Risk factors of anemia among Women of Reproductive Age in Rwanda: implications for designing better interventions

CURRENT STATUS: ACCEPTED

Dieudonne Hakizimana  dieudonnehakiziman@gmail.com
University of Global Health Equity
Corresponding Author
ORCiD: 0000-0002-5379-4129

Marie Paul Nisingizwe
The University of British Columbia School of Population and Public Health

Jenae Logan
The University of Global Health Equity

Rex Wong
The University of Global Health Equity

DOI:
10.21203/rs.2.14859/v1

SUBJECT AREAS
Health Policy

KEYWORDS
Anemia, Women of Reproductive Age, malaria, prevalence, associated factors
Abstract

Background Anemia among Women of Reproductive Age (WRA) continues to be among the major public health problems in many developing Rwanda where it was increased comparing 2015 to 2010 Demographic and Health Survey (DHS) reports. A thorough understanding of the its risk factors is necessary to design new better approaches. However, to the best of our knowledge, no study assessing factors associated with anemia among WRA has been conducted. Therefore, this study aims to identify anemia risk factors among WRA in Rwanda.

Methods This was a quantitative, cross-sectional study using secondary data from the Rwanda Demographic and Health Survey (RDHS) 2014-2015. The study population consisted of 6680 WRA who were tested for anemia during the survey. Anemia was defined as having equal or below to 10.9 g/dl for a pregnant woman, and hemoglobin level equal or below to 11.9 g/ for a non-pregnant woman. Pearson’s chi-squared test and multiple logistic regression were conducted for bivariate and multivariable analysis respectively. We reported Odds Ratio (OR), 95% Confidence Intervals (CI) and p-values. We used Stata version 14.2 for all analyses.

Results The prevalence of anemia among WRA was 19.2% (95% CI: 18.0 - 20.5). After controlling for other variables, the factors associated with were being obese (OR: 0.61, 95% CI: 0.40 - 0.91), being in rich category (OR: 0.74, 95% CI: 0.63 - 0.87), sleeping under a mosquito net (OR: 0.85, 95% CI: 0.74 - 0.98), and using hormonal contraceptives (OR: 0.61, 95% CI: 0.50 - 0.73). The factors associated with higher odds of anemia were being underweight (OR: 1.39, 95% CI: 1.09 - 1.78), using an Intra Uterus Device (OR: 1.98, 95% CI: 1.05 - 3.75), and living in the Southern province (OR: 1.45, 95% CI: 1.11 - 1.89) or in the Eastern province (OR: 1.41, 95% CI: 1.06 - 1.88).

Conclusion Anemia continues to pose public health challenges; novel public health
interventions should consider geographic variations, improve women economic status, and strengthen iron supplementation especially for IUD users. Additionally, given the association between anemia and malaria, interventions to prevent malaria should be enhanced.

**Background**

Anemia is a significant public health problem affecting around 1.93 billion people worldwide (1). It affects 29.4% of WRA and 38.2% of pregnant women (2). Anemia among pregnant women is associated with increased risk of maternal mortality, low birth weight, preterm birth, perinatal mortality and neonatal mortality as well as occurrence of anemia for the child (3,4) (5,6). It also affects cognitive development in children, reduces work abilities for affected women, and is ultimately associated with increased healthcare expenditures (2,7,8).

Anemia disproportionately affects developing countries, with Asian and Sub-Saharan African countries bear 89% of the anemia burden (1). Over 38% of all WRA in the African Region are anemic (2), with significant variations between countries; in some African countries, anemia among WRA is above 50% (9).

Rwanda has made progress to improve maternal health. However, anemia among WRA is still a burden. The recent Demographic and Health Survey (DHS) report showed that anemia among WRA in Rwanda is estimated to be 19.2% (10). Although it is still considered as a mild public health problem according to WHO criteria (11), the prevalence was on the rise from 17% in 2010 (10). Moreover, in 11 of Rwanda’s 30 districts, the prevalence of anemia among WRA is much higher than the national average, with some districts even reached over 30% (10,12,13).

Such increase in prevalence and disparity across subgroups and regions suggested that, if unaddressed, the problem will grow despite current efforts made to improve the health of
the population. Understanding the risk factors for anemia is crucial for the development of innovative and evidence-based interventions to reduce its prevalence nationwide. However, the few studies that have been conducted in Rwanda to identify risk factors for anemia were restricted to children or only a subset of WRA such as women living with Human Immunodeficiency Virus infection or young women (18—27 years old); such studies lack national representation and also had inconsistent and conflicting results (13–18). This study was carried out to identify the risk factors of anemia among WRA in Rwanda using nationally representative RDHS data in order help identify specific interventions to reduce the prevalence of anemia among WRA.

Methods

Study setting

Rwanda is a land-locked African country with an estimated population of 10,515,973 in 2012, of which 51.8% are female. Around 48.55% of all female are women of reproductive age—defined as all women aged 15–49 years (19). The country is characterized by rapid population growth (2.6% annually?) and a GDP per capita of 702.84 USD (19,20). Rwanda has demonstrated marked improvement in maternal health over the past 20 years (21). The Total Fertility Rate was 4.2 (down from 6.1 in 2005), and the maternal mortality rate was 210 per 100,000 live births, reduced from 1071 in 2000. Ninety-nine percent (99%) of women attend at least one antenatal care session, and 91% deliver at health facilities. The contraceptive prevalence rate is estimated at 53% (10).

Study design:

A secondary analysis was conducted using the 2014–2015 Rwanda Demographic and Health Survey (RDHS) data.

