Burden and determinants of under nutrition among young pregnant women in Ethiopia: A multivariable hierarchical regression analysis

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Abstract

Undernutrition is a major public health concern due to its association with mortality and disease burden of women and children. This study aimed at identifying the extent and determinants of undernutrition among young pregnant women in Ethiopia. A multivariable regression analysis was fitted to identify determinants of acute malnutrition (MUAC <23cm) and anemia (hemoglobin <11g/dl) in a sample of 1,393 pregnant women. Risk ratios with 95% confidence interval were estimated. The multiple coefficient of determination (R^2) was used to measure the percentage of variance explained. All the analyses were performed using STATA version 14 and adjusted for clustering. The study revealed that 38% of the women were undernourished and 22% were anaemic. Improved maternal education (RR=0.94, 95% CI: 0.89, 0.98), higher wealth status (RR=0.67, 95% CI: 0.47, 0.95), protected water source (RR=0.93, 95% CI: 0.86, 0.96) and ASF consumption (RR=0.85, 95% CI: 0.77, 0.94) decreased the risk of acute malnutrition. Higher MDDW decreased both the risk acute malnutrition (RR=0.87, 95% CI: 0.77, 0.98) and anemia (RR=0.95, 95% CI: 0.88, 0.98). Maternal illness during pregnancy (RR=1.20, 95% CI: 1.09, 1.33) and short stature (RR=1.71, 95% CI: 1.45, 2.02) increased risk of acute malnutrition while using unimproved toilet (RR=1.31, 95% CI: 1.06, 1.63) and depression (RR=1.33, 95% CI: 1.14, 1.55) increased risk of anemia. The burden of undernutrition is still high while improved socio-economic status and dietary practices have decreased the risk of undernutrition. Poor health and environmental conditions were still significant risk factors for maternal undernutrition in young pregnant women.

Key words: undernutrition, anemia, adolescent pregnancy, pregnant women, Ethiopia, ENGINE

Key messages:

- The burden of undernutrition in young pregnancies is still high in Ethiopia
- Improved socio-economic and educational statuses shown to protect against undernutrition in young pregnancies implying targeting social determinants through educational and economic empowerment of women may result in positive outcomes.
- Optimal dietary practices by dietary diversification and consumption of animal source foods also shown to protect against undernutrition.
- Pregnancy at adolescence, poor health and environmental condisions increased the risk of undernutrition.
- Prevention of early marriage and pregnancy, improving access to safe water and toilet can also help prevent undernutrition among young pregnant women.

Introduction

Maternal undernutrition remains an important public health condition in low and middle-income countries (LMICs) (Black et al., 2008). Women of reproductive age, especially pregnant women, in developing countries are recognized to be at risk of poor nutritional status including multiple micronutrient deficiencies, with a high risk of adverse effects on the mother and pregnancy outcomes (Black et al., 2010). Marriage for girls, before or very shortly after puberty, is common in Africa and South Asia curtailing their growth process. Nearly two thirds of women in sub-Saharan Africa and in several countries of south Asia have their first child before the age of 20 years (Rah et al., 2008). Evidence shows that in these settings chronic undernutrition can also delay physical maturation and extend the adolescent growth period beyond 20 years of age (Chulani & Gordon, 2014). The adverse nutritional status in this group is mainly due to adverse environmental conditions, low socioeconomic status and poor diets (Black et al., 2008; Lindsay, Gibney, & McAuliffe, 2012; Pheak Chhoun et al., 2016). Their poor nutritional practices result in nutrient deficiencies, and subsequently obstetric and nutritional complications (Lindsay et al., 2012).

