a corresponding saving of 16.4% (SAR 281,207.20) with FCM. The cost savings with FCM treatment can be attributed to the reduced frequency of patient visits and corresponding reduction in drug monitoring costs (SAR 266,995.20;77.3%), loss of productivity per year (SAR 163,550.20; 77.3%), and cost of transportation per year (SAR 573,920.00; 77.3%).

Conclusion:

The use of FCM, as opposed to ISC resulted in a reduced number of iron infusions (4.4 visits for ISC as compared to one visit for FCM), accompanied by a reduction in the total cost. FCM may represent a cost-saving option compared with the existing alternative therapy used for the management of IDA in KSA.

Keywords: Iron-deficiency anemia, Ferric carboxymaltose, Kingdom of Saudi Arabia, cost-comparative analysis, Intravenous Iron, Iron sucrose

Introduction

Anemia affects about 2 billion people globally, corresponding to over 27% of the world's population, with iron-deficiency anemia (IDA) being the most significant contributor [1, 2]. IDA is predominant in children, pre-menopausal women, and among population in low and middle-income countries [3, 4]. Although the prevalence of IDA varies widely, estimates suggest that the prevalence of IDA in the Kingdom of Saudi Arabia (KSA) ranges from 10%-60% [5, 6, 7].

The primary risk factors for IDA include inadequate iron intake, low nutritional iron absorption, blood loss (gastrointestinal, gynecological bleeding, urinary tract bleeding, respiratory bleeding), history of menometrorrhagia, and period of life with increased

iron requirements i.e. growth and pregnancy [8, 9, 10, 11]. According to the World Health organization (WHO), IDA is defined as blood hemoglobin (Hb) values of less than 7.7 mmol/l (13 g/dl) in men and 7.4 mmol/l (12 g/dl) in women and low serum ferritin levels [12, 13]. Serum ferritin concentrations below 15 µg/L are reflective of depleted iron stores, whereas concentrations between 30 and 100 µg/L indicate iron-deficiency due to other factors such as infection [14, 15]. Iron deprivation generates microcytic hypochromic red blood cells resulting in depleted oxygen delivery to body cells and reduced iron-cofactor-enzyme activity [16]. While some patients remain asymptomatic, reduced oxygen delivery in IDA leads to fatigue, dizziness, breathlessness, palpitations, and reduced cognitive function [1, 2, 11]. IDA is associated with reduced physical performance, ability to work, and low health-related quality of life (HR-QOL) [2].

The management of IDA is idiosyncratic, based on the etiology and severity of IDA [17]. Oral iron supplementation is typically the first line of therapy to restore Hb levels and replenish iron stores [17]. Parenteral iron supplementation (mostly intravenous [IV]) is recommended for patients who are intolerant to oral iron supplementations, with Hb below 10g/dL or with indications like gastrointestinal effects, worsening symptoms of inflammatory bowel disease (IBD), unresolved bleeding, chronic kidney disease or celiac disease [17, 18, 19]. Available IV iron supplementations include iron dextran, iron sucrose complex (ISC), sodium ferric gluconate, iron isomaltoside, and ferric carboxymaltose (FCM). Iron dextran is the oldest IV iron supplementation with a single dose infusion and low cost, however it is associated with a high incidence of anaphylactic reactions which are less frequent with newer IV formulations such as ISC and FCM [20, 21]. Sodium ferric gluconate, a safer alternative to iron dextran has been in clinical practice for about two decades [22]. Iron isomaltoside received approval by the United states Food and Drug Administration for the treatment of IDA in 2020, after being available in Europe for many years [23]. However, it is not used in clinical practice as IV iron supplementation for patients with IDA in the gulf countries [24].

Iron sucrose, a dextran-free formulation is administered as a 15-30-minute infusion in 200-300 mg doses [25]. It is recommended that the weekly dose of ISC must not exceed 600 mg, thereby resulting in multiple infusions for patients to achieve the required iron concentration [25]. If administered in recommended doses, ISC is safe and well tolerated with low incidence of adverse events or hypersensitivity reactions [26, 27]. FCM is a colloidal solution consisting of a polynuclear iron (III)-hydroxide core stabilized by carboxymaltose, and can be administered as a single dose of 1000 mg in a 15-minute-infusion [28]. FCM is approved for rapid and high-dose replenishment of depleted iron stores [28]. The favorable safety and efficacy profile of FCM has been assessed in clinical trials, and makes it a competent addition to the treatment armamentarium for IDA [29, 30, 31]. A network meta-analysis involving 21 randomized controlled trials with various IV formulations, reported that FCM provides rapid corrections of Hb and serum ferritin in iron-deficient patients [31]. FCM effectiveness is also supplemented with cost-saving benefits for hospitals, healthcare providers, and patients owing to less frequent and shorter hospital visits [32, 33, 34].

