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Non-adherence to antenatal iron supplementation and its determinants among pregnant women in 35 sub-saharan African countries: a generalized linear mixed-effects modeling with robust Poisson regression analysis

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Abstract

Background Despite the integration of iron supplementation into routine antenatal care programs as a nutritional intervention to prevent anemia in pregnant women, the use of this supplement for the recommended duration remains low in sub-Saharan Africa (SSA). Evidence on maternal compliance with iron supplementation at the SSA level is lacking and most of the previous studies have been limited to specific geographic areas. Therefore, the current study used large population survey data from 35 SSA countries to estimate the pooled prevalence of non-adherence and its determinants.

Methods A secondary analysis was conducted using data from the demographic and health surveys across 35 SSA countries. After excluding women with missing data on the outcome variable, a weighted sample of 158,941 women who received iron supplementation during their recent pregnancy was included in the analysis. Forest plot was used to present the pooled and country-level rates of non-adherence to antenatal iron supplementation. A multilevel mixed-effects Poisson regression with robust variance was done to identify determinants of non-adherence.

Results The pooled prevalence of non-compliance to iron supplementation in SSA was 65.1% [95% CI: 64.9 −65.3%], with the lowest level in Zambia (18%) and the highest in Burundi (97%). The analysis revealed that living in rural areas (aPR: 1.16, 95% CI: 1.13–1.19), lack of access to mass media (aPR: 1.10, 95% CI: 1.09–1.12), low household wealth (aPR: 1.11, 95% CI: 1.09–1.14), late (aPR: 1.19, 95% CI: 1.17–1.20) and frequent ANC visit (aPR: 1.28, 95% CI: 1.26, 1.29), women's employment status (aPR: 1.05, 95% CI: 1.03–1.06), husband illiteracy (aPR: 1.12, 95% CI: 1.10–1.13), and

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distance to a health facilities (aPR: 1.03, 95% CI: 1.01–1.05) were associated higher prevalence of non-adherence. Conversely, older maternal age was associated lower prevalence of non-compliance (aPR: 0.96, 95% CI: 0.94–0.97).

Conclusion More than six out of ten pregnant women in SSA do not take iron supplements for the recommended period, with substantial variations across the countries. The level of non-adherence was significantly varied by women's sociodemographic and reproductive characteristics. This urges the need for strengthening community health interventions and other existing programs to reach women in rural and economically disadvantaged settings. Furthermore, promoting antenatal care services through mass media and community-based health education strategies is key for scaling up the utilization of the supplement. Our results also suggest the importance of establishing the community-based distribution of iron supplements to address women with limited access to the healthcare system.

Keywords Determinants, Iron supplementation, Mixed-effects analysis, Non-adherence, Pregnant women, Robust Poisson regression, Sub-saharan Africa

Background

Iron deficiency is the main nutritional cause of anemia in pregnant women, associated with an increased physiologic need to maintain pregnancy [1, 2]. In addition to iron deficiency, anemia in pregnancy occurs due to poor dietary habits, gastrointestinal distress and bleeding disorders, nutritional insecurity, and poor maternal healthcare utilization [3–5]. Evidence has shown that iron deficiency anemia in pregnancy is associated with adverse maternal and neonatal outcomes [1, 6–9].

Globally, anemia remains a major public health problem, affecting more than a third (36%) of pregnant women [10]. It is estimated that approximately 49% of pregnant women in low- and middle-income countries are affected [11], with rates ranging from 20 to 40% in more than half of the countries in the region [12]. Regional estimates have also shown that 43% of pregnant women in sub-Saharan Africa (SSA) [13], 42% in East Africa [14], and 51% in the West Africa region [13] suffer from anemia.

Studies have shown that daily iron intake during pregnancy is associated with a reduced risk of maternal anemia and other adverse obstetric outcomes [15–17]. In this regard, the World Health Organization (WHO) recommends daily prenatal iron supplementation to prevent anemia in pregnant women in areas where anemia is a major public health problem [18]. However, despite the significant effect of prenatal iron supplementation on the prevention of anemia in pregnant women [15, 16, 19], non-compliance to this supplementation remains high in African countries, with huge regional and sub-regional variations [20–24].

According to recent estimates, non-compliance with prenatal iron supplementation in SSA range from 48% [21] to (71%) [20]. Furthermore, a secondary analysis of national surveys in African countries estimated the non-compliance with iron supplementation at 87% in Ethiopia [22], 63% in Malawi [23], and 46% in South Africa [24]. Additionally, several studies have identified women's sociodemographic characteristics (age, place of residence, education, occupation, marital status, and media exposure) and obstetric variables (number of children, antenatal care visit, and history of miscarriage) as the factors affecting compliance with antenatal iron supplementation [20, 22–28].