Sampling and Data Collection Method

The 2014–15 RDHS data were collected using standard DHS questionnaires, which were
adapted by stakeholders from the Rwandan government and its partners to include questions on specific issues related to the Rwandan social and cultural context. All questionnaires were translated from English to Kinyarwanda and were pre-tested prior to actual data collection. The data collection was conducted by qualified and trained professionals with rigorous supervision. Sampling was based on the 2012 Rwanda Population and Housing Census (RPHC) which consists of a list of villages, considered enumeration areas (EAs). They were stratified by type of residence (rural or urban) in each district, and 60 sampling strata were created from all districts. A two-stage cluster sampling design was used to ensure that estimates were representative at national level. At the first stage, 492 EAs were selected from all sampling strata (113 from urban areas and 379 from rural areas), and then, systematic sampling strategy was carried out by first listing all households in selected EAs. At the second stage, 26 households were randomly selected from each EA, resulting in 12,792 households total. Anemia was tested for in half of the households selected for the general survey, and this resulted in a representative sample of 6680 eligible women tested (10). On-site hemoglobin analysis was conducted to test for anemia using a battery-operated portable HemoCue analyzer, and results were adjusted for altitude and for smoking status (if known) using the recommended Centers for Disease Control and Prevention (CDC) formula (10). Our study analyzed all WRA in RDHS with anemia test results.

Variables

Dependent variables

Our dependent variable was anemia status at the time of the survey. Pregnant women with hemoglobin level equal to or below 10.9 g/dl and non-pregnant women with hemoglobin level equal to or below 11.9 g/dl were considered anemic. Moreover, the other
anemia operational definitions were considered where pregnant women and non-pregnant women with hemoglobin level between 10.0–10.9 g/dl and 10.0–11.9 g/dl respectively were considered to have mild anemia; women with hemoglobin level between 7.0–9.9 g/dl and less than 7.0 g/dl were considered to have moderate and severe anemia, respectively.

**Independent variables**

Based on previous literature and biological knowledge, the independent variables included: social and demographic characteristics (age of the respondent, province of residence, type of residence—rural or urban, educational attainment, economic status, union/marital status), variables related to reproductive health and mother health status (pregnancy status, number of children ever born from the women, breastfeeding status, body mass index, use of family planning method). We also include variables related to access to information (frequency of reading newspaper or magazine, listening to radio, and watching television), and variables related to living conditions (including having the toilet facility in the household, main source of drinking water for the household, having mosquito bed net for sleeping, respondent sleeping under mosquito bed net the night before the survey, and respondent considering distance to health facility as a problem).

**Data access and analysis**

The RDHS data were downloaded from the DHS program website in STATA format after the approval from the DHS program. We conducted descriptive analyses to summarize the anemia status according to the independent variables. Pearson’s chi-squared test was used to assess the association between anemia status and other independent variables. To identify factors associated with anemia among WRA in Rwanda, all significant variables in bivariate analysis were further analyzed using multivariate analysis with backward stepwise logistic regression, after checking collinearity. A variable was removed from the
full model when it was not statistically significant at p = 0.05. Marital status and age were maintained in the model to adjust for given their influence on other variables. Sampling weights were included in all analyses to adjust for the effects of the stratification and cluster sampling approaches used in RDHS. Odds Ratios (OR), 95% confidence intervals (CI) and p-values were reported. Data were analyzed using STATA version 14.2 (StataCorp Lakeway Drive College Station, Texas).

Results

Socio-demographic characteristics

A total of 6680 women were included in the analysis. The mean age was 28.6 years (SD: 9.4). Among the samples, 1386 (20.7%) were within the age group 15–19 years old while 1,225 (18.3%) were 20—24 and 1,153 (17.3%) were 25–29 years old. Around 24.6% (1646) of the participants were from the Eastern province, 21.6% (1442) were from the Western province, 24% (1605) were from the Southern province, 16.3% (1088) were from the Northern province and 13.5% (899) were from Kigali city. The highest education level achieved varied, with 2863 (42.9%) having completed primary school and only 184 (2.8%) having education above secondary education. More than half (n = 3434, 51.4%) of the women were married or living together with their husbands; 2622 (39.3%) were in poor economic status, 1249 (18.7%) were in middle class and 2809 (42.1%) were in rich class (Table 1).

Anemia status

The mean Haemoglobin (Hb) level across the sample, adjusted for altitude and smoking status, was 13.02 g/dl (SD: 1.52), translating to a 19.2% anemia prevalence among WRA (95% CI: 18.0 - 20.5). Most cases were of mild anemia, with a prevalence of 15.7% (95% CI: 14.6 - 16.8); 3.4% (95% CI: 2.9 - 3.9) were moderate anemia, and 0.2% (95% CI: 0.1 - 0.3) were severe anemia.
The anemia prevalence was found to be higher among women aged 45—49 years (24.2%, 95% CI: 20.3 - 28.1), among those aged 40—44 years (19.7%, 95% CI: 16.7 - 23.2), in the Southern province (22.9%, 95% CI: 20.4 - 25.6), in the Eastern province (21.8%, 95% CI: 18.9 - 25.0), among women in the poor category (22.5%, 95% CI: 20.6 - 24.5), among women with no education (22.5%, 95% CI: 19.5 - 25.8), who were separated from their husbands or widowed (24.8%, 95% CI: 21.4 - 28.5), who were underweight (26.3%, 95% CI: 22.0 - 31.1), those who did not sleep under a mosquito net (21.5%, 95% CI: 19.5 - 23.6), and among women who were using Intra-Uterus Devices (IUDs) as a contraceptive method (29.1%, 95% CI: 19.2 - 41.5) (Table 1).

Anemia prevalence was relatively low among those who completed secondary school (15.9%, 95% CI: 12.1 - 20.7) and primary school (16.8%, 95% CI: 14.8 - 19.1), as well as among women in the rich category (16.4%, 95% CI: 14.9 - 18.0).