The spectrum of nutritional problems among pregnant women in LMICs encompasses the entire range of acute and chronic malnutrition and micronutrient deficiencies (B, 2013; Black et al., 2008; Nguyen et al., 2017). These nutritional problems worsen when the pregnancy is during adolescence. An undernourished woman is likely to give birth to an undernourished child, causing the cycle of undernutrition to be repeated over generations (Leary, 2005; Prentice et al., 2013; United Nations, 1993). Factors at individual, household and community level, or a combination thereof are responsible for women being vulnerable to undernutrition throughout their lives (Lindsay et al., 2012; Nguyen et al., 2017; Pheak Chhoun et al., 2016). Pregnant women in Ethiopia, like in many other LMICs, suffer from a range of nutritional problems. Despite tremendous efforts being put in place, the burden of maternal undernutrition remained high as 27% of them are chronically malnourished (Central Statistical Agency, Ethiopia ICF International Calverton, Maryland, USA, 2012) and 32% of pregnant women were anemic (Kassa, Muche, Berhe, & Fekadu, 2017). Understanding the level and wide range of determinants of undernutrition in pregnant women is hence important in designing focused interventions. The present study is therefore aimed at identifying the extent and socio-demographic, dietary and health related determinants of undernutrition during pregnancy among young and pregnant women in Ethiopia. Determinants of both acute malnutrition and anemia will be examined and help identify important set of determinants to be targeted by interventions focusing on range of indicators of nutritional status in young and pregnant women.

Methods

Study setting, design and sample

Baseline data of the USAID Empowering New Generation in Nutrition and Economic opportunities (ENGINE) birth cohort study, which was conducted from January 2014 to March 2016 in the Oromia region of Ethiopia were used in the present study. Oromia was selected purposively being the largest region in the country targeted by USAID ENGINE. The three districts, namely Goma, Woliso and Tiro Afeta were further selected from the region based on (i) an expected population of more than 3,000 pregnant women so that we can account for loss to follow up, (ii) geographical similarities in agro-ecology and agricultural production practices and (iii) proximity and accessibility. Administratively, each district is further sub-divided into units called kebeles, which were the study clusters. All recruitment took place at the kebele level.

Trained data collectors who were nurses by profession, conducted a house-to-house active surveillance to recruit the study participants with support from the kebele health extension workers. Upon identification, pregnant women who were in their second and third trimester were invited to enroll in the study after receiving informed consent. From the original cohort, 1,393 who were 15-24 years old and for whom mid upper arm circumference (MUAC) and anemia measured were included in the present study.

Data quality control

Enumerators and supervisors were given adequate training on each item of the data collection tool and how to take all the measurements needed in the study using practical applications through role playing. A three days long pretesting was also conducted in order to ensure correct administration of questions and taking measurements among the enumerators before commencing actual data collection. Electronic data collection method was applied by using Android tablet computers to minimize errors in data collection and entry. The collected data was checked by the supervisors in regular basis before the data was sent to a centrally located server. Additionally, a data manager regularly checked completeness and consistency and took back mistakes and incomplete data to the field to be corrected.

Measurements

Data on household characteristics, socio-economic and demographic information, antenatal exposures, dietary data and household food security status were collected using a structured, pre-tested, interviewer administered questionnaire using an Android tablet computer at recruitment.

Maternal height was measured using a stadiometer (Weigh and Measure LCC, USA) to the nearest 0.1 cm with the women wearing no shoes. MUAC of the women was measured on the left arm using mid-way between the olecranon and acromion processes using a non-elastic MUAC tape (SECA 201, Germany) (Cogill, Bruce, 2003). A cut off of below 23 cm was used to identify acutely malnourished women using MUAC (Tang et al., 2013). Individual minimum dietary diversity for women (MDDW) was constructed based on data from a 24-hr qualitative dietary recall interview and according to the standard guideline (FAO and FHI 360, 2016). The MDDW ranged from 0 to 10 points and each point represents one food group. Women with MDDW <5 were considered to have lower micronutrient adequacy. Animal source food (ASF) consumption was constructed by counting consumption of animal source products (flesh foods, egg and dairy products) and a women who consumed either of these food products were considered to be a consumer. A wealth index was constructed using the principal components analysis based on information on housing conditions, ownership of assets and availability of basic services (Filmer & Pritchett, 2001). Maternal depression was assessed using Patient Health Questionnaire (PHQ9). The possible score ranged from 0-25 and women with mild to severe depression were all classified as having depression (Kroenke, 2012). HemoCue Hb 201 DM system was used to determine hemoglobin level and later anemia estimates were adjusted for altitude and trimester using standard methods (Cohen & Haas, 1999). Women with hemoglobin level <11g/dl were labeled as anemic (Daru et al., 2018; WHO, 2011).

