Original Article

Magnitude and determinants of malnutrition among pregnant women in eastern Ethiopia: evidence from rural, community-based setting

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Maternal malnutrition is a worldwide public health problem affecting a high proportion of pregnant women. This study aimed to determine the magnitude and determinants of malnutrition among pregnant women in eastern Ethiopia. A cross-sectional study was conducted on 1731 pregnant women selected by a cluster random sampling method. Data on maternal anthropometry and other factors were gathered by trained data collectors. Mid-upper arm circumference < 22 cm defined malnutrition. Mixed-effect, multilevel logistic regression was used to control clustering effect. On average, 19.06% of subjects were malnourished, while 23.3% study participants were underweight (body mass index < 19.8 kg m⁻²). In the final adjusted analysis, the risk of malnutrition was more than twofold higher in pregnant women with low (adjusted odds ratio = 2.47, 95% confidence interval = 1.41–4.34) and medium (adjusted odds ratio = 2.74, 95% confidence interval = 1.40–5.35) autonomy of household decision-making than those who had high level of autonomy in household decision-making. Husband illiteracy and not owning livestock were associated with increased risk of malnutrition. Women in the second and third trimester had a 66% and nearly twofold increased risk of malnutrition compared with their counterparts in the first trimester, respectively. Women who improved their eating habits had a 53% lower risk of malnutrition than those who did not. The risk of malnutrition was 39% lower in respondents who received prenatal dietary advice than in those who did not. Malnutrition affects at least one of every five pregnant women studied, calling for priority attention. Interventions that improve maternal involvement in household decision-making autonomy and provision of prenatal dietary advice are recommended.

Keywords: pregnancy, malnutrition, wasting, predictors, eastern Ethiopia, MUAC.

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Introduction

Maternal undernutrition is a global health problem affecting more women in developing countries (Adebawale *et al.* 2011). Women in sub-Saharan Africa, south central and southeastern Asia are the most affected. The median underweight in sub-Saharan countries is 10.4% and 6% for rural and urban women, respectively (Uthman & Aremu 2008). Maternal malnutrition in Ethiopia is higher

than the level for many African countries (Uthman & Aremu 2008). The analysis of Ethiopian Demographic Health Surveys (EDHS) 2000 and 2005 data revealed 30.5% and 26.9% of chronic energy deficiency among non-pregnant and non-postpartum women (Bitew & Telake 2010). Similarly, a prevalence of 27% from EDHS 2011 confirmed that the problem remained unchanged (Central Statistical Agency [Ethiopia] and ICF International 2012).

Maternal malnutrition is caused by multiples of factors. Among the causes of maternal malnutrition, inadequate food intake, poor nutritional quality of diet, frequent infections and short inter-pregnancy intervals are important factors (Lartey 2008). Ages of women, marital status, occupation, education, household income and/or wealth index are also known risk factors (Bitew & Telake 2010; Adebawale *et al.* 2011; Davies *et al.* 2011). Maternal prenatal malnutrition is associated with intrauterine growth restriction, low birthweight and other adverse health outcomes in women and their newborn babies (Landis *et al.* 2009; Goyal *et al.* 2012).

Globally, there is limited knowledge of prevalence and causes of malnutrition during pregnancy. Such gap could be explained by the lack of consensus on type and cut-off points of the anthropometric parameters to be applied among pregnant women. Some recent studies used mid-upper arm circumference (MUAC) (Elshibly & Schmalisch 2008; Assefa *et al.* 2012). Body mass index (BMI) is also used by others with a cut-off point of 19.8 kg m^{-2} (Kanadys 2007).

Generally, few studies assessed maternal nutritional status during pregnancy. Particularly, data on the Ethiopian situation regarding the nutritional status of pregnant women are lacking. However, such data are important in designing evidence-based maternal nutrition interventions for this vulnerable group. In addition, such data can be employed in programmes that are aimed to reduce maternal and child morbidity and mortality that prevails in Ethiopia. Therefore, the purpose of this study was to determine the prevalence and predictors of malnutrition during pregnancy in eastern Ethiopia.

Materials and methods

Study setting, population and design

A cross-sectional, community-based study was conducted in the rural communities of Haramaya district, eastern Ethiopia. The kebeles of this district surround the main campus of the Haramaya University. The details of the district have been described elsewhere in earlier study from the same setting (Kedir *et al.* 2013).

Sample size estimation and sampling process

Initially, estimation of the sample size required for the study was made for all objectives of the study. Compared with the sample size estimated for assessing prevalence of undernutrition, larger number of respondents were estimated when it was calculated for the objective of the study related with identification of predictors of undernutrition. To obtain adequate number of study subjects, the differences of malnutrition proportions between different categories of independent variables were considered. We preferred to use the educational status of women as exposure variable and a prevalence of 28% was assumed among illiterate pregnant women. In addition, a confidence interval (CI) of 95%, a power of 80%, and a difference of 10% in prevalence of malnutrition between literate and illiterate groups of pregnant women were assumed to estimate the required minimum sample size. Thus, a total sample size of 1717 pregnant women was estimated.

