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Iron supplement use in pregnancy – are the right women taking the right amount?

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Contribution to authorship

AK, AS, NN conceived and designed the study; RC, MW acquired data; AZK was responsible for the integrity of data and statistical analysis; RC drafted the manuscript; and all authors approved the manuscript and critically reviewed the manuscript for important intellectual content.

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Declaration of Competing Interests

None of the authors have a conflict of interest to declare.

Ethical Standards Disclosure

"This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects/patients were approved by the Northern Sydney Health District (HREC# LNR/13/HAWKE/340). Verbal informed consent was obtained from all subjects/patients. Verbal consent was witnessed and formally recorded."

ABSTRACT

Objectives: To examine the prevalence and determinants of iron supplement use and the amount of iron consumed from iron-containing supplements.

Methods: A cross-sectional survey was performed in antenatal clinics in two tertiary hospitals in Sydney, Australia between January and March 2014.

Results: Of 612 (91% response rate) pregnant women, 589 with complete data were analysed. The overall prevalence of iron-containing supplement use was 88.0%, of which 70.1% was MV only, 7.2% was iron-only and 22.2% was both. Use of iron-containing supplements was associated with increased gestational age, a diagnosis of anaemia or iron deficiency (ID) in the current pregnancy and pre-pregnancy use of an iron-containing supplement. Several risk factors for ID or anaemia such as on-red meat eating and previous miscarriage were not associated with current iron supplement use. About 65% of women diagnosed with ID, and 62.3% of women diagnosed with anaemia were taking an iron-only supplement, with or without a MV. The proportion of women consuming low (<30), preventative (30-99) and treatment (≥100) mg/day doses were 36.8%, 45.4%, and 17.8%, respectively. Only 46.7% of women diagnosed with ID were taking ≥100 mg/day iron from supplements, while 23.3% were taking <30 mg/day.

Conclusion: Women are consuming varying doses of iron and some high-risk women are taking inadequate doses of iron to prevent or treat ID or iron deficiency anaemia. Healthcare professionals are best positioned to advise women on iron supplement use in pregnancy and should educate women individually about the type and dose of supplement best suited to their needs.

Keywords: iron, supplement, pregnancy, iron deficiency

INTRODUCTION

It is well established that women are at increased risk of iron deficiency (ID) during pregnancy and are often unable to meet the increased iron requirements of pregnancy from dietary sources alone.[1] Dietary reference values for iron intake during pregnancy vary by geographical region. In Australia, the recommended daily intake for iron in pregnancy is 27 mg/day,[2] which is similar to other developed countries.[3] However, like in other developed countries (USA/Canada, United Kingdom, Europe, New Zealand, and Japan), data from Australian pregnant women indicate that dietary iron intakes are below national nutrient recommendations.[3]

There is strong evidence that iron supplementation in pregnancy improves maternal iron status and reduces the risk of iron deficiency anaemia (IDA).[4] In fact, the provision of iron supplements to pregnant women is one of the most widely practiced public health measures.[5] However, there is no consensus worldwide regarding the optimum iron dose for supplementation during pregnancy, with recommendations varying between 30 to 200 mg/day.[6] Recommendations not only vary by iron dose, but also by whether iron supplementation is routine (treatment of all pregnant women regardless of their iron status) or selective (only women with or at risk of developing ID or IDA), and by whether guidelines include specific doses for prevention versus treatment of anaemia and/or ID.

The International Nutritional Anemia Consultative Group (INACG) and the World Health Organization (WHO) both recommend universal supplementation in pregnancy with 60 mg of elemental iron daily for the prevention of ID, and if anaemia is detected, treatment with 120 mg of iron daily for three months.[7]

Among developed countries, the United States, Canada, and France recommend routine iron supplementation in pregnancy with 30–60 mg of elemental iron daily.[8,9] Other developed countries, such as the United Kingdom, Germany, Norway, New Zealand, and Australia recommend selective iron supplementation; however few of these countries provide guidance on the dose of supplemental iron.[10] The UK recommends 65 mg of elemental iron daily for non-anaemic women at increased risk of iron depletion (i.e. women with previous anaemia, multiple pregnancy, consecutive pregnancies with less than a year's interval between, and vegetarians). [11] The recommended dosage of daily elemental iron to treat IDA is 120 mg in the US,[8] 100-200 mg in the UK[11] and 100 mg in Norway.[12]

In Australia, there are no national guidelines that provide recommendations on dosage of iron supplementation during pregnancy. The Royal Australian and New Zealand College of Obstetricians and Gynaecologists (RANZCOG) recommend investigation and treatment of anaemia using haemoglobin levels at the first antenatal visit and again at approximately 28 weeks' gestation, as well as iron supplementation for pregnant women at particular risk of ID, including vegetarians and women with multiple pregnancies.[13] A wide range of pregnancy supplements with iron alone or in combination with other minerals and vitamins are commercially available on the market in Australia and each preparation varies in the amount of contained elemental iron from 5 to 105 mg.