Conceptual model: blocks and variables

Variables were grouped into three different blocks based on a proposed conceptual framework for promoting maternal nutrition (**Figure 1**). The first block included *socio-demographic and environmental characteristics* (maternal age, parity, maternal education, wealth index, toilet type and source of drinking water). The second one included variables on *maternal health status* (illness during pregnancy and antenatal depression). The third block focused on *nutritional and antenatal exposures* (dietary diversity score for women, animal source food consumption, iron-folic acid supplement, maternal height, deworming, ANC follow-up). The outcome variables were maternal MUAC measured in cm and maternal anemia measured in g/dl.

Statistical analysis

Exploratory analysis was performed to verify any missing values and outliers before doing the main analysis. Frequencies, percentages, mean and standard deviations (SD) were used to report descriptive data. The difference in various maternal characteristics by the outcomes measured (MUAC and anemia) is tested using a chi square test. First, a bivariate Poisson regression analysis was performed to estimate risk ratios (RRs) for both of the outcomes. Variables were selected for the next step based on statistical significance at $p<0.25$ (Bursac, Gauss, Williams, & Hosmer, 2008) and reviewing literatures. Following this, a multivariable Poisson regression models were estimated, in which variables from each block were included sequentially using *nestreg* command on STATA 14 (StataCorp, Texas, USA). This resulted in three regression models (A, B and C) by step by step inclusion of blocks of potential risk factors. The multiple coefficient of determination (R^2) was used to measure the percentage of variance in the outcomes explained by the independent variables for each block. Interaction terms between different covariates were included in the model to test for model improvement. Collinearity among the independent variables in the model was also assessed. All the analyses were performed using robust variance estimators to adjust for subject clustering by study kebele. All tests were two sided and statistical significance was considered at $p < 0.05$.

Ethical issues

Ethical approval was granted from the Institutional Review Board of Jimma University and Tufts University before commencement of the study. Informed consent was obtained from the participants after a detailed explanation of the objectives of the study. During the study women who had health problems were referred to a nearby health facility to seek proper medical care.

Results

The mean (± SD) age of the women was 20 years (±2 years). The study identified that 38% of the pregnant women had acute malnutrition and 22% were anaemic. Most of the independent variables were significantly associated to both the outcomes as tested using bivariate methods. The descriptive results are presented in table 1. Consumption of fruits, vegetables and ASF was also found to be much higher among pregnant women with higher MDDW compared to their counterparts (Figure 2).

Table 2 and Table 3 show the estimates from the multivariable hierarchical regression analyses after decomposing the variables in the three blocks and three regression models. **Model A** identified the role of socio-demographic and environmental factors in determining maternal MUAC. Variables in this block explained 10% of the variation in the outcome with improved maternal educational status (RR=0.90, 95% CI: 0.89, 0.98) and highest wealth tertile (RR=0.67, 95% CI:0.47, 0.90) significantly protecting against acute malnutrition. The variables in this block also explained 17% of the variation in maternal anemia. Younger maternal age (15-19) (RR=1.20, 95% CI:1.07, 1.33) and using unimproved toilet (RR=1.41, 95% CI: 1.07, 1.86) were significant risk factors for anemia.

Model B estimates the role of variables from the second block adjusted for variables from the first block. The variables in this model explained 12% and 20% of the variation in acute malnutrition and anemia respectively. On top of the previous significant determinants, illness during pregnancy (RR=1.20, 95% CI: 1.08, 1.33) and antenatal depression (RR=1.34, 95% CI: 1.09, 1.64) were significant risk factors for acute malnutrition and maternal anemia respectively after adjusting for socio-demographic and environmental factors.

Model C was constructed by including all variables in the three blocks to estimate the association of dietary practices of the women with their nutritional status adjusted for the variables from the first two blocks. This model explained 23% and 28% of the variation in acute malnutrition and maternal anemia respectively. Women with higher MDDW had decreased risk of acute malnutrition (RR=0.87, 95% CI: 0.77, 0.98) and anemia (RR=0.95, 95% CI: 0.88, 0.98) while consumption of animal source foods (RR=0.85, 95% CI: 0.77, 0.94) significantly decreased the risk of acute malnutrition. It is also shown that shorter maternal stature (RR=1.71, 95% CI: 1.45, 2.02) was significant risk factor for acute malnutrition.