The sampling method used was a cluster random sampling technique. The list of all rural kebeles was obtained and a unique identification number was

Key messages

- Nearly one in every five pregnant women suffers from malnutrition in rural eastern Ethiopia.
- Prenatal dietary advice and improved eating habits are protective factors against malnutrition in pregnancy, implying the potential applications in primary health care services and self-care practices.
- This study extended the existing body of knowledge about influences of women's autonomy to cover malnutrition in pregnancy.
- Aspects of prenatal nutrition advice that could be more effective in the prevention of malnutrition during pregnancy in this community or other similar setting should be further explored by future research.

assigned to each kebele. Thus, the list of kebele identification number was used as a sampling frame to select the kebeles. Twenty-two rural kebeles were selected by cluster random sampling from the list comprising a total of 33 rural kebeles existing in the district at the time of the study. Then, we performed identification and registration of all pregnant women existing in each selected kebele. The detailed description of procedures used for identification of pregnant women is provided elsewhere (Kedir *et al.* 2013). Women's self-report and observations by data collectors were used in case of visible pregnancies. The steps and techniques performed in the detection of early pregnancies were briefly described as follows: first, we applied the pregnancy screening checklist as used in the previous studies (Torpey *et al.* 2010) to identify pregnancy suspects; then the urine of the pregnancy suspects were tested for pregnancy confirmation using rapid dip-stick method. Overall, 1802 pregnant women were identified from the selected kebeles that was not too much larger than the required sample size estimated. Therefore, all identified pregnant women from each selected kebele were invited to participate in the study. Each of the pregnant women identified in the selected kebeles were from different households. Thus, there was no household with more than one pregnant woman in this study.

Data collection process

Data were collected between April and June 2010. Structured and field-tested questionnaire that covered items for assessing sociodemographic characteristics of the women and their households, prenatal health-seeking practices, obstetric/gynecological characteristics and dietary or feeding behaviour was used to obtain data through face-to-face interview. Data collectors who had a college-level education and working skill of local language collected the data. Public health graduates were recruited and supervised the data collection process together with the principal investigator.

Maternal anthropometric measurements were performed according to the international standard recommendations. Weight was measured to the nearest 100 g, as the woman stood wearing light clothing and

no shoes, on a portable, battery-operated digital scales (Seca model 881, Seca Corporation, Hamburg, Germany). The weighing scale was checked for zero reading before the woman was asked to stand on it. In addition, the proper performance of each scale was checked and calibrated every day before the field-work using known weights. Height was measured to the nearest 0.1 cm while the woman stood in upright position against locally developed wooden stadiometer, without wearing shoes and light or no head covers. MUAC of each woman was measured at the mid-point between the tip of the shoulder (olecranon process) and tip of the elbow (acromion process) of her left arm. An insertion type MUAC tape that is non-elastic and non-stretchable was used to take the measurement. After checking that the tape was applied with correct tension (not too loose or not too tight), the MUAC of the woman was read and recorded to the nearest 0.1 cm. All anthropometric measurements were performed with a pair of data collectors following the standard instructions and steps detailed elsewhere (Cogill 2003).

Composite variables construction

We developed the variable assessing maternal autonomy of decision-making at the household level by combining items that asked the woman about her independent decision-making on four aspects of household activities as has been used by other studies in Ethiopia (Medhin *et al.* 2010). Thus, the items asked the woman whether she was able independently to decide: (1) on her own health seeking; (2) on major household purchases; (3) on major household expenditures and (4) on visiting of friends/relatives or participations in meetings (Medhin *et al.* 2010). Women who responded that they were major decision-makers on each of the four items assigned a score of '1' and a score of '0' was assigned otherwise. Finally, responses on four items were aggregated to define maternal degree of household decision-making with possible values of 0 to 4. Then, the score of 0 implies low level of autonomy. The frequency distribution of the resulting score revealed that 1387 (80.1%), 172 (9.9%), 27 (1.6%), 6 (0.3%) and 139 (8.0%) for 0, 1, 2, 3 and 4, respectively. For ease of interpretation, scores

2 and 3 that had low frequency in initial analysis were combined with score 1 and the maternal household decision-making autonomy of three levels was developed. A value of 2 was assigned to the score 4 and the final score ranged from 0 to 2. The three levels of maternal household decision-making autonomy were defined from the final scores as: low (score 0), medium (score 1) and high (score 2).

Improved eating habits during pregnancy and prenatal dietary information received were assessed using the items adapted from the national nutrition survey conducted by the Ethiopian Health and Nutrition Institute in 2009. A composite variable examining presence or absence of improved eating habits was constructed by combining the responses of the subject to the following two items with yes/no response format (1 = yes, 0 = no) asking whether she made each of the eating habit changes after becoming pregnant: (1) increased the amount of her meal and (2) increased her meal frequency. Then, subjects were classified as practicing improved eating habits (coded as 1) if they at least answered yes to either of the two items and classified as not practicing improved feeding practice otherwise (coded as 0).

Prenatal dietary advice was constructed by combining three items that asked the woman whether she received each of the following advices: (1) advised to eat more, (2) advised to eat a balanced diet and (3) advised to eat different fruits and vegetables in this pregnancy. A value of 1 was assigned if the pregnant woman answered yes to each item and 0 was assigned otherwise. Then, an aggregate variable, prenatal dietary advice, with possible values ranging from 0 to 3 was constructed from the linear combination of the responses on the above items. The scores of prenatal dietary advice were recorded to develop dichotomous variable that divided the respondent who received any prenatal dietary information and those who did not.

The construction of the above-defined composite independent variables was motivated by the need for reducing number of predictor variables and the fact that combined items were used to assess the same concept that can be measured by a single aggregate variable constructed from such responses. Furthermore, composite variables have better validity than the individual variables leading to their construction (Van

der Heijde *et al.* 1992) and also help to avoid problems of multicollinearity in a multivariable analysis because of high correlation between items measuring the same concept (O'Brien 2007; Dormann *et al.* 2012).

Data processing and statistical analysis

Data were entered in EpiData version 3.1 (EpiData Association, Odense, Denmark) and analysed by Stata 11.0 for windows (Stata[®] StatCorp, Inc, Lakeway Drive, College Station, TX, USA). Descriptive measures for categorical data were presented as frequency and proportions and continuous data were presented as mean and standard deviations. Group comparisons for proportions were based on Chi-squared statistics.

