Dietary Practices, Iron–Folic Acid Supplementation Uptake and Haemoglobin-Defined Anaemia Among Pregnant Women Attending Antenatal Care at Archers Post Sub-County Hospital, Samburu County, Kenya

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ABSTRACT

Anaemia in pregnancy remains a major public health problem in sub-Saharan Africa and is associated with adverse maternal and perinatal outcomes. Iron and folic acid supplementation (IFAS) and an iron-adequate diet are the principal preventive measures, but their joint association with anaemia has not often been examined in pastoralist populations, where diets and infectious exposures differ from those in other settings. This study analysed the association between dietary practices, IFAS uptake and anaemia status among pregnant women attending antenatal care at Archers Post Sub-County Hospital, Samburu County, Kenya. An analytical cross-sectional study was conducted among pregnant women aged 18 to 49 years recruited at the antenatal clinic. Data were collected using an interviewer-administered questionnaire, abstraction of antenatal and laboratory records and point-of-care haemoglobin measurement. Dietary practices were assessed as dietary diversity, using the Minimum Dietary Diversity for Women (MDD-W) indicator, and as the weekly frequency of iron-rich foods and of enhancers and inhibitors of iron absorption. IFAS uptake was measured as self-reported tablet consumption over the preceding seven days, with consistent uptake defined as consumption on at least four of those days. Anaemia was defined from measured haemoglobin and classified using World Health Organization trimester-specific thresholds. Data were analysed using chi-square tests, tests for trend, correlation analysis and multivariable binary logistic regression. Of the 259 women approached, 210 were analysed (response rate 81.1%). Anaemia was identified in 27.6% of participants (mild 17.6%, moderate 10.0%), with a mean haemoglobin of 11.41 g/dL (SD = 1.16). After adjustment, consistent IFAS uptake (AOR = 0.26, 95% CI 0.12–0.54), consumption of flesh foods at least weekly (AOR = 0.18, 95% CI 0.08–0.43) and consumption of vitamin C-rich fruits at least weekly (AOR = 0.44, 95% CI 0.21–0.91) were independently associated with lower odds of anaemia, whereas adequate dietary diversity was not (AOR = 0.91, 95% CI 0.41–2.03). Malaria (AOR = 6.20, 95% CI 2.51–15.35) and helminth infection (AOR = 4.88, 95% CI 1.93–12.34) were the strongest factors associated with anaemia. Anaemia prevalence was 53.1% among women with neither adequate dietary diversity nor consistent uptake and 14.8% among those with both, with no evidence of interaction. Consistent IFAS uptake and the iron composition of the diet were independently associated with lower odds of anaemia in this setting, alongside strong associations with malaria and helminth infection. The findings support an integrated approach to anaemia control that combines promotion of IFAS with dietary counselling on haem iron and factors that enhance iron absorption, alongside malaria and helminth control.

Keywords: Anaemia, haemoglobin, pregnancy, iron and folic acid supplementation, dietary diversity, haem iron, malaria, helminth infection, pastoralist communities, Kenya.

INTRODUCTION

Anaemia is among the most common disorders in the world, and pregnant women bear a share of it well above their share of the population, with recent global estimates placing prevalence among pregnant women at approximately 37% (Gardner & Kassebaum, 2020; World Health Organization [WHO], 2023). The WHO defines anaemia in pregnancy as a haemoglobin concentration below 11.0 g/dL in the first and third trimesters and below 10.5 g/dL in the second, the lower second-trimester threshold reflecting the physiological

haemodilution that accompanies plasma expansion. Severity is graded as mild between 10.0 and 10.9 g/dL, moderate between 7.0 and 9.9 g/dL and severe below 7.0 g/dL. Maternal anaemia narrows the physiological margin available to withstand blood loss at delivery and is associated with increased maternal morbidity and mortality, while in the fetus and newborn it is associated with growth restriction, low birth weight, preterm delivery and poorer perinatal outcomes (Young et al., 2023).

The iron requirement rises steeply in pregnancy because maternal plasma volume and red cell mass expand, iron is transferred to the fetus and placenta, and iron is lost at delivery. Intestinal absorption becomes more efficient in response, but only partially, and in low-income settings the late-pregnancy requirement is rarely met from food alone (Abbaspour et al., 2014). Folate requirements rise in parallel because of its role in DNA synthesis and cell division (Viswanathan et al., 2023). Iron deficiency is the leading cause of anaemia in pregnancy, but it is never the only one. Folate and vitamin B12 deficiency, malaria, hookworm and other soil-transmitted helminths, haemoglobinopathies, HIV and chronic inflammation all contribute, and their relative importance differs between settings. This heterogeneity has important practical implications because iron and folic acid supplementation primarily addresses nutritional deficiencies, while anaemia resulting from infections such as malaria and helminthiasis requires additional preventive and therapeutic interventions (WHO, 2024).

The WHO recommends daily oral supplementation with 30 to 60 mg of elemental iron and 400 µg of folic acid for every pregnant woman, begun as early as possible and continued throughout pregnancy (WHO, 2016, 2024). Cochrane evidence indicates that daily supplementation reduces maternal anaemia and iron deficiency at term, although effects on clinical birth outcomes are less consistently demonstrated (Peña-Rosas et al., 2015). In practice, however, the benefit of supplementation depends on consumption rather than distribution. In sub-Saharan Africa, which carries the highest regional burden of anaemia in pregnancy with a pooled prevalence of 35.6%, only 28.7% of pregnant women took iron supplements for 90 days or more in a 22-country analysis, and pooled compliance in primary studies was 39.2% (Ba et al., 2019; Fite et al., 2021). These studies use the terms receipt, uptake, compliance, and adherence inconsistently, although they refer to distinct behaviours. Receiving supplements, consuming them during a specified recent period, and consistently following the prescribed daily regimen throughout pregnancy represent different levels of supplement use.