In a consensus statement by 16 clinical experts on the management of IDA in the gulf cooperation council countries published in 2019, IV iron therapy with FCM or ISC is recommended if a patient is intolerant or shows inadequate response (Hb rise <1.0 g/dL) to oral iron therapies [24]. FCM was approved in Prince Sultan Military Medical City (PSMMC) hospital for ambulatory treatment of IDA only while, ISC has no such restrictions. This study aimed to compare the cost of outpatient FCM (Ferinject®) versus ISC (Ferosac®) in the treatment of IDA in KSA from a tertiary care hospital setting perspective.

Methods

All of the experiments described here were conducted with permission from the Institutional Ethics Committee at Almaarefa University. A retrospective analysis was performed to compare the resource use and costs associated with the outpatient FCM and ISC in the treatment of IDA in a major tertiary hospital in Riyadh, KSA. The descriptive analysis was conducted using Microsoft Excel 2019 (Microsoft Corporation, Redmond, WA, USA).

Model Structure and scenarios

The model was developed in concordance with the data retrieved from literature and patient medical charts from PSMMC . The model estimated economic outcomes under two scenarios: a) only ISC being administered for the treatment of IDA; and b) Only FCM being administered for the treatment of IDA. The analysis was conducted based on the assumption that both the iron formulations were equivalent in terms of safety and efficacy. The economic impact was evaluated within a 1-year time horizon.

Study Population

Patients of all age-groups treated in the outpatient clinical setting at PSMMC for IDA with FCM from January 1, 2019, until December 31, 2019 were included in the study. The baseline demographic characteristics and treatment requirements were based on patient data retrieved from the hospital. The data for number of visits and dosage (number of vials) for each patient were extracted for the analysis. The total time consumed to administer either ISC or FCM treatment was calculated upon considering the time required for total dose infusion, number of visits, and the additional turnaround time per infusion.

Resource Use, Costs and Outcomes

Medical costs incurred in the outpatient hospital setting pertaining to drug acquisition, cost of disposables utilized in drug delivery, monitoring cost of infusion, other hospital-related expenses, patient productivity loss, and patient

traveling cost were incorporated in the model. All costs were reported in Saudi Riyals (SAR). Unit cost inputs for FCM (Ferinject®) and ISC (Ferosac®) substitute formulas were obtained from the hospital. The cost savings were calculated in terms of the difference in administration time per patient per year. Data regarding the disposables used for drug administration was obtained from the hospital records. It was assumed that one set of disposables (syringes, cannula, alcohol swabs) were used per patient for each hospital visit.

Drug monitoring cost include the time dedicated (in hours) by the hospital staff (nurses) in drug infusions and is based upon the salary and hours spent by nurses to monitor infusions, and the number of corresponding visits. The patients were under close medical observation during the drug infusion. The time for drug infusion was retrieved from the real time infusion used in the outpatient hospital setting.

Productivity loss represents the economic loss due to missed days of work to receive the treatment, including the waiting time per visit. The productivity loss cost per day was calculated as average salary per hour and the average waiting time per visit [35]. Traveling cost includes the expenses incurred by patients for traveling to and from the hospital for the treatment. The mean traveling cost per patient visit was estimated as SAR 100 as per excerpt insights. Discounting was not employed in the analysis as the costs were modeled for a year, and discounting is not recommended in the health economic evaluation guidelines from the International Society for Pharmacoeconomic and Outcomes Research [36].

The outcomes evaluated in the model included overall annual budget savings, cost breakdown in terms of drug cost and non-drug costs, the number of hospital visits and total cost per course of treatment for male and female patients.

Results

Study population distribution

Overall, 993 patients with 88.9% (n=883) females received FCM in an outpatient setting. FCM was administered in 1,688 outpatients' visits, with a majority; over 90.0% (n=1,522) of the patient visits being females– mean age (standard deviation [SD]) of 38.2 (±13.4) years (Figure 1). The mean age (SD) of male patient visits for FCM was 54.0 (±23.7) years. The most frequently used doses for FCM were 1000 mg and 500 mg in 74.9% (n=1,264) and 23.9% (n=403) visits, respectively. ISC was administered in 7,427 visits in the outpatient setting. To administer a complete iron dose, a patient required 4.4 visits for ISC compared to a single visit for FCM in an outpatient setting.