In this study, wasting (MUAC < 22 cm) and underweight (BMI < 19.8 kg m⁻²) were outcome variables. The criteria recommended by the Institute of Medicine for BMI cut-off points were applied and BMI values of <19.8, 19.8–26 and >26 kg m⁻² define underweight, normal weight and overweight or obese among pregnant women (IOM 1990). A MUAC value less than 22 cm has been recommended to classify acute malnutrition or wasting among women in third world countries (James *et al.* 1994) and also applied by others to classify African pregnant women elsewhere (Kruger 2005). Research evidences have also shown that it is not affected by non-nutritional changes (López *et al.* 2011). Furthermore, recently published paper based on review of evidences revealed that MUAC is a preferred anthropometric measurement during pregnancy (Ververs *et al.* 2013). Therefore, wasting (MUAC < 22 cm) was used to define malnutrition and exclusively used in multivariable analysis as dependent variable.

In order to control the effects of clustering of malnutrition by kebeles, a multilevel mixed effect logistic regression model with kebele identification number (kebele ID) as a random effect and the selected independent variables entered in to the model representing fixed effects was built. The independent variables considered in the crude and full model were based on their conceptual utility as individual or household-level risk factor for maternal malnutrition according to existing global or regional literature (Black *et al.*

Table 1. Independent variables entered in multivariable logistic regression model of malnutrition predictors of pregnant women in Haramaya, eastern Ethiopia, 2010

Independent variable	Categories	Reference category
Age group	15–24 years, 25–34 years, 35–49 years	35–49 years
Educational status of women	Illiterate, literate	Literate
Husband educational status	Illiterate, literate	Literate
Household livestock possession	Yes, no	Yes
Household decision-making autonomy	Low, medium, high	High
Household own vegetable/fruit garden	No, yes	No
Trimester of pregnancy	First, second, third	First
Number of previous births	0, 1–4, 5 or more	0
Source of prenatal visit	No visit, HP, HC/hospital	HC/hospital
Prenatal feeding advice	No, yes	No
Prenatal improved eating habit	No, yes	No
History of nausea or vomiting	No, yes	No

HC, health centre; HP, health post.

2008; Lartey 2008) and studies from Ethiopia (Medhin *et al.* 2010; Regassa & Stoecker 2012). In addition, pregnancy-specific variables that were hypothesized to be related with malnutrition during pregnancy were also considered. Parity and household size were correlated with each other ($r = 0.62$), thus the later was omitted from the full model.

The variables entered in the multivariable model multilevel analysis are presented in Table 1. In addition to the variables entered to the null and multivariable model, the final full model included a dichotomized altitude of the kebele to explain kebele-level variability. The adequacy of multilevel models was evaluated by comparing deviance information criterion (DIC). The lower the DIC value the better is the model fit. Effect of clustering was evaluated by comparing variance estimates and variance partition coefficient of the random effect for the null model and the full model. A P -value of <0.05 was considered statistically significant. The Chi-squared statistic was used to measure the difference in the distribution of malnutrition by maternal and household variables studied in bivariate analysis. The associations of the independent variables entered in logistic regression with malnutrition were assessed by comparing the crude odds ratios and adjusted odds ratios (AOR) together with respective 95% CI.

Ethical consideration

All women who took part in this study provided informed written consent. Institutional Review Board of Haramaya University and the National Research Ethics Review Committee of Ethiopia reviewed and approved the protocol. Women with malnutrition or those who were found to have health problems during the interview were referred to the nearby public primary health care based on their willingness for possible support. Health extension workers were also provided with some general problems noticed in their respective kebele without referring to individual pregnant women.

Results

Description of respondents' characteristics and distribution of malnutrition

Of the total 1802 pregnant women, initially planned for the study, 1731 (96%) of them were included in this analysis. Among the remaining 71 pregnant women excluded from the analysis, 30 refused to participate, 26 had missing anthropometric measurements and 15 cases were observed to have standardized residual values either <-3 or >3 in initial regression analysis which indicated that they were outliers.

The mean ($\pm$ SD) age, gestational age and number of previous births for the study participants were 26.4 ($\pm$ 5.7) years, 24.0 ($\pm$ 8.0) weeks and 3.1 ($\pm$ 2.4) births, respectively. The details of the respondents' characteristics are shown in Table 2. The majority (91.2%) were illiterate, nearly one-third (32.99%) had had five

or more births and few (14%) were in the first trimester of pregnancy (Table 2).

The mean ($\pm$ SD) weight, height BMI and MUAC of pregnant women studied were 54.0 kg ($\pm$ 6.9), 157.9 cm ($\pm$ 6.0), 21.7 kg m⁻² ($\pm$ 2.6) and 23.2 cm ($\pm$ 2.1), respectively. Wasting (MUAC < 22 cm) was observed

Table 2. Background characteristics, prenatal health histories, eating habits and malnutrition of pregnant women in Hamarya, eastern Ethiopia, 2010 ($n = 1731$)