Information on iron supplement use among Australian pregnant women is limited to prevalence data from older studies in single hospital settings.[14,15] Contemporary data on the prevalence and determinants of iron supplement use as well as the number of

iron-containing supplements, frequency, and dose of iron consumed by pregnant women is needed to understand whether women requiring treatment or at particular risk of ID are consuming iron supplements, and whether these dosages from iron supplements are adequate.

Therefore, the aims of the present study were to examine the prevalence and determinants of iron supplement use in pregnancy and to compare maternal and pregnancy characteristics by the amount of elemental iron consumed from iron-containing supplements.

METHODS

Design and study population

A survey on iron and dietary supplement use in pregnancy was administered to women of all gestational ages attending antenatal clinics of two large teaching hospitals in Sydney, Australia between January and March 2014. Both hospitals, the Royal North Shore Hospital and the Royal Hospital for Women, have tertiary obstetric and neonatal facilities. To be eligible, women had to be pregnant, able to complete the questionnaire in English, and completing the questionnaire for the first time. Women were approached by the recruiter while waiting for their appointment and provided verbal and written information about the study. Those who consented returned the survey to the recruiter or into a marked box.

The self-administered and anonymous survey was developed based on a review of the literature, existing surveys, and discussion with perinatal researchers and midwives, and took around 10 minutes to complete. Following a pilot study of 20 women, minor

modifications in the order of questions were made to improve clarity and ease of completion. The survey consisted of 22 items in three sections; '*About you and your pregnancy*', '*About your last pregnancy*', and '*Dietary supplements*'. The primary aim of the survey was to collect information on iron supplement use; however general information on the use of other select dietary and herbal supplements 3 months before and during the current pregnancy was also collected and is reported elsewhere. Ethics approval was obtained from Northern Sydney Health District (HREC# LNR/13/HAWKE/340), with site-specific approval received from both hospital sites.

Iron supplements

Prevalence, frequency and dose of iron consumed from iron-containing supplements, including multivitamin (MV) and/or iron-only, in the current pregnancy was assessed from information collected in a table within the survey that elicited detailed information including the brand name, the number of weeks the supplement was consumed, and the number of tablets consumed per week. Women were asked to report every iron-only or MV and mineral preparations consumed during the current pregnancy. Common iron-only and MV and mineral preparations were listed in the table and blank rows were provided for women to specify other brands. Information collected in the table was used to determine the dose of elemental iron in each of the iron-containing supplements mentioned.

Other maternal and pregnancy factors

The survey also collected information on maternal and pregnancy characteristics; factors related to the previous pregnancy that were regarded as potential determinants of current iron status and/or iron supplement use, the average amount of money spent

per month, and main sources of information for dietary supplement use in pregnancy. Potential determinants (explanatory variables) of iron supplement use included those related to maternal characteristics (maternal age, multiple pregnancy, no previous children, body mass index (BMI), cigarette smoking, educational attainment, and red meat consumption), the previous pregnancy (miscarriage, heavy bleeding, and ID), the current pregnancy (gestational age, gestational diabetes, gestational hypertension, anaemia, or ID) and iron supplement use (iron-only or MV supplement use 3 months prior to pregnancy, or MV supplement use in the current pregnancy).

Definitions

The total number of iron-containing supplements consumed in the current pregnancy was calculated as the sum of brands reported by each woman. Based on reporting of brand names of MV and iron-only supplements, woman were categorised as consuming MV only, iron only, both or neither. Frequency is reported as the maximum number of weeks that any iron-containing supplement was used because women often reported multiple brands for varying number of weeks. The dose of elemental iron (in mg) consumed per week from an iron-containing supplement was calculated by adding the dosage from each iron-only or MV and mineral preparation that women reported using during the current pregnancy. To compare the amount of elemental iron consumed from iron-containing supplements with recommended doses from other developed countries,[8,11,12] the average daily dose of elemental iron from iron-containing supplements was categorised as low dose (<30 mg), preventative dose (30-65 mg), intermediary dose (66-99 mg), treatment dose (100-200 mg) and high dose (>200 mg). Due to the small numbers, to examine possible determinants of the amount of iron consumed from iron-containing supplements, categories were

combined and <30, 30-99 and ≥100 mg were used to define low, preventative and treatment dosages of daily elemental iron, respectively. Maternal age was categorised into <25, 25-34, and >35 years and gestational age into ≤20, 21-26, ≥27 weeks, based on national guidelines of anaemia and ID testing during pregnancy.[13] Body mass index (BMI; kg/m^2) was calculated using patient reported booking weight and height, usually recorded at 12 weeks gestation, and categorised using international standards.[16]