Diet represents an important complementary pathway to achieving adequate iron intake and may interact with supplementation in ways that are not always adequately considered. Dietary diversity is widely used as a proxy for micronutrient adequacy and is commonly assessed using the Minimum Dietary Diversity for Women (MDD-W) indicator, which measures consumption across ten predefined food groups during the previous 24 hours, with consumption from at least five groups generally considered to indicate minimum dietary diversity (Food and Agriculture Organization of the United Nations [FAO] & FHI 360, 2016). Evidence from a systematic review and meta-analysis in Africa indicates that inadequate dietary diversity during pregnancy is associated with an increased risk of maternal anaemia and low birth weight (Seid et al., 2023). Nevertheless, dietary diversity alone does not capture the amount or type of iron consumed, and the bioavailability of dietary iron is an important consideration because absorption varies according to the food source and the presence of dietary factors that enhance or inhibit iron absorption.

Haem iron from animal sources is absorbed considerably more efficiently than non-haem iron from plant foods, and the absorption of non-haem iron is strongly modified by the foods and beverages that accompany it. Ascorbic acid enhances absorption, while phytates in cereals and legumes, calcium in dairy products and polyphenols in tea and coffee inhibit it (Abbaspour et al., 2014). These relationships have specific implications for pastoralist diets. Milk, meat and blood can provide important sources of dietary iron, with iron from meat and blood being predominantly haem iron and generally more bioavailable than non-haem iron. At the same time, diets with limited consumption of fruits, vegetables and legumes may provide less vitamin C and folate, while calcium-containing foods can reduce iron absorption under some dietary conditions. Consequently, dietary diversity scores alone may not fully capture the quantity, form or bioavailability of iron consumed (FAO/WHO, 2002; NIH Office of Dietary Supplements, 2024).

Infectious diseases are also important contributors to anaemia in many African settings. Malaria can cause anaemia through the destruction of parasitised red blood cells, increased splenic clearance, and impaired erythrocyte production, while soil-transmitted helminth infections, particularly hookworm, may contribute

through chronic intestinal blood loss. In areas where helminth infections are prevalent, antenatal deworming after the first trimester is recommended; however, evidence from a Cochrane review indicates that its effect on maternal anaemia is modest and varies across settings, partly reflecting differences in the prevalence and intensity of infection (Salam et al., 2015). Consequently, studies assessing anaemia without accounting for infectious conditions may overattribute observed anaemia to inadequate supplementation or dietary factors when infections may also contribute substantially to the outcome.

In Kenya, anaemia among pregnant women has been reported nationally at 55.1%, above the 40% threshold at which the WHO classifies anaemia as a severe public health problem (Ministry of Health [MoH], 2013). Mapping of maternal anaemia across Kenyan sub-counties between 2016 and 2019 documented a steep national rise in reported cases and identified elevated risk in the arid and semi-arid pastoralist sub-counties of the north and east, attributed in part to narrow diets dominated by milk and meat and compounded by erratic rainfall and weak food systems (Odhiambo & Sartorius, 2020). Samburu County, with a population of 310,327 at the 2019 census (Kenya National Bureau of Statistics [KNBS], 2019), is one such setting. Its economy rests on pastoralism, drought is recurrent, fruit and vegetables are purchased rather than grown and reach settlements irregularly, and malaria transmission is low and seasonal rather than stable.

Despite the recognised vulnerability of pastoralist populations, few studies have examined dietary practices, supplementation behaviour and anaemia together in the same women, and fewer still have distinguished the composition of the diet from its breadth or accounted for concurrent infection. National survey analyses omit variables that require primary data collection, including dietary diversity and haemoglobin measured against trimester-specific thresholds (Alemu et al., 2025), and Kenyan facility-based studies of supplementation have been conducted largely in urban and agrarian counties (Kamau et al., 2018; Bahati et al., 2021). No published study has examined the relationship between diet, supplementation and anaemia at Archers Post Sub-County Hospital or elsewhere in Samburu East Sub-County.

The present study was therefore undertaken to analyse the association between dietary practices, IFAS uptake and anaemia status among pregnant women attending the antenatal clinic at Archers Post Sub-County Hospital, Samburu County, Kenya. Dietary practices were treated as the nutritional exposure, IFAS uptake as uptake of a preventive intervention, and anaemia defined from measured haemoglobin as the clinical outcome. By examining these exposures jointly, and alongside malaria and helminth infection, the study sought to estimate the independent association of each with anaemia and to generate evidence to inform integrated anaemia prevention in pastoralist settings.

MATERIALS AND METHODS

Study Design

An analytical cross-sectional design was adopted. Data on anaemia status and on dietary, supplementation and clinical exposures were collected from each participant at a single point in time during a scheduled antenatal visit, supplemented by abstraction of clinical information from the antenatal booklet and laboratory records and, where consent was given, by point-of-care haemoglobin measurement on the same day. The design was appropriate because the objective required examination of associations between several exposures and a binary outcome, which an analytical cross-sectional design supports through bivariate analysis and multivariable logistic regression. It also allowed dietary, supplementation and infectious exposures to be measured in the same women, which was necessary to estimate the independent association of each with anaemia.

Study Area

The study was conducted at Archers Post Sub-County Hospital in Samburu East Sub-County, Samburu County, Kenya. Samburu County lies in the arid and semi-arid north of the former Rift Valley Province, covers approximately 21,000 square kilometres and had a population of 310,327 at the 2019 census (KNBS, 2019). Livelihoods rest largely on pastoralism based on cattle, sheep, goats and camels, with seasonal movement in search of pasture and water. Rainfall is low and erratic, drought is recurrent and food insecurity is widespread. These conditions shape maternal nutrition directly, since livestock products supply haem iron when herds are

productive but decline sharply in drought, while the fruit, vegetables and legumes that supply folate and vitamin C are purchased, costly and irregularly available. Archers Post lies on the Isiolo–Marsabit corridor near the Ewaso Ng'iro river and serves surrounding rangeland settlements and a mobile pastoralist population. Archers Post Sub-County Hospital is a Level 4 public facility providing outpatient and inpatient care, laboratory services, maternity services, nutrition counselling and a structured antenatal clinic through which iron and folic acid tablets are issued free of charge. The facility was selected purposively as the principal source of antenatal care for this population and because no previous research on supplementation or anaemia had been conducted there.

Study Population

The target population comprised pregnant women attending antenatal care services in Samburu East Sub-County. The accessible population comprised the 734 pregnant women aged 18 to 49 years who attended the antenatal clinic at Archers Post Sub-County Hospital during the data collection period. The lower age limit of 18 years allowed participants to provide informed consent in their own right, and the upper limit corresponds to the conventional upper bound of the reproductive age range.

