# Impact of anaemia in pregnancy on maternal and fetal wellbeing in Oman: a retrospective study

## Abstract

**Background/Aims** Anaemia is associated with negative outcomes for both mothers and infants. Better understanding of its consequences could lead to improved guidelines for screening and treatment. The aim of this study was to investigate anaemia in pregnancy and adverse maternal and fetal outcomes among pregnant women in Oman.
**Methods** This retrospective study examined the medical records of women who gave birth at a university hospital in Oman over a 3-year period. Chi-squared tests were used for data analysis.
**Results** A total of 723 pregnant women were included, with 62.8% diagnosed with anaemia. Anaemia was significantly associated with preterm birth ($P=0.037$), low birth weight ($P=0.009$), intrauterine growth restriction ($P=0.002$) and postpartum heamorrhage ($P=0.019$).
**Conclusions** Anaemia is a significant health concern for pregnant women in Oman. Further research will provide more data on its effects, informing targeted interventions and policy enhancements.
**Implications for practice** Early antenatal screening, targeted iron supplementation, nutritional education, appropriate treatment and active management during birth would help address this issue.

Phiona Gimono[1]

Ma'en Aljezawi[2]

Abdullah Alkhawaldeh[2]
dr-abd@aabu.edu.jo

Mohammed ALBashtawy[2]

Basma Salameh[3]

Ahmad Batran[4]

Ahmad Ayed[3]

Anas Khalifeh[2]

Islam Ali Oweidat[5]

Mohammad Rababa[6]

Mohammad Suliman[2]

Asem Abdalrahim[2]

Salam Bani Hani[7]

Zaid ALBashtawy[8]

Anaemia is a significant public health issue, affecting approximately 37% of pregnant women worldwide (World Health Organization (WHO), 2019; World Bank, 2019). It is classified as mild, moderate or severe based on specific haemoglobin thresholds (WHO, 2011). Symptoms include pallor, exhaustion, palpitations, dizziness and difficulty breathing (Chaparro and Suchdev, 2019).

Anaemia is influenced by the physiological changes that take place in the hematologic, renal and endocrine systems during pregnancy (Horowitz et al, 2013). The two key causes are hemodilution resulting from increased plasma volume in early pregnancy and inadequate increase in erythrocytes (Horowitz et al, 2013). The increased iron requirements during pregnancy make adequate iron supplementation an important measure to reduce the likelihood of developing anaemia. The WHO recommends a daily dose of 30–60mg of iron for pregnant women (Fisher and Nemeth, 2017).

Anaemia in pregnancy is more common in the third trimester and is defined by specific hemoglobin or hematocrit values for each trimester (Lebso et al, 2017; Fite et al, 2021; Ngimbudzi et al, 2021; Sun et al, 2021). If anaemia is present throughout pregnancy, it is termed 'persistent anaemia', while anaemia that resolves after

[1]College of Nursing, Sultan Qaboos University, Sultanate of Oman

[2]Department of Community and Mental Health Nursing, Princess Salma Faculty of Nursing, Al al-Bayt University, Jordan

[3]Faculty of Nursing, Arab American University, Palestine

[4]Faculty of Allied Medical Sciences, Department of Nursing, Palestine Ahliya University, Palestine

[5]Faculty of Nursing, Zarqa University, Jordan

[6]Department of Adult Health Nursing, Jordan University of Science and Technology, Jordan

[7]Irbid National University, Jordan

[8]Faculty of Medicine, Yarmouk University, Jordan

the first trimester is termed 'recovered anaemia' (Sun et al, 2021).

Globally, anaemia in pregnancy contributes to maternal and neonatal morbidity and mortality (Shi et al, 2022). Iron deficiency can lead to restricted blood circulation, oxidative stress and adverse outcomes for mother and infant (Garzon et al, 2020). It also impacts placental development, potentially affecting fetoplacental vascularisation and nutrient transfer, leading to fetal growth disorders (Moeller et al, 2019). Accurate diagnosis, timely interventions and monitoring are crucial to address the impact of anaemia on maternal and fetal health (Haider et al, 2013).

Research has shown that anaemia in pregnancy can negatively impact outcomes for both mother and fetus in low-, middle- and high-income countries (Kadhim Jasim et al, 2020). For mothers, studies have shown a significant association between anaemia in pregnancy and postpartum haemorrhage (Harrison et al, 2021; Omotayo et al, 2021; Shi et al, 2022), caesarean section (Vural et al, 2016; Tian et al, 2022; Adam et al, 2023) and prolonged length of hospital stay (Koyuncu et al, 2017; Kumar and Dhillon, 2020). Adverse fetal outcomes associated with anaemia in pregnancy include preterm birth (Kumari et al, 2019; Rahmati et al, 2020), low birth weight (Sukrat et al, 2013; Rahman et al, 2020; dos Santos et al, 2022) and intrauterine growth restriction (Surve and Jain, 2019; Yang et al, 2023).