Discussion

This study aimed to identify the burden and determinants of maternal undernutrition among young and pregnant women in Ethiopia. The findings revealed that, the level of undernutrition remains high. We also observed that improved maternal educational status, higher wealth status, using a protected water source and consumption of ASF protects against the risk of acute malnutrition while higher MDDW protects from both acute malnutrition and anemia. To the contrary, young maternal age (15-19 years), illness during pregnancy, short stature, unimproved toilet and depression were risk factors for either of the outcomes in the present study. Improved socio-economic status is a known to associate with nutritional status of pregnant women. Its role is linked to its ability to make the women create a healthy environment for them and the family (Ravaoarisoa et al., 2018). Higher educational attainment increases knowledge about healthy antenatal and dietary practices (Ravaoarisoa et al., 2018). Economic disparities on the other hand affect nutritional status of pregnant women as low economic status affects nutrition and food choices (Chhoun et al., 2016; Mtumwa, Paul, & Vuai, 2016; Nguyen et al., 2017; Ravaoarisoa et al., 2018). As wealth increases, the level of undernutrition among women decreases (Chhoun et al., 2016; Hong & Mishra, 2006). A large survey in Ethiopia also indicated improved economic status to an increased consumption of diversified diets among rural and urban households among whom consumption of ASF also was higher (Workicho et al., 2016). Therefore, empowering women by improving their educational status and income sources can have a positive impact on their nutritional status.

The role of hygiene and sanitation in determining maternal nutritional status has been documented in previous studies (World Health Organization, 2015). The higher risk of malnutrition among pregnant women who were using unprotected drinking water and unimproved type of toilet in the present study highlights the importance of hygiene and sanitation during pregnancy. Poor hygiene and sanitation increases the risk of infections such as intestinal parasites and diarrheal diseases (Speich, Croll, Fürst, Utzinger, & Keiser, 2016; Strunz et al., 2014; World Health Organization, 2015) causing disturbances in the digestive system hence absorption of essential nutrients directly resulting in undernutrition. Improving hygiene and sanitation therefore, is one of the most important interventions to combat maternal and child malnutrition in settings where maternal undernutrition is high (Bhutta et al., 2008; World Health Organization, 2015). This study also revealed that poor physical and psychosocial health during pregnancy negatively affected nutritional status of the young pregnant women. Presence of these conditions during pregnancy increases the risk of undernutrition through affecting dietary intake and also absorption of nutrients (Barker, Kirkham, Ng, & Jensen, 2013; Hurley, Caulfield, Sacco, Costigan, & Dipietro, 2005; Nguyen et al., 2017; Pheak Chhoun et al., 2016; Teegarden & Bale, 2008). Malaria, tuberculosis, diarrheal diseases and other infections highly impacted nutritional status of pregnant women in impoverished settings (Papathakis & Rollins, 2005; Strunz et al., 2014; Unger, Ashorn, Cates, Dewey, & Rogerson, 2016; World Health Organization, 2015). Similarly depression during pregnancy also results in maternal undernutrition through engaging them in unhealthy behavioral and antenatal practices like unhealthy eating patterns (Barker et al., 2013; Teegarden & Bale, 2008). These disease processes increase energy expenditure and protein catabolism, draining nutritional reserves (Unger et al., 2016). In many LMICs, interventions targeted to protect pregnant women from infectious diseases and macro and micro nutrient undernutrition remain less integrated. Considering the interaction between these infectious diseases and maternal nutrition as a cofactor through an integrated approach will help substantially address the burden of maternal nutritional problems.

This study has shown also that pregnant women consuming a diversified diet and animal source foods were at lesser risk of undernutrition. A more diversified diet is associated with adequate levels of calories, fat, protein and micronutrients satisfying the nutritional requirements hence preventing undernutrition among the women (Hoddinott & Yohannes, 2002; National Academy of Science, 1991). In the present study consumption of fruits, vegetables and ASF is found to be much higher among pregnant women with higher MDDW than their counter parts. These food groups are known for their rich nutrients thus improving nutritional status of the women. Unfortunately, there are a lot of social, economic and cultural barriers in consuming ASF especially during pregnancy in LMICs (Joel Gittelsohn & Amy E. Vastine, 2003). Even in the face of these barriers, its consumption in relatively small amounts can provide protein and essential micronutrients which are needed in extra amounts during times like pregnancy (Darapheak, Takano, Kizuki, Nakamura, & Seino, 2013; Joel Gittelsohn & Amy E. Vastine, 2003; Speedy, 2003). Programs working in promotion of maternal nutrition should consider promoting the consumption of ASFs. This could be done through direct messaging that increase awareness of the importance of ASF and/or through agricultural interventions that increase availability and accessibility.