Inclusion and Exclusion Criteria

Women were eligible if they had a pregnancy confirmed and documented in the antenatal record, were aged 18 to 49 years, were attending the antenatal clinic during the data collection period, had resided within the facility catchment area for at least six months, were willing to give written informed consent in English, Kiswahili or Samburu, and agreed to abstraction of information from their antenatal and laboratory records. Women were excluded if they declined consent, were acutely unwell or required urgent clinical attention, lacked capacity to consent at the time of the visit, or had already been interviewed at an earlier visit. Women with a documented condition that alters iron or folate metabolism independently of diet or that requires a therapeutic rather than preventive regimen, including known haemoglobinopathy such as sickle cell disease, chronic kidney disease, malabsorption syndrome or current treatment for severe anaemia including recent transfusion, were also excluded because their haemoglobin would not be interpretable within the analytical framework adopted. Women who declined point-of-care haemoglobin testing but consented to all other procedures were retained, and the haemoglobin value recorded in the antenatal booklet was used.

Sample Size Determination

The sample size was determined using Yamane's simplified formula for a finite population:

$$n = N / [1 + N(e^2)]$$

where n is the required sample size, N is the accessible population (734) and e is the acceptable margin of error (0.05). Substituting these values gave $n = 734 / [1 + 734(0.0025)] = 734 / 2.835 = 258.9$, which was rounded up to 259 participants. For multivariable modelling, the number of degrees of freedom was constrained by the events-per-variable criterion, under which it could not exceed one tenth of the number of outcome events.

Sampling Procedure

Participants were enrolled by consecutive sampling. Every woman presenting at the antenatal clinic during the data collection period was screened against the eligibility criteria in the order in which she was registered, and every eligible woman who consented was enrolled until the required sample of 259 had been approached. Women who were ineligible, declined consent or did not complete the interview were not replaced out of sequence. A screening log recorded the outcome for each woman approached, enabling calculation of the response rate and documentation of exclusions.

Study Variables and Operational Definitions

The analysis distinguished three domains. Dietary practices were treated as the nutritional exposure and IFAS

uptake as uptake of a preventive intervention, and these were the two principal exposures. Anaemia status, defined from measured haemoglobin concentration, was the clinical outcome. Infectious, obstetric, anthropometric and sociodemographic characteristics were recorded as covariates.

Dietary practices were defined as a set of specific, separately measured components rather than as an overall dietary pattern: dietary diversity, as the number of MDD-W food groups consumed in the preceding 24 hours; the usual weekly frequency of flesh foods, the principal iron-rich foods supplying haem iron; the usual weekly frequency of vitamin C-rich fruits, which enhance the absorption of non-haem iron; consumption of tea or coffee, which inhibit it, including whether they were taken with meals; and the number of meals per day, avoidance of foods for cultural reasons, use of herbal or traditional preparations and pica. Household food insecurity was recorded as a characteristic of the participant's circumstances and not as a dietary practice.

IFAS refers to the iron and folic acid tablets issued through the antenatal clinic under national policy, which provides for one combined tablet containing 60 mg of elemental iron and 400 µg of folic acid daily from conception, or as early in pregnancy as possible, until delivery (MoH, 2013). Uptake was defined as reported consumption of these tablets, as distinct from their receipt, and was measured over the seven days preceding the interview. Current consumption was defined as taking a tablet on at least one of those seven days. Consistent uptake, the principal supplementation exposure, was defined as taking a tablet on four or more of the seven days. The number of days on which a tablet was taken was also analysed in ordered bands. The term adherence is reserved here for daily consumption sustained over the course of pregnancy, which a seven-day measure does not establish; gestational age at initiation and the cumulative duration of supplementation were not analysed.

Anaemia was defined from haemoglobin concentration using WHO trimester-specific thresholds and graded by severity, as described below. Gestational age at interview was recorded in weeks and used to assign trimester, so that gestational age entered the definition of the outcome. Covariates considered as potential confounders of the associations between the exposures and anaemia were malaria test result, stool examination for ova and cysts, deworming during the index pregnancy, use of an insecticide-treated net the previous night, mid-upper arm circumference, heavy or prolonged menstrual periods before pregnancy and, among multigravid women, anaemia in a previous pregnancy. Age, education, residence, gravidity and household food insecurity were recorded to describe the participants.

Data Collection Methods and Instruments

Data were collected using a structured interviewer-administered questionnaire developed for the study, abstraction of information from the antenatal booklet and laboratory register, and point-of-care measurement. The questionnaire was developed in English, translated into Kiswahili and Samburu and back-translated independently, and content validity was established through expert review by three specialists in public health, maternal nutrition and epidemiology. It was pretested among 38 pregnant women at a comparable facility outside the study site. Research assistants with health-related backgrounds and fluency in Kiswahili and Samburu were trained for two days, and interviews were conducted in private after the participant's routine clinical consultation.

Dietary diversity was assessed using the MDD-W module, which records consumption of each of ten food groups in the preceding 24 hours; consumption of five or more groups was classified as adequate (FAO & FHI 360, 2016). Because a single 24-hour recall may misclassify usual intake where diets vary seasonally, a usual-week frequency questionnaire recorded how often eleven iron-relevant foods were eaten, from which the frequency of flesh foods supplying haem iron, the frequency of vitamin C-rich fruits and the frequency of tea or coffee consumption were derived. Participants were also asked about meal frequency, tea or coffee taken with meals, avoidance of foods for cultural reasons, use of herbal or traditional preparations and pica during the current pregnancy. IFAS consumption on each of the seven days preceding the interview was ascertained by day-by-day probing and cross-checked against the antenatal booklet and remaining tablets where available.

Haemoglobin concentration was measured by finger-prick using a portable haemoglobinometer according to the manufacturer's instructions, with a new single-use lancet and microcuvette for each participant. The

instrument was checked against its control cuvette at the start of each clinic day and readings outside the physiologically plausible range were repeated. Anaemia was defined using WHO trimester-specific thresholds (below 11.0 g/dL in the first and third trimesters and below 10.5 g/dL in the second) and graded as mild, moderate or severe. Malaria test results, stool examination for ova and cysts, deworming during the index pregnancy and use of an insecticide-treated net the previous night were obtained from the antenatal and laboratory records and the interview. Mid-upper arm circumference (MUAC) was measured twice at the midpoint of the left upper arm with a non-stretch tape and the mean recorded. Participants found to be anaemic were referred to the attending clinician, and the research team did not alter clinical management.