While the majority of studies have established a significant association between anaemia in pregnancy and adverse maternal and fetal outcomes, there is insufficient literature to support its relationship with length of hospital stay or intrauterine growth restriction. Many studies have used retrospective designs, leading to challenges related to missing data, or have not reported whether iron supplements were given to participants. Other challenges include variation in haemoglobin measurement techniques, timing of anaemia diagnosis, categorising anaemia, reference groups, inclusion criteria and sample sizes.

The relationship between anaemia in pregnancy and adverse maternal and fetal outcomes has not been well explored in the Gulf Cooperation Council, including in Oman. Studies that have explored adverse outcomes in this union primarily focused on conditions other than anaemia (Al-Rifai et al, 2020). This may be because other conditions have been prioritised in research agendas, which can create a significant gap in knowledge and literature (Afifi, 2003; Seshan et al, 2018; Garzon et al, 2020).

This study's aims were to investigate the relationship between anaemia during pregnancy and adverse maternal and fetal outcomes, focusing specifically on preterm births, low birth weight, intrauterine growth restriction and postpartum hemorrhage. These outcomes are crucial indicators of maternal and fetal health, often associated with maternal anaemia, and have significant implications for maternal wellbeing and infant development. Research in this area may offer insights to guide targeted interventions and the creation of comprehensive prevention guidelines in order to enhance maternal and fetal health outcomes in Oman and the broader Gulf Cooperation Council.

## Methods
This retrospective study reviewed pregnant women's medical records from the Department of Obstetrics and Gynaecology, Sultan Qaboos University Hospital, selected by convenience sampling for its significant intake of pregnant women from regions across Oman. This ensured a diverse and representative sample for the study (Talari and Goyal, 2020). The hospital uses an advanced electronic medical records system that facilitates efficient storage and easy retrieval of patient data. The research team retrospectively examined the records to identify cases of anaemia and compare these with cases without anaemia.

### Sample
The study used non-probability convenience sampling to select eligible women from the target population (Stratton, 2021). The sampling frame encompassed all births between 1 January 2020 to 31 December 2022. The inclusion criteria were women with singleton pregnancies and a recorded third-trimester haemoglobin level. Women classified as anaemic were those with haemoglobin levels <11.0g/dL, while those with ≥11.0g/dL were classified as non-anaemic.

Pregnant women were excluded if they had chronic or acute illnesses that could affect haemoglobin levels (such as chronic kidney disease, sickle cell anaemia, infection, thalassemia and haemoglobinopathies, chronic inflammatory diseases), or if they had received a blood transfusion in the 3 months before their haemoglobin level was measured. Women who first visited the hospital to give birth were excluded because of an expected lack of antenatal care and follow-up.

The sample size was calculated using Epi Info statistical software (version 7.2.5.0), which provides specialised tools for determining sample size. The calculation used a 95% confidence interval, 80% statistical power, a ratio of pregnant women with anaemia to without of 1:2, an estimated exposure of 43.5% based on a similar study (Belyhun et al, 2010) and a 10% rate of incomplete data entry, giving a minimum sample size of 111 women with anaemia and 222 without. This was a total sample size of 333 pregnant women (Weldekidan et al, 2018). The records of 723 women were included in the study, as using a larger sample size can improve statistical power, enhancing precision and supporting more robust conclusions.

## Data collection

The lead researcher contacted the midwife in charge of the birth ward at the hospital, who was responsible for the storage of birth registers, to gain access to the necessary data. To facilitate data collection, a standardised data collection sheet was devised, which consisted of three sections: demographics and obstetric history, maternal outcomes and fetal outcomes. The data sheet was created following a comprehensive review of previously published studies (Quezada-Pinedo et al, 2021; Kharate and Choudhari, 2024) to ensure its accuracy and relevance. With the assistance of the hospital's information technology department, the research team retrieved the records of all pregnant women who met the inclusion criteria. These were manually searched for the relevant study variables, which were documented on the data collection sheet.

As a result of data that were inaccessible or not recorded accurately, and some adverse maternal and fetal outcomes that fell under the exclusion criteria, not all outcomes were included. The study focused on postpartum hemorrhage, caesarean section, length of stay at the hospital, low birth weight, preterm birth and intrauterine growth restriction.

## Data analysis

The data were analysed using the Statistical Package for Social Sciences (version 23). Data were initially entered into an Excel spreadsheet and checked for errors or missing information. In cases where errors or missing data were identified, the records were consulted again to ensure complete and accurate data. Cases with incomplete entries were removed from the sample to maintain data integrity and reliability.

Chi-square tests were used to test the association between anaemia and birth outcomes. A significance level of $P \leq 0.05$ was set.

## Ethical considerations

Ethical approval for the study was granted by both the ethics committees of Sultan Qaboos University's College of Nursing (approval number: CON/MAS/2022/6) and the Medical Research Ethics Committee of the College of Medicine (approval number: SQU-EC/ 176/2022, MREC #2888). Permission for data collection was granted by the hospital's Director Generals.

