Dietary Iron Consumption Estimates Among Women Of Reproductive Age In Kersa, Eastern Ethiopia: Cross-Sectional Study

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Research

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Abstract

Dietary iron inadequacy is a public health concern in developing countries. Women of reproductive age (WRA) are the most at risk for this micronutrient deficiency due to biological, socio-cultural, and dietary factors. This analysis aimed to assess estimated dietary intakes of iron (including heme and non-heme) and estimate bioavailability of dietary iron intake in Ethiopian women of reproductive age in Kersa district, Eastern Ethiopia.

A total of 1140 randomly selected women from households in Kersa participated in this study. We used a non-quantitative food frequency questionnaire to assess total dietary iron consumption in WRA. Adjusted prevalence ratios (APRs) and 95% confidence intervals (CIs) were computed using modified Poisson regression to evaluate factors for inadequate dietary iron intake.

The median usual iron consumption was 24.7 mg/d and 41.8% of WRA were at risk for iron inadequacy. The following factors were associated with a greater likelihood for the risk of iron inadequacy: seasonal (APR 1.56; 95% CI 1.36-1.80) and part-time (APR 1.75; 95% CI 1.45-2.12) agricultural employment, market food source (APR 1.30; 95% CI 1.14-1.49), old age (APR 1.29; 95% CI 1.05-1.60) and low women’s dietary diversity (APR 2.34; 95% CI 1.88-2.91).

Two-fifths of women had an inadequate dietary iron intake. Improving dietary diversity and food security, fortifying staple foods that have low iron bioavailability, and increasing animal-based foods and fruit consumption with meals would help to decrease the burden of iron dietary inadequacy and deficiency in WRA.

Introduction

The human body needs iron ($Fe$), which is a trace mineral that is essential for the synthesis of Heme, a constituent of hemoglobin - an oxygen carrier in the body, iron-containing enzymes, and for neural development in the fetus and during childhood [1, 2]. Dietary iron intake is composed of both heme (from meat, poultry, and fish) and non-heme iron (from cereals, legumes, fruits, and vegetables). Bioavailability is high for heme compared to non-heme iron. It is estimated that a quarter of heme-iron and one-tenth of non-heme iron is bioavailable from the diet [3, 4]. Iron is actively absorbed in the gut and transported by transferrin to the bone marrow for producing blood products and is reversibly stored as ferritin [5, 6]. The body’s balance of iron depends upon its reserve, loss, and absorption (bioavailability and intake).

Iron deficiency occurs when the diet cannot supply enough iron to cover the body’s physiological requirements. This can occur due to dietary intake is quantitatively inadequate, reduced absorption, or increased demands for iron for example among women of reproductive age (WRA) during pregnancy or due to menstruation [7, 8]. Iron deficiency is the most frequently encountered micronutrient malnutrition in the world [9]. Although the global prevalence of iron deficiency in non-pregnant women has decreased from 33–29% in the past decade [10], it is still a significant public health concern as it affects up to 500-600 million people, the majority in low- and middle-income countries (LMICs) [11, 12]. Inadequate iron intake can cause iron deficiency anemia (IDA), and IDA prevalence is high in WRA (because of loss in menstruation) in
developing countries [13, 14]. It also leads to reduced work capacity, loss of appetite, weakened immunity and puts pregnancies at risk contributing to 20% of all perinatal and maternal deaths [15, 16]. IDA can also disrupt the metabolic process and affect behavioral and cognitive function, with severe consequences for children [5, 17].

The mean dietary iron intake among WRA reported in Kenya, Nigeria, and South Africa ranged from 3.8 to 97.8 mg/d and around 34–100% of the WRA had inadequate intakes [13]. Studies suggest that only 8–12% of the WRA in Ethiopia have inadequate Fe intake, however, most of the staples consumed in Ethiopia including iron-rich foods such as teff have low bioavailability of iron [13, 18]. Additionally, the prevalence of maternal and child anemia in Ethiopia at 23% and 56% is among the highest globally [19]. Therefore, understanding the role of dietary intake in iron status among Ethiopians is of critical importance.

Several factors contribute to inadequate intake of dietary iron in Ethiopia. As dietary intake in Ethiopia is mostly plant-based with limited diversity and consumption of animal source foods, the presence of anti-nutritional factors has made the bioavailability of iron significantly low [18]. Additionally, poverty, illiteracy and limited knowledge of nutrition, and poor lifestyle choices are also contributing factors [5, 20]. Studies in other LMICs have also shown that high cost and limited access to micronutrient-rich foods, low acceptability of fortified foods, fasting, and sub-optimal dietary practices influence dietary iron intake in WRA [21].

Little is known about the dietary iron intake of Ethiopian women and the factors influencing it. Past research is outdated, and there are considerable discrepancies between regions. This study aims to estimate the usual dietary iron consumption and its components in Ethiopian WRA in the Kersa district in eastern Ethiopia. These findings will help to estimate the risk of inadequate iron intake among WRA in the area, and the factors associated with estimated dietary iron inadequacy. The findings help health officials to collaborate with stakeholders in improving the food security and fortification policy of locally available foods in Ethiopia.

**Methods And Methods**

**Study design and settings**

This study took place in the Kersa Health Demographic Surveillance system (Kersa HDSS) field research site, in Oromia region of eastern Ethiopia. Kersa HDSS includes 24 kebeles (the lowest administrative unit in Ethiopia), out of the 38 kebeles in the district [22]. Of the HDSS Kebeles, 21 are rural. The 2016 national census reported that the population of Kersa district was 170,816, of which 50% were women and 6.7% were urban dwellers [23].