Data Management and Analysis

Completed questionnaires were checked for completeness and consistency on the day of collection, double-entered by two clerks working independently and reconciled against the paper forms. Analysis was conducted using SPSS version 25. Categorical variables were summarised as frequencies and percentages and continuous variables as means with standard deviations. The association between each dietary, supplementation and clinical variable and anaemia status was tested using the Pearson chi-square test, or Fisher's exact test where expected counts were small, and crude odds ratios (COR) with 95% confidence intervals (CI) were obtained from univariable logistic models.

Dose-response relationships were examined by grouping the dietary diversity score and the number of days on which tablets were taken into ordered bands and applying the chi-square test for linear trend, and by computing Pearson correlation coefficients between these continuous exposures and haemoglobin concentration. Mean haemoglobin was compared across groups using one-way analysis of variance. To examine the joint association of diet and supplementation with anaemia, participants were classified into four groups according to adequate dietary diversity and consistent uptake (neither, adequate diet only, consistent uptake only, and both), and odds ratios were computed against the group with neither exposure. Effect modification was tested by adding an interaction term to a logistic model containing both exposures and comparing models using the likelihood ratio test.

Variables associated with anaemia at $p < 0.25$ in the bivariate analysis were considered for multivariable binary logistic regression. Because the model could support no more than six degrees of freedom under the events-per-variable criterion, candidates with the weakest bivariate associations were withdrawn in turn. Dietary diversity was retained irrespective of its screening position because the objective required its independent association with anaemia to be estimated alongside the other dietary measures. Results are reported as adjusted odds ratios (AOR) with 95% CI alongside the corresponding crude estimates. Sociodemographic and obstetric characteristics, including age, gravidity, gestational age, education and household food insecurity, were not entered into the model, and markers of inflammation were not measured; residual confounding by these factors is therefore possible. Because the design is cross-sectional, all associations were interpreted without causal language, recognising in particular that a diagnosis of anaemia may itself prompt more intensive supplementation. Statistical significance was set at $p < 0.05$.

Ethical Considerations

Ethical approval was obtained from the Institutional Ethics and Research Committee, and a research licence was obtained from the National Commission for Science, Technology and Innovation (NACOSTI). Written authorisation was obtained from the Samburu County Department of Health, the Samburu East Sub-County Health Management Team and the Medical Superintendent of Archers Post Sub-County Hospital. Written informed consent was obtained from every participant, and consent was sought separately for the interview, record abstraction and haemoglobin measurement, so that a woman could take part in the interview while declining the finger-prick. Women unable to write provided a thumbprint witnessed by an independent person. Participation was voluntary and did not affect the care received. The finger-prick carried minimal risk, which was minimised by the use of sterile single-use equipment and safe disposal of sharps. No direct identifiers were recorded on the questionnaire, and data were stored securely and accessed only by the researcher. The study was conducted in accordance with the Declaration of Helsinki.

RESULTS

Of the 259 pregnant women approached, 7 (2.7%) declined consent, 5 (1.9%) returned substantially incomplete questionnaires, 2 (0.8%) were ineligible and 35 (13.5%) did not complete the interview, leaving an analytical sample of 210 women and a response rate of 81.1%. The mean age of participants was 31.9 years (SD = 8.0), 41.9% had no formal education or primary education only, 62.9% lived in rural settlements and 45.7% reported household food insecurity in the preceding 30 days. The mean gestational age at interview was 23.5 weeks (SD = 9.5), with 18.1%, 46.2% and 35.7% of participants in the first, second and third trimesters respectively, and 126 participants (60.0%) were multigravid. With respect to IFAS uptake, 156 participants (74.3%) had taken a tablet on at least one of the preceding seven days and 122 (58.1%) met the criterion for consistent uptake by taking tablets on four or more days; 56 (26.7%) had taken tablets on six or seven days and 54 (25.7%) on none.

The dietary practices and clinical characteristics of the participants are presented in Table 1. Although 144 women (68.6%) reached the MDD-W threshold of five or more food groups, almost one third (31.4%) did not. Consumption of flesh foods, the principal source of haem iron, was relatively common, 78.6% reporting intake at least one to three times a week, but 36.7% consumed vitamin C-rich fruits less than weekly. Tea or coffee consumption was widespread, 82.4% reporting daily or near-daily intake and 57.6% taking these beverages with meals. Deworming had been received by only 45.2% of participants, 16.2% had a positive malaria test and 15.2% had a positive stool examination for ova or cysts.

Overall, 58 participants (27.6%) were anaemic, comprising 37 (17.6%) with mild anaemia and 21 (10.0%) with moderate anaemia. No case of severe anaemia was identified, and the mean haemoglobin concentration was 11.41 g/dL (SD = 1.16). Among multigravid women, 44 of 126 (34.9%) reported anaemia in a previous pregnancy.

Table 1: Dietary Practices, Clinical Characteristics and Anaemia Status of the Participants (n = 210)

Variable	Category	n	%
Dietary diversity (MDD-W)	Adequate (5 or more groups)	144	68.6
	Inadequate (fewer than 5 groups)	66	31.4
Flesh foods (haem iron)	1–3 times a week or more	165	78.6
	Less than weekly	45	21.4
Vitamin C-rich fruits	1–3 times a week or more	133	63.3
	Less than weekly	77	36.7
Tea or coffee	Daily or near daily	173	82.4
	Less often	37	17.6
Tea or coffee taken with meals	Yes	121	57.6
Meals per day	2 or fewer	70	33.3
	3 or more	140	66.7
Foods avoided for cultural reasons	Yes	57	27.1
Herbal or traditional preparation used	Yes	34	16.2

Pica in current pregnancy	Yes	37	17.6
Consistent IFAS uptake	Yes	122	58.1
Deworming received in current pregnancy	Yes	95	45.2
Malaria test	Positive	34	16.2
Stool ova and cysts	Positive	32	15.2
Mid-upper arm circumference	Below 23 cm	41	19.5
Heavy or prolonged periods before pregnancy	Yes	41	19.5
Anaemia in a previous pregnancy	Yes (multigravidae, n = 126)	44	34.9
Anaemia status (WHO cut-offs)	Anaemic (all)	58	27.6
	Mild	37	17.6
	Moderate	21	10.0
	Severe	0	0.0

MDD-W = Minimum Dietary Diversity for Women; IFAS = iron and folic acid supplementation; WHO = World Health Organization. Consistent IFAS uptake = tablet taken on four or more of the preceding seven days.