Statistical analysis

Percentage tabulation and contingency tables were performed to describe study population characteristics and to compare maternal and pregnancy characteristics by current use of iron-containing supplements, type of iron-containing supplement (MV only, iron-only, both or neither) and by categories of average daily dosages of elemental iron (low, preventative and treatment). Logistic regression analysis was used to compare maternal and pregnancy characteristics by type of iron-containing supplement, whereby the reference group was "neither" and by categories of average daily dosages of elemental iron, whereby the reference group was "preventative dosage of iron). Multivariate logistic regression analysis was conducted to take into account potential confounding by explanatory variables that were statistically significant in the unadjusted analyses. Backward stepwise selection was performed whereby variables with least significance were progressively dropped from each model until all remaining covariates were statistically significant (2-tailed P<0.05). Results are presented as the odds ratio (OR) and 95% confidence intervals (CIs). All analyses were performed using SAS version 9.3 (SAS Institute Inc).

RESULTS

A total of 674 women were invited to participate, of whom 612 completed the survey with a response rate of 91%. Reasons for declining included busy caring for children, not interested, or called into an appointment. After excluding 26 surveys due to incomplete data, 589 women were included in the final analyses. The majority of women were aged 25 years or more (95.1%) and nearly half (45.1%) already had a child. Approximately two-thirds of women had attained a university undergraduate degree or higher (67.0%) and were more than 26 weeks gestation (64.2%) at the time of the survey. Based on BMI, 61.6% of women were normal weight, 10.7% were underweight, 17.3% were overweight, and 10.5% were obese. Only 8 women (1.4%) smoked cigarettes, 9.1% reported not eating any red meat, and 14.4% had experienced a miscarriage in their previous pregnancy. In the current pregnancy, 10.4% of women had been diagnosed with anaemia and 26.6% with ID.

Based on women's reporting of brand names of any iron-containing MV and primarily iron-only supplements used in the current pregnancy, the prevalence of iron supplement use was 88.0% (518/589). Of these 518 women, the majority (70.1%) reported consuming a MV only, with 7.2% consuming an iron-only supplement and 22.2% consuming both.

Comparisons of maternal and pregnancy characteristics and iron-containing supplement use between current users and non-users are presented in **Table 1**. Of the 156 women diagnosed with ID, 25.6% (40/156) were taking MV supplement(s) only and 9.6% (15/156) were taking neither iron nor MV. Of the 61 women diagnosed with anaemia, 32.7% women were taking MV only, and 5% were taking neither iron nor MV supplements.

Table 1

Maternal and pregnancy characteristics by type of iron-containing supplement in the current pregnancy (n=589).[1]

	Type of iron-containing supplement use in reported current pregnancy, N (%)				Unadjusted odds ratio (95% confidence intervals)[2]		
	MV[3] only 363 (61.6)	Iron only 40 (6.8)	Both 115 (19.5)	Neither 71 (12.1)	MV[2] only vs. Neither	Iron only vs. Neither	Both vs. Neither
Maternal characteristics							
Maternal age, years							
<25	14 (3.9)	3 (7.5)	8 (7.0)	4 (5.6)	0.65 (0.20, 2.08)	1.39 (0.29, 6.82)	1.04 (0.30, 3.67)
25-34	210 (57.9)	21 (52.5)	75 (65.2)	39 (54.9)	Reference	Reference	Reference
≥35	139 (38.3)	16 (40.0)	32 (27.8)	28 (39.4)	0.92 (0.54, 1.57)	1.06 (0.47, 2.40)	0.59 (0.31, 1.13)
Previous children	163 (45.0)	19 (47.5)	51 (44.4)	32 (45.1)	1.00 (0.60, 1.67)	1.10 (0.51, 2.40)	0.95 (0.53, 1.73)
BMI categories							
Underweight	33 (10.0)	4 (10.5)	16 (14.7)	5 (7.6)	1.33 (0.49, 3.59)	1.81 (0.44, 7.50)	2.33 (0.79, 6.86)
Normal weight	214 (64.7)	19 (50.0)	59 (54.1)	43 (65.2)	Reference	Reference	Reference
Overweight or obese	84 (25.4)	15 (39.5)	34 (31.2)	18 (27.3)	0.94 (0.51, 1.72)	1.89 (0.79, 4.51)	1.38 (0.69, 2.75)
Educational attainment							
Less than up to year 12	26 (7.3)	2 (5.0)	10 (8.8)	9 (12.7)	Reference	Reference	Reference
Trade/apprenticeship/diploma	88 (24.9)	9 (22.5)	30 (26.3)	17 (23.9)	1.79 (0.72, 4.49)	2.38 (0.42, 13.47)	1.59 (0.54, 4.67)
University or higher	240 (67.8)	29 (72.5)	74 (64.9)	45 (63.4)	1.85 (0.81, 4.20)	2.90 (0.59, 14.39)	1.48 (0.56, 3.92)
Do not eat red meat	24 (6.7)	6 (15.0)	17 (14.9)	6 (8.6)	0.77 (0.30, 1.95)	1.88 (0.56, 6.29)	1.87 (0.70, 4.99)
Previous pregnancy							
Previous miscarriage	39 (12.8)	4 (12.9)	16 (17.2)	12 (18.8)	1.57 (0.77, 3.21)	1.56 (0.46, 5.29)	1.11 (0.49, 2.54)
Heavy bleeding before or after birth[4]	23 (6.3)	4 (10.0)	8 (7.0)	3 (4.2)	1.53 (0.45, 5.25)	2.52 (0.53, 11.87)	1.69 (0.43, 6.61)
Diagnosed with iron deficiency	16 (4.4)	6 (15.4)	24 (20.9)	5 (7.0)	0.61 (0.22, 1.73)	2.40 (0.68, 8.45)	3.48 (1.26, 9.60)
Current pregnancy							