We conducted a cross-sectional survey among households in Kersa HDSS from August 1 to September 30, 2019 [22]. The total sample size for the study was 1,200 women. Study participants were selected using a random selection method from a sampling frame derived from the Kersa HDSS database. Households with at least one married WRA (15-49 years old) or women head of the households were included in the sampling
frame. If more than one WRA lived in the household and was present at the interview, one woman was randomly selected using a number generator. We excluded pregnant women from the study.

**Data collection tool**

The participants responded to the questionnaire; which had five sections, including information on socio-demographic characteristics, health information, food choices, and cooking practices, food security, food expenditures, homestead food production, and dietary intake. Data were collected via interviewer-administered tablet-based questionnaires, using an Open Data Kit (ODK) platform.

**Sociodemographic and anthropometric assessment**

Household wealth index was calculated from principal component analysis including 10 items describing the household asset ownership, crowding, housing roof or floor quality, and water and sanitation facilities. The wealth index was used to group women using tertiles (the poor, middle, and rich) [24]. Women's employment status was classified according to the Ethiopian Demographic and Health survey defined categories [23]. Women who were classified as entirely employed had a skilled and stable job and had been working at least for 7 days before the survey. Hard labor or agricultural employment was categorized as partial and seasonal based on monthly employment and experience before the survey.

Height and weight of WRA were measured to the nearest centimeter (cm) and kilograms (kg) using a stadiometer and standard weighing scale [25]. We calculated body mass index (BMI) as weight in kilograms divided by height in meters squared. Based on BMI, individuals were classified using standard cutoffs as underweight (<18.5 kg/m²), normal weight (18.5–24.9 kg/m²), or overweight/obese (≥ 25 kg/m²). Overweight was classified as BMI 25-29.9 kg/m² and obesity BMI ≥30 kg/m² [26].

**Dietary assessment:**

Participants’ dietary intake was assessed using a 69-item non-quantitative, food frequency questionnaire (FFQ), locally adapted from a semi-quantitative FFQ version validated for use among urban Tanzanian adults [27]. The FFQ included locally available foods and varieties and an option to specify other foods. The participants were asked the number of days they consumed each food out of the past seven days. The number of food items consumed per week was divide by seven to derive daily consumption. If a participant reported consuming a particular food with respective once twice, thrice and every day, a week, the frequency of consumption recorded would be 0.14, 0.29, 0.43, and 1. Portion sizes and frequencies of intake were not collected. The mean portion sizes for each food item were computed from previous population-based study protocol [19, 28]. The Ethiopian Food Composition table and other studies were used to capture iron composition data of reported foods [29–31].

Diet diversity was assessed using the minimum dietary diversity for women (MDD-W) indicator [32]. We grouped foods consumed by women (based on the FFQ) into ten non-overlapping food groups according to Food Agriculture Organization (FAO) guidance [33, 34]. The 10 food groups are 1) starchy staples, 2) pulses 3) nuts and seeds 4) dairy products 5) flesh foods 6) eggs 7) dark green leafy vegetables 8) vitamin-a rich fruits and vegetables 9) other vegetables, and 10) other fruits [34]. Foods made from grains cereals roots
and tubers are grouped into starchy staples. Poultry and all meat products were categorized as flesh foods and all milk products as dairy [33]. If a participant reported daily consuming at least one of the food items in a particular food group, it is scored one and if a participant didn’t consume any of the food items, it is scored zero. The scores are then summed into a dietary diversity score (DDS-W, range 0-10). We categorized women as meeting minimum dietary diversity (MDD) if they consumed at least five food groups (DDS ≥ 5) out of the 10 groups, as a proxy for micronutrient adequacy [33, 35, 36].

The usual iron intake of participants was estimated by multiplying the mean portion size and iron composition for each reported food item with its converted daily consumption. Heme and non-heme iron intake were estimated based on assumptions that 40% of animal food sources had heme iron and 60% of animal, and all plant source foods and dairy contained non-heme iron [37]. We estimated iron bioavailability after food intake assuming that 25% of all heme-iron and 10% non-heme would be bioavailable on average after consuming a cooked meal or ripe food [37]. We calculated the usual iron, heme and, non-heme iron intake in milligrams per day.

We calculated the risk of inadequate dietary iron intake based on consumption less than the age- and sex-specific Estimated Average Requirement (EAR) for iron for WRA. We assumed a low bioavailability of iron absorption (5%). A cut-off of < 22.4 mg/d was used to define inadequate intake of dietary iron [38].

**Data analysis**

Data were analyzed using STATA 16. We characterized sociodemographic characteristics of the study population using means, and standard deviations (SDs) and medians, and interquartile ranges for variables that were not normally distributed for continuous variables; and, counts and percentages for categorical variables. Data points with more than 50% missing data and with usual amounts (outliers) were removed from the analysis. Wilcoxon rank-sum test was used to evaluate significant differences in medians for the outcome measures. We describe dietary iron intake by specific food type and women’s characteristics. We evaluated for multi-collinearity among the independent variables using the covariance matrix.