Despite the inclusion of iron supplementation in routine antenatal care packages as a nutritional intervention intended to prevent anemia during pregnancy [18], the use of this supplement for the recommended period among women in resource-limited settings like SSA remains low [20–24]. In addition, recent statistics show that the prevalence of anemia in pregnant women in this region has decreased by only 5% over the past two decades from 41% in 2000 to 36% in 2019 [10], falling well short of the global nutritional target of a 50% reduction in anemia by 2025 [29]. Therefore, up-to-date evidence on the level and determinants of maternal non-compliance with iron supplementation in the prenatal period is essential in developing context-specific strategies to increase the uptake of iron supplements, which in turn helps to reduce anemia in pregnant women. However, there is a dearth of evidence on maternal compliance with iron supplementation in Africa and most of the previous studies across this region were limited to a specific geographic area or single country [14, 20, 22, 24, 27, 28, 30, 31]. Thus, the current study used data from large population surveys conducted in 35 SSA countries to estimate the pooled prevalence of non-adherence to iron supplementation and its determinants among pregnant women.

Methods

Study design and data source

A secondary analysis of data obtained from the most recent Demographic and Health Surveys (DHS) of 35 sub-Saharan African countries was conducted in this study. The selection of country was based on the survey year, availability of a standardized and unrestricted dataset, and presence of observations for the outcome

variable in the datasets. For the current analysis, we included the countries that have their recent DHS conducted between 2010 and 2021. The survey across all countries employed a cross-sectional study design and collected data on basic sociodemographic characteristics and different health indicators (household characteristics, maternal and child health, HIV/AIDS, malaria, and family planning).

Sampling technique and data collection

Across all countries, the surveys used a multistage stratified cluster sampling technique to select the study participants. In the first stage, each country was divided into clusters, and clusters were randomly selected based on the probability proportional to their contribution to overall country's population. In the second stage, using the housing census as a sampling frame, a representative number of households was selected from each cluster. A standardized data collection tool and face-to-face interview were used to collect the survey's data. For this study, since we intended to examine the level and determinants of non-adherence to iron supplementation during pregnancy, we used the women's dataset (IR dataset) of the included country. Based on DHS guideline (https://www.dhsprogram.com/pubs/pdf/DHSG1/Guide_to_DHS_Statistics_DHS-8.pdf), women with missing data were excluded from the study. Finally, after handling the missing observations, a weighted sample of 158,941 women who received iron supplementation during their most recent pregnancy was used in the analysis (Table 1). Details about DHS methodology can be accessed online (https://dhsprogram.com/Methodology/index.cfm).

Table 1 Survey year and sample size of 35 SSA countries included in the study, 2010–2021

Country	Survey year	Unweighted sample size	Weighted sample size
Angola	2016	4,754	4,997
Burkina Faso	2010	8,353	8,360
Benin	2018	5,517	5,594
Burundi	2017	3,546	3,681
DR Congo	2014	4,914	5,234
Congo	2012	4,158	3,978
Cote d'Ivoire	2012	3,387	3,297
Cameroon	2018	4,195	4,242
Ethiopia	2016	2,663	2,558
Gabon	2012	2,768	2,624
Ghana	2014	3,370	3,316
Gambia	2020	4,614	4,360
Guinea	2018	3,604	3,571
Kenya	2014	4,144	4,138
Comoros	2012	822	796
Liberia	2020	3,205	2,992
Lesotho	2014	1,648	1,629
Madagascar	2021	6,125	6,197
Mali	2018	3,259	3,524
Mauritania	2021	4,460	4,397
Malawi	2016	10,878	10,870
Mozambique	2011	5,213	5,197
Nigeria	2018	11,511	11,618
Niger	2012	4,768	5,159
Namibia	2013	2,043	1,904
Rwanda	2019	4,606	4,674
Sierra Leone	2019	4,718	4,612
Senegal	2019	3,356	3,119
Chad	2015	4,046	4,449
Togo	2014	3,748	3,575
Tanzania	2016	4,949	5,027
Uganda	2016	7,745	7,620
South Africa	2016	2,140	2,060
Zambia	2018	5,789	5,814
Zimbabwe	2015	3,694	3,754
Total		158,710	158,941

Variables and measurements

The dependent variable for this study was "adherence to antenatal iron supplementation". In the DHS dataset, this variable was recorded as the number of days women took iron tablets or syrup during the pregnancy of the most recent birth. For the analysis purpose, this variable was dichotomized based on the WHO recommendation using a cut-off point of 90 days of taking the supplement. Thus, women who took iron supplementation for at least 90 days were considered adherent (coded as "0") and those who received the supplement for less than 90 days were labeled non-adherent (coded as "1").