Implication

Maternal undernutrition, before and during pregnancy is prevalent in many sub-Saharan countries. It is a major public health concern due to its association with mortality and overall disease burden for the mothers and their children (Black et al., 2008). It is also documented that micronutrient deficiencies during pregnancy result in severe consequences. Anemia during pregnancy, which is majorly due to iron deficiency is one indicator of maternal malnutrition. Its presence in any level increases the risk obstetric complications and also diminishes productivity (Black et al., 2008; The Manoff Group, 2011). Younger pregnancies are at a greater risk of these adverse health consequences since the risk of anemia is much higher among them as evidenced in the present study due to competitions for nutrients with their fetus. This study informs the need to improve access to WASH in order to decrease the level of undernutrition especially among the very poor and vulnerable rural communities. Although notable activities have been done in improving access to WASH in Ethiopia (Save the Children/Ethiopia ENGINE Project, 2014), and decreasing the level of undernutrition (Government of the Federal Democratic Republic of Ethiopia, 2013), the findings indicate that there remains significant work to be done. We can also learn from the findings that promotion of optimal dietary practices during pregnancy through dietary diversification and consumption of ASF would positively affect nutritional status of the women. Indeed, the revised national nutrition program in Ethiopia emphasized promotion of diversified diets as one of the strategies to intervene maternal and child undernutrition (Government of the Federal Democratic Republic of Ethiopia, 2013). For this to be effective, it is imperative to work on economic and educational empowerment of women. Recommendation on optimal maternal nutrition behaviors and practices have been forwarded in LMICs although they are not as well established as the guidelines for infant and young child nutrition (Huffman et al., 2001). The lesser attention to maternal nutrition may in part reflect a focus on mortality reduction rather than on growth and development. On the other hand, the complexity of the intergenerational aspects of maternal nutrition may also have made designing of interventions difficult. Understanding important determinants of nutritional status of pregnant women in LMICs which majorly can be grouped under socio-economic, health and dietary exposures has paramount importance in designing interventions and guidelines for the promotion of optimal maternal nutritional practices. In this regard, we believe that findings from the present study identified important exposures, which need to be targeted in policies and programs which work towards the improvement of nutritional status of pregnant women in these settings.

The strength of this study is that it included a relatively large sample size and explored a range of determinants based on the predefined conceptual framework. The analysis approach we used also helps us understand which set of determinants explain the majority of the variation in both of the outcomes studied so that we can focus in targeting them while planning interventions to improve maternal nutritional status. One limitation pertinent to this study is that we were not able to adjust anemia status of the women for presence of inflammation, which could under estimate the burden of the problem.

Conclusion

Findings from the study indicated that the burden of undernutrition is still high among pregnant women in Ethiopia. We also demonstrated that improved socio-economic statuses and dietary practices have decreased the risk of undernutrition among pregnant women. In the contrary, young maternal age and poor health and environmental conditions were important risk factors for maternal undernutrition during pregnancy. This findings highlight that significant proportion of the burden of undernutrition among pregnant women can be decreased by targeting these set of important determinants.

List of abbreviations

ENGINE: Empowering New Generation In Nutrition and Economic opportunities

MDDW: Minimum Dietary Diversity for Women

MUAC: Mid Upper Arm Circumference

PHQ: Patient Health Questionnaire

WASH: Water Hygiene and Sanitation

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Legend:

Figure 1: Conceptual framework

Figure 2: Percentage consumption of fruits, vegetables and ASF by minimum dietary diversity score for women

Table 1: Baseline characteristics by nutritional status of pregnant women

Table 2: Multivariable hierarchical regression analysis of determinants of acute malnutrition among young pregnant women in Ethiopia

Table 3: Multivariable hierarchical regression analysis of determinants of anemia among young pregnant women in Ethiopia