Informed consent from women whose data were accessed for the study was deemed unnecessary, as it was a retrospective review of previously collected data. The data were anonymised and handled according to ethical guidelines, ensuring the protection of participants' privacy and confidentiality.

## Results

A total of 723 eligible pregnant women were included, 62.8% of whom were anaemic. The majority were Omani citizens (94.5%), aged 19–34 years (68.5%) and had received university-level education (70.5%). The majority gave birth at full term (37–42 weeks' gestation) (94.9%), and had had 2–4 pregnancies (59.2%) and 2–4 children (64.5%). Almost two-thirds of the sample (63.4%) had attended 7 or more antenatal care visits, and (60.1% had an overweight body mass index. Full demographic and obstetric details are shown in *Table 1*.

### Adverse maternal outcomes

For adverse maternal outcomes, there was a higher prevalence of postpartum haemorrhage among anaemic women ($n$=37, 8.1% vs $n$=10, 3.7%), which was a

| Table 1. Participants' characteristics | | | |
|---|---|---|---|
| **Characteristic** | | **Frequency, *n*=723 (%)** | |
| | | **No anaemia (*n*=269)** | **Anaemia (*n*=454)** |
| Nationality | Omani | 249 (92.6) | 437 (96.3) |
| | Non-Omani | 20 (7.4) | 17 (3.7) |
| Residence | Muscat city | 138 (51.3) | 213 (46.9) |
| | Outside Muscat | 131 (48.7) | 241 (53.1) |
| Age (years) | 19–34 | 178 (66.2) | 321 (70.7) |
| | 35–47 | 91 (33.8) | 133 (29.3) |
| Education | School | 66 (24.5) | 85 (18.7) |
| | University | 186 (69.1) | 326 (71.8) |
| | Postgraduate | 17 (6.3) | 43 (9.5) |
| Body mass index | <18.5 | 5 (1.9) | 19 (4.2) |
| | 18.5–24.9 | 91 (33.8) | 181 (39.9) |
| | >24.9 | 173 (64.3) | 254 (55.9) |
| Gestation (weeks) | <37 | 9 (3.3) | 32 (7.0) |
| | >37 | 260 (96.7) | 422 (93.0) |
| Gravidity | <1 | 54 (20.1) | 81 (17.8) |
| | 2–4 | 157 (58.4) | 272 (59.9) |
| | >4 | 58 (21.6) | 101 (22.2) |
| Parity | <1 | 68 (25.3) | 100 (22.0) |
| | 2–4 | 169 (62.8) | 300 (66.1) |
| | >4 | 32 (11.9) | 54 (11.9) |
| Antenatal visits | <4 | 8 (3.0) | 18 (4.0) |
| | 4–6 | 88 (32.7) | 149 (32.8) |
| | >6 | 173 (64.3) | 287 (63.2) |

statistically significant difference (*P*=0.019). Similarly, length of stay exceeding 5 days was more common among women with anaemia (*n*=18, 4.0% vs *n*=10, 3.8%), although the difference was not statistically significant. A similar proportion of women had an emergency caesarean section in both the anaemic and non-anaemic groups (*n*=115, 25.3% vs *n*=68, 25.3%). Full details are shown in *Table 2*.

### Adverse fetal outcomes

All three adverse fetal outcomes assessed were significantly associated with anaemia. Preterm birth was significantly more common in anaemic women (*n*=32, 7.0% vs *n*=9, 3.3%; *P*=0.037), as was low birth weight (*n*=56, 12.3% vs *n*=17, 6.3%; *P*=0.009) and intrauterine growth restriction (n=69, 15.2% vs n=20, 7.4%; *P*=0.002). Full details are shown in *Table 3*.

### Discussion

This study found strong associations between anaemia in pregnancy and adverse maternal and fetal outcomes, including postpartum haemorrhage, preterm birth, low birth weight and intrauterine growth restriction. The World Bank (2024) reported that 30% of pregnant Omani women have anaemia. This high prevalence along with physiological changes leading to haemodilution and reduced blood supply to the uterus, may contribute to these associations (Horowitz et al, 2013; Petry et al, 2020).

There was a strong association between anaemia and increased risk of postpartum hemorrhage. This relationship has been supported by studies conducted worldwide, in both high- and low to middle-income countries (Frass, 2015; Kebede et al, 2019; Randall et al, 2019; Barut and Mohamud, 2023; Mehrnoush et al, 2023). However, some studies have not supported this association, possibly as a result of variations in visual estimation of blood loss, haemoglobin cut-off levels and sample sizes (Rukuni et al, 2016; Chu et al, 2020). Overall, most research supports the link between anaemia and postpartum haemorrhage, which is attributed to factors such as haemodilution and reduced uterine muscle strength (Soltan et al, 2012; Horowitz et al, 2013).