Individual-level variables were current age, marital status, woman's education, partner's education, women's employment status, media exposure, household head, wealth index, women's participation in the household decisions (women empowerment), number of living children, the timing of first antenatal care visit, number of antenatal care visits, and history of pregnancy loss. While, place of residence, SSA regions, distance to the health facility, community-level media exposure, community-level women literacy, and community-level poverty were the community-level variables.

Exposure to mass media was generated using three variables (frequency of watching television, listening to the radio, and reading newspapers) that have three response options (i.e. not at all, less than once a week, and at least once a week). Thus, women who reported watching television or listening to the radio, or reading the newspaper less than once a week and at least once a week were considered as having media exposure (coded = Yes "1"), while those who reported not watching television or listening to the radio or reading a newspaper

at all were labeled as not having exposure to mass media (coded = No "0").

Women empowerment was created by computing four variables (i.e. who usually decides on women's earnings, health care, large household purchase, and a family visit) that have four responses (respondent alone, respondent and partner, partner alone, and someone else). Therefore, women were considered to have been empowered if they reported that the decision was made by themselves or jointly with their partner and otherwise regarded as not empowered. Other community-level variables (i.e. community-level media exposure, women illiteracy, and poverty) were generated by aggregating the individual-level observations at the cluster level and the aggregates were dichotomized using the average values of the proportions of women in each category of a given variable and median values were used to categorize the aggregated variables into two groups (i.e. low and high).

Data management and statistical analysis

Stata version 17 was used for data cleaning and analysis. Before analysis, the availability of the outcome variable in the DHS dataset of each country was confirmed and all variables considered in the study were checked for missing values. Then, the datasets of 35 SSA countries were appended and weighted to restore the representativeness of the sample and obtain reliable estimates and standard errors.

To calculate the pooled prevalence of non-adherence to prenatal iron supplementation, we used weighted data on the number of women who were non-adherent and the total number of study participants in each country included the analysis. Finally, a Stata command for meta-analysis i.e. metan was executed to present the country-specific and pooled estimates with 95% CI in the forest plot form.

A multilevel mixed-effects Poisson regression model with robust error variance was fitted to identify the determinants of non-adherence to iron supplementation during pregnancy. We applied Poisson regression with robust error variance since the odds ratio estimated using a common binary outcome from cross-sectional data may significantly overestimate the strength of association [32, 33]. In addition, to account for the dependency of data due to the nested nature of DHS (i.e. women were nested within the households, and households were nested within the clusters), a multilevel mixed-effects logistic regression modelling was applied. Bivariable multilevel robust Poisson regression analysis was done and all variables with a *p*-value of less than 0.25 in this analysis were considered for multivariable multilevel robust Poisson regression model [34, 35].

In our analysis, four hierarchal models were fitted to select the model that best fits the data: model I (a model with outcome variable only to assess the random variability in the intercept), model II (a model with only individual-level explanatory variables), model III (a model with only community-level explanatory variables), and model IV (a model with both individual and community-level predictors). Random variability in non-adherence to antenatal iron supplementation across clusters was assessed by intra-class correlation coefficient (ICC), proportion change in variance (PCV), and median odds ratio (MOR). Akaike's information criteria (AIC), Bayesian information criteria (BIC), Log-likelihood (LL), and deviance (i.e. -2*LL) values were used for model comparison. The presence of multicollinearity between explanatory variables was checked using variance inflation factor values and the values for the included variables ranged from 1.23 to 3.67, suggesting that there was no multi-collinearity. Finally, in the multivariable analysis, a *p*-value less than 0.05 and an adjusted prevalence ratio with the corresponding 95% confidence interval was used to identify the factors associated with non-adherence to antenatal iron supplementation.

Ethical considerations

In this study, we used publicly available DHS data from 35 SSA countries, and the survey procedures were approved by the ICF Institutional Review Board (IRB) and the host country IRB. Thus, we did not require ethical approval, but we have received permission to access the data from ICF International (referenced AuthLetter_180923). In addition, the accessed dataset does not contain any identifications that specify the individual women included in the study.

Results

Out of 158,941 women included in the analysis, 111,166 (69.9%) were between the ages of 25 and 49 years, and 132,181 (83.5%) were currently married. Nearly one-third (32.6%) of women had no formal education, while 52,858 (33.3%) had attended higher education. The majority (64.2%) of women were employed and 111,364 (70%) had exposure to mass media. It was also found that 100,513 (63.2%) women resided in rural areas and 61,284 (38.6%) were from households with poor wealth index. Moreover, 74,362 (46.8) women were from western African countries, and 96,307 (62.1%) women perceived that the distance to the nearest health facility was a big problem (Table 2).