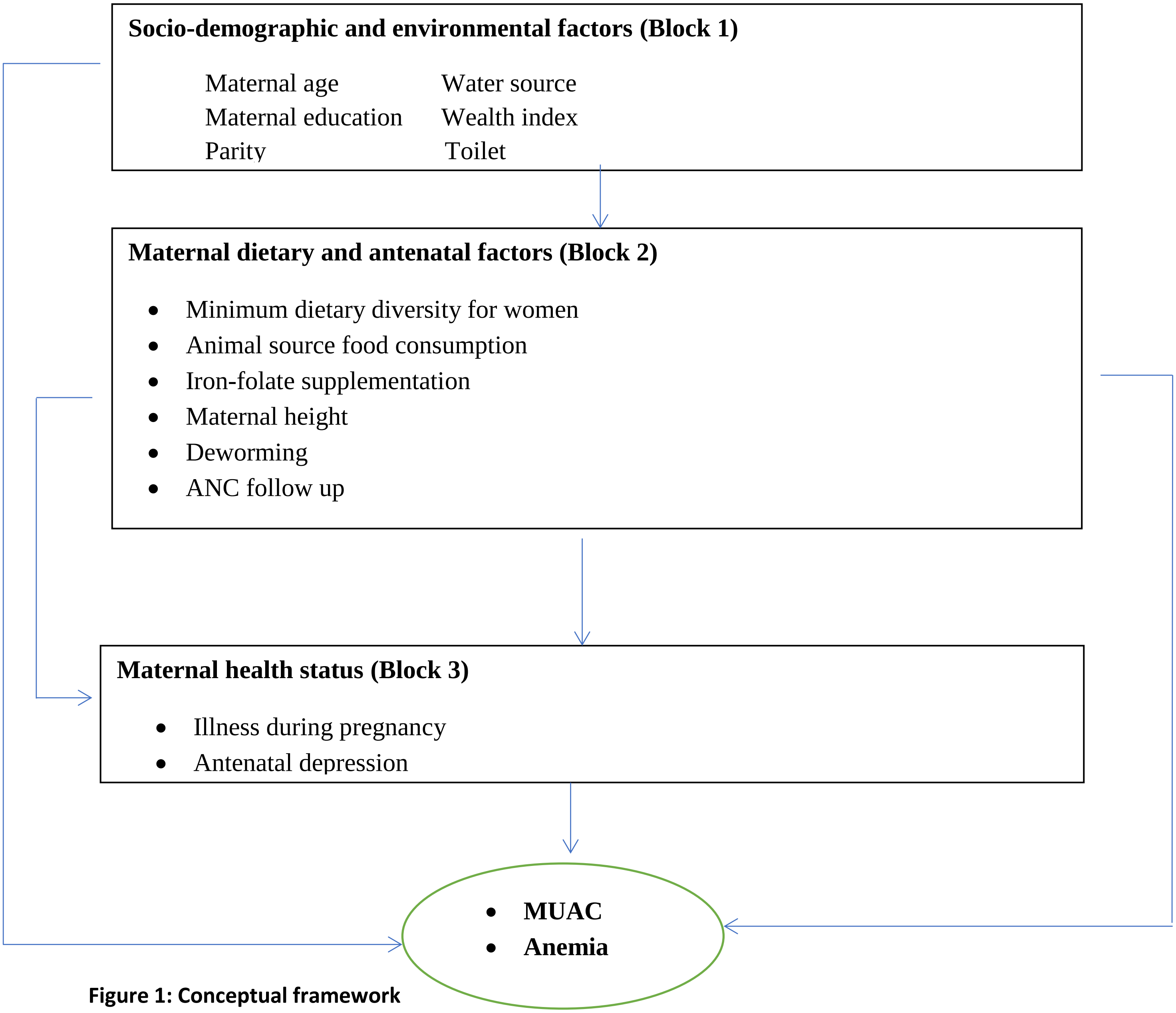

Figure 1: Conceptual framework

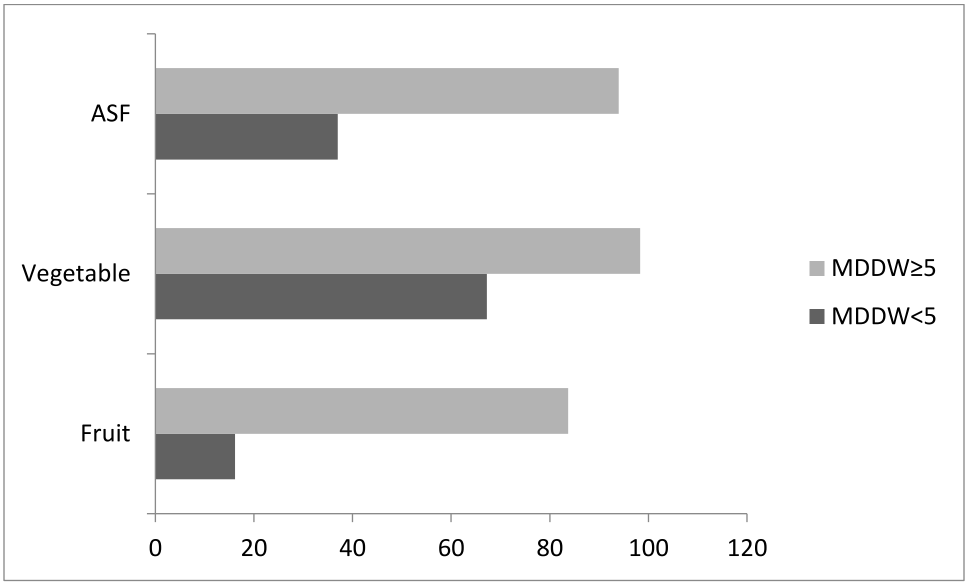

Figure 2: Percentage consumption of fruits, vegetables and ASF by minimum dietary diversity score for women

Table 1: Baseline characteristics by nutritional status of pregnant women

Variables		MUAC<23cm n=1,393		*P-value*	Anemia n=X1,393		*P-value*
		Yes	No		Yes	No	
Maternal age in years	15-19	152(39)	237(61)	0.208*	80(20.6)	309(79.4)	0.479
	20-24	379(38)	625(62)		224(22.3)	780(77.7)	
Educational status	No formal education	183(41)	261(59)	0.097**	115(26)	329(74)	0.042***
	Primary	309(38)	514(62)		164(20)	659(80)	
	Secondary and above	39(31)	87(69)		25(20)	101(80)	
Parity	Primi para	311(39)	485(61)	0.399	101(17)	496(83)	0.001***
	Multi para	220(37)	377(63)		203(25.5)	593(74.5)	
Wealth index	Lowest	220(42)	298(58)	0.001***	124(24)	394(76)	0.017***
	Middle	178(44)	226(56)		98(24)	306(76)	
	Highest	133(28)	338(72)		82(17.4)	389(82.6)	
Family size	<5	448(38)	733(62)	0.737	253(21.4)	928(78.6)	0.393
	≥5	83(39)	129(61)		51(24)	161(76)	
Toilet type	Improved	146(36.5)	254(73.5)	0.705	70(17.5)	330(82.5)	0.043***