Gestational age, weeks							
≤ 20	95 (26.5)	5 (12.5)	6 (5.3)	22 (31.9)	Reference	Reference	Reference
21-26	56 (15.6)	3 (7.5)	15 (13.3)	6 (8.7)	2.16 (0.83, 5.65)	2.20 (0.41, 11.95)	9.17 (2.48, 33.91)*
≥ 27	208 (57.9)	32 (80.0)	92 (81.4)	41 (59.4)	1.18 (0.66, 2.08)	3.43 (1.17, 10.07)*	8.23 (3.10, 21.81)**
Diagnosed with anaemia	20 (5.5)	10 (25.6)	28 (24.6)	3 (4.2)	1.33 (0.38, 4.58)	7.82 (2.00, 30.50)**	7.38 (2.15, 25.31)**
Diagnosed with iron deficiency	40 (11.1)	23 (59.0)	78 (67.8)	15 (21.1)	0.47 (0.24, 0.90)	5.37 (2.28, 12.63)**	7.87 (3.94, 15.71)***
Supplement use 3 months before current pregnancy							
Iron supplement	29 (8.1)	5 (12.5)	23 (20.0)	2 (2.9)	3.00 (0.70, 12.85)	4.86 (0.90, 26.31)	8.50 (1.94, 37.28)**
Multivitamin supplement	174 (48.6)	10 (25.0)	46 (40.0)	21 (30.0)	2.21 (1.27, 3.83)**	0.78 (0.32, 1.87)	1.56 (0.83, 2.93)

[1] Values represent number of women (%). Multiple pregnancies were not examined because of small and empty cell sizes. The number (%) of women with multiple pregnancies consuming a multivitamin supplement only was 13 (3.6), an iron supplement only was 2 (5.0), both types of supplements was 15 (13.2) and neither was 0.

[2] Association between maternal characteristics and pregnancy characteristics with use and type of current iron-containing supplement is reported using P-values with the "neither" as the reference group. * P<0.05, **P<0.01, ***P<0.001.

[3] Abbreviations include MV for multivitamin.

[4] Includes women who reported receiving blood transfusion.

Unadjusted analyses found that compared to non-users, woman who consumed MV supplements 3 months prior to pregnancy were more likely to consume MV supplements in the current pregnancy (**Table 1**). None of the other factors were significant; therefore, adjusted analysis was not performed. Compared to non-users, unadjusted analyses found that women ≥27 weeks gestational age and with a diagnosis of anaemia or ID in the current pregnancy were significantly more likely to consume iron-only supplement(s). In the adjusted analyses, current diagnosis of anaemia (AOR 5.52, 95% CI: 1.32, 23.18, P=0.02) or ID (AOR 4.16, 95% CI: 1.70, 10.20, P=0.002) remained statistically significant.

And finally, compared to non-users, unadjusted analyses found that increased gestational age of 21-26 weeks or ≥27 weeks (compared to ≤ 20 weeks), a diagnosis of anaemia or ID in the current pregnancy and use of iron-only supplement(s) 3 months prior to pregnancy were significantly associated with current use of both MV and iron-only supplement(s). In the adjusted model, all except gestational age remained statistically significant such that use of both MV and iron-only supplement(s) in the current pregnancy was more likely among woman with a diagnosis of anaemia (AOR 4.08; 95% CI: 1.09, 15.29, P=0.04) or ID (AOR 6.05; 95% CI: 2.91, 12.58, P<0.0001) in the current pregnancy and who used iron-only supplement(s) 3 months prior to pregnancy (AOR 9.24, 95% CI: 1.97, 43.23, P=0.005).