Variables	Total Frequency (%)	Normal Frequency (%)	Wasting Frequency (%)	χ^2 (df)	P-value
Education of women				0.03 ₍₁₎	0.86
Illiterate	1578 (91.2)	1278 (81.0)	300 (19.0)		
Literate	153 (8.8)	123 (80.4)	30 (19.6)		
Age group of women				1.23 ₍₂₎	0.54
15–24	673 (38.9)	539 (80.1)	134 (19.9)		
25–34	920 (53.1)	746 (81.1)	174 (18.9)		
35–49	138 (8.0)	116 (84.1)	22 (15.9)		
Parity				1.06 ₍₂₎	0.59
0	276 (15.94)	218 (78.99)	58 (21.01)		
1–3	884 (51.07)	715 (80.88)	169 (19.12)		
4 or more	571 (32.99)	468 (81.96)	103 (18.04)		
Trimester of pregnancy				9.44 ₍₂₎	0.01
First	243 (14.0)	212 (87.2)	31 (12.8)		
Second	644 (37.2)	524 (81.4)	120 (18.6)		
Third	844 (48.8)	665 (78.8)	179 (21.2)		
Nausea and vomiting				6.20 ₍₁₎	0.01
No	1171 (67.6)	967 (82.6)	204 (17.4)		
Yes	560 (32.4)	434 (77.5)	126 (22.5)		
Improved feeding				8.41 ₍₁₎	0.004
No	820 (47.4)	640 (78.1)	180 (22.0)		
Yes	911 (52.6)	761 (83.5)	150 (16.5)		
Source of antenatal visit				12.36 ₍₂₎	0.002
No antenatal visit	974 (56.27)	810 (83.16)	164 (16.84)		
Health post	453 (26.17)	341 (75.28)	112 (24.72)		
Health centre/hospital	304 (17.56)	250 (82.24)	54 (17.76)		
Got prenatal dietary advice				5.87 ₍₁₎	0.015
No	1257 (72.62)	1000 (79.55)	257 (20.45)		
Yes	474 (27.38)	401 (84.6)	73 (15.4)		
Chew khat				1.05 ₍₁₎	0.31
Yes	1045 (60.37)	854 (81.72)	191 (18.28)		
No	686 (39.63)	547 (79.74)	139 (20.26)		
Current pregnancy intention				0.64 ₍₁₎	0.42
Yes	1186 (68.52)	966 (81.45)	220 (18.55)		
No	545 (31.48)	435 (79.82)	110 (20.18)		
Illness history in 4 weeks				0.83 ₍₁₎	0.36
Yes	324 (18.72)	268 (82.72)	56 (17.28)		
No	1407 (81.28)	1133 (80.53)	274 (19.47)		
Food restriction in pregnancy				0.09 ₍₁₎	0.76
Yes	658 (38.01)	866 (80.71)	207 (19.29)		
No	1073 (61.99)	535 (81.31)	123 (18.69)		

χ^2 , Chi-squared statistic; df, degree of freedom.

in 330 of 1731 pregnant women studied. This resulted in a wasting prevalence (cluster adjusted 95% CI) of 19.1 % (16.1–22.0%). Underweight (BMI < 19.8 kg m⁻²) affected 403 of the 1731 respondents, yielding a prevalence (cluster adjusted 95% CI) of 23.3% (20.4–26.1%). The study subjects with normal and overweight BMI classifications were 1250 (72.2%) and 78 (4.5%), respectively.

From maternal characteristics and prenatal health and dietary habits, the distribution of malnutrition was statistically associated with trimester of pregnancy (Chi-squared: $\chi^2_{(2)} = 9.44$, $P = 0.01$), prenatal dietary advice (Chi-squared: $\chi^2_{(1)} = 5.87$, $P = 0.015$),

improved eating habits (Chi-squared: $\chi^2_{(1)} = 8.41$, $P = 0.004$) and history of nausea or vomiting in current pregnancy (Chi-squared: $\chi^2_{(1)} = 6.20$, $P = 0.01$), but there was no statistical association of the distribution of malnutrition with maternal age (Chi-squared: $\chi^2_{(2)} = 1.23$, $P = 0.54$) and educational status (Chi-squared: $\chi^2_{(1)} = 0.03$, $P = 0.86$) (Table 2). Women in the second and third trimester and those who had nausea or vomiting in the current pregnancy constitute higher proportion of malnourished cases (Table 2).

The distribution of maternal malnutrition with the household variables studied is detailed in Table 3.

Table 3. Distribution of household variables and wasting among pregnant women in Haramaya district, eastern Ethiopia, 2010 ($n = 1731$)

Variable	Total Frequency (%)	Normal Frequency (%)	Malnourished Frequency (%)	$\chi^2_{(df)}$	P -value
Husband education				8.13 ₍₁₎	0.004
Illiterate	1414 (81.7)	1127 (79.7)	287 (20.3)		
Literate	317 (18.3)	274 (86.4)	43 (13.6)		
Possession of live stock				6.53 ₍₁₎	0.01
Yes	1113 (64.3)	921 (82.8)	192 (17.2)		
No	618 (35.7)	480 (77.7)	138 (22.3)		
Autonomy in household decisions				3.22 ₍₂₎	0.20
Low	1387 (80.1)	1114 (80.3)	273 (19.7)		
Medium	205 (11.8)	167 (81.5)	38 (18.5)		
High	139 (8.0)	120 (86.3)	19 (13.7)		
Own vegetable/fruit garden				3.13 ₍₁₎	0.08
No	1468 (84.8)	1178 (80.2)	290 (19.8)		
Yes	263 (15.2)	223 (84.8)	40 (15.2)		
Polygamy marriage				2.18 ₍₁₎	0.14
Yes	248 (14.3)	209 (84.3)	39 (15.7)		
No	1483 (85.7)	1192 (80.4)	291 (19.6)		
Family size				4.39 ₍₂₎	0.11
3 or less	622 (35.9)	490 (78.8)	132 (21.2)		
4–6 persons	932 (53.8)	760 (81.6)	172 (18.5)		
7 or more	177 (10.2)	151 (85.3)	26 (14.7)		
Possession of toilet facility				0.03 ₍₁₎	0.86
Yes	1088 (62.8)	882 (81.07)	206 (18.93)		
No	643 (37.2)	519 (80.72)	124 (19.28)		
Drinking water				0.27 ₍₁₎	0.60
Unprotected	530 (30.6)	425 (80.2)	105 (19.8)		
Protected	1201 (69.4)	976 (81.3)	225 (18.7)		
Drinking water location				0.95 ₍₁₎	0.33
Out of compound	1622 (93.7)	1309 (80.7)	313 (19.3)		
In compound	109 (6.3)	92 (84.4)	17 (15.6)		
Farm land size				0.28 ₍₂₎	0.87
<0.5 hectare	644 (37.2)	519 (80.6)	125 (19.4)		
0.5–1 hectare	835 (48.2)	680 (81.4)	155 (18.6)		
>1 hectare	252 (14.6)	202 (80.2)	50 (19.8)		

χ^2 , Chi-squared statistic; df, degree of freedom.