Modified Poisson regression models were used to evaluate associations between the independent variables and risk of dietary Fe inadequacy (0 = no risk of Fe dietary inadequacy, 1 = risk of Fe inadequacy) based on EAR-derived cut-offs for WRA. Covariates were selected based on significance in univariate analysis at p < 0.2. Crude Prevalence Ratios (CPR) and Adjusted Prevalence Ratio (CPR) and 95% CI were calculated. The statistical association level was p < 0.05 to identify independent variables associated with the risk of dietary iron inadequacy.

**Results**

The study included 1,123 WRA from the community. Forty-seven households refused to participate in the study, making a response rate of 96%. We excluded 52 missing observations and 25 outlier observations from the analysis.

The median age of participants was 30 years (Inter Quantile Range (IQR) 26; 30) and half of the participants had never attended school. Most participants (96%) were Muslims and played a spouse and head role of
the household. Even though a majority of WRA (67.1%) worked full time, more than half of the households were in the poor wealth index category. The median weight and height for WRA were 51 kg (IQR 47.8; 56.0) and 157 cm (IQR 154.5; 161.1), respectively. Most study participants (90.7%) had under-five children in their household with a median age of 36 months (IQR 23; 48). The median number of previous pregnancies reported was four (IQR 3; 6). Many women (76.0%) reported using household products as a primary source of food and travels more than half a kilometer (0.7 km) for reaching a food source. The median dietary diversity score was 4.0 (IQR 3.0; 5.0) and 34.6% of women met minimum dietary diversity (Table 1).
Table 1
Sociodemographic, reproductive characteristics, and food source, and diversity study participants women of reproductive age, Kersa, Eastern Ethiopia (N=1123)

| Variables                              | N    | Values |
|----------------------------------------|------|--------|
| Woman's age (years)                    | 1123 |        |
| 16- 25                                 |      | 267 (23.8) |
| 26- 35                                 |      | 633 (56.4) |
| ≥ 36                                   |      | 223 (19.8) |
| Highest Education                      | 1123 |        |
| Never attended school                  |      | 609 (54.2) |
| Did not finished first grade           |      | 99 (8.8) |
| Completed 10 grade and more            |      | 415 (37.0) |
| Partner Highest Education              | 1123 |        |
| Never attended school                  |      | 571 (50.8) |
| Did not finished first grade           |      | 84 (7.5) |
| Completed 10 grade and more            |      | 468 (41.7) |
| Religion                               | 1123 |        |
| Muslim                                 |      | 1079 (96.1) |
| Orthodox                               |      | 33 (2.9) |
| Other b                                |      | 11 (1.0) |
| Employment type                        | 1123 |        |
| Full-time                              |      | 753 (67.1) |
| Part-time                              |      | 102 (9.1) |
| seasonal                               |      | 268 (23.8) |
| Occupational status of women           | 1123 |        |
| Farmer                                 |      | 925 (82.4) |
| Trade                                  |      | 44 (3.9) |
| Professional/technical                 |      | 61 (5.4) |
| Other d                                |      | 93 (8.3) |
| Role in the household                  | 1123 |        |
| Head of the HH                         |      | 141 (12.5) |
| Variables                                      | N   | Values                           |
|-----------------------------------------------|-----|----------------------------------|
| Spouse                                        | 971 | (86.5)                           |
| Another                                      | 11  | (1.0)                            |
| Wealth index                                  | 1123|                                 |
| Poor                                          | 639 | (56.9)                           |
| Middle                                        | 255 | (22.7)                           |
| Rich                                          | 229 | (20.4)                           |
| Weight \(^a\) (kg)                            | 1123| 51.0 (47.8; 56.0)                |
| Height \(^a\) (cm)                            | 1123| 157.0 (154.5; 161.1)             |
| Body mass index                               |     |                                 |
| Underweight                                   | 1123| 188 (16.7)                       |
| Normal                                        | 868 | (77.3)                           |
| Overweight                                    | 67  | (6.0)                            |
| Family size \(#\)                             | 1123| 5.9 ± (3.0)                      |
| Has an under 5 children                       | 1123| 1018 (90.6)                      |
| Age of Under 5 children \(^a^*)                | 1018| 36.0 (23.0; 48.0)                |
| Number of previous pregnancies \(#\)          | 1123| 4.45 ± (2.4)                     |
| Source of household food                      | 1123|                                 |
| Household production                          | 853 | (76.0)                           |
| Street Vendor and local market                | 270 | (24.0)                           |
| Food source distance from Household \(#^e\)    | 284 | 0.7 ±(1.4)                       |
| Women's DDS \(^a^f\)                         | 1123| 4.0 (3; 5)                       |
| Minimum dietary diversity                     | 1123|                                 |
| Optimum                                       | 389 | (34.6)                           |
| Estimated daily iron intake (mg/d) \(^a\)     | 1123| 24.7 (17.7; 33.2)                |
| Estimated daily non-heme iron consumption (mg/d) \(^a\) | 1123| 24.7 (17.7; 33.1)                |
| Estimated daily heme-iron consumption (mg/d) \(^a\) | 1123| 0.0 (0.0; 0.0)                   |
### Variables

| Variables                                                                 | N   | Values     |
|---------------------------------------------------------------------------|-----|------------|
| Estimated heme-iron consumption after consuming animal products (mg/d)   | 114 | 0.3 (0.1; 0.6) |
| Estimated relative bioavailable Iron                                     | 1123| 2.5 (1.8; 3.3) |
| Low usual Iron intake                                                    | 1123| 381 (33.9)   |

Values are mean ± SD, median [IQR], or frequency (percent).