The bivariate analysis found 11 variables were significantly associated with anemia: 1) province of residence (p = <0.001), 2) educational attainment (p = 0.010), 3) economic status (p = <0.001), 4) marital status (p = 0.001), 5) pregnancy status (p = 0.019), 6) type of FP method used (p = <0.001), 7) nutrition status (p = <0.001), 8) have a mosquito bed net for sleeping (p = 0.020), 9) sleeping under a mosquito bed net the night before the survey (p = 0.003), 10) type of toilet facility used in the household (p = 0.003), and 11) type of residence (p = 0.010) (Table 1).

Factors associated with anemia

Six risk factors for anemia among WRA adjusted for age and marital status were found in the multivariate analysis, they were: 1) the nutrition status, 2) economic status, 3) type of contraceptive method used, 4) use of a mosquito net, 5) marriage status, and 6) province of residence (Table 2).

Compared to WRA with normal BMI, underweight women were more likely to have anemia
(OR: 1.39, 95% CI: 1.09 - 1.77, p value = 0.009) while obese women were less likely to have anemia (OR: 0.61, 95% CI: 0.41 - 0.92, p value = 0.019).

Compared to women in poor category, women in the rich category were less likely to have anemia (OR: 0.74, 95% CI: 0.63 - 0.87, p value <0.001). There was a marginally significant difference in the likelihood of having anemia between women in the poor category and women in the middle category (OR: 0.83, 95% CI: 0.69—1.00, p value = 0.044).

Women who were using hormonal contraceptives were less likely to have anemia (OR: 0.60, 95% CI: 0.50 - 0.72, p value: <0.001) while those who were using Intrauterine Devices were more likely to have anemia (OR: 1.97, 95% CI: 1.04 - 3.73, p value = 0.037) compared to those who were not using any contraceptive method or who were using natural barriers or permanent contraceptive methods.

Compared to women who were not married, women who were separated or widowed were more likely to have anemia (OR: 1.35, 95% CI: 1.09 - 1.67, p = 0.006). There was no difference between married and non-married women (p = 0.25).

Women who reported sleeping under a mosquito net the night before the survey were less likely to have anemia (OR: 0.85, 95% CI: 0.73 - 0.98, p value = 0.025) than those who did not sleep under a mosquito net the night before the survey. Additionally, women who were living in Southern province (OR: 1.45, 95% CI: 1.15 - 1.82, p value = 0.002) and in Eastern province (OR: 1.41, 95% CI: 1.11 - 1.79, p value = 0.005) were more likely to be have anemia than were WRA living in Kigali city.

Discussion

According to the analysis, the prevalence of anemia among WRA in Rwanda was 19.2%. Although lower than many other countries in the Sub-Saharan Africa region (2,9), it is still a public health problem according to WHO criteria (22). In addition, the prevalence had increased from previous years and varied across population subgroups (10,23).
Similar to study results in other settings including Ethiopia and Pakistan, our analysis found that poor and undernourished women are more likely to have anemia (24, 25). Anemia is a multifaceted problem where nutrition and economic status work in synergy. Evidence suggested that improved economic status was associated with appropriate nutrition conditions (26), lower infection morbidity (25), increased access to health services as well as other favourable living conditions (26, 27), all of which influence anemia. Malnourished women have greater risk of iron deficiency - the most common proximate cause of anemia (1) and they are mostly associated with poor socio-economic status (28). Interventions that aim to empower women economically should be considered in order to positively impact anemia. Moreover, malnutrition management programs should ensure sustained effort for supplementation of iron.

In this study, the use of hormonal contraceptives was associated with lower risk of anemia among WRA, while the use of IUDs was associated with higher risk. Using hormonal contraceptive can be resulted in less bleeding during the menstruation, which ultimately reduces blood loss over time (29, 30); similar findings were seen in other studies conducted in 14 different low- and middle-income countries including Tanzania and Ethiopia (31) (24)(32). Another study conducted in seven countries also found that hormonal contraceptive users had higher haemoglobin and ferritin levels compared to non-users (33).

A study conducted in Pakistan also observed higher anemia risk among IUD users (34). IUD may increase uterine blood flow, menstruation bleeding and the duration of menstruation periods especially during the first months of usage, which in turn increase the likelihood of anemia (35)(36). In addition, some research has found that IUD users have a reduction in hemoglobin content and iron saturation/ ferritin levels, which may trigger or worsen existing anemia (33,37). While more investigations are needed to understand the real
physiological mechanisms, our study findings supported existing evidence that IUD use is among the risk factors of anemia in WRA. Clinical guidelines should take into consideration bleeding treatments (38) as well as iron supplementation as an additional option for IUD users especially during the first months of usage. Geographic area of residence was found to be associated with anemia, with women in the Eastern and Southern provinces being more likely to have anemia. The Eastern and Southern provinces in Rwanda are considered to be high malaria endemic provinces, and thus people living in those areas are likely to be affected by malaria, which is itself considered to be among anemia risk factors (39). Similar associations between anemia and geographic location were found in another study in Tanzania (31). In Rwanda, iron supplementation during pregnancy is less commonly used in the Eastern province than in other provinces (10). While further investigations are needed to better understand why, interventions that aim to address anemia, including iron supplementation and promotion of foods rich in iron and other micronutrients, as well as interventions to prevent malaria (12,40), should consider geographic variations and prioritized the most affected areas. Consistent to the results from other studies, sleeping under mosquito nets was associated with lower likelihood of anemia in our study, as malaria is a risk factor of anemia (41). As mosquito nets coverage and usage remain challenges in many developing countries (42,43)(44), malaria prevention strategies including, efforts to ensure the availability as well as proper use of mosquito nets in the community should be integrated in anemia programs. Marital status was found to be a risk factor for anemia, with widowers or women separated with husband being more likely to have anemia. Traditionally men are breadwinners in most developing societies (45). Many widows and women separated from their husbands face social and economic challenges, and those challenges may worsen when they lack
support to sustain their families, predisposing them to economic deprivation, poverty, malnutrition and poor access to health services (26–28). In addition, our analysis showed a correlation between marital status and age \((r = 0.63)\). Older age was found to be associated with anemia in some studies (24). While further investigations are needed to better understand the possible associations between marital status, age and anemia status, our findings suggest that old women, especially widows, may face many other health problems that are understudied. Special attention and priority should be provided to this vulnerable group.