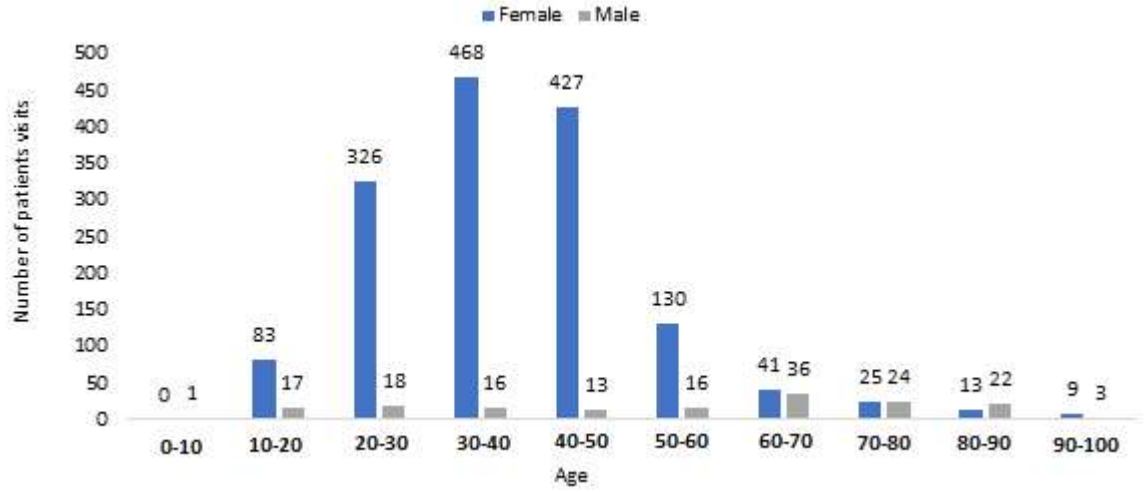


Figure 1 : Study patients visits distribution by age- groups

Total cost savings

Overall, the per annum cost of treatment in outpatient clinical setting in KSA was SAR 1,434,092.50 with FCM treatment and SAR 1,715,299.70 with ISC treatment. Treatment of IDA patients with FCM delivered a corresponding saving of 16.4% (SAR 281,207.20) in comparison to ISC (**Error! Reference source not found.**). The cost savings with FCM treatment can be attributed to reduced frequency of patient visits and corresponding reduction in drug monitoring costs (SAR 266,995.20; 77.3%), loss of productivity per year (SAR 163,550.20; 77.3%) and cost of transportation per year (573,920.00; 77.3%).

Direct costs of treatment

The total direct costs estimated for FCM was higher than ISC (SAR 1,217,189.50 versus SAR 760,926.50, respectively) in the outpatient clinical setting (**Error! Reference source not found.**).

The cost of FCM drug per visit was SAR 642.10, while that of ISC was SAR 23.50, as derived from the Ministry of Defense and Aviation (MODA), KSA (**Error! Reference source not found.**). The total cost per visit per male/female patient treated with FCM was SAR 1017.50/SAR 831.30, while with ISC it was SAR 398.90/SAR 212.60, respectively. The total cost of medical infusion per year for FCM was SAR 1,138,661.50 while that for ISC was SAR 415,403.30.

TABLE 1: NET BUDGET IMPACT IN EACH TREATMENT ARM PER ANNUM

Cost item (in SAR)	Ferric carboxymaltose	Iron sucrose complex	Incremental cost	Incremental %
Cost of Medication Infusion Per Year	1,138,661.5	415,403.3	723,258.2	174.1%
Total Cost of Nurse Per Year	78,528.0	345,523.2	-266,995.2	-77.3%
Total Direct Cost	1,217,189.5	760,926.5	456,263.0	60.0%
Loss of Productivity Per Year	48,103.0	211,653.2	-163,550.2	-77.3%
Cost of Transportation Per Year	168,800.0	742,720.0	-573,920.0	-77.3%
Total Indirect Cost	216,903.0	954,373.2	-737,470.2	-77.3%
Total Cost (Direct + Indirect)	1,434,092.5	1,715,299.7	-281,207.2	-16.4%