The bivariate associations between dietary practices, supplementation, clinical factors and anaemia are presented in Table 2. Consistent IFAS uptake, the frequency of flesh foods, dietary diversity and the frequency of vitamin C-rich fruits were each significantly associated with lower prevalence of anaemia. The strongest dietary association was with flesh foods: anaemia affected 53.3% of women eating haem-iron sources less than weekly compared with 20.6% of those eating them at least one to three times a week (COR = 0.23, 95% CI 0.11–0.46, $p < 0.001$), an association stronger than that of the diversity score (COR = 0.49, 95% CI 0.26–0.92, $p = 0.024$). Anaemia affected 17.2% of consistent users against 42.0% of non-consistent users (COR = 0.29, 95% CI 0.15–0.54, $p < 0.001$). Malaria and helminth infection produced the largest positive associations, anaemia affecting 52.9% and 53.1% of infected women respectively compared with fewer than a quarter of those not infected. Use of an insecticide-treated net was associated with lower odds of anaemia (COR = 0.51, 95% CI 0.28–0.95, $p = 0.032$), and a history of anaemia in a previous pregnancy was associated with higher odds (COR = 3.77, 95% CI 1.68–8.43, $p < 0.001$). Neither cultural food avoidance nor pica was associated with anaemia, and the association with daily tea or coffee consumption did not reach significance ($p = 0.087$).

Table 2: Bivariate Associations between Dietary Practices, IFAS Uptake, Clinical Factors and Anaemia

Variable	**Category**	**n**	**Anaemic n (%)**	**COR (95% CI)**	**χ^2**	**p-value**
Consistent IFAS uptake	Not consistent	88	37 (42.0)	1.00 (reference)	15.77	<0.001
	Consistent	122	21 (17.2)	0.29 (0.15–0.54)		
Currently consuming IFAS	No	54	25 (46.3)	1.00 (reference)	12.68	<0.001
	Yes	156	33 (21.2)	0.31 (0.16–0.60)		

Flesh foods (haem iron)	Less than weekly	45	24 (53.3)	1.00 (reference)	18.94	<0.001
	1–3 times a week or more	165	34 (20.6)	0.23 (0.11–0.46)		
Dietary diversity (MDD-W)	Inadequate	66	25 (37.9)	1.00 (reference)	5.07	0.024
	Adequate	144	33 (22.9)	0.49 (0.26–0.92)		
Vitamin C-rich fruits	Less than weekly	77	29 (37.7)	1.00 (reference)	6.13	0.013
	1–3 times a week or more	133	29 (21.8)	0.46 (0.25–0.86)		
Tea or coffee	Less often	37	6 (16.2)	1.00 (reference)	2.92	0.087
	Daily or near daily	173	52 (30.1)	2.22 (0.87–5.64)		
Foods avoided culturally	No	153	42 (27.5)	1.00 (reference)	0.01	0.929
	Yes	57	16 (28.1)	1.03 (0.52–2.03)		
Pica	No	173	47 (27.2)	1.00 (reference)	0.10	0.752
	Yes	37	11 (29.7)	1.13 (0.52–2.48)		
Deworming received	No	115	37 (32.2)	1.00 (reference)	2.64	0.104
	Yes	95	21 (22.1)	0.60 (0.32–1.12)		
Malaria test	Negative	176	40 (22.7)	1.00 (reference)	13.01	<0.001
	Positive	34	18 (52.9)	3.82 (1.79–8.18)		
Stool ova and cysts	Negative	178	41 (23.0)	1.00 (reference)	12.29	<0.001
	Positive	32	17 (53.1)	3.79 (1.74–8.24)		
Insecticide-treated net used	No	84	30 (35.7)	1.00 (reference)	4.59	0.032
	Yes	126	28 (22.2)	0.51 (0.28–0.95)		
Mid-upper arm circumference	23 cm or more	169	43 (25.4)	1.00 (reference)	2.05	0.152
	Below 23 cm	41	15 (36.6)	1.69 (0.82–3.49)		
Heavy or prolonged periods	No	169	42 (24.9)	1.00 (reference)	3.32	0.069
	Yes	41	16 (39.0)	1.94 (0.94–		

				3.97)		
Anaemia in a previous pregnancy	No	82	16 (19.5)	1.00 (reference)	10.99	<0.001
	Yes	44	21 (47.7)	3.77 (1.68–8.43)		

COR = crude odds ratio; CI = confidence interval; χ^2 = Pearson chi-square statistic (1 degree of freedom); MDD-W = Minimum Dietary Diversity for Women; IFAS = iron and folic acid supplementation. Consistent IFAS uptake = tablet taken on four or more of the preceding seven days; currently consuming IFAS = tablet taken on at least one of the preceding seven days.

Dose-response relationships and combined exposure to adequate dietary diversity and consistent IFAS uptake are presented in Table 3. Anaemia prevalence fell across the dietary diversity bands from 37.9% among women consuming four or fewer food groups to 23.9% and 21.4% among those consuming five to six and seven or more groups respectively, while mean haemoglobin rose from 11.10 to 11.51 and 11.62 g/dL. The general chi-square across the three bands was not significant ($\chi^2 = 5.17$, df = 2, $p = 0.075$), but the test for trend ($\chi^2 = 4.31$, df = 1, $p = 0.038$) and the analysis of variance of haemoglobin ($F = 3.72$, $p = 0.026$) were.

The gradient across the number of days on which tablets were taken was steeper, anaemia falling from 46.3% among women who had taken no tablet in the preceding week to 15.2% among those taking tablets on four or five days ($\chi^2 = 17.34$, df = 3, $p < 0.001$; test for trend $\chi^2 = 13.72$, $p < 0.001$). The number of days on which tablets were taken correlated with haemoglobin concentration ($r = 0.331$, 95% CI 0.205–0.447, $p < 0.001$) more strongly than the dietary diversity score did ($r = 0.184$, 95% CI 0.049–0.311, $p = 0.008$).