The present study did not find a significant correlation between anaemia in pregnancy and caesarean section, possibly because the study excluded high-risk women and other factors that contribute to caesarean section. The existing literature shows mixed findings, with some studies supporting an association, especially in high-income countries, (Harrison et al, 2021; Shah et al, 2022; Tian et al, 2024). This link has been attributed to physiological factors, such as haemodilution and inadequate blood supply to the uterus, which lead to the need for caesarean section. Other studies did not find a significant link (Masukume et al, 2015; Barut and

Mohamud, 2023), potentially as a result of variations in sample characteristics and diagnostic criteria (Soltan et al, 2012).

The present study found a higher rate of prolonged hospital stays among anaemic women, although the overall association was not statistically significant. The exclusion of high-risk women and the use of enhanced recovery strategies, such as fast surgery tracking, preoperative education, optimised pain management, and early mobilisation, may have influenced this finding. Research from other regions has found a positive association between anaemia and longer hospital stays, which could be attributed to specific treatments and sample characteristics (Koyuncu et al, 2017; Kumar and Dhillon, 2020).

The link found between anaemia and low birth weight in the present study may be related to maternal malnutrition, physiological changes, placental vascularisation and reduced blood supply to the fetus, all of which will contribute to lower birth weight (Garzon et al, 2020). Systematic reviews and meta-analyses have reported similar findings (Young et al, 2019; Shah et al, 2022). However, studies in Europe and East Asia have not

| Table 2. Comparison of adverse maternal outcomes | | | | | |
|---|---|---|---|---|---|
| **Variable** | | **Frequency, *n*=732 (%)** | | **Chi-squared** | ***P* value** |
| | | **No anaemia (*n*=269)** | **Anaemia (*n*=454)** | | |
| Postpartum haemorrhage | No | 259 (96.3) | 417 (91.9) | 5.460 | 0.019 |
| | Yes | 10 (3.7) | 37 (8.1) | | |
| Length of hospital stay | 0–2 | 190 (70.6) | 297 (65.4) | 3.031 | 0.082 |
| | 3–4 | 69 (25.7) | 139 (30.6) | | |
| | >4 | 10 (3.7) | 18 (4.0) | | |
| Caesarean section | Yes | 68 (25.3) | 115 (25.3) | 0.000 | 0.988 |
| | No | 201 (74.7) | 339 (74.7) | | |

| Table 3. Comparison of adverse fetal outcomes | | | | | |
|---|---|---|---|---|---|
| **Variable** | | **Frequency, *n*=732 (%)** | | **Chi-squared** | ***P* value** |
| | | **No anaemia (*n*=269)** | **Anaemia (*n*=454)** | | |
| Preterm birth | No | 260 (96.7) | 422 (93.0) | 4.329 | 0.037 |
| | Yes | 9 (3.3) | 32 (7.0) | | |
| Intrauterine growth restriction | Yes | 20 (7.4) | 69 (15.2) | 9.431 | 0.002 |
| | No | 249 (92.6) | 385 (84.8) | | |
| Low birth weight | No | 252 (93.7) | 398 (87.7) | 6.733 | 0.009 |
| | Yes | 17 (6.3) | 56 (12.3) | | |

reported a significant relationship between anaemia and low birth weight, possibly because of the low prevalence of anaemia, the inclusion of low-risk samples and more advanced healthcare systems in these regions (Masukume et al, 2015; Uzunov et al, 2022). These systems typically include universal access to care, comprehensive antenatal programs, heightened public health awareness and better-equipped facilities, all of which contribute to more effective anaemia management during pregnancy. Implementing similar strategies in Oman could help reduce adverse fetal outcomes related to anaemia.

Anaemia in pregnancy was significantly associated with preterm birth, a link that has been attributed to physiological changes during pregnancy, accelerated placenta maturation and reduced oxygen and nutrient supply to the fetus (Lelic et al, 2014; Gebremeskel et al, 2020). Evidence from low- and high-income countries supports this association (Joshi et al, 2011; Young et al, 2019; Kumari et al, 2019; Chu et al, 2020; Uzunov et al, 2022; Khezri et al, 2023). However, studies from Europe have reported no association, likely because of the region's lower anaemia prevalence and effective healthcare systems (Masukume et al, 2015; Sun et al, 2021). Enhancing antenatal care programmes, expanding public health education on nutrition and iron supplementation, strengthening healthcare infrastructure and adopting evidence-based practices could significantly improve the management of anaemia in pregnancy in Oman, reducing the risk of low birth weight and other complications.

The present study also found a significant association between anaemia and intrauterine growth restriction. Physiological changes during pregnancy, placental adaptations and maternal undernutrition may contribute to this association (Roseboom et al, 2011; Horowitz et al, 2013; Salam et al, 2013; Sharma et al, 2016; American College of Obstetricians and Gynecologists, 2019; Gebremeskel et al, 2020; Jain et al, 2022). These findings align with other studies from low- to middle-income nations such as India and Pakistan, as well as high-income countries such as China (Bakhtiar et al, 2007; Joshi et al, 2011; Surve and Jain, 2019; Shi et al, 2022). However, studies often did not differentiate between intrauterine growth restriction and babies born small for gestational age.