	Unimproved	385(39)	608(61)		234(23.6)	754(76.4)	
Water source	Protected	341(36)	606(64)	0.017***	202(21.3)	745(78.6)	0.537
	Unprotected	189(43)	254(57)		101(23)	342(77)	
MUAC	<23cm	--	--		137(26)	394(74)	0.005***
	≥23cm	--	--		167(19.3)	695(80.7)	
MDDW	<5	470(39)	745(61)	0.138*	267(22)	948(78)	0.720
	≥5	61(34)	117(66)		37(21)	141(79)	
Maternal height	<150cm	63(62)	39(31)	0.001***	23(22.5)	79(71.5)	0.857

	≥150cm	468(36)	822(64)		281(22)	1,009(78)	
ASF consumption	Consume	250(40.5)	367(59.5)	0.100**	128(21)	489(79)	0.385
	Not consume	281(36)	495(64)		176(22)	600(78)	
Iron-folic acid supplemnt	≤ 3 months	369(38)	607(62)	0.714	221(22.6)	755(71.4)	0.227*
	> 3 months	162(39)	255(61)		83(20)	334(80)	
Deworming	Yes	25(37)	43(63)	0.814	16(23.5)	52(76.5)	0.727
	No	506(38)	819(62)		288(22)	1,037(80)	
ANC follw-up	No	51(41.5)	72(58.5)	0.424	37(30)	86(70)	0.020***
	At least one	480(38)	790(62)		267(21)	1,003(79)	
Any illness	Yes	103(43.6)	133(56.4)	0.055**	50(21)	186(79)	0.975
	No	428(37)	729(63)		254(22)	903(78)	
Depression	Yes	132(41)	189(59)	0.207*	88(27.4)	233(72.6)	0.006***
	No	399(37)	673(63)		216(20)	856(80)	