\[a = \text{Median (25th ; 75th percentile)}\]

\[\# = \text{Mean ±(SD)}\]

\[b = \text{Protestant, Jehovah-witness}\]

\[c = \text{sister, daughter, aunt}\]

\[d = \text{un skilled and manual labor, clerical}\]

\[e = 284 \text{ observations}\]

\[f = \text{total score = 10}\]

\[* = \text{age in Months}\]

\[g = 114 \text{ observations}\]

## Usual iron, non-heme, heme, and bioavailable iron intake

The median dietary iron intake estimated in this study was 24.7 mg/day: 95% CI (23.9– 25.5). The mean heme and non-heme iron intakes respectively were 0.05 (95% CI 0.04-0.06) and 24.7 mg/d (95% CI 23.9-25.5). Around 2.5 mg/d (95% CI 2.4-2.6) of iron is estimated to be bioavailable after consumption. Total Fe consumption distribution was positively skewed. 41.8% of women of reproductive age were at risk of iron inadequacy based on a cut-off for Fe inadequacy of EAR. Heme-Fe contributes less than one percent of the total iron intake. The median daily iron intake for women who met minimum dietary diversity (5+ food groups) and those with low dietary diversity was 32.7 (95% CI 31.1 – 34.3) and 21.6 (95% CI 20.8- 22.4) mg/d, respectively Figure 1-3

## Food frequency distribution and total iron consumption

Table 2 shows the amounts of total and bioavailable dietary Fe consumption was lower in women whose ages were 36 or above than the other groups. The median intake of all types of iron was higher in women meeting criteria for minimum dietary diversity, as well as in women in the overweight category and among those in the highest SES. The mean dietary intake of all types of iron was higher in a household that
depended on a household food source. Participants who reported concurrent intake of flesh foods and fruits daily had the highest amount of dietary iron intake across all groups.
Table 2
Stratified dietary Iron, heme, non-heme, and bioavailable iron of women of reproductive age in Kersa, Eastern Ethiopia, 2019

| Variable                        | N (%) | Iron (mg/d) * | P-value b | Non-hem Iron (mg/d) | P-value b | Bioavailable Iron (mg/d) | P-value |
|---------------------------------|-------|---------------|-----------|---------------------|-----------|--------------------------|---------|
| Age (in Years)                  |       |               |           |                     |           |                          |         |
| 16- 25                          | 267 (23.8) | 24.6 (17.4;33.5) | 24.6 (17.4;33.1) | 2.5 (1.7;3.4) |
| 26- 35                          | 633 (56.4) | 25.3 (18.6;34.9) | 0.01** | 25.3 (18.5;34.4) | 0.01** | 2.5 (1.9;3.5) | 0.01** |
| ≥ 36                            | 223 (19.9) | 22.0 (15.7;28.6) | 22.0 (15.7;28.5) | 2.2 (1.6;2.9) |
| Employment type                 |       |               |           |                     |           |                          |         |
| Full-time                       | 753 (67.1) | 26.3 (19.3;34.9) | 26.3 (19.3;34.9) | 2.6 (1.9;3.5) |
| Part-time                       | 102 (9.1) | 20.4 (15.4;30.0) | 0.000** | 20.4 (15.4;29.9) | 0.000** | 2.0 (1.5;3.0) | 0.000** |
| Seasonal                        | 268 (23.9) | 20.6 (16.6;28.1) | 20.6 (16.5;28.1) | 2.1 (1.7;2.8) |
| BMI                             |       |               |           |                     |           |                          |         |
| Underweight                     | 188 (16.7) | 23.0 (17.1;30.1) | 23.0 (17.1;30.1) | 2.3 (1.7;3.0) |
| Average                         | 868 (77.3) | 24.9 (17.9;33.1) | 0.05 | 24.9 (17.9;33.1) | 0.04** | 2.5 (1.8;3.3) | 0.06 |
| Overweight                      | 67 (6.0) | 27.5 (17.5;49.8) | 27.5 (17.5;49.4) | 2.7 (1.7;5.0) |
| Wealth Index                    |       |               |           |                     |           |                          |         |
| Poor                            | 639 (56.9) | 22.2 (16.6;27.8) | 22.2 (16.6;27.8) | 2.2 (1.7;2.8) |
| Middle                          | 255 (22.7) | 29.2 (20.9;41.9) | 0.000** | 29.2 (20.9;41.9) | 0.000** | 2.9 (2.1;4.2) | 0.000** |
| Rich                            | 229 (20.4) | 30.6 (20.1;47.6) | 30.6 (20.0;47.6) | 3.1 (2.0;4.8) |
| Dietary Diversity               |       |               |           |                     |           |                          |         |

a = 114 observations consumed flesh foods  
b = Wilcoxon rank-sum test  
*median (IQR)  
** significance at 0.05 level
| Variable                                           | N (%)       | Iron (mg/d) * | P-value b | Non-hem Iron (mg/d) | P-value b | Bioavailable Iron (mg/d) | P-value |
|---------------------------------------------------|-------------|---------------|-----------|---------------------|-----------|-------------------------|---------|
| Optimum (5+ food groups)                         | 389 (34.6)  | 32.7 (23.9;49.4) | 0.000**   | 32.4 (23.7;49.0)    | 0.000**   | 3.3 (2.4;5.0)           | 0.000** |
| Low                                               | 734 (65.4)  | 21.6 (15.7;27.7) |           | 21.6 (15.7;27.7)    |           | 2.2 (1.6;2.8)           |         |
| Food source                                       |             |               |           |                     |           |                         |         |
| Household                                         | 853 (76.0)  | 24.9 (18.7;32.5) | 0.02**    | 24.9 (18.6;32.5)    | 0.02**    | 2.5 (1.9;3.3)           | 0.04**  |
| Market                                            | 270 (24.0)  | 22.6 (15.7;39.1) |           | 22.6 (15.7;38.9)    |           | 2.3 (1.6;3.9)           |         |
| Concurrent Consumption of flesh and fruit         |             |               |           |                     |           |                         |         |
| Yes                                               | 39 (3.5)    | 45.5 (31.1;57.7) | 0.000**   | 45.3 (30.8;57.3)    | 0.000**   | 4.6 (3.2;5.8)           | 0.000** |