Prevalence of non-adherence to antenatal iron supplementation

The pooled prevalence of non-adherence to antenatal iron supplementation in SSA countries was 65.1% [95% CI = 64.9-65.3%], with significant heterogeneity across the countries. The lowest level of non-adherence was found

Table 2 Background characteristics of women in 35 SSA countries, 2010–2021 ($n = 158,941$)

Characteristics	Frequency (weighted %)	Adherence to iron supplementation	
		Non-adherent	Adherent
Age			
15–24	47,775 (30.1)	27,984 (58.6)	19,791 (41.4)
25–49	111,166 (69.9)	62,751 (56.5)	48,414 (43.5)
Marital status			
Never married	13,133 (8.3)	6,599 (50.3)	6,534 (49.8)
Currently married	132,181 (83.5)	76,347 (57.5)	56,406 (42.5)
Formerly married	13,027 (8.2)	7,762 (59.6)	5,265 (40.4)
Woman's education			
No formal education	51,753 (32.6)	31,262 (60.4)	20,491 (39.6)
Primary education	54,330 (34.2)	34,282 (63.1)	20,047 (36.9)
Higher education	52,858 (33.3)	25,191 (47.7)	27,667 (52.3)
Partner Education			
No formal education	45,874 (33.5)	27,134 (59.2)	18,740 (40.9)
Primary education	38,460 (28.1)	24,558 (64.6)	13,601 (35.4)
Higher education	52,540 (38.4)	26,901 (51.2)	25,639 (48.8)
Woman's employment			
Not working	56,809 (35.8)	31,541 (55.5)	25,268 (44.5)
Working	102,050 (64.2)	59,137 (58.0)	42,913 (42.1)
Media exposure			
No	47,397 (29.9)	31,100 (65.6)	16,297 (34.4)
Yes	111,364 (70.1)	59.505 (53.4)	51,859 (46.6)
Head of household			
Male	122,838 (77.3)	70,434 (57.4)	52,405 (42.7)
Female	36,103 (22.7)	20,302 (56.2)	15,800 (43.8)
Household wealth			
Poor	61,284 (38.6)	38,206 (62.3)	23,077 (37.7)
Middle	32,358 (20.4)	18,653 (57.7)	13,705 (42.3)
Rich	65,299 (41.1)	33,876 (51.9)	31,423 (48.1)
Women empowerment			
Not empowered	32,802 (24.7)	19,026 (58.0)	13,775 (42.0)
Empowered	99,914 (75.3)	57,298 (57.4)	42,616 (42.6)
Residence			
Urban	58,427 (36.8)	28,033 (48.0)	30,394 (52.0)
Rural	100,513 (63.2)	62,702 (62.4)	37,811 (37.6)
SSA regions			
Central	27,014 (17.0)	19,871 (73.6)	7,144 (64.4)
Eastern	26,336 (16.6)	20,228 (76.8)	6,108 (23.2)
Southern	31,229 (19.7)	14,792 (47.4)	16,436 (52.6)
Western	74,362 (46.8)	35,844 (48.2)	38,517 (51.8)
Distance to HF			
Big problem	58,641 (37.9)	35,559 (60.6)	23,082 (39.4)
Not a big problem	96,307 (62.1)	52,621 (54.6)	43,686 (45.4)
Community women literacy			
Low	15,410 (9.7)	8,837 (57.4)	6,573 (42.6)
High	143,531 (90.3)	81,899 (57.1)	61,632 (42.9)
Community media exposure			
High	44,577 (28.1)	24,511 (55.0)	20,066 (45.0)
Low	114,364 (71.9)	66,244 (57.9)	48,139 (42.1)
Community-level poverty			
Low	51,651 (32.5)	28,607 (55.4)	23,068 (44.6)
High	107,266 (67.5)	62,128 (57.9)	45,137 (42.1)
Number of living children			

Table 2 (continued)

Characteristics	Frequency (weighted %)	Adherence to iron supplementation	
		Non-adherent	Adherent
1–3	98.668 (62.1)	54,707 (55.5)	43,961 (44.5)
≥ 4	60,273 (37.9)	36,028 (59.8)	24,245 (40.2)
History of pregnancy loss			
No	134,636 (84.7)	77,625 (57.7)	57,011 (42.3)
Yes	24,302 (15.3)	13,108 (53.9)	11,194 (46.1)
Timing of ANC			
Early	101,398 (63.8)	51,521 (50.8)	49,877 (49.2)
Late	57,543 (36.2)	39,215 (68.2)	18,328 (31.8)
Number of ANC visits			
≥ 4	101,268 (63.7)	49,792 (49.2)	51,475 (50.8)
1–3	57,673 (36.3)	40,943 (71.0)	16,730 (29.0)

SSA = sub-Saharan Africa; HF = Health Facility; ANC = Antenatal Care.

in Zambia (18%), while Burundi had the highest prevalence (97%). In addition, out of 35 countries included in the analysis, we found that in 23 countries, more than 50% of pregnant women did not receive the recommended dose of iron supplementation (Fig. 1).