Proportion of malnutrition was 20.3% in women with illiterate husbands as compared with 13.6% among those with literate husbands (Chi-squared: $\chi^2_{(1)} = 8.13$, $P = 0.004$) and 22.3% in women residing in households not possessing any livestock as opposed to 17.2% among those whose households possess livestock (Chi-squared: $\chi^2_{(1)} = 6.53$, $P = 0.01$). The proportion of malnutrition was 19.7% and 18.5% in women with low and medium autonomy in household decision-making, respectively as opposed to 13.7% in those who had high autonomy of household decision-making (Chi-squared: $\chi^2_{(2)} = 3.22$, $P = 0.20$).

Multilevel modelling, model fit statistic and the effect of clustering on variance estimates

The model fit statistic for the models showed significant reduction as one moved from the null model to the full model, indicating better performance of the multivariable model and the full model. The DIC was 1678.8 ($P = 0.003$), 1582.8 ($P = 0.06$) and 1579.8 ($P = 0.20$) in the null, multivariable and full model, respectively. The intraclass correlation was reduced from 2.6% in the null model to 1.50% in multivariable model that was additionally adjusted for independent variables studied and to 0.9% in full model that additionally included altitude of the kebele. Compared with the null model, 42.1% and 65.4% of the initial variability in intraclass correlation was explained by the multivariable model and the full model, respectively.

Predictors of malnutrition in multilevel analysis

The unadjusted analysis of the associations of malnutrition with variables selected for multivariable model are presented in second and third columns of Table 4. In the bivariate analysis, the risk of malnutrition was significantly associated with husband illiteracy ($P = 0.006$), household not possessing livestock ($P = 0.01$), being in second ($P = 0.04$) or third trimester ($P = 0.004$) and history of nausea or vomiting in present pregnancy ($P = 0.012$), while the risk of malnutrition was reduced with statistical significance among women who improved their eating habits ($P = 0.004$) and those who received prenatal dietary

advice ($P = 0.02$) (Table 4). The bivariate analysis further revealed marginally significant ($P = 0.09$) and non-significant ($P = 0.24$) higher risk of malnutrition in women who had low and medium levels of autonomy in household decision-making than those who had high level of autonomy in household decision-making (Table 4).

The magnitudes of the odds ratios (OR) of the risk factors were not significantly different between the multivariable model without the altitude of the kebele and the final full model that included it (Table 4). Similarly, the independent predictors identified by the two models were the same.

In the full model that comprised all covariates and independent variables selected for multivariable analysis, the risk of malnutrition was positively and significantly associated with lower levels of maternal autonomy in household decision-making. Accordingly, there was more than twofold increased risk of malnutrition in pregnant women with low (AOR = 2.47, 95% CI = 1.41–4.34, $P = 0.002$) and medium (AOR = 2.74, 95% CI = 1.40, 5.35, $P = 0.003$) levels of autonomy in household decision-making than those who had high level of autonomy in household decision-making.

The associations of risk of malnutrition with husband illiteracy and household not possessing livestock were consistent to the findings in the bivariate analysis, but both became stronger in the adjusted model. Thus, the risk of malnutrition was doubled among women with illiterate husband compared with those with literate husbands (AOR = 2.00, 95% CI = 1.36, 2.93, $P < 0.001$) and household lack of livestock possession was associated with a 66% increased risk of malnutrition (AOR = 1.66, 95% CI = 1.29–3.07, $P < 0.001$). Similarly, the increased risk of malnutrition among respondents in the second and third trimesters of pregnancy were also maintained in the adjusted analysis and the risk increased by 66% in second trimester (AOR = 1.66, 95% CI = 1.07, 2.59, $P = 0.024$) and nearly doubled in the third trimester (AOR = 1.95, 95% CI = 1.26–3.00, $P = 0.003$).

The findings of the adjusted analysis in the full model also revealed that the risk of malnutrition was reduced by 53% among women who reported improved eating habits than those who did not

Table 4. Predictors of malnutrition in multilevel modelling in eastern Ethiopia, Haramaya, 2010