### Implications for practice

The discrepancies between studies in approaches to measuring anaemia and assessing maternal and fetal outcomes underscore the need for further investigation and standardised approaches to better understand and address the implications of anaemia in pregnancy globally. Early screening, proper treatment, active management during birth, targeted individualised iron supplementation and nutritional education are essential strategies to prevent and mitigate the impact of anaemia in pregnancy. However, further research is needed to explore the specific impact of anaemia and its management in Oman, as well as other regions, to develop more efficient preventive measures.

The present study findings can be used by policymakers to review and improve existing policies and guidelines related to anaemia in pregnancy and nutrition. Healthcare professionals and managers should explore how to improve the screening and referral process and implement effective interventions for addressing anaemia in pregnancy. Healthcare services in Oman require increased funding to further develop and enhance care, ensuring effective management of current challenges and improving overall patient outcomes (Lai et al, 2024).

Healthcare professionals should be able to offer a wide range of high-quality services, including targeted iron supplementation based on individual needs and nutritional education. Efforts should be made to promote active management of third-stage labour to reduce the risk of postpartum hemorrhage for women with anaemia. It is also essential to provide comprehensive information and obtain informed consent from women regarding their choices in managing this stage of labour.

Finally, conducting prospective studies will overcome the limitations of retrospective methods that have frequently been used in studies of anaemia in pregnancy, and provide more accurate and reliable data.

### Limitations

The retrospective nature of the study meant that some records were missing data. Variables such as socioeconomic status, income and occupation were not available for some women, and there was no evidence of targeted iron supplementation. This meant it was not possible to identify potential confounding variables, which might introduce confounding bias. The study also could not differentiate between asymmetrical or symmetrical intrauterine growth restriction, as this information was missing. Efforts were made to compensate for missing data by cross-referencing the medical database with birth records and using robust eligibility criteria.

Another limitation was the single-site nature of the study, although this was partially addressed by having a large sample size and the hospital's role as a referral centre, meaning patients were from across Oman.

### Conclusions

Anaemia in pregnancy is a significant global health concern and is associated with adverse maternal and fetal outcomes, increasing maternal and neonatal morbidity and mortality. The study's findings show a significant association between anaemia postpartum haemorrhage,

preterm birth, low birth weight and intrauterine growth restriction. The impact of these factors may vary across different populations and settings. To reduce anaemia-related complications, early screening, proper treatment, active management during birth, targeted iron supplementation and nutritional education are essential. Further research on anaemia's impact in Oman is needed to develop more effective preventive strategies. **BJM**

## Key points

- This study found that 62.8% of pregnant women who participated were anaemic.
- Anaemia during pregnancy was associated with significant adverse outcomes, including postpartum haemorrhage, preterm birth, low birth weight and intrauterine growth restriction.
- Regional healthcare practices and anaemia prevalence significantly impact the outcomes observed in different regions
- This study underscores the importance of early screening, effective treatment and nutritional education to address anaemia in pregnancy.

American College of Obstetricians and Gynecologists. ACOG practice bulletin no. 204: fetal growth restriction. Obstet Gynecol. 2019;133(2):e97–e109. https://doi.org/10.1097/AOG.0000000000003070

Adam I, Salih Y, Hamdan HZ. Association of maternal anemia and cesarean delivery: a systematic review and meta-analysis. J Clin Med. 2023;12(2):490. https://doi.org/10.3390/jcm12020490

Afifi M. Anemia in pregnancy at South Sharqiya health centers, Oman. J Egypt Public Health Assoc. 2003;78(1–2):39–54

Al-Rifai RH, Ali N, Barigye ET et al. Maternal and birth cohort studies in the Gulf Cooperation Council countries: a systematic review and meta-analysis. Syst Rev. 2020;9(1):14. https://doi.org/10.1186/s13643-020-1277-0

Bakhtiar UJ, Khan Y, Nasar R. Relationship between maternal hemoglobin and perinatal outcome. Age (Dordr). 2007;25:24

Barut A, Mohamud DO. The association of maternal anaemia with adverse maternal and foetal outcomes in Somali women: a prospective study. BMC Womens Health. 2023;23(1):193. https://doi.org/10.1186/s12905-023-02382-4

Belyhun Y, Meshing G, Amberbir A et al. Prevalence and risk factors for soil-transmitted helminth infection in mothers and their infants in Butajira, Ethiopia: a population based study. BMC Public Health. 2010;10:21. https://doi.org/10.1186/1471-2458-10-21

Chaparro CM, Suchdev PS. Anemia epidemiology, pathophysiology, and etiology in low- and middle-income countries. Ann N Y Acad Sci. 2019;1450(1):15–31. https://doi.org/10.1111/nyas.14092