Considered jointly, anaemia prevalence fell in an orderly sequence across the four exposure groups, from 53.1% among women with neither adequate dietary diversity nor consistent supplementation to 35.7% with adequate diet only, 23.5% with consistent supplementation only and 14.8% with both ($\chi^2 = 19.80$, df = 3, $p < 0.001$). Mean haemoglobin rose across the same sequence from 10.64 to 11.87 g/dL ($F = 13.02$, $p < 0.001$).

Relative to women with neither exposure, the odds of anaemia were 73% lower among those with consistent supplementation only (OR = 0.27, 95% CI 0.09–0.78) and 85% lower among those with both (OR = 0.15, 95% CI 0.06–0.38), while adequate diet alone did not reach significance (OR = 0.49, 95% CI 0.20–1.19). The likelihood ratio test for interaction was not significant ($\chi^2 = 0.04$, df = 1, $p = 0.837$), indicating no evidence that the association of either exposure with anaemia differed according to the other.

Table 3: Dose-Response Relationships and Combined Exposure to Dietary Diversity and IFAS Uptake

Analysis	**Category**	**n**	**Anaemic n (%)**	**Mean Hb, g/dL (SD)**
Dietary diversity band	4 groups or fewer	66	25 (37.9)	11.10 (1.16)
	5–6 groups	88	21 (23.9)	11.51 (1.14)
	7 groups or more	56	12 (21.4)	11.62 (1.15)
	Test		χ^2 trend = 4.31, p = 0.038	F = 3.72, p = 0.026
Days IFAS taken in last 7	0 days	54	25 (46.3)	–
	1–3 days	34	12 (35.3)	–

	4–5 days	66	10 (15.2)	–
	6–7 days	56	11 (19.6)	–
	Test		χ^2 = 17.34 (df 3), p < 0.001; χ^2 trend = 13.72, p < 0.001	
Combined exposure	Neither	32	17 (53.1)	10.64 (1.14)
	Adequate diet only	56	20 (35.7)	11.05 (1.05)
	Consistent uptake only	34	8 (23.5)	11.52 (1.01)
	Both	88	13 (14.8)	11.87 (1.08)
	Test		χ^2 = 19.80 (df 3), p < 0.001	F = 13.02, p < 0.001

Hb = haemoglobin; IFAS = iron and folic acid supplementation; SD = standard deviation. Adequate diet = five or more MDD-W food groups; consistent uptake = IFAS taken on four or more of the preceding seven days.

Thirteen variables met the screening threshold for the multivariable model. With 58 outcome events the model could support no more than six degrees of freedom, and the candidate set was reduced accordingly, with dietary diversity retained on conceptual grounds. The results are presented in Table 4. Five of the six variables retained an independent association with anaemia.

Consistent IFAS uptake was associated with 74% lower odds of anaemia (AOR = 0.26, 95% CI 0.12–0.54, p < 0.001), consumption of flesh foods at least one to three times a week with 82% lower odds (AOR = 0.18, 95% CI 0.08–0.43, p < 0.001) and consumption of vitamin C-rich fruits at least as often with 56% lower odds (AOR = 0.44, 95% CI 0.21–0.91, p = 0.027). A positive malaria test was associated with more than sixfold higher odds of anaemia (AOR = 6.20, 95% CI 2.51–15.35, p < 0.001) and helminth infection with almost fivefold higher odds (AOR = 4.88, 95% CI 1.93–12.34, p < 0.001).

Table 4: Multivariable Logistic Regression of Factors Associated with Anaemia (n = 210)

Variable	**Category**	**COR (95% CI)**	**AOR (95% CI)**	**p-value**
Consistent IFAS uptake	Not consistent	1.00 (reference)	1.00 (reference)	
	Consistent	0.29 (0.15–0.54)	0.26 (0.12–0.54)	<0.001
Flesh foods (haem iron)	Less than weekly	1.00 (reference)	1.00 (reference)	
	1–3 times a week or more	0.23 (0.11–0.46)	0.18 (0.08–0.43)	<0.001
Vitamin C-rich fruits	Less than weekly	1.00 (reference)	1.00 (reference)	
	1–3 times a week or more	0.46 (0.25–0.86)	0.44 (0.21–0.91)	0.027
Dietary diversity (MDD-W)	Inadequate	1.00 (reference)	1.00 (reference)	
	Adequate	0.49 (0.26–0.92)	0.91 (0.41–2.03)	0.814
Malaria test	Negative	1.00 (reference)	1.00 (reference)	
	Positive	3.82 (1.79–8.18)	6.20 (2.51–15.35)	<0.001

Stool ova and cysts	Negative	1.00 (reference)	1.00 (reference)	
	Positive	3.79 (1.74–8.24)	4.88 (1.93–12.34)	<0.001

COR = crude odds ratio; AOR = adjusted odds ratio; CI = confidence interval; MDD-W = Minimum Dietary Diversity for Women; IFAS = iron and folic acid supplementation. All six variables were entered simultaneously.

The behaviour of the dietary diversity score was the most notable result of the model. Its crude odds ratio of 0.49 was significant, but on adjustment it moved to 0.91 and lost all significance (p = 0.814). Women who reached the threshold of five food groups were largely the same women who ate flesh foods regularly, and once the frequency of those foods was included in the model the diversity count added no further explanatory value. The infection estimates moved in the opposite direction, strengthening from crude values of 3.82 and 3.79 to adjusted values of 6.20 and 4.88. Infected women in the sample were somewhat more likely than others to be taking supplements consistently and to be eating flesh foods, so that their crude associations were partly masked by these exposures.

DISCUSSION

This study examined dietary practices, IFAS uptake and haemoglobin-defined anaemia in the same pregnant women attending antenatal care in a pastoralist setting in northern Kenya, a population in which these exposures have rarely been studied together. There were three principal findings. Consistent IFAS uptake was independently associated with substantially lower odds of anaemia. The iron-related composition of the diet, namely regular consumption of flesh foods and of vitamin C-rich fruits, was independently associated with lower odds of anaemia, whereas dietary diversity was not once these were taken into account. Malaria and helminth infection were the factors most strongly associated with anaemia. As the design was cross-sectional, these findings describe associations and do not establish cause.