Variable	Crude model* OR (95% CI)	<i>P</i>	Multivariable† OR (95% CI)	<i>P</i>	Full model‡ OR (95 % CI)	<i>P</i>
Age group of women						
15–24 years	1.31 (0.80, 2.15)	0.28	1.18 (0.67, 2.08)	0.56	1.17 (0.66, 2.05)	0.593
25–34 years	1.23 (0.76, 2.00)	0.40	1.15 (0.68, 1.93)	0.60	1.12 (0.67, 1.88)	0.663
35–39 years	1		1		1	
Education of women						
Illiterate	0.96 (0.63, 1.46)	0.86	0.81 (0.51, 1.28)	0.36	0.81 (0.51, 1.28)	0.363
Literate	1		1		1	
Husband education						
Illiterate	1.62 (1.15, 2.29)	0.006	2.01 (1.37, 2.95)	<0.001	2.00 (1.36, 2.93)	<0.001
Literate	1		1		1	
Possessing livestock						
Yes	1		1		1	
No	1.38 (1.08, 1.76)	0.01	1.66 (1.26, 2.19)	<0.001	1.66 (1.26, 2.19)	<0.001
Own vegetable garden						
No			1		1	
Yes	0.73 (0.51, 1.04)	0.09	0.76 (0.52, 1.12)	0.17	0.73 (0.50, 1.07)	0.111
Decision-making autonomy						
Low	1.55 (0.94, 2.56)		2.55 (1.45, 4.48)	0.001	2.47 (1.41, 4.34)	0.002
Medium	1.44 (0.79, 2.61)		2.77 (1.42, 5.41)	0.003	2.74 (1.40, 5.35)	0.003
High	1		1		1	
Trimester of pregnancy						
First	1		1		1	
Second	1.57 (1.02, 2.40)	0.039	1.70 (1.09, 2.65)	0.02	1.66 (1.07, 2.59)	0.024
Third	1.84 (1.22, 2.78)	0.004	1.99 (1.29, 3.07)	0.002	1.95 (1.26, 3.00)	0.003
Parity of women						
0	1		1		1	
1–3	0.89 (0.64, 1.24)	0.49	0.89 (0.62, 1.29)	0.55	0.88 (0.61, 1.28)	0.512
4 or more	0.83 (0.58, 1.19)	0.30	0.85 (0.55, 1.32)	0.48	0.85 (0.55, 1.30)	0.449
Source of ANC						
No ANC	0.94 (0.67, 1.32)	0.71	0.82 (0.57, 1.19)	0.29	0.82 (0.57, 1.18)	0.284
Health post	1.52 (1.06, 2.19)	0.02	1.60 (1.08, 2.36)	0.02	1.56 (1.06, 2.30)	0.024
Health centre/hospital	1		1		1	
Received feeding advice						
No	1					
Yes	0.71 (0.53, 0.94)	0.02	0.59 (0.43, 0.82)	0.001	0.61 (0.44, 0.83)	0.002
Improved feeding						
No	1		1		1	
Yes	0.70 (0.55, 0.89)	0.004	0.46 (0.33, 0.63)	<0.001	0.47 (0.34, 0.65)	<0.001
Nausea or vomiting						
No	1	1	1		1	
Yes	1.38 (1.07, 1.77)	0.012	0.85 (0.58, 1.23)	0.39	0.86 (0.59, 1.25)	0.442
Altitude (>2035 masl)					1.35 (1.00, 1.83)	0.053

CI, confidence interval; masl, meters above sea level; OR, odds ratio. *Bivariate analysis. †Adjusted for random effect parameters and all variables in the table and the interaction term as product of improved eating habit and nausea/vomiting. ‡Adjusted for variables described in multivariable model and additionally kebele altitude.

(AOR = 0.47, 95% CI = 0.34–0.65, $P \leq 0.001$), and by 39% among pregnant women who had received prenatal dietary advice, compared with those who had not received prenatal dietary advice (AOR = 0.61, 95% CI = 0.44–0.83, $P = 0.002$).

Existence of interaction between improved eating habit and history of nausea or vomiting was assessed using stratified analysis and was confirmed. Therefore, an interaction term was developed from the product of the two variables and then added to the adjusted

model. After the entry of the interaction term, history of nausea or vomiting was no longer associated with risk of malnutrition (AOR = 0.85, 95% CI = 0.58–1.23, $P = 0.39$). In the stratified analysis, the risk of malnutrition was significantly lower among women who improved their eating habits in a group of women who did not experience nausea or vomiting (OR = 0.49, 95% CI = 0.36–0.66, $P < 0.001$), but not among the group who did (OR = 1.35, 95% CI = 0.90–2.01, $P = 9.14$).

Discussion

In this study, we used two accepted yardsticks of nutritional status indicators and measured magnitude of malnutrition among pregnant women. The two parameters used to classify nutritional status (MUAC and BMI) were strongly correlated to each other ($r = 0.51$, $P < 0.001$). Our result revealed that 23.7% and 19.8% of pregnant women had underweight and wasting, respectively. The risk of malnutrition during pregnancy was increased significantly with low or medium autonomy levels in household decision-making, household not possessing livestock and husband illiteracy. In addition, malnutrition was increased in the second and the third trimesters. However, the risk of malnutrition was reduced by improved eating habit and prenatal dietary advice.

The magnitude of wasting observed in this study was lower than the 31.4% reported by the study conducted in Sidama zone of southern Ethiopia (Regassa & Stoecker 2012). This difference could be explained by geographical and other differences between the population involved in our study and the previous study.

Higher risk of malnutrition observed among women with lower levels of decision-making autonomy in present study is consistent with previous study of non-pregnant women from Ethiopia (Tebekaw 2011). We did not come across any previous work examining the effect of autonomy in household decision-making on malnutrition of pregnant women. Previous authors working in India have documented the association of maternal autonomy with stunting in children (Shroff *et al.* 2009). Other authors have demonstrated that high maternal autonomy is associated

with better child-feeding practices (Shroff *et al.* 2011). The evidences from previous authors have further demonstrated that women with higher autonomy are more likely to utilize health services (Fotso *et al.* 2009; Singh *et al.* 2012). This observation could be explained by the fact that women having better autonomy have better more likely to provide better health and nutrition care for themselves and their children and could get foods of better quality and quantity of food.

Pregnant women are recommended to improve their feeding during pregnancy in order to maintain the increased demand for nutrients (Picciano 2003). This recommendation is supported by the finding of reduced risk of malnutrition among women who improved their eating habit. Our finding on the effect of improved eating habits made by the women following their pregnancy was further supported by our other finding that those women who received prenatal dietary information were at lower risk of malnutrition. Such results emphasize the importance of prenatal dietary counseling and improved feeding practice as key interventions.

Furthermore, the risk of malnutrition was higher among women in households not possessing livestock. This could be explained by the role of livestock as source of income and/or improving access to animal source foods (Randolph *et al.* 2007). Consistent to the study from India, husband education was associated with maternal malnutrition in the present study (Kumar *et al.* 2009). Women, whose husbands had some education, may have better access to information regarding nutrition during pregnancy through their husbands. Hence, such women may get better health and nutrition support than their counterparts. The association of husband education and household livestock possession in present study can also reflect importance of household income consistent to previous findings (Milton *et al.* 2010).