Chu FC, Shen-Wen Shao S, Lo LM, Hsieh TT, Hung TH. Association between maternal anemia at admission for delivery and adverse perinatal outcomes. J Chin Med Assoc. 2020;83(4):402–407. https://doi.org/10.1097/JCMA.0000000000000215

dos Santos CC, da Silva SL, Costa Caminha MF, Maia SB, Figueiroa JN, Batista Filho M. Anemia in pregnant women according to two different assessment criteria (WHO versus CDC). Int J Gynaecol Obstet. 2022;159(3):928–937. https://doi.org/10.1002/ijgo.14275

Fisher AL, Nemeth E. Iron homeostasis during pregnancy. Am J Clin Nutr. 2017;106(S6):1567S–1574S. https://doi.org/10.3945/ajcn.117.155812

Fite MB, Assefa N, Mengiste B. Prevalence and determinants of anemia among pregnant women in sub-Saharan Africa: a systematic review and meta-analysis. Arch Public Health. 2021;79(1):219. https://doi.org/10.1186/s13690-021-00711-3

Frass KA. Postpartum hemorrhage is related to the hemoglobin levels at labor: observational study. Alex J Med. 2015;51(4):333–337. https://doi.org/10.1016/j.ajme.2014.12.002

Garzon S, Cacciato PM, Certelli C, Salvaggio C, Magliarditi M, Rizzo G. Iron deficiency anemia in pregnancy: novel approaches for an old problem. Oman Med J. 2020;35(5):e166. https://doi.org/10.5001/omj.2020.108

Gebremeskel T, Mulu A, Kumbi S, Ergete W. Histopathological changes of placenta associated with maternal anaemia in northeast Ethiopia: a comparative study. Ethiop J Health Sci. 2020;30(5):777–784. https://doi.org/10.4314/ejhs.v30i5.18

Haider BA, Olofin I, Wang M et al. Anaemia, prenatal iron use, and risk of adverse pregnancy outcomes: systematic review and meta-analysis. BMJ. 2013;346:f3443. https://doi.org/10.1136/bmj.f3443

Harrison RK, Lauhon SR, Colvin ZA, McIntosh JJ. Maternal anemia and severe maternal morbidity in a US cohort. Am J Obstet Gynecol MFM. 2021;3(5):100395. https://doi.org/10.1016/j.ajogmf.2021.100395

Horowitz KM, Ingardia CJ, Borgida AF. Anemia in pregnancy. Clin Lab Med. 2013;33(2):281–291. https://doi.org/10.1016/j.cll.2013.03.016

Jain S, Maheshwari A, Jain SK. Maternal nutrition and fetal/infant development. Clin Perinatol. 2022;49(2):313–330. https://doi.org/10.1016/j.clp.2022.02.005

Joshi S, Ghike S, Bhalerao A, Kawthalkar A. Anemia during pregnancy: most preventable yet most prevalent. J South Asian Fed Obstet Gynecol. 2011;3(2):75–77. https://doi.org/10.5005/jp-journals-10006-1133

Kadhim Jasim S, Al-Momen H, Al-Asadi F. Maternal anemia

prevalence and subsequent neonatal complications in Iraq. Open Access Macedon J Med Sci. 2020;8(B):71–75. https://doi.org/10.3889/oamjms.2020.3593

Kebede BA, Abdo RA, Anshebo AA, Gebremariam BM. Prevalence and predictors of primary postpartum hemorrhage: an implication for designing effective intervention at selected hospitals, Southern Ethiopia. PLoS One. 2019;14(10):e0224579. https://doi.org/10.1371/journal.pone.0224579

Kharate MA, Choudhari SG. Effects of maternal anemia affecting fetal outcomes: a narrative review. Cureus. 2024;16(7):e64800. https://doi.org/10.7759/cureus.64800

Khezri R, Salarilak S, Jahanian S. The association between maternal anemia during pregnancy and preterm birth. Clin Nutr ESPEN. 2023;56:13–17. https://doi.org/10.1016/j.clnesp.2023.05.003

Koyuncu K, Turgay B, Şükür YE, Yıldırım B, Ateş C, Söylemez F. Third trimester anemia extends the length of hospital stay after delivery. J Turkish Soc Obstet Gynecol. 2017;14(3):166–169. https://doi.org/10.4274/tjod.87864

Kumar P, Dhillon P. Length of stay after childbirth in India: a comparative study of public and private health institutions. BMC Pregnancy Childbirth. 2020;20(1):181. https://doi.org/10.1186/s12884-020-2839-9

Kumari S, Garg N, Kumar A et al. Maternal and severe anaemia in delivering women is associated with risk of preterm and low birth weight: a cross sectional study from Jharkhand, India. One Health. 2019;8:100098. https://doi.org/10.1016/j.onehlt.2019.100098

Lai T, Al Salmi Q, Koch K, Hashish A, Ravaghi H, Mataria A. Health system performance assessment and reforms, Oman. Bull World Health Organ. 2024;102(7):533–537. https://doi.org/10.2471/blt.24.291750