Of the 432 women who provided information on the dose and frequency of supplements taken, the median (25^{th}, 75^{th} percentile) daily dose of elemental iron was 60 mg (10.0, 64.6). The prevalence of women consuming an average daily dose of

<30, 30-65, 66-99, 100-200 and >200 mg of elemental iron from iron-containing supplements was 36.8% (n=159), 39.6% (n=171), 5.6% (n=24), 15.1% (n=65) and 3.0% (n=13), respectively.

Descriptive statistics of maternal and pregnancy factors and average daily intake of low (<30 mg), preventative (30-99 mg) or treatment (≥100 mg) dosages of elemental iron from iron-containing supplements; and the association between low and treatment dosages compared with preventative (30-99 mg) dosages of elemental iron are presented in **Table 2**.

Unadjusted analyses found that women with previous children were more likely to consume low vs. preventative iron dosages (OR 2.09, 95% CI: 1.36, 3.20). None of the other factors were significant therefore, adjusted analysis was not performed. Unadjusted analyses comparing women consuming preventative versus treatment dosages of elemental iron found statistically significant associations with the following explanatory variables: multiple pregnancy, BMI, diagnosis of ID in previous pregnancy, increased gestational age, and current pregnancy diagnosis with either anaemia or ID. Adjusted analyses found that women were significantly more likely to consume treatment dosages of iron if they had previous children (AOR 2.15; 95% CI 1.11, 4.15, P=0.02) or a diagnosis of ID in the current pregnancy (AOR 13.77, 95% CI 7.06, 26.86, P<0.0001) and significantly less likely to consume treatment dosages if that had consumed a MV 3 months prior to the current pregnancy (AOR 0.32; 95% CI 0.16, 0. 64, P=0.001). None of the other factors found to be statistically significant in the unadjusted analyses remained in the final model.

Table 2

Maternal and pregnancy characteristics according to pregnant women's average daily intake of elemental iron from iron-containing supplements in the current pregnancy, for women taking iron containing supplements in whom the daily dose of iron was known (n=432).[1]

	Average daily dose of elemental iron from iron-containing supplements[1]			**Unadjusted odds ratio (95% confidence intervals)**	
	Low (<30 mg) n =159, 36.8%	**Preventative (30-99 mg) n =196, 45.4%**	**Treatment (≥100 mg) n=77, 17.8%**	**Low vs. preventative dose**	**Treatment vs. preventative dose**
Maternal characteristics					
Maternal age, years					
<25	5 (3.1)	10 (5.1)	5 (6.5)	0.65 (0.22, 1.98)	1.23 (0.40, 3.80)
25-34	89 (56.0)	116 (59.2)	47 (61.0)	Reference	Reference
≥35	65 (40.9)	70 (35.7)	25 (32.5)	1.21 (0.78, 1.87)	0.88 (0.50, 1.56)
Educational attainment					
Less than up to year 12	14 (8.9)	13 (6.8)	6 (7.8)	Reference	Reference
Trade/apprenticeship/diploma	38 (24.2)	49 (25.8)	18 (23.4)	0.72 (0.30, 1.71)	0.80 (0.26, 2.41)
University or higher	105 (66.9)	128 (67.4)	53 (68.8)	0.76 (0.34, 1.69)	0.90 (0.32, 2.49)
Multiple pregnancy	5 (3.1)	8 (4.1)	12 (15.6)	0.76 (0.24, 2.37)	4.32 (1.69, 11.03)**
Previous children	88 (55.4)	73 (37.2)	40 (52.0)	2.09 (1.36, 3.20)***	1.82 (1.07, 3.10)
BMI categories					
Underweight	18 (12.5)	13 (7.1)	11 (14.9)	1.95 (0.91, 4.19)	2.92 (1.20, 7.06)*
Normal weight	88 (61.1)	124 (67.8)	36 (48.7)	Reference	Reference
Overweight/obese	38 (26.4)	46 (25.1)	27 (36.5)	1.16 (0.70, 1.94)	2.02 (1.11, 3.69)*
Do not eat red meat	11 (7.0)	16 (8.3)	11 (14.3)	0.82 (0.37, 1.83)	1.83 (0.81, 4.16)
Previous pregnancy					
Previous miscarriage	23 (16.4)	21 (13.6)	10 (15.6)	1.26 (0.67, 2.38)	1.18 (0.52, 2.67)