Our study found samples with lower education levels had slightly higher prevalence of anemia, although statistical significance was not found. Other studies have found education level as a risk factor of anemia (24,31). The differences in settings of the studies could be related to the discrepancy. in the 2014/2015 Rwanda DHS, only 19 percent of women had no education; while 67 percent were reported in Ethiopia in 2005 and 27 percent in Tanzania in 2010 (10,46,47), the variation in the sample composition could have affected the analysis outcome.

This study successfully identified some risk factors among WRA in Rwanda and proposed some recommendation. However, the results must be seen in light of some limitations. This study could only variables that were in the DHS, due to the nature of secondary data analysis. Qualitative information could provide more insights into the risk factors of anemia in Rwandan community, leading to improved understanding of the attitudes and practices related to variations in food consumption patterns. However, the DHS survey used a national representative sample and was conducted with standardized quality assurance measures in both data collection and management to ensure reliability and validity of the results (48,49), that could improve the generalizability of the results of our analysis.
Conclusions

In order to address anemia among WRA in Rwanda, programs that improve women’s economic livelihoods, and malnutrition. Furthermore, clinical guidelines should ensure that women using IUDs as contraceptive methods have access to bleeding treatments as well as iron supplementation. Special attention should be provided based on geographic variations. Integrating malaria prevention strategies into anemia program should also be considered.

Abbreviations

CI: Confidence Interval; Hb: Hemoglobin; FP: Family Planning; OR: Odds Ratio; RDHS: Rwanda Demographic and Health Survey; WHO: World Health Organization; WRA: Women of Reproductive Age.

Declarations

Acknowledgements

The authors thank Dr. Michael Law, Associate Professor from the University of British Columbia - School of Population and Public Health and Dr. Vedaste Ndahindwa, Lecturer from the University of Rwanda—School of Public Health, for their guidance and support on this study. In addition, the authors thank the faculty from the University of Rwanda for their support during the courses. Furthermore, the authors also thank the MEASURE DHS Project for availing open access to the data.

Authors’ contributions

DH designed the project, acquired the data, conducted the literature review, wrote the manuscripts, and was responsible to submit it. DH and MN conducted the statistical analysis. RW and JL provided overall advisory on the project and manuscript revision. All authors reviewed and approved the final manuscript.
Funding
No funding received for this study

Availability of data and materials
The data used for this study are from the Rwanda Demographic and Health surveys (DHS) and are publicly available here: https://dhsprogram.com/data/available-datasets.cfm.

Ethics approval and consent to participate
Since this study was a secondary analysis of the Rwanda Demographic and Health surveys (RDHS) data, which are publicly available, the study did not require any ethics approval. Only DHS program authorization was requested to download the dataset.

Consent for publication
Being a secondary analysis, no consent to publish was needed for this study. There was no identifiable data.

Competing interests
No competing interests by the authors

Authors’ information
1Lecturer, Bill and Joyce Cummings Institute of Global Health - University of Global Health Equity (UGHE)
Kigali Heights, Plot 772, KG 7 Ave., 5th Floor, PO Box 6955, Kigali—Rwanda

2Doctoral Fellowship in Population and Public Health (PhD)
The University of British Columbia - School of Population and Public Health

3Executive Education - University of Global Health Equity (UGHE)
Kigali Heights, Plot 772, KG 7 Ave., 5th Floor, PO Box 6955, Kigali—Rwanda

4Associate Professor, Bill and Joyce Cummings Institute of Global Health - University of
Corresponding author:

Correspondence to Dieudonne Hakizimana—dieudonnehakiziman@gmail.com or dhakizimana@ughe.org

References

1. Kassebaum N on behalf of G 2013 AC. The Global Burden of Anemia. Hematol Oncol Clin North Am [Internet]. 2016;30(2):247-308. Available from: http://dx.doi.org/10.1016/j.hoc.2015.11.002

2. World Health Organization. The Global Prevalence of Anaemia in 2011. WHO Rep [Internet]. 2015;48. Available from: http://apps.who.int/iris/bitstream/10665/177094/1/9789241564960_eng.pdf?ua=1

3. Daru J, Zamora J, Fernández-Félix BM, Vogel J, Oladapo OT, Morisaki N, et al. Risk of maternal mortality in women with severe anaemia during pregnancy and post partum: a multilevel analysis. Lancet Glob Heal. 2018;6(5):e548-54.

4. Frass KA. Postpartum hemorrhage is related to the hemoglobin levels at labor: Observational study. Alexandria J Med. 2015;51(4):333-7.