Random-effect analysis result (measures of variation)

The ICC value in the null model (Model 1) indicated that about 16.7% of the variability in the level of non-adherence to iron supplementation during pregnancy was explained by variation across the clusters, while the remaining 83.3% was attributed to individual-level differences. In the final model (Model 4), the values of explained variance also showed that about 42% of the total variation in the prevalence of non-adherence to antenatal iron supplementation was attributed to the mutual effect of individual and community-level factors. Moreover, the presence of heterogeneity in the level of non-adherence across the clusters was indicated by the MOR of 2.10 and 1.59 in the null and full models, respectively. This indicated that pregnant women in the cluster with a higher level of non-adherence had about 2.10 times higher likelihood of non-adherence to antenatal iron supplementation compared to women in the clusters with a lower level of non-adherence. Model 4 had the lowest AIC, BIC, and deviance values and was hence selected as the best-fitted model (Table 3).

Determinants of non-adherence to antenatal iron supplementation

Our analysis revealed that the prevalence of non-adherence to antenatal iron supplementation among rural women was 16% higher (aPR: 1.16, 95% CI: 1.13–1.19) compared to their urban counterparts. Women who did not have exposure to mass media (television, radio, or newspaper) exhibited 10% higher prevalence of non-adherence (aPR: 1.10, 95% CI: 1.09–1.12) than those who had access to media. Additionally, women aged 25 years or older had a lower prevalence of non-compliance (aPR: 0.96, 95% CI: 0.94–0.97) compared to younger women. Moreover, women from poor households had 11% higher prevalence of non-adherence (aPR: 1.11, 95% CI: 1.09–1.14) than those from higher-income households. Women who initiated antenatal care late (beyond 12 weeks of gestation) had a 19% higher prevalence of non-adherence (aPR: 1.19, 95% CI: 1.17–1.20), while those who attended fewer than four visits exhibited a 28% higher prevalence (aPR: 1.28, 95% CI: 1.26, 1.29) compared to their counterparts. Furthermore, working (aPR: 1.05, 95% CI: 1.03–1.06), currently married (aPR = 1.04, 95% CI: 1.02–1.07), and formerly married women (aPR: 1.08, 95% CI: 1.05–1.11), those with uneducated partners or husbands (aPR: 1.12, 95% CI: 1.10–1.13), and women who perceive the distance to a health facility as a big problem (aPR: 1.03, 95% CI: 1.01–1.05) had a higher level of non-adherence compared to their reference groups (Table 4).

Discussion

Despite the significant effect of iron supplementation in reducing anemia, the majority of pregnant women in resource-constrained settings like SSA do not adhere to the recommended prenatal iron supplementation [14, 20, 22, 24, 27, 28, 30, 31]. This study used pooled data from nationally representative surveys conducted in 35 SSA countries between 2010 and 2021. We found that the overall prevalence of non-adherence to antenatal iron supplementation among pregnant women in SSA was 65.1% [95% CI: 64.9-65.3%], with the lowest and highest non-adherence levels in Zambia (18%) and Burundi (97%), respectively. This prevalence is lower than the previous studies in Ethiopia (87%) [22] and SSA (71%) [20] but higher than other studies in Oman (27%) [36], twenty-five African countries (48%) [21], South Africa (46%) [24], Ethiopia (59%) [37], and Malawi (63%) [23]. Variations in non-adherence rates across the studies