Table 2: Multivariable hierarchical regression analysis of determinants of acute malnutrition among young pregnant women in Ethiopia

Variables	**Model A (blocks 1)** R^2=10% **RR (95%CI)**	**Model B (blocks 1&2)** R^2=12% **RR (95%CI)**	**Model C (blocks 1,2,&3)** R^2=23% **RR (95%CI)**
Maternal age (15-19)	1.04(0.82, 1.31)	1.03(0.80, 1.33)	1.05(0.78, 1.40)
Maternal education			
No formal	Reference	Reference	Reference
Primary	0.98(0.84, 1.13)	0.97(0.84, 1.13)	0.99(0.88, 1.12)
≥Secondary	0.90(0.89, 0.98)*	0.90(0.83, 0.98)*	0.94(0.89, 0.98)*
Primipara	0.97(0.74, 1.27)	0.98(0.75, 1.28)	0.97(0.70, 1.35)
Wealth index			
Lowest	Reference	Reference	Reference
Middle	1.03(0.83, 1.27)	1.02(0.82, 1.27)	1.03(0.82, 1.29)
Highest	0.67(0.47, 0.90)*	0.67(0.45, 0.96)*	0.68(0.47, 0.95)*
Toilet (unimproved)	1.12(0.92, 1.36)	1.12(0.91, 1.39)	1.10(0.91, 1.34)
Water sourc(protected)	0.93(0.84, 1.02)	0.92(0.85, 1.00)	0.93(0.86, 0.96)*
Any illness(yes)		1.20(1.08, 1.33)*	1.20(1.09, 1.33)*
Depression (yes)		1.11(0.88, 1.39)	1.07(0.83, 1.39)
MDDW (≥5)			0.87(0.77, 0.98)*
Height (<150cm)			1.71(1.45, 2.02)*
ASF consume (yes)			0.85(0.77, 0.94)*
Iron-folic acid supplemnt(≥3 months)			1.07(0.87, 1.32)
Deworming(yes)			0.87(0.65, 1.18)
ANC follow-up (≥1)			0.95(0.72, 1.26)

Table 3: Multivariable hierarchical regression analysis of determinants of maternal anemia

Variables	Model A (blocks 1) R^2=17% RR (95%CI)	Model B (blocks 1&2) R^2=20% RR (95%CI)	Model C (blocks 1,2,&3) R^2=28% RR (95%CI)
Maternal age (15-19)	1.20(1.07, 1.33)*	1.17(1.08, 1.28)*	1.14(1.06, 1.21)*
Maternal education			
No formal	Reference	Reference	Reference
Primary	0.86(0.66, 1.12)	0.86(0.66, 1.13)	0.91(0.71, 1.16)
≥Secondary	1.00(0.70, 1.51)	1.03(0.71, 1.52)	1.15(0.80, 1.66)
Primipara	0.65(0.51, 0.81)*	0.66(0.52, 0.83)*	0.65(0.52, 0.81)*
Wealth index			
Lowest	Reference	Reference	Reference
Middle	0.92(0.74, 1.16)	0.92(0.73, 1.16)	0.98(0.82, 1.18)
Highest	0.69(0.39, 1.22)	0.68(0.39, 1.19)	0.79(0.47, 1.32)
Toilet (unimproved)	1.41(1.07, 1.86)*	1.40(1.06, 1.87)	1.31(1.06, 1.63)*
Water sourc(protected)	1.08(0.70, 1.66)	1.07(0.71, 1.62)	1.05(0.68, 1.64)
Any illness(yes)		1.00(0.75, 1.29)	0.96(0.77, 1.21)
Depression (yes)		1.34(1.09, 1.64)*	1.33(1.14, 1.55)*
MUAC (<23 cm)			1.26(1.01, 1.57)*
MDDW (≥5)			0.95(0.88, 0.98)*
Height (<150cm)			0.96(0.63, 1.47)
ASF consume (yes)			1.01(0.97, 1.12)
Iron-folic acid supplement (≥3 months)			0.96(0.80, 1.15)
Deworming(yes)			1.07(0.66, 1.76)
ANC follow-up (≥1)			0.81(0.60, 1.08)