Higher risk of wasting among pregnant women during third trimester reported by the present study could be explained by the increased but unmet energy demand during this period of pregnancy (Butte & King 2005). The higher proportion of malnutrition observed among pregnant women in second and third trimester also imply the need of nutrition interventions to be initiated during early stage of pregnancy or

prior to conception in order to prevent malnutrition during pregnancy in this setting.

Unlike some previous studies, no association was seen between malnutrition and maternal age (Lindsay *et al.* 2012; Ramlal *et al.* 2012). This could be due to the differences in the predictors of malnutrition among communities with different sociocultural backgrounds.

It is necessary to discuss some caveats requiring precaution when applying the findings of this study. First, errors in anthropometric measurements cannot be completely removed as we used multiples of data collectors. Intensive training, performance assessment of field workers prior to the actual data collection, close supervision of the anthropometric measurement and repeat measures of doubtful case should have reduced risk of such errors. Second, most data on exposure variables were obtained by maternal self-report and this creates a potential for recall and reporting biases. However, triangulation of data collection methods and use of short reference time of events were used to minimize such biases. Despite our efforts to cover wide range of risk factors, there still exist some variables unmeasured such as laboratory assessment of some nutritional relevant diseases including intestinal parasites, malaria and others, as it is difficult to measure all relevant covariates in large study from a community-based setting. Given our large sample size, we feel that such cases could have little effect in explaining our identified predictors.

Despite the limitations discussed above, the present study has several considerable strengths. It adds to the global body of literature on maternal nutrition during pregnancy. Furthermore, it has several implications for policy, health service and self-care practice. From the policy perspective, the observed level of malnutrition during pregnancy calls for evaluation of existing nutrition programmes and make appropriate amendments. The observed association of malnutrition with husband education and livestock possession reflects the need to improve household socioeconomic positions to control malnutrition. The findings also imply importance of women empowerment or role of improved autonomy in household decision-making. Most of the communities in Ethio-

pia including the one investigated by the present study are characterized by male dominance in almost all household matters, which further indicate the importance of the present study. Based on the findings of the present study, pregnant women can be educated to improve their self-care practice in making positive modifications of their eating habit. In this study, we observed that receiving prenatal dietary information have the potential to reduce risk of malnutrition and this need to be examined by further studies to identify the specific information package with more effect.

Conclusion

Malnutrition affected nearly one of every five pregnant women studied. This indicates that malnutrition during pregnancy demands priority attention intervention. Maternal improved eating habit and provision of prenatal dietary advice reduce malnutrition in this community. Thus, further research should investigate the specific aspects and timings of prenatal information to effectively reduce risk of malnutrition. The findings imply the need of community or social dialogue to improve autonomy of women in the households of the study population. In addition, improving household socioeconomic position through asset-building programmes focusing on household livestock is recommended in order to lower level of malnutrition in pregnancy. Interventions should be initiated in earlier stages of pregnancy to prevent the high level of malnutrition during the second and third trimester in this community.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

Contributions

HK, YB and AW significantly participated in the conception, implementation analysis of the data and writing and submission of this manuscript.

References

- Adebowale S.A., Adepoju O.T., Okareh O.T. & Fagbamigbe F.A. (2011) Social epidemiology of adverse nutritional status outcomes among women in Nigeria: NDHS, 2008. *Pakistan Journal of Nutrition* **10**, 888–898.
- Assefa N., Berhane Y. & Worku A. (2012) Wealth status, mid upper arm circumference (MUAC) and antenatal care (ANC) are determinants for low birth weight in Kersa, Ethiopia. *PLoS ONE* **7**, e39957.
- Bitew F.H. & Telake D.S. (2010) Undernutrition among Women in Ethiopia: Rural-Urban Disparity. DHS Working Papers No. 77. ICF Macro, Calverton, Maryland, USA.
- Black R.E., Allen L.H., Bhutta Z.A., Caulfield L.E., De Onis M., Ezzati M. *et al.* (2008) Maternal and child undernutrition: global and regional exposures and health consequences. *Lancet* **371**, 243–260.
- Butte N.F. & King J.C. (2005) Energy requirements during pregnancy and lactation. *Public Health Nutrition* **8**, 1010–1027.
- Central Statistical Agency [Ethiopia] and ICF International (2012) Ethiopia Demographic and Health Survey 2011. Central Statistical Agency and ICF International. Addis Ababa, Ethiopia and Calverton, Maryland, USA.
- Cogill B. (2003) Anthropometric Indicators Measurement Guide, Food and Nutrition Technical Assistance Project. Academy for Educational Development: Washington, DC.
- Davies H.R., Visser J., Tomlinson M., Rotherham-Borus M.J., LeRoux I. & Gissane C. (2011) An investigation into the influence of socioeconomic variables on gestational body mass index in pregnant women living in a peri-urban settlement, South Africa. *Maternal and Child Health Journal* **16**, 1732–1741.
- Dormann C.F., Elith J., Bacher S., Buchmann C., Carl G., Carrã G. *et al.* (2012) Collinearity: a review of methods to deal with it and a simulation study evaluating their performance. *Ecography* **36**, 27–46.
- Elshibly E.M. & Schmalisch G. (2008) The effect of maternal anthropometric characteristics and social factors on gestational age and birth weight in Sudanese newborn infants. *BMC Public Health* **8**, 244.
- Fotso J.-C., Ezech A.C. & Essendi H. (2009) Maternal health in resource-poor urban settings: how does women's autonomy influence the utilization of obstetric care services. *Reproductive Health* **6**, 1–8.
- Goyal R., Mudey A., Banginwar A. & Khanam N. (2012) Intra-uterine growth restriction (IUGR) among teenage and elderly pregnant women in Vidharba region of Maharashtra, India. *Int J Cur Bio Med Sci* **2**, 199.
- IOM (1990) Nutrition During Pregnancy: Part I, Weight Gain; Part II, Nutrient Supplements. The National Academies Press: Washington, DC.
- James W., Mascie-Taylor G., Norgan N., Bistran B., Shetty P. & Ferro-Luzzi A. (1994) The value of arm circumference measurements in assessing chronic energy deficiency in Third World adults. *European Journal of Clinical Nutrition* **48**, 883–894.
- Kanadys W.A.M. (2007) Maternal underweight and pregnancy outcome: prospective cohort study. *Perinatal Medicine* **13**, 23–26.
- Kedir H., Berhane Y. & Worku A. (2013) Khat chewing and restrictive dietary behaviors are associated with anemia among pregnant women in high prevalence rural communities in Eastern Ethiopia. *PLoS ONE* **8**, e78601.
- Kruger H. (2005) Maternal anthropometry and pregnancy outcomes: a proposal for the monitoring of pregnancy weight gain in outpatient clinics in South Africa. *Curationis* **28**, 40–49.
- Kumar K.S.K., Ramachandran M. & Viswanathan B. (2009) What characterises women vulnerable to chronic energy deficiency? *Social Indicators Research* **90**, 365–380.
- Landis S., Lokomba V., Ananth C., Atibu J., Ryder R., Hartmann K. *et al.* (2009) Impact of maternal malaria and undernutrition on intrauterine growth restriction: a prospective ultrasound study in Democratic Republic of Congo. *Epidemiology and Infection* **137**, 294–304.
- Lartey A. (2008) Maternal and child nutrition in sub-Saharan Africa: challenges and interventions. *Proceedings of the Nutrition Society* **67**, 105–108.
- Lindsay K.L., Gibney E.R. & McAuliffe F.M. (2012) Maternal nutrition among women from sub-Saharan Africa, with a focus on Nigeria, and potential implications for pregnancy outcomes among immigrant