Lebso M, Anato A, Loha E. Prevalence of anemia and associated factors among pregnant women in Southern Ethiopia: a community based cross-sectional study. PLoS One. 2017;12(12):e0188783. https://doi.org/10.1371/journal.pone.0188783

Lelic M, Bogdanovic G, Ramic S, Brkicevic E. Influence of maternal anemia during pregnancy on placenta and newborns. Med Arh. 2014;68(3):184–187. https://doi.org/10.5455/medarh.2014.68.184-187

Masukume G, Khashan AS, Kenny LC, Baker PN, Nelson G; SCOPE Consortium. Risk factors and birth outcomes of anaemia in early pregnancy in a nulliparous cohort. PLoS One. 2015;10(4):e0122729. https://doi.org/10.1371/journal.pone.0122729

Mehrnoush V, Ranjbar A, Farashah MV, Darsareh F, Shekari M, Jahromi MS. Prediction of postpartum hemorrhage using traditional statistical analysis and a machine learning approach. AJOG Global Reports. 2023;3(2):100185. https://doi.org/10.1016/j.xagr.2023.100185

Moeller SL, Schmiegelow C, Larsen LG et al. Anemia in late pregnancy induces an adaptive response in fetoplacental vascularization. Placenta. 2019;80:49–58. https://doi.org/10.1016/j.placenta.2019.03.009

Ngimbudzi EB, Massawe SN, Sunguya BF. The burden of anemia in pregnancy among women attending the antenatal clinics in Mkuranga District, Tanzania. Front Public Health. 2021;9:724562. https://doi.org/10.3389/fpubh.2021.724562

Omotayo MO, Abioye AI, Kuyebi M, Eke AC. Prenatal anemia

and postpartum hemorrhage risk: a systematic review and meta-analysis. J Obstet Gynaecol Res. 2021;47(8):2565–2576. https://doi.org/10.1111/jog.14834

Petry N, Al-Maamary SA, Woodruff BA et al. National prevalence of micronutrient deficiencies, anaemia, genetic blood disorders and over- and undernutrition in Omani women of reproductive age and preschool children. Sultan Qaboos Univ Med J. 2020;20(2):151. https://doi.org/10.18295/squmj.2020.20.02.005

Quezada-Pinedo HG, Cassel F, Duijts L et al. Maternal iron status in pregnancy and child health outcomes after birth: a systematic review and meta-analysis. Nutrients. 2021;13(7):2221. https://doi.org/10.3390/nu13072221

Rahman KMN, Rahman MM. Maternal anaemia and risk of adverse obstetric and neonatal outcomes in South Asian countries: a systematic review and meta-analysis. Public Health in Practice. 2020;1:100021. https://doi.org/10.1016/j.puhip.2020.100021

Rahmati S, Azami M, Badfar G, Parizad N, Sayehmiri K. The relationship between maternal anemia during pregnancy with preterm birth: a systematic review and meta-analysis. J Matern Fetal Neonatal Med. 2020;33(15):2679–2689. https://doi.org/10.1080/14767058.2018.1555811

Randall DA, Patterson JA, Gallimore F et al. The association between haemoglobin levels in the first 20 weeks of pregnancy and pregnancy outcomes. PLoS One. 2019;14(11):e0225123. https://doi.org/10.1371/journal.pone.0225123

Roseboom TJ, Painter RC, de Rooij SR et al. Effects of famine on placental size and efficiency. Placenta. 2011;32(5):395–399. https://doi.org/10.1016/j.placenta.2011.03.001

Rukuni R, Bhattacharya S, Murphy MF, Roberts D, Stanworth SJ, Knight M. Maternal and neonatal outcomes of antenatal anemia in a Scottish population: a retrospective cohort study. Acta Obstet Gynecol Scand. 2016;95(5):555–564. https://doi.org/10.1111/aogs.12862

Salam RA, Das JK, Ali A, Lassi ZS, Bhutta ZA. Maternal undernutrition and intrauterine growth restriction. Expert Rev Obstet Gynecol. 2013;8(6):559–567. https://doi.org/10.1586/17474108.2013.850857

Seshan V, Alkhasawneh E, Al Kindi S, Al Simadi FAM, Arulappan J. Can gestational anemia be alleviated with increased awareness of its causes and management strategies? Implications for health care services. Oman Med J. 2018;33(4):322–330. https://doi.org/10.5001/omj.2018.59

Shah T, Khaskheli MS, Ansari S et al. Gestational anemia and its effects on neonatal outcome, in the population of Hyderabad, Sindh, Pakistan. Saudi J Biol Sci. 2022;29(1):83–87. https://doi.org/10.1016/j.sjbs.2021.08.053

Sharma D, Shastri S, Sharma P. Intrauterine growth restriction: antenatal and postnatal aspects. Clin Med Insights Pediatr. 2016;10:CMPed.S40070. https://doi.org/10.4137/CMPed.S40070