5. Rahman MM, Abe SK, Rahman MS, Kanda M, Narita S, Bilano V, et al. Maternal anemia and risk of adverse birth and health outcomes in low- and middle-income countries: systematic review and meta-analysis. Am J Clin Nutr [Internet]. 2016;103(2):495-504. Available from: http://www.ncbi.nlm.nih.gov/pubmed/26739036

6. Ntenda PAM, Nkoka O, Bass P, Senghore T. Maternal anemia is a potential risk factor for anemia in children aged 6—59 months in Southern Africa: a multilevel analysis.
7. Haas JD, Brownlie T. Iron deficiency and reduced work capacity: a critical review of the research to determine a causal relationship. J Nutr [Internet]. 2001;131(2S-2):676S–688S; discussion 688S–690S. Available from: http://www.ncbi.nlm.nih.gov/pubmed/11160598

8. Smith RE. The clinical and economic burden of anemia. Am J Manag Care [Internet]. 2010;16 Suppl I:S59–66. Available from: http://www.ncbi.nlm.nih.gov/pubmed/20297873

9. Stevens GA, Finucane MM, De-Regil LM, Paciorek CJ, Flaxman SR, Branca F, et al. Global, regional, and national trends in haemoglobin concentration and prevalence of total and severe anaemia in children and pregnant and non-pregnant women for 1995–2011: A systematic analysis of population-representative data. Lancet Glob Heal. 2013;1(1).

10. National Institute of Statistics of Rwanda (NISR), Ministry of Health (MOH) [Rwanda] and II. Rwanda Demographic and Health Survey 2014–15 Final Report. Rockville, Maryland, USA: NISR, MOH, and ICF International; 2015.

11. McLean E, Cogswell M, Egli I, Wojdyla D, de Benoist B. Worldwide prevalence of anaemia, WHO Vitamin and Mineral Nutrition Information System, 1993–2005. Public Heal Nutr [Internet]. 2009;12(4):444–54. Available from: http://whqlibdoc.who.int/publications/2008/9789241596657_eng.pdf

12. Haas JD, Luna S V., Lung’aho MG, Wenger MJ, Murray-Kolb LE, Beebe S, et al. Consuming Iron Biofortified Beans Increases Iron Status in Rwandan Women after 128 Days in a Randomized Controlled Feeding Trial. J Nutr [Internet]. 2016;146(8):1586–92. Available from: http://jn.nutrition.org/cgi/doi/10.3945/jn.115.224741

13. Masaisa F, Gahutu JB, Mukiibi J, Delanghe J, Philippé J. Anemia in human
immunodeficiency virus-infected and uninfected women in Rwanda. Am J Trop Med Hyg. 2011;84(3):456–60.

14. Kateera F, Ingabire CM, Hakizimana E, Kalinda P, Mens PF, Grobusch MP, et al. Malaria, anaemia and under-nutrition: Three frequently co-existing conditions among preschool children in rural Rwanda. Malar J. 2015;14(1).

15. Danquah I, Gahutu JB, Zeile I, Musemakweri A, Mockenhaupt FP. Anaemia, iron deficiency and a common polymorphism of iron-regulation, TMPRSS6 rs855791, in rwandan children. Trop Med Int Heal. 2014;19(1):117–22.

16. Donahue Angel M, Berti P, Siekmans K, Tugirimana PL, Boy E. Prevalence of Iron Deficiency and Iron Deficiency Anemia in the Northern and Southern Provinces of Rwanda. Food Nutr Bull. 2017;38(4):554–63.

17. Murray-Kolb LE, Wenger MJ, Scott SP, Rhoten SE, Lung’aho MG, Haas JD. Consumption of Iron-Biofortified Beans Positively Affects Cognitive Performance in 18- to 27-Year-Old Rwandan Female College Students in an 18-Week Randomized Controlled Efficacy Trial. J Nutr [Internet]. 2017 [cited 2019 Aug 30];jn255356. Available from: https://doi.org/10.3945/jn.117.255356.

18. National Institute of Statistics of Rwanda. Fourth Population and Housing Census, Rwanda, 2012 Final Results, Main indicators report [Internet]. Kigali; 2014. Available from: http://www.lmis.gov.rw/scripts/publication/reports/Fourth_Rwanda_Population_and_Housing_Census_Housing.pdf

19. The World Bank Group. GDP per capita (current US$) | Data [Internet]. 2017. 2017 [cited 2019 Jan 9]. Available from: https://data.worldbank.org/indicator/NY.GDP.PCAP.CD

20. Binagwaho A, Farmer PE, Nsanzimana S, Karema C, Gasana M, de Dieu Ngirabega J, et al. Rwanda 20 years on: investing in life. Lancet [Internet]. 2014 Jul
26;384(9940):371–5. Available from:
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4151975/

21. World Health Organization. Worldwide prevalence of anaemia 1993–2005. WHO
Global Database on Anaemia [Internet]. World Health Organization. 2008. Available
from: http://whqlibdoc.who.int/publications/2008/9789241596657_eng.pdf?ua = 1

22. NISR - MOH and ICF International. Rwanda Demographic and Health Survey 2010.
2011.

23. Gebremedhin S, Enquselassie F. Correlates of anemia among women of reproductive
age in Ethiopia: Evidence from Ethiopian DHS 2005. Ethiop J Heal Dev.
2011;25(1):22–30.

24. Soofi S, Khan GN, Sadiq K, Ariff S, Habib A, Kureishy S, et al. Prevalence and possible
factors associated with anaemia, and vitamin B 12 and folate deficiencies in women
of reproductive age in Pakistan: analysis of national-level secondary survey data. BMJ
Open [Internet]. 2017;7(12):e018007. Available from:
http://bmjopen.bmj.com/lookup/doi/10.1136/bmjopen–2017–018007

25. Apouey BH. Health policies and the relationships between socioeconomic status,
access to health care, and health. Isr J Health Policy Res. 2013;2(1):1–2.