Prevalence and Severity of Anaemia

More than one in four participants (27.6%) were anaemic, and all cases were mild or moderate. This prevalence is below the national estimate of 55.1% (MoH, 2013), the pooled estimate of 35.6% for sub-Saharan Africa (Fite et al., 2021) and the global estimate of approximately 37% (WHO, 2023). The participants were clinic attenders, three quarters of whom had taken IFAS in the preceding week, and are unlikely to represent women who attend late or not at all. In addition, anaemia was defined using trimester-specific thresholds, which classify fewer second-trimester women as anaemic than a single cut-off of 11.0 g/dL, and 46.2% of participants were in the second trimester. The prevalence reported here should therefore be read as a facility-based estimate that probably understates the burden in the wider community. Among multigravid women, a reported history of anaemia in a previous pregnancy was associated with almost fourfold higher odds of current anaemia (COR = 3.77, 95% CI 1.68–8.43), which identifies a group who could be recognised at booking.

Consistent IFAS Uptake and Anaemia

Consistent IFAS uptake was associated with 74% lower odds of anaemia after adjustment for diet and infection (AOR = 0.26, 95% CI 0.12–0.54). The association was graded. Anaemia was present in 46.3% of women who had taken no tablet in the preceding week and 35.3% of those who had taken tablets on one to three days, compared with 15.2% and 19.6% of those who had taken them on four to five and six to seven days respectively (test for trend $\chi^2 = 13.72$, $p < 0.001$). The number of days on which tablets were taken also correlated positively with haemoglobin concentration (r = 0.331, 95% CI 0.205–0.447). This pattern is consistent with Cochrane evidence that daily oral iron supplementation in pregnancy reduces maternal anaemia and iron deficiency at term (Peña-Rosas et al., 2015) and with the rationale for universal antenatal supplementation (WHO, 2016, 2024). It also indicates that consumption, rather than receipt of tablets, is the measure of supplementation that relates to haemoglobin. The seven-day measure describes recent consumption and not adherence sustained across pregnancy. The temporal order of supplementation and anaemia also cannot

be determined from cross-sectional data. The proportion with consistent uptake (58.1%) exceeds the pooled compliance of 39.2% reported from primary studies in sub-Saharan Africa (Fite et al., 2021), although definitions of compliance differ between studies. Even so, only 26.7% of participants had taken tablets on six or seven days, as the daily regimen requires. A considerable share of women already in contact with antenatal services were therefore not consuming IFAS as recommended.

Dietary Composition and Dietary Diversity

Among the dietary practices examined, those related to the supply and absorption of iron were associated with anaemia. Women who ate flesh foods at least weekly had 82% lower odds of anaemia (AOR = 0.18, 95% CI 0.08–0.43), and those who ate vitamin C-rich fruits at least weekly had 56% lower odds (AOR = 0.44, 95% CI 0.21–0.91). Haem iron from animal sources is absorbed considerably more efficiently than non-haem iron, and ascorbic acid enhances the absorption of non-haem iron (Abbaspour et al., 2014), which offers a biological explanation for both associations.

Adequate diversity on the MDD-W indicator was associated with lower odds of anaemia in the bivariate analysis (COR = 0.49, 95% CI 0.26–0.92), a result in keeping with the meta-analysis by Seid et al. (2023), which found that inadequate dietary diversity in pregnancy increased the risk of maternal anaemia in Africa. After adjustment, however, the association was no longer present (AOR = 0.91, 95% CI 0.41–2.03). Women who reached the diversity threshold were largely those who also ate flesh foods regularly, which suggests that the crude association reflected haem iron intake and not the number of food groups consumed. The MDD-W indicator was developed as a proxy for overall micronutrient adequacy (FAO & FHI 360, 2016) and does not distinguish between sources of iron that differ in bioavailability. Studies that measure diversity alone may therefore attribute to the breadth of the diet an association that belongs to its composition. The distinction is particularly relevant to pastoralist populations, whose access to flesh foods depends on herds that decline in drought (Odhiambo & Sartorius, 2020). Diet and supplementation were also examined jointly. Anaemia prevalence was 53.1% among women with neither adequate dietary diversity nor consistent IFAS uptake and 14.8% among those with both ($\chi^2 = 19.80$, $p < 0.001$), corresponding to 85% lower odds in the latter group (OR = 0.15, 95% CI 0.06–0.38), with no evidence that either exposure modified the association of the other.

Malaria and Helminth Infection

Malaria and helminth infection were the factors most strongly associated with anaemia. A positive malaria test was associated with sixfold higher odds (AOR = 6.20, 95% CI 2.51–15.35) and a positive stool examination with almost fivefold higher odds (AOR = 4.88, 95% CI 1.93–12.34), and more than half of the women in each infected group were anaemic. Both estimates were larger after adjustment than before. Infected women in this sample were somewhat more likely than others to be taking IFAS consistently and eating flesh foods. The findings accord with established mechanisms: malaria lowers haemoglobin through haemolysis of parasitised red cells and suppression of red cell production, and hookworm through chronic intestinal blood loss.

The strength of the malaria association in a county of low and seasonal transmission indicates that malaria should not be discounted as a cause of anaemia in such settings. Cochrane evidence indicates that the effect of antenatal deworming on maternal anaemia varies with the local prevalence and intensity of infection (Salam et al., 2015), and the magnitude of the association observed here suggests that helminth infection may be an important contributor in this population. In the bivariate analysis, use of an insecticide-treated net the previous night was associated with lower odds of anaemia (COR = 0.51, 95% CI 0.28–0.95), although this variable could not be retained in the adjusted model. Because IFAS and diet address only the nutritional component of anaemia, their association with lower anaemia in this study was observed in the presence of an infectious burden that they cannot be expected to reduce.

Overall, the results indicate that anaemia among pregnant women in this setting is associated with nutritional, behavioural and infectious factors at the same time. Each of the five factors retained an independent association in the adjusted model, which implies that none can be addressed adequately through the others. Confirmation of these associations, and of their direction, requires longitudinal data.