- populations in developed countries. *Journal of Human Nutrition and Dietetics* **25**, 534–546.
- López L.B., Calvo E.B., Poy M.S., del Valle Balmaceda Y. & Cámara K. (2011) Changes in skinfolds and mid-upper arm circumference during pregnancy in Argentine women. *Maternal and Child Nutrition* **7**, 253–262.
- Medhin G., Hanlon C., Dewey M., Alem A., Tesfaye F., Worku B. *et al.* (2010) Prevalence and predictors of undernutrition among infants aged six and twelve months in Butajira, Ethiopia: the P-MaMiE Birth Cohort. *BMC Public Health* **10**, 27.
- Milton A.H., Smith W., Rahman B., Ahmed B., Shahidullah S.M., Hossain Z. *et al.* (2010) Prevalence and determinants of malnutrition among reproductive aged women of rural Bangladesh. *Asia-Pacific Journal of Public Health* **22**, 110–117.
- O'Brien R.M. (2007) A caution regarding rules of thumb for variance inflation factors. *Quality & Quantity* **41**, 673–690.
- Picciano M.F. (2003) Pregnancy and lactation: physiological adjustments, nutritional requirements and the role of dietary supplements. *The Journal of Nutrition* **133**, 1997S–2002S.
- Ramlal R.T., Tembo M., Soko A., Chigwenembe M., Tohill B.C., Kayira D. *et al.* (2012) Patterns of body composition among hiv-infected, pregnant Malawians and the effects of famine season. *Maternal and Child Health Journal* **17**, 265–273.
- Randolph T.F., Schelling E., Grace D., Nicholson C.F., Leroy J.L., Cole D.C. *et al.* (2007) Invited review: role of livestock in human nutrition and health for poverty reduction in developing countries. *Journal of Animal Science* **85**, 2788–2800.
- Regassa N. & Stoecker B.J. (2012) Contextual risk factors for maternal malnutrition in a food-insecure zone in southern Ethiopia. *Journal of Biosocial Science* **44**, 537.
- Shroff M., Griffiths P., Adair L., Suchindran C. & Bentley M. (2009) Maternal autonomy is inversely related to child stunting in Andhra Pradesh, India. *Maternal & Child Nutrition* **5**, 64–74.
- Shroff M.R., Griffiths P.L., Suchindran C., Nagalla B., Vazir S. & Bentley M.E. (2011) Does maternal autonomy influence feeding practices and infant growth in rural India? *Social Science & Medicine* **73**, 447–455.
- Singh L., Rai R.K. & Singh P.K. (2012) Assessing the utilization of maternal and child health care among married adolescent women: evidence from India. *Journal of Biosocial Science* **44**, 1–26.
- Tebekaw Y. (2011) Women's decision-making autonomy and their nutritional status in Ethiopia. In: *The Demographic Transition and Development in Africa: The Unique Case of Ethiopia* (eds T. Charles & A. Hailemariam), 1st edn, Springer: Heidelberg Platz 3, Berlin.
- Torpey K., Mwenda L., Kabaso M., Malebe T., Makelele P., Mwema F. *et al.* (2010) Research article excluding pregnancy among women initiating antiretroviral therapy: efficacy of a family planning job aid. *BMC Public Health* **10**, 249.
- Uthman O. & Aremu O. (2008) Malnutrition among women in sub-Saharan Africa: rural-urban disparity. *Rural and Remote Health* **8**, 931.
- van der Heijde D.M., van't Hof M.A., van Riel P.L., van Leeuwen M.A., van Rijswijk M.H. & van de Putte L.B. (1992) Validity of single variables and composite indices for measuring disease activity in rheumatoid arthritis. *Annals of the Rheumatic Diseases* **51**, 177–181.
- Ververs M.-T., Antierens A., Sackl A., Staderini N. & Captier V. (2013) Which anthropometric indicators identify a pregnant woman as acutely malnourished and predict adverse birth outcomes in the humanitarian context? *PLoS Currents* **5**, ecurrents.dis.54a8b618c1bc031ea140e3f2934599c8. 10.1371/currents.dis.54a8b618c1bc031ea140e3f2934599c8.