26. Arpey NC, Gaglioti AH, Rosenbaum ME. How Socioeconomic Status Affects Patient
Perceptions of Health Care: A Qualitative Study. J Prim Care Community Health. 2017;

27. Mawani M, Aziz Ali S. Iron Deficiency Anemia among Women of Reproductive Age, an
Important Public Health Problem: Situation Analysis. Reprod Syst Sex Disord
[Internet]. 2016;5(3):1–6. Available from: https://www.omicsonline.org/open-
access/iron-deficiency-anemia-among-women-of-reproductive-age-an-important-
public-health-problem-situation-analysis–2161–038X–1000187.php?aid = 78570

28. Hillard PA. Menstrual suppression: Current perspectives. Int J Womens Health.
29. Miller L, Hughes JP. Continuous combination oral contraceptive pills to eliminate withdrawal bleeding: a randomized trial. Obstet Gynecol [Internet]. 2003 Apr [cited 2018 Jul 8];101(4):653–61. Available from: http://www.ncbi.nlm.nih.gov/pubmed/12681866

30. Wilunda C, Massawe S, Jackson C. Determinants of moderate-to-severe anaemia among women of reproductive age in Tanzania: Analysis of data from the 2010 Tanzania demographic and health survey. Trop Med Int Heal. 2013;18(12):1488–97.

31. Bellizzi S, Ali MM. Effect of oral contraception on anemia in 12 low- and middle-income countries. Contraception [Internet]. 2018;97(3):236–42. Available from: https://doi.org/10.1016/j.contraception.2017.11.001

32. Bathija H, Lei ZW, Cheng XQ, Xie L, Wang Y, Rugpao S, et al. Effects of contraceptives on hemoglobin and ferritin. Contraception. 1998;

33. Khan R, Jamil S. Hematologic variations associated with the long term use of contraceptives in young females. Vol. 2, American Journal of Phytomedicine and Clinical Therapeutics. 2014. 580-586 p.

34. Fouda UM, Yossef D, Gaafar HM. Uterine artery blood flow in patients with copper intrauterine device-induced abnormal uterine bleeding. Middle East Fertil Soc J [Internet]. 2010;15(3):168-73. Available from: http://dx.doi.org/10.1016/j.mefs.2010.07.003

35. Turok DK, Gawron L, Steele K, Storck K BH. Tracking IUD Bleeding Experiences (TRIBE): A prospective evaluation of bleeding profiles among new IUD users. Contraception. 2016.

36. Hassan EO, El-Husseini M, El-Nahal N. The effect of 1-year use of the Cu-T 380a and oral contraceptive pills on hemoglobin and ferritin levels. Contraception. 1999;
37. Godfrey EM, Folger SG, Jeng G, Jamieson DJ, Curtis KM. Treatment of bleeding irregularities in women with copper-containing IUDs: A systematic review. Contraception. 2013.

38. Castelli F, Sulis F, Caligaris S. The relationship between anaemia and malaria: Apparently simple, yet controversial. Trans R Soc Trop Med Hyg. 2014;108(4):181-2.

39. Wang Z, Sun J, Wang L, Zong M, Chen Y, Lin Y, et al. [Effect of iron supplementation on iron deficiency anemia of childbearing age women in Shanghai]. Wei Sheng Yan Jiu [Internet]. 2012 Jan [cited 2019 Aug 22];41(1):51–5. Available from: http://www.ncbi.nlm.nih.gov/pubmed/22443058

40. Ouma P, Van Eijk AM, Hamel MJ, Parise M, Ayisi JG, Otieno K, et al. Malaria and anaemia among pregnant women at first antenatal clinic visit in Kisumu, western Kenya. Trop Med Int Heal. 2007;12(12):1515–23.

41. Larsen DA, Hutchinson P, Bennett A, Yukich J, Anglewicz P, Keating J, et al. Community coverage with insecticide-treated mosquito nets and observed associations with all-cause child mortality and malaria parasite infections. Am J Trop Med Hyg. 2014;91(5):950–8.

42. Ntonifor NH, Veyufambom S. Assessing the effective use of mosquito nets in the prevention of malaria in some parts of Mezam division, Northwest Region Cameroon. Malar J. 2016;15(1):1–8.

43. Korenromp, E. L., Miller, J., Cibulskis, R. E., Kabir, C. M., Alnwick, D. & Dye C. Monitoring mosquito net coverage for malaria control in Africa: possession vs. use by children under 5 years. Trop Med Int Health;8:693–703. 2003;8(8):693–703.

44. Sossou MA. Widowhood practices in West Africa: The silent victims. Int J Soc Welf. 2002;11(3):201-9.

45. National Bureau of Statistics (NBS) [Tanzania] and ICF Macro. Tanzania Demographic
and Health Survey 2016 [Internet]. Dar es Salaam, Tanzania: NBS and ICF Macro. 2011. Available from: http://www.measuredhs.com/pubs/pdf/FR243/FR243%5B24June2011%5D.pdf

46. Central Statistical Agency [Ethiopia] and ORC Macro. Ethiopia Demographic and Health Survey 2005 [Internet]. Addis Ababa, Ethiopia and Calverton, Maryland, USA: Central Statistical Agency and ORC Macro. 2006. Available from: http://www.measuredhs.com/pubs/pdf/FR179/FR179[23June2011].pdf

47. Corsi DJ, Neuman M, Finlay JE, Subramanian S V. Demographic and health surveys: A profile. Int J Epidemiol. 2012;

48. ICF International. Demographic and Health Surveys Sampling and Household Listing Manual. MEASURE DHS, Calverton, Maryland, USA. 2012.