SAR: Saudi Riyal

Table 1: Direct costs associated with FCM versus ISC

Costs Item (in SAR)	Ferric Carboxymaltose	Iron Sucrose Complex	Difference
Total Cost Per Visit for Male	1,017.5	398.9	-618.6
Total Cost Per Visit for Female	831.3	212.6	-618.6
Total Cost of all Visits for Male	168,909.0	291350.2	122441.3
Total Cost of all Visits for Female	1,265,183.5	1423949.5	158765.9
Cost of Medication Infusion Per Year	1,138,661.5	415,403.3	723,258.2
Total Cost of Nurse Per Year	78,528.0	345,523.2	-266,995.2
Total Direct Cost (in SAR)	**1,217,189.5**	**760,926.5**	**456,263.0**

SAR: Saudi Riyal

Table 3: Costs Used in the model

Cost item (in SAR)	Ferric carboxymaltose	Iron Sucrose complex
Cost of drug per visit	642.1	23.5
IV cannula G-20	4.0	4.0
IV line sets	23.8	23.8
Alcohol swap	0.0	0.0
IV plaster	0.9	0.9
Plaster	0.1	0.1
Syringe 10cc without needle 10 ml	0.4	0.4
Syringe 10cc with needle	0.4	0.4
Normal saline 10cc	0.2	0.2
Normal saline 250cc	2.8	2.8
Cost of nurse per visit	196.4	196.4
Cost of transportation	10.2	10.2

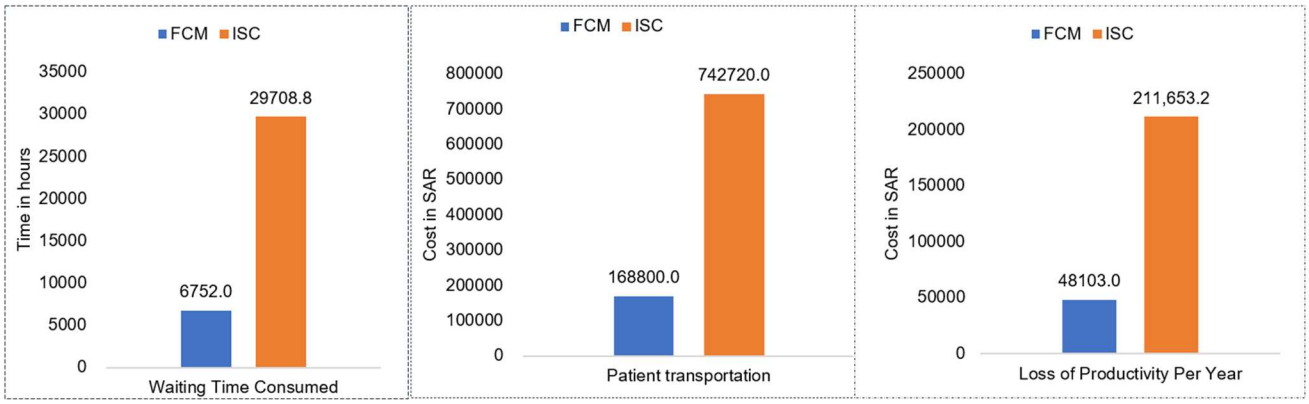
IV: intravenous; SAR: Saudi Riyal

Although, FCM was associated with higher cost of treatment per visit and higher medical infusion costs in comparison to ISC, the total cost of all visits in FCM reduced by SAR 122,441.30 and SAR 158,765.90 in male and female patients, respectively (**Error! Reference source not found.**). It was estimated that six nurses (four technician nurses and two senior nurses) were involved in the treatment infusion in both the scenarios with an average salary of SAR 5,000 for technician nurses and SAR 10,000 for senior nurses. Correspondingly, the cost of nurse for each patient visit was calculated as SAR 46.50. The total cost of nurse per year for FCM and ISC was SAR 78,528.00 and SAR 345,523.20, respectively, indicating a cost savings of SAR 266,995.20 in annual nurse

cost in the FCM scenario (**Error! Reference source not found.**).

Indirect costs of treatment

The total indirect costs associated with FCM and ISC treatment was SAR 216,903.00 and SAR 954,373.20, respectively. The average salary for a male in KSA was estimated as 49.10 SAR/hour based on global survey statistics [37] and for female it was 2.60 SAR/hour, as derived from MODA. With an estimated waiting time of 4 hours for each patient visit, the loss of productivity per visit for male/female patient was estimated as SAR 196.40/SAR 10.20 for both regimens. The total waiting time consumed in the FCM scenario was 6,752 hours, while in the ISC scenario it was 29,709 hours. The waiting time was reduced by 22,957 hours in patients treated with FCM in comparison to ISC. FCM treatment scenario was associated with low productivity loss. The total annual productivity loss in patient treated with FCM and ISC was SAR 48,103.00 and SAR 211,653.20, respectively. The cost of transportation was calculated as SAR 100.00 per visit. To administer the iron doses, patients spent more on transportation for ISC (SAR 742,720.00) compared to FCM (SAR 168,800.00), owing to the increased patient visits in ISC treatment (**Error! Reference source not found.**).