Heavy bleeding before or after last birth[2]	15 (9.4)	9 (4.6)	7 (9.1)	2.16 (0.92, 5.09)	2.08 (0.75, 5.79)
Diagnosed with iron deficiency	14 (8.9)	12 (6.2)	16 (20.8)	1.47 (0.66, 3.27)	3.96 (1.77, 8.83)**
Current pregnancy					
Gestational age, weeks					
≤ 20	40 (25.5)	47 (24.1)	5 (6.6)	Reference	Reference
21-26	21 (13.4)	29 (14.9)	10 (13.2)	0.85 (0.42, 1.72)	3.24 (1.01, 10.43)
≥ 27	96 (61.2)	119 (61.0)	61 (80.3)	0.95 (0.58, 1.56)	4.82 (1.82, 12.74)*
Diagnosed with anaemia	18 (11.3)	13 (6.6)	19 (25.0)	1.80 (0.85, 3.79)	4.69 (2.18, 10.09)***
Diagnosed with iron deficiency	28 (17.7)	36 (18.4)	56 (72.7)	0.96 (0.56, 1.65)	11.85 (6.39, 21.99)***
Supplement use 3 months before current pregnancy					
Iron supplement	13 (8.2)	23 (11.9)	15 (19.5)	0.66 (0.32, 1.36)	1.79 (0.88, 3.67)
Any multivitamin supplement	75 (47.5)	96 (49.7)	21 (27.3)	0.91 (0.60, 1.39)	0.38 (0.21, 0.67)

[1]Values represent number of women (%). Of 589 women, 157 were excluded because of missing information required to calculate the daily dose of elemental iron, such as the brand name for the iron-containing supplement(s) (n=71) or the iron frequency and number of pills consumed per week (n=86). * P<0.05, **P<0.01, ***P<0.001

[2] Includes women who reported receiving a blood transfusion.

When asked for details about the type and frequency of iron-containing supplement use in the current pregnancy, 63.1% of women reported having consumed one supplement, 29.4% had consumed two supplements, and 7.5% had consumed between 3 and 6 different brands of supplements. Most women were consuming iron from a MV, with only 26.3% reporting intake from an iron-only supplement. A list of the iron-containing supplements reported and the elemental dose and form of iron in each brand is presented in **Supplementary Table 1**.

Supplementary Table 1

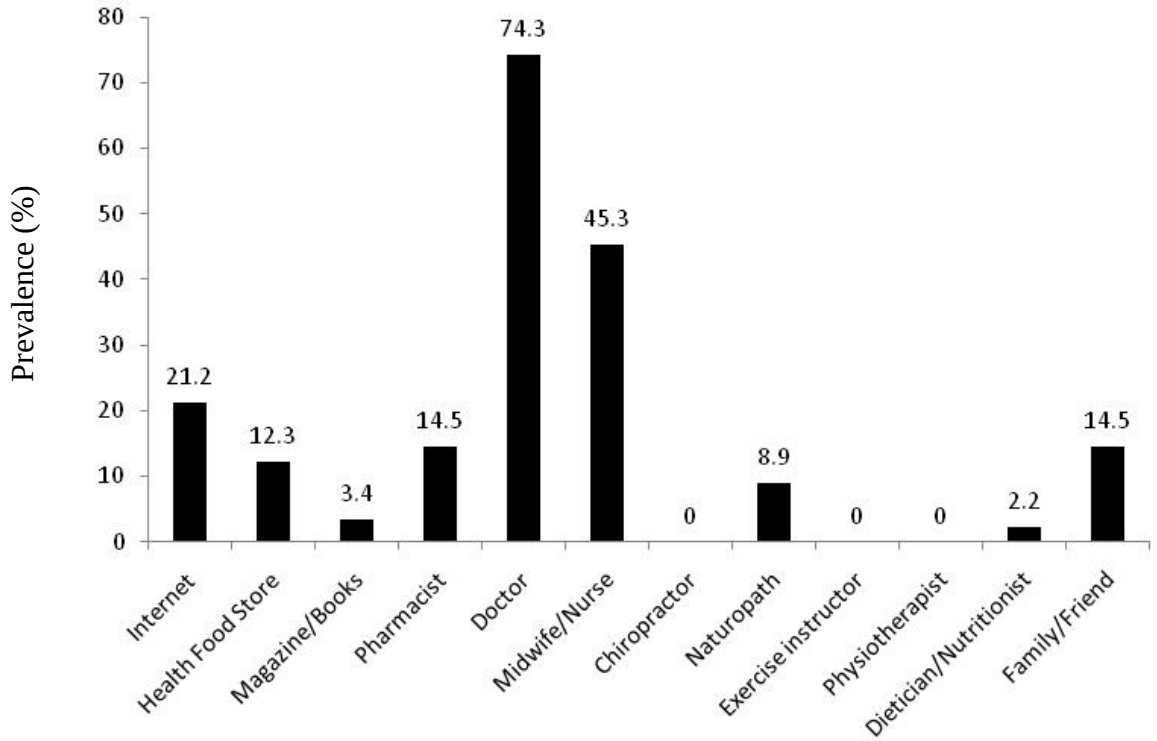
List of iron-containing supplements that women reported using in the current pregnancy by MV and iron-only by type of iron and dose of elemental iron (mg).