**Tables**

Table 1: Prevalence of anemia per background characteristics

| Variables            | Anemia prevalence |
|----------------------|-------------------|
|                      | N     | %   | 95% CI |
| Sample size (weighted n=6680) | 1284  | 19.2 | [18.0 - 20.5] |
| Age categories       |       |     |       |
| 15-19 (n=1386)       | 260   | 18.8 | [16.6 - 21.2] |
| 20-24 (n=1225)       | 240   | 19.6 | [17.3 - 22.1] |
| 25-29 (n=1153)       | 208   | 18.1 | [15.9 - 20.5] |
| 30-34 (n=1024)       | 184   | 18   | [15.6 - 20.7] |
| 35-39 (n=795)        | 155   | 19.5 | [16.6 - 22.6] |
| 40-44 (n=614)        | 121   | 19.7 | [16.7 - 23.2] |
| 45-49 (n=482)        | 116   | 24   | [20.3 - 28.1] |
| Province             |       |     |       |
| Kigali city (n=900)  | 133   | 14.8 | [12.2 - 17.8] |
| South (n=1605)       | 367   | 22.9 | [20.4 - 25.6] |
| West (n=1442)        | 258   | 17.9 | [15.6 - 20.5] |
| North (n=1088)       | 167   | 15.4 | [13.1 - 17.9] |
| East (n=1646)        | 359   | 21.8 | [18.9 - 25.0] |
| Educational attainment |     |     |       |
| Complete primary (n=1452) | 244  | 16.8 | [14.8 - 19.1] |
| Incomplete primary (n=2863) | 580  | 20.3 | [18.5 - 22.1] |
| Economic Status                  | Incomplete secondary (n=1044) | Complete secondary (n=340) | Higher (n=184) | No education (n=798) |
|--------------------------------|-------------------------------|-----------------------------|----------------|----------------------|
| Poor (n=2622)                   | 589                           | 22.5                        | [20.6 - 24.5]  |                      |
| Middle class (n=1249)           | 235                           | 18.8                        | [16.3 - 21.7]  |                      |
| Rich (n=2809)                   | 460                           | 16.4                        | [14.9 - 18.0]  |                      |

| Marital status                  | Single (n=2543)               | Married/living together (n=3434) | Separated/widowed (n=703) |                      |
|--------------------------------|-------------------------------|---------------------------------|---------------------------|----------------------|
| Single (n=2543)                 | 485                           | 19.1                            | [17.4 - 20.8]  |                      |
| Married/living together (n=3434)| 625                           | 18.2                            | [16.7 - 19.8]  |                      |
| Separated/widowed (n=703)       | 174                           | 24.8                            | [21.4 - 28.5]  |                      |

| Currently pregnant             | No or unsure (n=6189)         | Yes (n=491)                     |                      |                      |
|--------------------------------|-------------------------------|--------------------------------|----------------------|----------------------|
| No or unsure (n=6189)           | 1170                          | 18.9                            | [17.7 - 20.2]  |                      |
| Yes (n=491)                     | 115                           | 23.4                            | [19.6 - 27.6]  |                      |

| Number of children ever born   | Had no child (n=2327)         | 1-3 children (n=2532)           | 4-6 children (n=1354) | 7 or more (n=467)   |
|--------------------------------|-------------------------------|---------------------------------|----------------------|---------------------|
| Had no child (n=2327)          | 456                           | 19.6                            | [17.9 - 21.4]  |                      |
| 1-3 children (n=2532)          | 472                           | 18.6                            | [17.0 - 20.4]  |                      |
| 4-6 children (n=1354)          | 259                           | 19.2                            | [17.0 - 21.6]  |                      |
| 7 or more (n=467)              | 97                            | 20.8                            | [17.1 - 25.2]  |                      |

| Currently breastfeeding        | No (n=4787)                   | Yes (n=1893)                    |                      |                      |
|--------------------------------|-------------------------------|--------------------------------|----------------------|----------------------|
| No (n=4787)                    | 919                           | 19.2                            | [17.8 - 20.6]  |                      |
| Yes (n=1893)                   | 366                           | 19.3                            | [17.4 - 21.4]  |                      |

| Type of contraceptive method used | None, natural, barriers or permanent (n=4572) | Hormonal (n=1565) | IUD (n=52) | Pregnant (n=491) |
|-----------------------------------|-----------------------------------------------|-------------------|-----------|-----------------|
| None, natural, barriers or permanent (n=4572) | 940                           | 20.6        | [19.1 - 22.1]  |                      |
| Hormonal (n=1565)                 | 215                           | 13.7        | [11.9 - 15.8]  |                      |
| IUD (n=52)                        | 15                            | 29.1        | [19.2 - 41.5]  |                      |
| Pregnant (n=491)                  | 115                           | 23.4        | [19.6 - 27.6]  |                      |

| Nutrition status/Body Mass Index | Normal (n=4774) | Underweight (n=411) | Overweight (n=1229) | Obese (n=258) |
|---------------------------------|-----------------|---------------------|---------------------|--------------|
| Normal (n=4774)                 | 912             | 19.1                | [17.8 - 20.5]  |              |
| Underweight (n=411)             | 108             | 26.3                | [22.0 - 31.1]  |              |
| Overweight (n=1229)             | 233             | 19                  | [16.7 - 21.5]  |              |
| Obese (n=258)                   | 30              | 11.6                | [8.1 - 16.4]   |              |

| Frequency of reading newspaper or magazine | Not at all (n=4916) | Less than once a week (n=1351) | At least once a week (n=403) |
|-------------------------------------------|-------------------|---------------------------------|-----------------------------|
| Not at all (n=4916)                        | 970               | 19.7                            | [18.3 - 21.2]  |                      |
| Less than once a week (n=1351)             | 235               | 17.4                            | [15.4 - 19.6]  |                      |
| At least once a week (n=403)               | 78                | 19.3                            | [15.5 - 23.8]  |                      |