FCM: Ferric carboxymaltose; ISC: Iron sucrose complex; SAR: Saudi Riya

Figure 1: Indirect costs of treatment: a: waiting time consumed b: transportation per year c: loss of productivity per year

Discussion

Being one of the most prevalent nutritional deficiency across the globe, it is imperative to explore cost effective alternatives for IDA management. The present study provides preliminary results for the comparison of the cost of outpatient FCM versus ISC in the management of IDA in 993 patients from a tertiary care hospital setting perspective in KSA. A previous study from the region by Hejazi et al. assessed cost comparisons for FCM and ISC in IDA patients with heavy uterine bleeding (HUB) [38].

Majority of the patient visits in this study were females (90.2%), with an overall mean (SD) age of 39.8 (±15.5) years, in line with previous epidemiological studies from KSA confirming higher occurrence of IDA in pre-menopausal women [39, 40]. The present study results demonstrated that FCM presents cost-saving of 16.4% (SAR 281,207.20) in comparison to ISC for the treatment of patients with IDA in KSA. The results of the present study are congruent with the Hejazi et al. study that demonstrated a cost-saving of SAR 355,000 over a one-year time horizon with FCM versus ISC in treating IDA patients with HUB [38]. Present study outcomes are directionally in concurrence with previous studies. The findings of a budget impact analysis of ISC versus FCM in Switzerland by Brock et al. suggested a cost savings of 30%-44% per patient per treatment cycle with FCM [41]. An economic evaluation by Fragoulakis et al. comparing management of IDA with FCM, ISC, and low-molecular-weight iron dextran in 100 patients in a Greek hospital outpatient settings, concluded that the total cost of FCM was 201.1% lower as compared to ISC [42]. Another study conducted in Denmark to evaluate the health care costs of ISC and FCM treatment in 111 IBD patients with iron-deficiency in an outpatient setting, represented FCM as a cost-saving alternative [43].

In this study the direct cost of medical infusions per year in FCM scenario (SAR 1,138,661.50) was nearly three times higher compared to ISC scenario (SAR 415,403.30). Yet, FCM emerged as a cost-saving alternative for treatment of patients with IDA in the outpatient setting. The primary factor driving the cost savings related to FCM in the present study was a considerable reduction in the number of infusions required to correct iron deficits in patients with IDA. The reduction in infusions was supplemented with reduction in drug monitoring costs (SAR 266,995.20; 77.3%), loss of productivity per year (SAR 163,550.20; 77.3%) and cost of transportation per year (SAR 573,920.00; 77.3%) with FCM relative to ISC over 1-year horizon. High-dose iron supplementation has previously been shown to reduce waiting time for patients with IDA owing to the rapid iron repletion [44]. Furthermore, it must be underlined that the cost of productivity loss in the present study is underestimated as most of the times the

patients are accompanied by an attendant and thus the productivity loss cost could be higher.
While the study design was conducted using real-world hospital data, the study results must be interpreted in context to its limitations that are common to other studies using similar methodologies. The study model lacked ‘‘clinical discretion modeling’’ in determining the number of subsequent iron infusions. The model assumed that both the IV iron formulations (FCM and ISC) were equally effective in repletion of the iron-deficiency. In clinical practice, however, practical aspects of administration may result in different effectiveness outcomes. The study represents results from a hospital setting in KSA based on current resources and drug prices, therefore the results must be considered in KSA settings only. Nevertheless, this study presents an estimate of the potential savings from the utilization of FCM for the treatment of patients with IDA in KSA and provides valuable information for medical decision making in routine clinical practice as a vital supplement to the results obtained from previous clinical trials and real-world studies.

Conclusion

The study results indicate that FCM delivers higher cost-saving benefits than ISC for hospitals, healthcare providers, and patients in the outpatient setting. The cost savings with FCM was primarily driven by reduced frequency of hospital visits leading to lower indirect costs (productivity loss and transportation cost) and decreased drug monitoring costs. In the present COVID-19 scenario, fewer hospital visits benefit both the patient to reduce COVID-19 exposure and the hospital with reduced capacity.