Type and brand of supplement	**Type and amount of iron**	**Dose of elemental iron (mg)**
Iron-containing multivitamin supplements		
Brand A	15.7 mg of ferrous fumarate	5
Brand B	183 mg of ferrous fumarate	60
Brand C	14.97 mg of iron phosphate	5
Brand D	25 mg of iron amino acid chelate	5
Primarily iron-only supplements		
Brand E	60 mg of iron amino acid chelate	12
Brand F	270 mg of ferrous sulphate	87.4
Brand G	310 mg of ferrous fumarate	100
Brand H	325 mg of ferrous sulphate	105
Brand I	325 of ferrous sulphate	105
Brand J	250 mg of ferrous sulphate	80

The prevalence of women taking the three most common iron-containing MV supplements was 44.5% for a brand which contains 60 mg of elemental iron per tablet, 31.5% for a brand which contains 5 mg of elemental iron per tablet, and 4.4% for a different brand which contains 5 mg of elemental iron per tablet. The prevalence of women taking the three most common iron-only supplements was 15.3% for a brand which contains 105 mg of elemental iron per tablet, 2.3% for a brand which contains

87.4 mg of elemental iron per tablet, and 1.9% for a brand which contains 100 mg of elemental iron per tablet. The median of the maximum number of weeks of supplement use was 20 weeks (25^{th}, 75^{th} percentile: 4, 30). The average monthly expenditure was $43AUD, ranging from $5 to $300; and the most common sources of information on dietary supplements reported by women were a woman's doctor (74.3%), midwife or nurse (45.3%), and the internet (21.2%) (**Figure 1**).

Figure 1. Main sources of information on dietary supplements reported by pregnant women currently consuming an iron-containing supplement.



DISCUSSION

The present study found that the vast majority of pregnant women are consuming an iron-containing supplement. Women were more likely to consume an iron-containing supplement if they had increased gestational age, a diagnosis of anaemia or ID in the

current pregnancy and reported using an iron-containing supplement 3 months prior to the current pregnancy. However, only two thirds of women (64.7%) diagnosed with ID, and 62.3% of women diagnosed with anaemia were taking an iron supplement, with or without a MV. Less than half of women (46.7%) diagnosed with ID were taking ≥100 mg iron per day from supplements, and a quarter (23.3%) were taking <30 mg per day. Several risk factors for ID examined in this study were not associated with greater likelihood of iron supplement use in pregnancy, including age, multiple pregnancies, having previous children, BMI, educational attainment, not eating red meat, previous miscarriage, heavy bleeding in previous pregnancy before or after birth, and diagnosis with ID in previous pregnancy. Among women consuming some form of iron from either a MV or primarily iron-only supplement, more than a third of women were consuming a low dose (<30 mg), nearly half were consuming a preventative dose (30-99 mg) and nearly one fifth were consuming a treatment (≥100 mg) dose of oral iron daily. Compared with preventative dosages of average daily elemental iron, women with previous children were more likely to take low doses. While high treatment dosages were more common among women with previous children and a diagnosis of ID in the current pregnancy and less common among those who consumed a MV 3 months prior to pregnancy.

The prevalence of iron-containing supplement use in our study (88%) was higher than those reported in previous Australian studies which found a prevalence of 35% among pregnant women at 36-38-weeks gestation in a tertiary hospital in Melbourne in 2003[14] and a prevalence of 14%, 13%, and 27% in the 1st, 2nd, and 3rd trimesters respectively, among women attending an antenatal clinic in Adelaide in 2001.[15] These differences may be related to how data was collected, as our study included

MVs containing iron in the overall prevalence estimate; however, only 7.2% of women were consuming an iron-only supplement and 22.2% were consuming both. There may also be differences in study populations and changes in the use of iron supplements in pregnancy over time.

Our study found use of iron-containing supplements in pregnancy was not associated with many of the risk factors for iron supplement use such as multiple pregnancies, having previous children, not eating red meat and a previous miscarriage, that are highlighted in national recommendations by RANZCOG[13] and international guidelines issued by the World Health Organisation on iron and folic acid supplementation in pregnancy.[17] These data suggest that a small proportion of women with these risk factors require greater attention and perhaps counselling about the importance of adequate iron status in pregnancy. It is uncertain from our data whether these women at increased risk of ID are not being identified as requiring an iron supplement or are self-selecting not to take an iron supplement. Most women reported a clinician as their main source of information, therefore efforts to improve awareness among this high-risk group could be achieved by providing additional educational materials in healthcare settings and to professionals to hand out to their patients.