\(a=114\) observations consumed flesh foods \(b=\) Wilcoxon rank-sum test *median (IQR) ** significance at 0.05 level

Table 3 shows the consumption patterns of the study women and the contribution of food groups consumed to Fe intake. The median intake of iron for women who reported eating beans and peas, and dairy products was 5.8 mg/d and 4.8 mg/d, respectively. Almost all participants reported consumption of starchy staples (99.6%) and other vegetables (98.1%) in the previous 7 days; the 2 food groups providing 16.5 and 1.1 mg/d iron (median), respectively. Of the usual Fe consumed; starchy staples contributed 66.8% (16.5/24.7) of the intake. Nuts and seeds, and flesh foods were the least consumed food groups and eggs, and other fruits contributed the least amount of Fe. Many of the participants (66.5%) reported an intake of dairy products at least once a week. Participants who reported at least a daily intake of starchy stables had the highest estimated bioavailable iron after consumption.
| Food group                                      | Rank/ contribution | Consumed | Iron (mg/d) * | Bioavailable Fe* |
|------------------------------------------------|--------------------|----------|---------------|------------------|
| 1) All starchy staples                         | 1/66.8%            | 1119 (99.6) | 16.5 (11.7;23.2) | 1.6 (1.2;2.3)    |
| Consumed everyday                              |                    | 756 (67.3)  | 18.3 (12.8;24.1) | 1.8 (1.3;2.4)    |
| Consumed ≤6 days in 7 days                    |                    | 363 (32.3)  | 12.7 (8.8;18.6)  | 1.3 (0.9;1.9)    |
| 2) Beans and Peas                              | 2/23.5%            | 454 (40.4)  | 5.8 (2.3;12.6)   | 0.6 (0.2;1.3)    |
| Consumed everyday                              |                    | 16 (1.4)    | 20.3 (8.0;29.5)  | 2.0 (0.8;2.9)    |
| Consumed ≤6 days                               |                    | 438 (39.0)  | 5.7 (2.3;12.6)   | 0.6 (0.2;1.3)    |
| 3) Nuts and Seeds                              | 6/3.2%             | 69 (6.1)    | 0.8 (0.7;1.0)    | 0.0 (0.0;0.0)    |
| Consumed everyday                              |                    | 0.0 (0.0)   | 0 (0; 0)         | 0.0 (0.0;0.0)    |
| Consumed ≤6 days                               |                    | 69 (6.1)    | 0.8 (0.7;1.0)    | 0.0 (0.0;0.0)    |
| 4) All Diary                                   | 3/19.4%            | 747 (66.5)  | 4.8 (3.2;5.6)    | 0.5 (0.3;0.6)    |
| Consumed everyday                              |                    | 289 (25.7)  | 5.6 (5.6;5.6)    | 0.6 (0.6;0.6)    |
| Consumed ≤6 days                               |                    | 458 (40.8)  | 3.2 (2.4;4.8)    | 0.3 (0.2;0.5)    |
| 5) Flesh Foods                                 | 8/2.8%             | 114 (10.2)  | 0.7 (0.4;1.4)    | 0.4 (0.4;0.7)    |
| Consumed everyday                              |                    | 4 (0.4)     | 2.5 (2.5;4.3)    | 0.4 (0.4;0.7)    |
| Consumed ≤6 days                               |                    | 110 (9.8)   | 0.7 (0.4;1.4)    | 0.1 (0.1;0.2)    |
| 6) Eggs                                        | 9/0.4%             | 128 (11.4)  | 0.1 (0.1;0.3)    | 0.0 (0.0;0.0)    |
| Consumed everyday                              |                    | 2 (0.2)     | 0.5 (0.5;0.5)    | 0.0 (0.0;0.0)    |
| Consumed ≤6 days                               |                    | 126 (11.2)  | 0.1 (0.1;0.3)    | 0.0 (0.0;0.0)    |
| 7) Vitamin A-rich dark green leafy vegetables  | 4/7.7%             | 514 (45.8)  | 1.9 (1.2;3.1)    | 0.2 (0.1;0.3)    |
| Consumed everyday                              |                    | 09 (0.8)    | 4.3 (4.3;4.3)    | 0.4 (0.4;0.4)    |
| Consumed ≤6 days                               |                    | 505 (45.0)  | 1.9 (1.2;3.1)    | 0.2 (0.1;0.3)    |
| 8) Other vitamin A-rich vegetables and fruits  | 7/3.2%             | 344 (30.6)  | 0.8 (0.3;1.0)    | 0.07/0.07        |