Transparency

Declaration of funding: Vifor Pharmaceuticals provided the funding for the study for medical writing, editorial support, and formatting assistance.
Declaration of financial/other interests: Authors A. Narang and O. Mohamed are employees of IQVIA, that received consulting fees from Vifor Pharma for the conduct of the study.
Acknowledgments: The authors would like to thank Koshu Mahajan and Vibha Dhamija (IQVIA, India) for their medical writing and editing support.

References

1. Kassebaum NJ, Jasrasaria R, Naghavi M, et al. A systematic analysis of global anemia burden from 1990 to 2010. Blood. 2014;123(5):615-624. doi: 10.1182/blood-2013-06-508325. PubMed PMID: 24297872;
2. Kassebaum NJ. The Global Burden of Anemia. Hematology/Oncology Clinics of North America. 2016 2016/04/01/;30(2):247-308. doi: https://doi.org/10.1016/j.hoc.2015.11.002.
3. Chaparro CM, Suchdev PS. Anemia epidemiology, pathophysiology, and etiology in low- and middle-income countries. Annals of the New York Academy of Sciences. 2019 Aug;1450(1):15-31. doi: 10.1111/nyas.14092. PubMed PMID: 31008520; PubMed Central PMCID PMCPMC6697587
4. Mantadakis E, Chatzimichael E, Zikidou P. Iron Deficiency Anemia in Children Residing in High and Low-Income Countries: Risk Factors, Prevention, Diagnosis and Therapy. Mediterr J Hematol Infect Dis. 2020;12(1):e2020041-e2020041. doi: 10.4084/MJHID.2020.041. PubMed PMID: 32670519;
5. Al Hassan NN. The prevalence of iron deficiency anemia in a Saudi University female students. J Microsc Ultrastruct. 2015 Jan-Mar;3(1):25-28. doi: 10.1016/j.jmau.2014.11.003. PubMed PMID: 30023178;
6. Owaidah T, Al-Numair N, Al-Suliman A, et al. Iron Deficiency and Iron Deficiency Anemia Are Common Epidemiological Conditions in Saudi Arabia: Report of the National Epidemiological Survey. Anemia. 2020 2020/12/29;2020:6642568. doi: 10.1155/2020/6642568.
7. Verster A, Vander Pols, Jolieke C. Anaemia in the Eastern Mediterranean Region. 1995 1995.
8. Goddard AF, James MW, McIntyre AS, et al. Guidelines for the management of iron deficiency anaemia. Gut. 2011;60(10):1309. doi: 10.1136/gut.2010.228874.
9. Means RT. Iron Deficiency and Iron Deficiency Anemia: Implications and Impact in Pregnancy, Fetal Development, and Early Childhood Parameters. Nutrients. 2020 Feb 11;12(2). doi: 10.3390/nu12020447. PubMed PMID: 32053933; PubMed Central PMCID PMCPMC7071168
10. Wang M. Iron Deficiency and Other Types of Anemia in Infants and Children. American family physician. 2016 Feb 15;93(4):270-8. PubMed PMID: 26926814;
11. DeLoughery TG. Iron Deficiency Anemia. The Medical clinics of North America. 2017 Mar;101(2):319-332. doi: 10.1016/j.mcna.2016.09.004. PubMed PMID: 28189173;
12. WHO. Haemoglobin concentrations for the diagnosis of anaemia and assessment of severity. Vitamin and mineral nutrition information system; World Health Organization Geneva, Switzerland2011. Available from: https://www.who.int/vmnis/indicators/haemoglobin.pdf
13. Ko CW, Siddique SM, Patel A, et al. AGA Clinical Practice Guidelines on the Gastrointestinal Evaluation of Iron Deficiency Anemia. Gastroenterology. 2020;159(3):1085-1094. doi: 10.1053/j.gastro.2020.06.046.
14. WHO. Serum ferritin concentrations for the assessment of iron status and iron deficiency in populations; World Health Organization Geneva, Switzerland2011. Available from: https://www.who.int/vmnis/indicators/serum_ferritin.pdf
15. Daru J, Colman K, Stanworth SJ, et al. Serum ferritin as an indicator of iron status: what do we need to know? Am J Clin Nutr. 2017;106(Suppl 6):1634S-1639S. doi: 10.3945/ajcn.117.155960. PubMed PMID: 29070560;