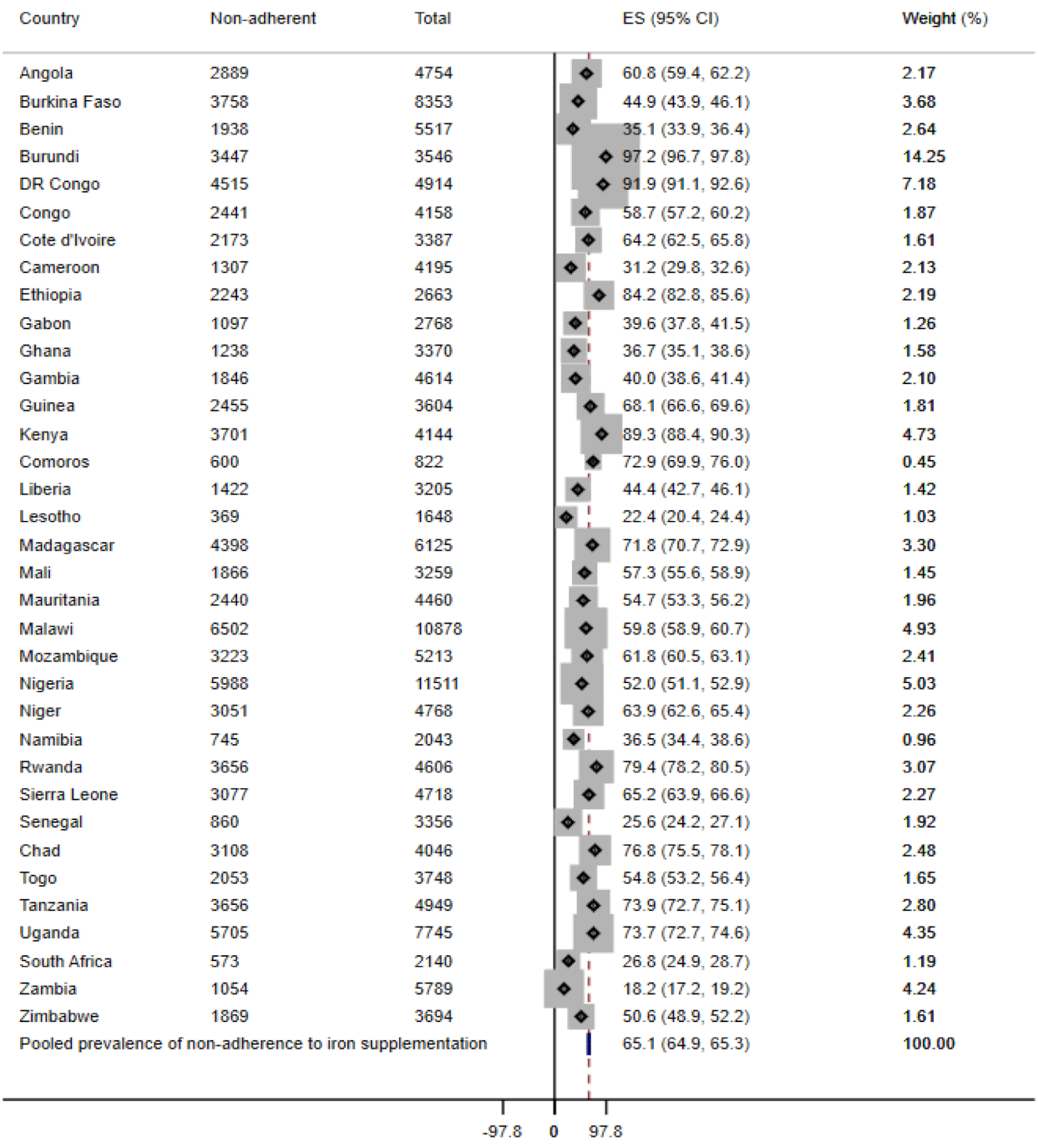

Fig. 1 Country-level and pooled prevalence of non-adherence to antenatal iron supplementation across 35 SSA countries, 2010–2021

might be due to differences in the scope of the studies, population characteristics, and methods used. For example, previous studies were narrow in that they were country-level studies [22, 24, 36, 37] and included a limited number of countries in their analyses [20, 21].

Our result showed that both individual and community-level factors contributed to non-compliance with iron supplementation during pregnancy. In this study, women living in rural areas were more likely to be non-compliant than women in urban areas. Previous studies have consistently shown higher odds of non-adherence among rural women [20, 22, 23]. This finding can be explained by the urban-rural differences in the availability of health infrastructure and related health services, which disproportionately affect rural residents.

Table 3 Random intercept models (measures of variation) at cluster or community level for non-adherence to iron supplementation among pregnant women in 35 SSA countries, 2010–2021

Measure of variation	Model 1	Model 2	Model 3	Model 4
Cluster-level variance (SE)	0.66 (0.05)	0.54 (0.04)	0.49 (0.03)	0.38 (0.03)
Intra-class correlation (%)	16.71%	14.10%	12.96%	10.35%
Explained variance (%)	Reference	18.18%	25.76%	42.42%
Median odds ratio	2.10	1.90	1.81	1.59
Model statistics summary				
Akaike's information criteria	282,829	274,098	277,865	270,500
Bayesian information criteria	282, 849	274,168	278,004	270,689
Log-likelihood	-142,762	-138,400	-140,326	-136,628
Deviance	285,524	276,800	280,652	273,256

Late and infrequent antenatal care visits were positively associated with a higher prevalence of non-adherence. For instance, women who made their first antenatal check-up during the second trimester or later had a 19% higher rate of non-adherence than those who booked early in the first trimester. Similarly, women who attended fewer than four visits had a higher prevalence of non-compliance than women who attended four or more visits. This result is consistent with the findings of the previous studies that revealed frequent antenatal care visits [20–22, 27, 37, 38] and early antenatal booking [31, 37] as an enabling factors for compliance. This might be because women who had early and frequent antenatal care visits are more likely than their counterparts to receive comprehensive and repeated nutritional advice and health education about the benefits of iron supplementation and are therefore more likely to adhere to the recommendation.