* Median/ Inter-Quantile Range (25th ;75th percentile) of daily Iron of those consumed
| Food group             | Rank/contribution | Consumed | Iron (mg/d) * | Bioavailable Fe* |
|-----------------------|-------------------|----------|---------------|-----------------|
| Consumed everyday     |                   | 3 (0.3)  | 1.8 (0.9; 1.8) | 0.2 (0.1;0.2)  |
| Consumed ≤6 day       |                   | 341 (30.4)| 0.8 (0.3; 1.0) | 0.1 (0.0;0.1)  |
| 9) Other vegetables   | 5 /4.4%           | 1102 (98.1)| 1.1 (1.1; 1.2) | 0.1 (0.1;0.1)  |
| Consumed everyday     |                   | 877 (78.1)| 1.10 (1.1; 1.2)| 0.1 (0.1;0.1)  |
| Consumed ≤6 days      |                   | 225 (20.0)| 0.9 (0.8; 1.0) | 0.1 (0.1; 0.1) |
| 10) Other fruits      | 10 /0.4%          | 142 (12.6)| 0.1 (0.1; 0.3) | 0.0 (0.0; 0.0) |
| Consumed everyday     |                   | 21 (1.9) | 1.5 (1.5; 1.5) | 0.2 (0.2,0.2)  |
| Consumed ≤6 days      |                   | 121 (10.8)| 0.1 (0.1; 0.2) | 0.0 (0.0; 0.0) |

* Median/ Inter-Quantile Range (25th ;75th percentile) of daily Iron of those consumed

Factors associated with dietary iron inadequate consumption.

Table 4 shows factors associated with inadequate dietary Fe intake using the EAR cut-off. Women's age was positively associated with the risk of dietary iron inadequacy. Participants whose aged 36 and higher were 29% more likely (APR 1.29, 95% CI 1.05-1.60) to have iron inadequacy compared to women aged 15 to 25. Seasonal and part-time agricultural employment, having street food sources, and low dietary diversity was associated with increased risk of dietary iron inadequacy. Women who had seasonal agricultural employment were 56% more likely (APR 1.56, 95% CI 1.36-1.80) to have dietary iron inadequacy compared to those employed full-time. Compared to wealthier households, women in the lowest wealth tertile were 1.2 (APR 1.2 95%CI 0.9-1.4) times as likely to have iron inadequacy. This relationship was statistically insignificant. Women with low dietary diversity intake were almost two and half times as likely (APR 2.4 CI 1.9-2.9) to have inadequate dietary iron compared to women with optimum dietary diversity (consuming 5 or more food groups daily). We found similar findings when categorized iron tertiles of iron intake as shown in Table 5.
Table 4
Factors Associated with risk of dietary iron inadequacy of women of reproductive age in Kersa, Eastern Ethiopia, 2019

| Risk of iron inadequacy N (%) | CPR  | 95% CI  | APR  | 95% CI  | P-value |
|-------------------------------|------|---------|------|---------|---------|
| Age                           |      |         |      |         |         |
| 16- 25                        | 108 (40.4) | ref     |      |         |         |
| 26- 35                        | 245 (38.7) | 0.96 | 0.80-1.14 | 1.05 | 0.88-1.25 | 0.6 |
| ≥ 36                          | 117 (52.7) | 1.30 | 1.07-1.57 | 1.29 | 1.05-1.60 | 0.02** |
| Employment type               |      |         |      |         |         |
| Full-time                     | 260 (34.5) | ref | ref | ref |         |         |
| Part-time                     | 57 (55.9) | 1.62 | 1.33-1.97 | 1.75 | 1.45-2.12 | 0.000** |
| Seasonal                      | 153 (57.1) | 1.65 | 1.43-1.91 | 1.56 | 1.36-1.80 | 0.000** |
| BMI                           |      |         |      |         |         |
| Underweight                   | 89 (47.3) | 1.15 | 0.98-1.37 | 1.10 | 0.9-1.3 | 0.20 |
| Average                       | 355 (40.9) | ref | ref | ref |         |         |
| Overweigh                     | 26 (38.8) | 0.95 | 0.69-1.29 | 1.01 | 0.76-1.33 | 0.95 |
| Wealth Index                  |      |         |      |         |         |
| Poor                          | 322 (50.4) | 1.56 | 1.27-1.91 | 1.17 | 0.97-1.42 | 0.08 |
| Middle                        | 74 (29.0) | 0.90 | 0.69-1.17 | 0.84 | 0.65-1.08 | 0.18 |
| Rich                          | 74 (32.3) | ref |         |      |         |         |
| Number of previous pregnancies a | 4.6(2.4) | 1.03 | 1.00-1.01 | 0.99 | 0.96-1.02 | 0.72 |
| Dietary Diversity             |      |         |      |         |         |
| a = mean (SD)                 |      |         |      |         |         |

CPR = Crude Prevalence Ratio

APR = Adjusted Prevalence Ratio

** = significant at p = 0.05
| Risk of iron inadequacy | CPR | 95% CI | APR | 95% CI | P-value |
|------------------------|-----|--------|-----|--------|---------|
| Optimum                | 80 (20.6) | ref | ref |        |         |
| Low                    | 390 (53.1) | 2.58 | 2.10-3.18 | 2.34 | 1.88-2.91 | 0.000** |

**Food source**

|                | CPR | 95% CI | APR | 95% CI | P-value |
|----------------|-----|--------|-----|--------|---------|
| Household      | 338 (39.6) | ref | ref |        |         |
| Market         | 132 (48.9) | 1.23 | 1.06-1.43 | 1.30 | 1.14-1.49 | 0.000** |

\[a = \text{mean (SD)}\]