An important finding from our study is that pregnant women are consuming varying doses of iron from iron-containing supplements. In our study, about 45% of women were consuming a daily dose of 30-99 mg of elemental iron, which is similar to the preventative dose of iron that is routinely recommended for all pregnant women in countries such as the United States, Canada and France (30-60 mg) and the

preventative dose (65 mg) for women at risk of or with ID in the UK.[8,9,11] About 1 in 5 women were consuming a daily dose of iron (≥100 mg) that in most developed countries is recommended for treatment of IDA in pregnancy.[8,9,12,17] While there are some concerns with iron excess, such as the potential for iron, as a redox-active transitional metal, to trigger oxidation stress and to cause decreased absorption of other essential divalent metal ions, such as zinc,[18] results from our study suggest very few Australian pregnant (~3%) women are at risk of consuming excess iron (>200 mg/day) from iron-containing supplements.

Our study did find; however, that 37% of women were consuming a low dose (<30 mg) of daily elemental iron, some of whom had or were at high-risk for ID. While a trial by Australian researchers demonstrated that a routine low-dose iron supplement (20 mg per day) is an effective strategy for preventing IDA and ID;[6] higher doses of supplemental iron are required to treat IDA or ID.[4] A study of Danish pregnant women which evaluated the effect of 20, 40, 60, and 80 mg of iron daily found 20 mg was inadequate to prevent ID in a substantial number of women and that 40 mg of iron prevented IDA in more than 95% of the women.[19]

Our findings reveal a high prevalence of women taking popular pregnancy MVs, with most containing only 5 mg of elemental iron per tablet. Furthermore, it appears many women may not take the recommended number of tablets on a daily basis. This may be problematic as many pregnant women may not be aware that the MVs they are purchasing may not be providing them with an adequate daily dose of iron to ensure optimal iron status. Compliance with iron supplement use is also reported to be generally low because of the potential side effects, such as epigastric discomfort,

nausea, diarrhoea, and constipation.[18] Pregnant women may also not be aware that the form of iron in supplements varies (i.e. ferrous sulfate, ferrous gluconate, ferric citrate), which may influence its bioavailability and possible side effects. Certain forms of supplemental iron, such as heme iron polypeptides, carbonyl iron, iron amino-acid chelates, and polysaccharide-iron complexes, might have fewer gastrointestinal side effects than ferrous or ferric salts. Elemental iron is listed on supplements, so consumers do not need to calculate the amount of iron supplied by various forms of iron supplements; however, healthcare professionals should notify women of what to look for when selecting the appropriate iron supplement for their needs.

Pregnant women should also be counseled on how to consume oral iron supplements correctly. Both the US and UK guidelines include such advice, such as consuming iron supplements on an empty stomach, an hour before meals, with a source of vitamin C to maximize absorption and not at the same time as other medications or antacids.[8,11] Further research is needed to examine women's knowledge and beliefs around brand choice, the required amounts of iron in pregnancy supplements and also what advice healthcare professionals are providing to women about what type and dose of iron supplements to use during pregnancy.

Despite iron supplementation during pregnancy being common, there is limited contemporary data in Australia on iron supplement use. Strengths of this study include the collection of detailed information on the frequency and dose of iron from iron-containing supplements on a range of maternal and pregnancy factors, and the inclusion of women of all gestational ages. Limitations are the cross-sectional nature

of the study which limited us from examining individual and group differences over time, the lack of data on dietary iron intakes and use of intravenous iron. We also do not know how many women received the recommendation to take iron supplementation by a healthcare professional, in which amount, and how many of them followed the recommendation. This would provide relevant information on the effect of the intention to treat and on the appropriateness of the amount recommended when comparing with the international guidelines. Another limitation is the sociodemographic differences between our study population and the total state maternity population during the same period.[20] Women in the present study were predominantly tertiary educated and older which, limits the generalisability of our study findings to all pregnant women in Australia.

In summary, results from our study suggest that a small proportion of women with or at risk of ID are not consuming an iron-containing supplement during pregnancy. Women are consuming varying doses of iron and women with or at risk of ID or anaemia are taking inadequate doses of iron to prevent or treat ID or IDA. Australia does not have established national guidelines on preventative or prophylactic iron to pregnant women, and therefore it is up to healthcare professionals to advise women individually about the type, dose and duration of iron supplement use best suited to their needs. National public health guidelines in Australia on the management and treatment of ID in pregnancy would help ensure greater consistency and optimal antenatal care around iron supplement use in pregnancy.

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