According to our analysis, household socio-economic status was significantly associated with non-compliance to antenatal iron supplementation. Women from low- and middle-class households were more likely to be non-compliant than women in higher-income households. This finding is supported by the previous study in Ethiopia which found higher odds of non-adherence in women of poorer households [22]. Moreover, it is consistent with the positive influence of the improved household wealth index on adherence levels observed in the previous studies [20, 21, 23, 39]. The most likely explanation for this finding is that women in low-income families have less access to or are less likely to afford maternal health services due to financial constraints [40, 41].

Women's exposure to mass media was also found as an important determinant of non-compliance to antenatal iron supplementation. Our result showed that women who were not exposed to any of the three media (television, radio, or newspaper) were 10% more likely to be non-compliant than those who had exposure. The finding is in line with a study conducted in India, which found a 34% likelihood of adherence in women exposed to media [39]. This might be because repeated exposure to mass media helps women better understand and become more aware of maternal health services, which in turn influences their health seeking-behavior. The finding can also be explained by the effect of media exposure on maternal uptake of frequent antenatal screening [42].

Another important factor associated with non-compliance with antenatal iron supplementation was women's age. In this regard, women aged 25 years or older had significantly lower non-compliance rates than younger women (15–24 years). This is consistent with the finding of a study in Tigray, Ethiopia [26] but contradicts the results of the studies in Cameroon [43] and Malawi [23], which reported a lower likelihood of non-compliance among young women. This discrepancy might be due to differences in the study setting and population characteristics. For instance, previous studies were conducted at a single district or country level [23, 43] and a study in Cameroon was based on the data obtained from postpartum mothers [43]. The association between older maternal age and lower levels of non-adherence can be explained by the fact that older women had better awareness about maternal healthcare services due to their prior exposure to the healthcare system and therefore more likely to adhere to these services compared to young women [44].

In addition, our analysis also showed that the likelihood of non-adherence to antenatal iron supplementation was 12% higher among women of uneducated husbands than those whose husbands had attended at least primary education. This finding is inconsistent with the studies in Ethiopia [25, 45], in which husband education was found to have a negative association with maternal adherence to iron supplementation. The discrepancy between the present and previous studies can be attributed to differences in the data source, measurement of the outcome variable, and characteristics of the study population. For example, both of the aforementioned previous studies differ from our study in that they relied on the primary data and measured the outcome variable using a pill count, which is not the case in our study.

Table 4 Bivariable and multivariable multilevel mixed-effects robust Poisson regression analysis of determinants of non-adherence to antenatal iron supplementation among pregnant women in 35 SSA countries, 2010–2021

Covariates	Adherence to iron supplementation		cPR with 95%	aPR with 95%
	Non-adherent	Adherent		
Residence				
Urban	28,033 (48.0)	30,394 (52.0)	1	1
Rural	62,702 (62.4)	37,811 (37.6)	1.29(1.27, 1.33)	1.16(1.13, 1.19)**
Community media exposure				
High				
Low	24,511 (55.0)	20,066 (45.0)	1	1
	66,244 (57.9)	48,139 (42.1)	1.04 (1.02, 1.07)	0.98(0.951, 1.01)
Community poverty				
Low	28,607 (55.4)	23,068 (44.6)	1	1
High	62,128 (57.9)	45,137 (42.1)	1.05 (1.03, 1.07)	0.99(0.97, 1.01)
Distance to HF				
Big problem	35,559 (60.6)	23,082 (39.4)	1	1
Not a big problem	52,621 (54.6)	43,686 (45.4)	0.90 (0.89, 0.92)	1.03(1.01, 1.05)**
Women employment				
Not working	31,541 (55.5)	25,268 (44.5)	1	1
Working	59,137 (58.0)	42,913 (42.1)	1.04 (1.03, 1.06)	1.05(1.03, 1.06)**
Age				
15–24	27,984 (58.6)	19,791 (41.4)	1	1
25–49	62,751 (56.5)	48,414 (43.5)	0.97 (0.95, 0.98)	0.96 (0.94, 0.97)**
Partner Education				
Formal education	25,191 (47.7)	27,667 (52.3)	1	1
No formal education	65,545 (61.8)	40,538 (38.2)	1.29 (1.27, 1.31)	1.12 (1.10, 1.13)**
Marital status				
Never married	6,599 (50.3)	6,534 (49.8)	1	1
Currently married	76,347 (57.5)	56,406 (42.5)	1.14 (1.11, 1.17)	1.04(1.02, 1.07)*
Formerly married	7,762 (59.6)	5,265 (40.4)	1.18 (1.15, 1.22)	1.08 (1.05, 1.11)*
Media exposure				
Yes	59.505 (53.4)	51,859 (46.6)	1	1
No	31,100 (65.6)	16,297 (34.4)	1.22 (1.20, 1.24)	1.10 (1.09, 1.12)**
Household wealth				
Rich	33,876 (51.9)	31,423 (48.1)	1	1
Middle	18,653 (57.7)	13,705 (42.3)	1.11 (1.09, 1.13)	1.07 (1.05, 1.09)*
Poor	38,206 (62.3)	23,077 (37.7)	1.20 (1.18, 1.22)	1.11 (1.09, 1.14)*
Number of living children				
1–3				
≥ 4	54,707 (55.5)	43,961 (44.5)	1	1
	36,028 (59.8)	24,245 (40.2)	1.08 (1.06, 1.09)	1.01 (0.99, 1.03)
Timing of ANC				
Early	51,521 (50.8)	49,877 (49.2)	1	1
Late	39,215 (68.2)	18,328 (31.8)	1.34 (1.32, 1.35)	1.19 (1.17, 1.20)**
Number of ANC visits				
≥ 4	49,792 (49.2)	51,475 (50.8)	1	1
1–3	40,943 (71.0)	16,730 (29.0)	1.44 (1.42, 1.46)	1.28 (1.26, 1.29)**