CPR = Crude Prevalence Ratio

APR = Adjusted Prevalence Ratio

** = significant at p = 0.05
Table 5
Factors Associated with low usual iron consumption of women of reproductive age in Kersa, Eastern Ethiopia, 2019

| Low usual Iron intake N (%) | CPR | 95% CI | P-value | APR | 95% CI | P-value |
|-----------------------------|-----|--------|---------|-----|--------|---------|
| Age                         |     |        |         |     |        |         |
| 16- 25                      | 88 (32.96) | 0.81  | 0.64-1.02 | 0.07 | 0.86  | 0.67-1.10 | 0.2 |
| 25- 35                      | 202 (31.91) | 0.78  | 0.64-0.95 | 0.01 | 0.89  | 0.74-1.07 | 0.2 |
| ≥ 36                        | 91 (40.8) | ref   | ref      |     |       |         |
| Employment type             |     |        |         |     |        |         |
| Full-time                   | 206 (27.36) | ref   | ref      |     |       |         |
| Part-time                   | 50 (49.02) | 1.79  | 1.42-2.25 | 0.000 | 1.99  | 1.59-2.49 | 0.000** |
| Seasonal                    | 125 (46.64) | 1.70  | 1.43-2.03 | 0.000 | 1.60  | 1.35-1.89 | 0.000** |
| BMI                         |     |        |         |     |        |         |
| Underweight                 | 72 (38.30) | 1.15  | 0.94-1.42 | 0.17 | 1.10  | 0.91-1.33 | 0.34 |
| Average                     | 288 (33.18) | ref   | ref      |     |       |         |
| Overweight and obese        | 21 (31.34) | 0.94  | 0.65-1.36 | 0.76 | 1.01  | 0.73-1.39 | 0.95 |
| Wealth Index                |     |        |         |     |        |         |
| Poor                        | 266 (41.63) | 1.67  | 1.31-2.13 | 0.000 | 1.19  | 0.95-1.50 | 0.12 |
| Middle                      | 58 (22.75) | 0.91  | 0.66-1.26 | 0.58 | 0.87  | 0.64-1.18 | 0.27 |
| Rich                        | 57 (24.89) | ref   | ref      |     |       |         |
| Number of previous pregnancies a | 4.73(2.48) | 1.04  | 1.01-1.08 | 0.01 | 1.01  | 0.98-1.05 | 0.51 |
| Dietary Diversity           |     |        |         |     |        |         |
| a = mean (SD)               |     |        |         |     |        |         |

CPR = Crude Prevalence Ratio
APR = Adjusted Prevalence Ratio
** = significant at p = 0.05
| Low usual Iron intake N (%) | CPR 95% CI | P-value | APR 95% CI | P-value |
|-----------------------------|------------|---------|------------|---------|
| Optimum 53 (13.62) ref ref |
| Low 328 (44.69) 3.28 2.52-4.27 0.000 2.96 2.25-3.91 0.000** |

**Food source**

| Household 271 (31.77) ref ref |
| Market 110 (40.74) 1.28 1.07-1.53 0.005 1.36 1.16-1.59 0.000** |

\(a = \text{mean (SD)}\)

CPR = Crude Prevalence Ratio

APR = Adjusted Prevalence Ratio

** = significant at p = 0.05

**Discussion**

This study assessed the usual iron, hem, non-heme, and bioavailable iron intake among women of reproductive age in Kersa, Eastern Ethiopia. The median usual iron consumption was 24.7 mg/d and 41.8% of WRA were at risk for iron inadequacy. The following factors were associated with a greater likelihood for the risk of iron inadequacy: seasonal and part-time agricultural employment, market food source, and low women’s dietary diversity. Older women in the study were more likely to have inadequate dietary iron intake.

The mean dietary total iron intake in this study was lower than a study that was done in an urban resident of Gonder, which reported a mean iron dietary of 97.81 mg/d [39]. The size of dietary iron inadequacy was also high compared to the national report that listed 14% and others that reported iron inadequacy in women of reproductive age group [40, 41]. This difference could be due to the disparity of malnutrition in the regions and cities of Ethiopia. The district, like most rural areas, is dependent solely on rainfall and traditional agricultural means of food productions [42]. Moreover, the study’s accuracy in the estimation of the total dietary iron intake might be limited due to not measuring biochemical markers of iron amount and storage and the use of a non-quantitative FFQ which can distinguish between high and low consumers of nutrients, but is not ideal for measuring absolute intake.

Diets for study participants were plant-based and poor as expected. Most participants consumed starchy staples and all types of vegetables, and the least food groups consumed were fish, eggs, flesh foods, and fruits. Non-heme iron-made up most of the dietary intake.

The dietary iron inadequacy found in this study was high compared to the recommended cut-off point in a population [38]. The finding is not surprising Ethiopia has high levels of poverty, food insecurity, and malnutrition [43]. Malnutrition and hunger are also common in this rural district being a major cause of
death in children under five [22]. Many households are also dependent on handouts from Ethiopia’s Productive Safety Net Program (PSNP) due to chronic malnutrition [44].