| Frequency of listening to radio | Not at all (n=1079) | Less than once a week (n=1490) | At least once a week (n=4099) |
|--------------------------------|-------------------|---------------------------------|-----------------------------|
| Not at all (n=1079)             | 233               | 21.6                            | [18.8 - 24.7]  |                      |
| Less than once a week (n=1490)  | 292               | 19.6                            | [17.2 - 22.1]  |                      |
| At least once a week (n=4099)   | 759               | 18.5                            | [17.1 - 20.0]  |                      |

| Frequency of watching television | Not at all (n=3799) | Less than once a week (n=1760) | At least once a week (n=1107) |
|---------------------------------|-------------------|---------------------------------|-----------------------------|
| Not at all (n=3799)             | 755               | 19.9                            | [18.3 - 21.5]  |                      |
| Less than once a week (n=1760)  | 330               | 18.8                            | [16.8 - 20.9]  |                      |
| At least once a week (n=1107)   | 195               | 17.6                            | [15.3 - 20.1]  |                      |
| Variables                          | Full model | Final model |
|-----------------------------------|------------|-------------|
|                                   | OR        | 95% CI     | P-value | AOR | 95% CI |
| **Age categories**                |           |            |         |     |        |
| 15-19                             | 1         |            |         |     | 1      |
| 20-24                             | 1.13      | [0.90 - 1.42] | 0.285  |     |        |
| 25-29                             | 1.01      | [0.77 - 1.33] | 0.915  |     |        |
| 30-34                             | 1.02      | [0.76 - 1.37] | 0.871  |     |        |
| 35-39                             | 1.18      | [0.86 - 1.60] | 0.304  |     |        |
| 40-44                             | 1.07      | [0.77 - 1.49] | 0.669  |     |        |
| 45-49                             | 1.24      | [0.88 - 1.75] | 0.223  |     |        |
| **Nutrition status/Body Mass Index** |           |            |         |     |        |
| Normal                            | 1         |            |         |     | 1      |
| Underweight                       | 1.38*     | [1.08 - 1.78] | 0.011  | 1.39* | [1.09 - 1.77] |
| Overweight                        | 1.1       | [0.93 - 1.31] | 0.270  | 1.09 | [0.92 - 1.30] |

Table 2: Factors associated with anemia: multivariate analysis results (Logistic Regression)
|                                | Odds Ratio | 95% CI        | p-values   | Odds Ratio | 95% CI        |
|--------------------------------|------------|---------------|------------|------------|---------------|
| Obese                          | 0.60*      | [0.40 - 0.91] | 0.015      | 0.61*      | [0.41 - 0.92] |
| Economic Status                |            |               |            |            |               |
| Poor                           | 1          |               |            | 1          |               |
| Middle class                   | 0.83       | [0.69 - 1.01] | 0.057      | 0.83*      | [0.69 - 1.00] |
| Rich                           | 0.74**     | [0.61 - 0.89] | 0.002      | 0.74*      | [0.63 - 0.87] |
| Type of contraceptive method used |            |               |            |            |               |
| None - natural - barriers or permanent | 1          |               |            | 1          |               |
| Hormonal                       | 0.60*      | [0.49 - 0.73] | <0.001     | 0.60*      | [0.50 - 0.72] |
| IUD                            | 1.93*      | [1.01 - 3.68] | 0.045      | 1.97*      | [1.04 - 3.73] |
| Pregnant                       | 1.18       | [0.90 - 1.53] | 0.227      | 1.15       | [0.89 - 1.49] |
| Educational attainment         |            |               |            |            |               |
| No education                   | 1          |               |            | 1          |               |
| Incomplete primary            | 0.97       | [0.78 - 1.21] | 0.810      |            |               |
| Complete primary              | 0.81       | [0.64 - 1.03] | 0.087      |            |               |
| Incomplete secondary          | 0.99       | [0.74 - 1.32] | 0.929      |            |               |
| Complete secondary            | 0.89       | [0.61 - 1.30] | 0.545      |            |               |
| Higher                         | 1.35       | [0.88 - 2.08] | 0.171      |            |               |
| Respondent slept under mosquito bed net |            |               |            |            |               |
| No                             | 1          |               |            | 1          |               |
| Yes                            | 0.85*      | [0.74 - 0.98] | 0.031      | 0.85*      | [0.73 - 0.98] |
| Marital status                 |            |               |            |            |               |
| Single                         | 1          |               |            | 1          |               |
| Married/living together        | 1.07       | [0.86 - 1.34] | 0.537      | 1.11       | [0.94 - 1.30] |
| Separated/widowed              | 1.28       | [0.98 - 1.69] | 0.073      | 1.35*      | [1.09 - 1.67] |
| Type of toilet facility        |            |               |            |            |               |
| Nonimproved                    | 1          |               |            |            |               |
| Improved                       | 0.96       | [0.82 - 1.12] | 0.624      |            |               |
| Type of residence              |            |               |            |            |               |
| Urban                          | 1          |               |            |            |               |
| Rural                          | 0.97       | [0.79 - 1.18] | 0.745      |            |               |
| Province of residence          |            |               |            |            |               |
| Location      | Value  | CI        | p-value | Value  | CI        |
|--------------|--------|-----------|---------|--------|-----------|
| Kigali city  | 1      | 1         |         |        |           |
| South        | 1.52*  | [1.17 - 1.97] | 0.002   | 1.45*  | [1.15 - 1.82] |
| West         | 1.07   | [0.81 - 1.41] | 0.636   | 1.03   | [0.80 - 1.33] |
| North        | 0.95   | [0.71 - 1.28] | 0.756   | 0.92   | [0.70 - 1.20] |
| East         | 1.50*  | [1.15 - 1.95] | 0.003   | 1.41*  | [1.11 - 1.79] |

*: significant variables