16. Pasricha SR, Tye-Din J, Muckenthaler MU, et al. Iron deficiency. Lancet (London, England). 2021 Jan 16;397(10270):233-248. doi: 10.1016/s0140-6736(20)32594-0. PubMed PMID: 33285139;
17. Aleem A, Alsayegh F, Keshav S, et al. Consensus Statement by an Expert Panel on the Diagnosis and Management of Iron Deficiency Anemia in the Gulf Cooperation Council Countries. Medical Principles and Practice. 2020;29(4):371-381. doi: 10.1159/000503707.
18. Goddard AF, James MW, McIntyre AS, et al. Guidelines for the management of iron deficiency anaemia. 2011;60(10):1309-1316. doi: 10.1136/gut.2010.228874 %J Gut.
19. Johnson-Wimbley TD, Graham DY. Diagnosis and management of iron deficiency anemia in the 21st century. Therap Adv Gastroenterol. 2011;4(3):177-184. doi: 10.1177/1756283X11398736. PubMed PMID: 21694802;
20. Trumbo H, Kaluza K, Numan S, et al. Frequency and Associated Costs of Anaphylaxis- and Hypersensitivity-Related Adverse Events for Intravenous Iron Products in the USA: An Analysis Using the US Food and Drug Administration Adverse Event Reporting System. Drug safety. 2021 Jan;44(1):107-119. doi: 10.1007/s40264-020-01022-2. PubMed PMID: 33237523; PubMed Central PMCID PMCPMC7813702 Lawrence T. Goodnough is a consultant for American Regent. Karolina Kaluza and Syed Numan are employees of American Regent, the manufacturers of ferric carboxymaltose.
21. Wang C, Graham DJ, Kane RC, et al. Comparative Risk of Anaphylactic Reactions Associated With Intravenous Iron Products. Jama. 2015 Nov 17;314(19):2062-8. doi: 10.1001/jama.2015.15572. PubMed PMID: 26575062;
22. Fishbane S, Kowalski EA. The comparative safety of intravenous iron dextran, iron saccharate, and sodium ferric gluconate. Seminars in dialysis. 2000 Nov-Dec;13(6):381-4. doi: 10.1046/j.1525-139x.2000.00104.x. PubMed PMID: 11130261;
23. USFDA. MONOFERRIC (ferric derisomaltose) injection, for intravenous use; Prescribing information 2020. Available from: https://www.accessdata.fda.gov/drugsatfda_docs/label/2020/208171s000lbl.pdf
24. Aleem A, Alsayegh F, Keshav S, et al. Consensus Statement by an Expert Panel on the Diagnosis and Management of Iron Deficiency Anemia in the Gulf Cooperation Council Countries. Medical principles and practice : international journal of the Kuwait University, Health Science Centre. 2020;29(4):371-381. doi: 10.1159/000503707. PubMed PMID: 31698356; PubMed Central PMCID PMCPMC7445696
25. Vifor. Prescribing Information; Venofer (iron sucrose) injection 200 [updated 2017;June 15, 2021]. Available from: https://www.accessdata.fda.gov/drugsatfda_docs/label/2017/021135s032lbl.pdf
26. Aronoff GR, Bennett WM, Blumenthal S, et al. Iron sucrose in hemodialysis patients: safety of replacement and maintenance regimens. Kidney international. 2004 Sep;66(3):1193-8. doi: 10.1111/j.1523-1755.2004.00872.x. PubMed PMID: 15327417;
27. Charytan C, Schwenk MH, Al-Saloum MM, et al. Safety of iron sucrose in hemodialysis patients intolerant to other parenteral iron products. Nephron Clinical practice. 2004;96(2):c63-6. doi: 10.1159/000076401. PubMed PMID: 14988600;
28. Vifor. INJECTAFER® (ferric carboxymaltose injection); Food and Drug Administration 2013. Available from: https://www.accessdata.fda.gov/drugsatfda_docs/label/2018/203565s005lbl.pdf
29. Covic A, Mircescu G. The safety and efficacy of intravenous ferric carboxymaltose in anaemic patients undergoing haemodialysis: a multi-centre, open-label, clinical study. Nephrol Dial Transplant. 2010;25(8):2722-2730. doi: 10.1093/ndt/gfq069. PubMed PMID: 20190247;
30. Kulnigg S, Stoinov S, Simanenkov V, et al. A novel intravenous iron formulation for treatment of anemia in inflammatory bowel disease: the ferric carboxymaltose (FERINJECT) randomized controlled trial. The American journal of gastroenterology. 2008 May;103(5):1182-92. doi: 10.1111/j.1572-0241.2007.01744.x. PubMed PMID: 18371137;
31. Rognoni C, Venturini S, Meregaglia M, et al. Efficacy and Safety of Ferric Carboxymaltose and Other Formulations in Iron-Deficient Patients: A Systematic Review and Network Meta-analysis of Randomised Controlled Trials. Clinical drug investigation. 2016 Mar;36(3):177-94. doi: 10.1007/s40261-015-0361-z. PubMed PMID: 26692005; PubMed Central PMCID PMCPMC4761015
32. Al-Shaghana M, Brooke E, Sinha A, et al. Efficacy and cost effectiveness of ferric carboxymaltose (Ferinject) in the treatment of pregnant women with iron deficiency anaemia. European Journal of Obstetrics and Gynecology and Reproductive Biology. 2016;206:e6. doi: 10.1016/j.ejogrb.2016.07.046.
33. Hofmarcher T, Borg S. Cost-effectiveness analysis of ferric carboxymaltose in iron-deficient patients with chronic heart failure in Sweden. Journal of medical economics. 2015;18(7):492-501. doi: 10.3111/13696998.2015.1029491. PubMed PMID: 25766863;
34. Calvet X, Ruíz M, Dosal A, et al. Cost-minimization analysis favours intravenous ferric carboxymaltose over ferric sucrose for the ambulatory treatment of severe iron deficiency. PloS one. 2012;7(9):e45604. doi: 10.1371/journal.pone.0045604. PubMed PMID: 23029129; PubMed Central PMCID PMCPMC3448662 board and teaching activities. The remaining authors have declared that no competing interests exist. This does not alter the authors' adherence to all the PLOS ONE policies on sharing data and materials.