cPR = Crude Prevalence Ratio; aPR = Adjusted Prevalence Ratio; ANC = Antenatal Care; HF = Health Facility. * *P*-value less than 0.05; ** *P*-value less than 0.01

In this study, distance to the health facility was also found as a significant factor affecting compliance with iron supplementation. Accordingly, women who perceive the distance to the nearest health facility as a big problem were more likely to have a higher level of non-adherence than their counterparts. This finding is comparable to a study in Tanzania that reported lesser odds of adherence in women who traveled long distances to the nearest health facility [46]. This could be because women who live far from the health facility are more likely to have suboptimal healthcare service utilization due to a lack of

access related transportation and poor road conditions [28, 42].

Our analysis also showed that the likelihood of non-adherence to antenatal iron supplementation was higher among working women compared to unemployed women. This could be due to the reason that working women might forget to take the nutritional supplementation as per the recommendations due to workload and therefore have higher odds of non-adherence [30, 47].

Strengths and limitations

The use of a larger sample size, nationally representative data from 35 countries, and advanced statistical methods are the main strengths of this study. However, it is impossible to explain the causal relationship between the independent and dependent variables due to the cross-sectional nature of the survey's design. There might also be a recall bias since women were asked about the events that took place five years or more preceding the survey. Additionally, this study did not examine the effect of women's knowledge and attitude toward iron supplements and the availability of the supplement at the facility on the outcome variable, since these variables were not assessed in the survey.

Conclusion

More than six out of ten pregnant women in SSA do not take prenatal iron supplements for the recommended period, with substantial variations across the countries. Place of residence, media exposure, women's age and employment status, household wealth, antenatal care visit, husband education, and distance to a health facility were the significant determinants of non-adherence to antenatal iron supplementation. This urges the need for strengthening community health interventions and other existing programs to reach women in rural and economically disadvantaged settings. Furthermore, promoting antenatal care services through mass media and community-based health education strategies is key for scaling up the utilization of the supplement. Our results also suggest the importance of establishing the community-based distribution of iron supplements to address women with limited access to the healthcare system.

Abbreviations

AIC Akaike's Information Criteria
APR Adjusted Prevalence Ratio
BIC Bayesian Information Criteria
CI Confidence Interval
CPR Crude Prevalence Ratio
DHS Demographic and Health Survey
ICC Intra Class Correlation Coefficient
IRB Institutional Review Board
LL Log-Likelihood
MOR Median Odds Ratio
PCV Proportional Change in Variance
SSA Sub-Saharan Africa
WHO World Health Organization

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Author contributions

KUM and BLS conceived and designed the study, obtained and analyzed the data, interpreted the results, and drafted and revised the manuscript. SBA, KGS, OAE, TMT, and GFM were involved in the study design, data acquisition, and drafting of the manuscript. All authors read and approved the final manuscript and agreed to take responsibility for the contents of this work.

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Data availability

The raw dataset used and analyzed in this study can be accessed from the DHS website (http://www.measuredhs.com).

Declarations

Consent for publication

Not Applicable.

Competing interests

The authors declare no competing interests.

Ethics approval and consent to participate

Access to the data used in this study was authorized by the Data Archivist of Demographic and Health Survey (DHS) Program through an online request made at http://www.dhsprogram.com, supported by an authorization letter AuthLetter_180923 on dated 03/06/2023.

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