Some Sub-Saharan African countries have implemented fortification of cereal and other food products with iron to meet their high dietary needs [45] There are limited iron-fortified foods or enriched food products yet available in Ethiopia, and food insecurity has made the matter even worse [40]. Fortifying wheat and cereals, availing inexpensive nutrient-rich food alternatives, and eliminating hunger have significantly improved nutrition and the health status of WRA. The World Health Organization (WHO) currently recommends iron supplementation for women of reproductive age and children [46], fortification of foods, and food and nutrition education as a strategy in combating iron deficiency [47]. The application and effectiveness of these strategies in developing countries are affected by economic, socio-cultural, and infrastructural challenges. Therefore, dietary approaches are a top priority in addressing IDA.

Low iron intake among women of reproductive age impacts the women's life and future pregnancy and birth outcomes. Several studies have shown that a woman with low iron intake is at risk for antepartum and postpartum hemorrhage, which is the number one cause of maternal morbidity and mortality [7]. In addition, women with low iron stores and consumption are more likely to have poor birth outcomes including preterm birth, stillbirth, and low birth weight babies (ref). Babies that were born from anemic women tended to show poor physical growth performance, predisposition to infection, and retarded brain development, which affects eventual schooling and social development [48]. Therefore, it would be an important addressing problem.

Furthermore, older women had a higher risk of dietary iron inadequacy in this study. Because the need for higher dietary iron intake for old women increases due to larger families and have more children, they are the most at risk for iron deficiency and insufficiency [21]. On the contrary, other studies had shown traditional social and cultural inequities, younger women are also more likely to impose dietary restrictions that would decrease the consumption level and inadequacy of iron [49]. This difference could arise from other unmeasured confounders and the potential introduction of recall bias in the study.

Women that had lower dietary diversity were also found to be at higher risk of dietary iron inadequacy. This could be explained by poor individuals are more likely to consume foods that are less diverse and healthy [50]. Furthermore, the mean dietary total iron in our sample with higher dietary diversity had roughly twice the amount of recommended dietary iron and was statistically different across the subtypes of Fe [38]. Having a lower dietary diversity tends to decrease the consumption level of a balanced and healthy diet, leading to nutrient inadequacy and deficiency. This is in line with different studies that describe a strong relationship between individual dietary diversity score and micronutrient inadequacy [34, 51, 52]. Research has shown that women meeting minimum dietary diversity for the FAO MDDW are more likely to meet their RDAs/EARs for iron, vitamin A and other micronutrients [53]. It is also worth noting that women’s dietary diversity varies in the seasonal availability of foods, which was not considered in this study.

In addition, Others have also shown poor individuals had a higher restrain on financial freedom in the household that would limit securing and choosing nutrient-rich food for the family. This not only predisposes families to hunger but also other poor health outcomes [54]. are more likely to consume foods
that are less diverse and healthy [50]. Furthermore, the mean dietary total iron in our sample with higher dietary diversity had roughly twice the amount of recommended dietary iron and was statistically different across the subtypes of Fe [38].

**Conclusion**

This study sheds light on a burden of dietary iron inadequacy in women of reproductive age in Kersa, Eastern Oromia using the FFQ questionnaire. Even though Teff-based foods and staples have high iron with low bioavailability [41], their fortification with iron and diversification with other foods would improve bioavailability and adequacy of iron in women of the reproductive age group. The authors recommend further study of FFQ with iron biomarkers for accurate identification of iron deficiency and insufficiency. National nutrition-based surveillance system should be strengthened, as well as further collaboration with stakeholders to improve and modernize agricultural systems to meet the global sustainable goals. Ethiopia's commitment to the fortification of iron, diversification of our diet, and frequent use of animal source food and fruits may help in decreasing the burden of iron insufficiency and increase its bioavailability and absorption. Improving and identifying dietary iron intake alone is not the most efficient in identifying anemia, other socio-cultural inequities, women empowerment, other causes of non-nutritional anemia, and nutrition knowledge were not addressed in this paper.

**Abbreviations**

DDS; dietary diversity score; EAR: Estimated Average Requirement FFQ; food frequency questionnaire; MDD; minimum dietary diversity, PSA; principal component analysis, SSA; Sub-Saharan Africa, WRA; women of reproductive age,

**Declarations**

**Ethics approval and consent to participate**

This study was ethically approved by the Institution Health Research Ethical Review Board of the College of Health and Medical Sciences with reference number SHE/S1M/14.4/708/19. The study procedures were also undertaken per the Helenski Declaration. At the time of visit to the household, written informed, voluntary consent was secured from respondents

**Consent for publication**

Not Applicable

**Availability of data and materials**

The datasets used and analyzed during this study are available from the corresponding author on reasonable request

**Competing Interest**
The authors declare no conflicts of interest.

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Authors' contributions

NS, AA, KTR, YD, and WWF designed a concept note. NS, AA, KTR, and YD developed a proposal. NS, AA, KTR, and YD worked on data generation and fieldwork. NS, YYA, EC, and IM performed statistical analysis. NS, YYA, EC, IM, and WWF developed the manuscript. All authors reviewed, edited, and approved manuscript the final manuscript.

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Figures

Figure 1

This is Figure 1 Total Daily Dietary Iron consumption among women of reproductive age, Kersa, Eastern Ethiopia, 2019
Figure 2

This is Figure 2 Total Dietary Iron Consumption Distribution by Dietary Diversity of among women of reproductive age, Kersa, Eastern Ethiopia, 2019
Figure 3

This is Figure 3 Daily Hem and non-Hem Iron Consumption among women of reproductive age, Kersa, Eastern Ethiopia, 2019