Shi H, Chen L, Wang Y et al. Severity of anemia during pregnancy and adverse maternal and fetal outcomes. JAMA Netw Open. 2022;5(2):e2147046. https://doi.org/10.1001/jamanetworkopen.2021.47046

Soltan MH, Ibrahim EM, Tawfek M, Hassan H, Farag F. Raised nitric oxide levels may cause atonic postpartum hemorrhage in women with anemia during pregnancy. Int J Gynaecol Obstet. 2012;116(2):143–147. https://doi.org/10.1016/j.

ijgo.2011.09.017

Stratton SJ. Population research: convenience sampling strategies. Prehosp Disaster Med. 2021;36(4):373–374. https://doi.org/10.1017/S1049023X21000649

Sukrat B, Wilasrusmee C, Siribumrungwong B et al. Hemoglobin concentration and pregnancy outcomes: a systematic review and meta-analysis. BioMed Res Int. 2013;2013:1–9. https://doi.org/10.1155/2013/769057

Sun CF, Liu H, Hao YH et al. Association between gestational anemia in different trimesters and neonatal outcomes: a retrospective longitudinal cohort study. World J Pediatr. 2021;17(2):197–204. https://doi.org/10.1007/s12519-021-00411-6

Surve R, Jain A. Risk factors associated with intrauterine growth restriction (IUGR) in neonates: a matched case–control study in tertiary care hospital. Pravara Med Rev. 2019;11(3)

Talari K, Goyal M. Retrospective studies – utility and caveats. J R Coll Phys Edinb. 2020;50(4):398–402. https://doi.org/10.4997/jrcpe.2020.409

Tian Q, Chen S, Jiang D. Effects of anemia during the third trimester of pregnancy on postpartum depression and pregnancy outcomes in pregnant women older than 35 years: a retrospective cohort study. Ann Palliat Med. 2022;11(3):1048–1057. https://doi.org/10.21037/apm-22-165

Tian ML, Ma GJ, Du LY, Xiao YG, Zhang Y, Tang ZJ. Prevalence and adverse perinatal outcomes of anaemia in the third trimester of pregnancy in Hebei Province, China. Int Health. 2024;16(1):91–96. https://doi.org/10.1093/inthealth/ihad028

Uzunov AV, Cîrstoiu MM, Secară DC et al. Mode of delivery and neonatal outcome in adolescent pregnancy (13–16 years old) associated with anemia. Medicina (Kaunas). 2022;58(12):1796. https://doi.org/10.3390/medicina58121796

Vural T, Toz E, Özcan A, Biler A, İleri A, İnan AH. Can anemia predict perinatal outcomes in different stages of pregnancy? Pak J Med Sci. 2016;32(6):1354–1359. https://doi.org/10.12669/pjms.326.11199

Weldekidan F, Kote M, Girma M, Boti N, Gultie T. Determinants of anemia among pregnant women attending antenatal clinic in public health facilities at Durame Town: unmatched case control study. Anemia. 2018;2018:1–8. https://doi.org/10.1155/2018/8938307

World Bank. Prevalence of anemia among pregnant women (any age), with Hb<110 g/L. 2024. https://genderdata.worldbank.org/indicators/sh-prg-anem/ (accessed 13 August 2024)

World Health Organization. Haemoglobin concentrations for the diagnosis of anaemia and assessment of severity. 2011. https://www.who.int/vmnis/indicators/haemoglobin.pdf (accessed 5 August 2024)

World Health Organization. Oman data. 2019. https://www.who.int/data/gho/data/themes/topics/anaemia_in_women_and_children (accessed 5 August 2024)

World Bank. Global health statistics, prevalence of anemia among pregnant women in the world (%). 2019. https://data.worldbank.org/indicator/SH.PRG.ANEM (accessed 5 August 2024)

Yang L, Feng L, Huang L et al. Maternal factors for intrauterine growth retardation: systematic review and meta-analysis of observational studies. Reprod Sci. 2023;30(6):1737–1745. https://doi.org/10.1007/s43032-021-00756-3

Young MF, Oaks BM, Tandon S, Martorell R, Dewey KG, Wendt AS. Maternal hemoglobin concentrations across pregnancy and maternal and child health: a systematic review and meta-analysis. Ann NY Acad Sci. 2019;1450(1):47–68. https://doi.org/10.1111/nyas.14093

## CPD reflective questions

- How might the high prevalence of anaemia among pregnant women in Oman influence maternal and neonatal health outcomes in the region?
- What factors in Oman's healthcare system could contribute to the high rate of anaemia and its associated complications during pregnancy?
- How could implementation of advanced healthcare practices, similar to those in Europe and East Asia, improve the management of anaemia in pregnancy in Oman?
- In what ways can early screening, targeted treatment and nutritional education be optimised to reduce anaemia-related adverse outcomes in pregnant women?

© 2024 MA Healthcare Ltd

# Submit a research paper

## Contact the editor at bjm@markallengroup.com