35. General Authority for Statistics; Kingdom of Saudi Arabia; Gross Domestic Product 2019: GASTAT; 2019. Available from: https://www.stats.gov.sa/en/823
36. Husereau D, Drummond M, Petrou S, et al. Consolidated Health Economic Evaluation Reporting Standards (CHEERS)—Explanation and Elaboration: A Report of the ISPOR Health Economic Evaluation Publication Guidelines Good Reporting Practices Task Force. Value in Health. 2013;16(2):231-250. doi: 10.1016/j.jval.2013.02.002.
37. Statista. Statista Research Department; Average monthly salary in Saudi Arabia H1 2020, by sector 2020. Available from: https://www.statista.com/statistics/717265/saudi-arabia-average-monthly-wage-by-sector/
38. Hejazi A, Mohamed O, Alhowimel M, et al. Ferric carboxymaltose solution versus iron sucrose complex in treating Iron-deficiency anemia patients with heavy uterine bleeding: A cost-efficacy study from a tertiary care hospital in the Kingdom of Saudi Arabia [Original Article]. 2021 January 1, 2021;12(1):17-21. doi: 10.4103/joah.joah_134_20.
39. Al-Jamea L, Woodman A, Elnagi E, et al. Prevalence of Iron-deficiency anemia and its associated risk factors in female undergraduate students at prince sultan military college of health sciences [Original Article]. 2019 October 1, 2019;10(4):126-133. doi: 10.4103/joah.joah_44_19.
40. Alquaiz A-JM, Khoja TAM, Alsharif A, et al. Prevalence and correlates of anaemia in adolescents in Riyadh city, Kingdom of Saudi Arabia. Public Health Nutrition. 2015;18(17):3192-3200. doi: 10.1017/S1368980015001214.
41. Brock E, Braunhofer P, Troxler J, et al. Budget impact of parenteral iron treatment of iron deficiency: methodological issues raised by using real-life data. The European journal of health economics : HEPAC : health economics in prevention and care. 2014 Dec;15(9):907-16. doi: 10.1007/s10198-013-0533-9. PubMed PMID: 24081613;
42. Fragoulakis V, Kourlaba G, Goumenos D, et al. Economic evaluation of intravenous iron treatments in the management of anemia patients in Greece. Clinicoecon Outcomes Res. 2012;4:127-134. doi: 10.2147/CEOR.S30514. PubMed PMID: 22629113;
43. Bager P, Dahlerup JF. The health care cost of intravenous iron treatment in IBD patients depends on the economic evaluation perspective. Journal of Crohn's & colitis. 2010 Oct;4(4):427-30. doi: 10.1016/j.crohns.2010.01.007. PubMed PMID: 21122539;
44. Gozzard D. When is high-dose intravenous iron repletion needed? Assessing new treatment options. Drug design, development and therapy. 2011 Jan 20;5:51-60. doi: 10.2147/dddt.S15817. PubMed PMID: 21340038; PubMed Central PMCID PMCPMC3038995