CONCLUSION

This study analysed the association between dietary practices, IFAS uptake and anaemia status among pregnant women attending antenatal care at Archers Post Sub-County Hospital in Samburu County, Kenya. More than a quarter of the women were anaemic, in mild and moderate forms only, indicating a burden of chronic depletion that calls for preventive rather than purely clinical responses. Consistent IFAS uptake was independently associated with substantially lower odds of anaemia, and the frequency of supplementation showed a clear dose-response relationship with anaemia and haemoglobin. Regular consumption of flesh foods and vitamin C-rich fruits was also independently associated with lower odds of anaemia, while the crude association of dietary diversity as measured by the MDD-W indicator was no longer evident once the frequency of these foods was taken into account. The composition of the diet, rather than its breadth, therefore carries the association with anaemia in this population. Supplementation and diet showed no evidence of interaction, and anaemia was lowest among women with both adequate diet and consistent supplementation. Malaria and helminth infection were the strongest factors associated with anaemia, and their associations were stronger than unadjusted estimates suggested. Because the study was cross-sectional and could not adjust for all potential confounders, these associations do not establish causation. Overall, the findings suggest that anaemia in pregnancy in this pastoralist setting is unlikely to be resolved through supplementation and diet alone while infection continues at present levels, and that effective anaemia control is likely to require the integration of consistent supplementation, composition-focused dietary counselling and infection control within routine antenatal care.

RECOMMENDATIONS

Antenatal care providers at Archers Post Sub-County Hospital and similar facilities should strengthen support for consistent IFAS consumption, since consistent uptake was associated with 74% lower odds of anaemia. Dietary counselling should be redirected from the breadth of the diet to its composition, emphasising regular consumption of iron-bearing animal-source foods where available, pairing of plant sources of iron with vitamin C-rich fruits, and separation of tea and coffee from meals and from the iron tablet by at least an hour. The Samburu County Department of Health should incorporate these messages into antenatal nutrition education materials and community health promoter activities, adapted to local food availability and seasonal variation.

Facilities should integrate supplementation with malaria and helminth control rather than delivering it in isolation. Deworming should be provided routinely after the first trimester in accordance with national guidance, malaria testing and intermittent preventive treatment should be completed as indicated, and possession and use of insecticide-treated nets should be verified at each antenatal contact. Women with a history of anaemia in a previous pregnancy should be identified at booking and monitored more closely. County authorities should also link maternal anaemia prevention with drought early warning and food security programmes, given the dependence of dietary haem iron on livestock productivity.

Strengths and Limitations of the Study

This study has several important strengths. Dietary practices, IFAS uptake, and infection status were assessed concurrently in the same women, enabling the independent and combined associations of these factors with anaemia to be examined. Dietary exposure was assessed using both the Minimum Dietary Diversity for Women (MDD-W) indicator and a food frequency measure, allowing dietary diversity to be distinguished from the frequency and composition of food consumption. Anaemia was determined from measured haemoglobin concentrations and classified according to trimester-specific thresholds, thereby reducing potential misclassification associated with the physiological haemodilution of pregnancy.

The findings should nonetheless be interpreted in light of several limitations. The cross-sectional design precludes inference about temporal sequence, and reverse causation cannot be excluded, particularly for the association between IFAS uptake and anaemia. IFAS uptake was self-reported over a seven-day recall period; it is therefore subject to recall and social desirability bias and reflects recent consumption rather than adherence sustained across pregnancy. Dietary diversity was derived from a single 24-hour recall, which may

not represent usual intake at the individual level. Anaemia was defined from haemoglobin concentration alone, and in the absence of ferritin and inflammatory markers, iron-deficiency anaemia could not be differentiated from anaemia of other aetiologies. The number of outcome events restricted the multivariable model to six variables, and sociodemographic and obstetric characteristics were not adjusted for, so residual confounding is possible. Recruitment from a single facility also limits the generalisability of the findings to pregnant women who do not attend antenatal care.

Implications for Policy and Practice

The findings have implications for anaemia control policy in Kenya's arid and semi-arid counties. National nutrition guidance and monitoring frequently rely on dietary diversity as the principal dietary indicator, yet in this population dietary diversity was not independently associated with anaemia once the consumption of haem iron was considered. Nutrition programmes and surveys in pastoralist settings should therefore include simple measures of the frequency of iron-bearing foods and absorption-related practices alongside diversity scores. The strong associations of malaria and helminth infection with anaemia further suggest that maternal anaemia programmes should be jointly planned and monitored by nutrition, malaria and neglected tropical disease programmes, with antenatal care serving as the common delivery platform. Monitoring of IFAS programmes should shift from tablets issued to consistent consumption, which is the measure associated with lower anaemia prevalence.

Areas for Future Research

Future research should employ prospective cohort designs, following women from booking to delivery, to establish whether consistent supplementation precedes improvement in haemoglobin and to resolve the direction of the association between supplementation and anaemia. Such studies should record gestational age at initiation of supplementation and cumulative tablet consumption, so that adherence across pregnancy rather than recent uptake alone can be related to haemoglobin, and should be large enough to adjust for sociodemographic and obstetric confounders. Studies incorporating iron-status biomarkers such as ferritin, together with inflammatory markers and screening for haemoglobinopathies, would allow the relative contributions of iron deficiency, infection and other causes of anaemia to be quantified. Seasonal studies comparing dietary intake and anaemia during periods of rainfall and drought would clarify the vulnerability of pastoralist women to changes in livestock productivity. Intervention studies evaluating integrated packages of supplementation support, composition-focused dietary counselling and infection control would establish whether the associations observed here translate into measurable reductions in anaemia.

Declarations

Ethical Approval and Consent to Participate

Ethical approval for the study was obtained from the Institutional Ethics and Research Committee [P451/05/2024], and a research licence was obtained from the National Commission for Science, Technology and Innovation . Written informed consent was obtained from all participants before participation in the study, with separate consent for haemoglobin measurement.

Consent for Publication

Not applicable.

Availability of Data and Materials

The datasets used and analysed during the current study are available from the corresponding author upon reasonable request.

Competing Interests

The authors declare that they have no competing interests.

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Authors' Contributions

LSH conceptualised the study, collected the data, conducted the analysis and drafted the manuscript. DGM provided technical guidance, reviewed the manuscript and contributed to interpretation of the findings. All authors reviewed and approved the final manuscript.

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