

RESEARCH ARTICLE

Dietary practice among cohort pregnant women who gave birth to neonates with and without neural tube defect: a comparative cross-sectional study

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Abstract

Despite the high burden of neural tube defects (NTD) in eastern Ethiopia, there is no evidence that it is related to maternal dietary practice. The aim of the present study was to compare dietary practice between women who gave birth to newborns with and without NTDs. A comparative cross-sectional study was performed on a total of 276 (138 in each group) mothers who delivered neonates with or without NTD. Study participants were selected from three hospitals found in the eastern part of Ethiopia. The dietary practice was determined using the indicators including meal frequency, dietary diversity score (DDS), food variety score (FVS) and consumption of animal source food (ASF) generated from the dietary data collected using validated and pre-tested Food Frequency Questionnaire (FFQ). A multivariable logistic regression model was fitted to isolate independent predictors of dietary practices. The prevalence of good dietary practice was 29 % (95 % CI 23.6 %, 34.3 %). There was a significant difference in dietary practices ($P = 0.034$), in FVS ($P = 0.01$), in DDS ($P = 0.045$) between the two groups. In multivariable logistic regression, independent predictors of having good dietary practice were: not being the mother of a newborn with NTDs [adjusted odds ratio (AOR) 2.1, 95 % CI 1.07, 4.1], being from a rural residence area (AOR 0.29, 95 % CI 0.1, 0.7) and being illiterate (AOR 0.16, 95 % CI 0.03, 0.8). The present study found that dietary practice is associated with the development of NTDs. Nutrition education, food fortification and supplementation are needed to address this issue, and further research is needed to explore the mechanism.

Keywords: Developing neural tube defects: Dietary practice: Pregnant women

Background

Ensuring appropriate dietary practice is critical for optimising maternal and newborn health. Poor maternal nutritional status has been linked to a variety of adverse birth outcomes. Nonetheless, the relationship between maternal diet and birth outcome is complex and influenced by a variety of biological, socioeconomic and demographic factors that vary widely across populations⁽¹⁾. Nutrients have been shown to

influence the risk of neural tube defect (NTD) due to the role of folic acid and other nutrients^(2,3). Folate is an essential nutrient for fetal development as it is a cofactor in many important cellular reactions, including the synthesis of deoxy-ribonucleic acid (DNA) and ribonucleic acid (RNA)⁽⁴⁾ and other nutrients⁽⁵⁾. Poor dietary practice⁽⁶⁾, low maternal weight⁽⁷⁾, the short intervals between pregnancies⁽⁸⁾ and food insecurity^(9,10) could lead to deficiency of nutrients that have

Abbreviations: ASF: animal source food; AOR: adjusted odds ratio; CI: confidence interval; DDS: dietary diversity score; FVS: food variety score; NTD: neural tube defect; OR: odds ratio

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an effect on the development of the neural tube. There have been reports of NTDs in the offspring of women who had gastric bypass surgery⁽¹¹⁾, long-term restrictive diets⁽¹²⁾ and weight loss due to dieting during early pregnancy⁽¹³⁾. The extent to which these factors explain the population burden of NTDs is unknown due to a lack of knowledge about the underlying mechanisms in the causation of NTDs. Continued research into nutritional exposures related to implicated nutrients will help to understand the nutritional aetiologies of NTDs. Understanding the relationship between women's dietary practices is therefore critical to prevent adverse birth outcomes including NTDs. We hypothesised that the dietary practice would be associated with an increased risk of having offspring with NTDs. The present study, therefore, compared dietary practices between groups of women giving birth to newborns with and without NTDs (apparently healthy newborns) in a setting high burden of NTDs.

Method and materials

Study design and study site

A comparative cross-sectional study was employed to compare dietary practices of women who gave birth to newborns with NTD and their counterparts with NTD free newborns. The study was conducted in Dire Dawa City Administration, Harari Region and Adama City, located in eastern Ethiopia. Dire Dawa Referral Hospital is located in Dire Dawa, 515 km east of Addis Ababa and serves approximately five million people from Oromia and Somali regions adjacent to Dire Dawa. Hiwot Fana Specialized Teaching Hospital is located in Harari Region located 526 km east of Addis Ababa and serves the entire community in eastern Ethiopia. In addition, the hospital also functions as an educational centre for health and medical students. Adama Hospital Medical College is located in Oromia Region eastern Shoa, Adama city 100 km east of Addis Ababa and serves as a referral centre for more than six million people from different regions, including Afar, Amharic and Somali, as well as neighbouring zones and regions.

Study population

The study population consisted of two groups: women who gave birth to a newborn with NTDs and those who gave birth to apparently healthy newborns (without NTDs). NTDs were defined according to the ICD-10 criteria and a neonate born with anencephaly or spinal bifida, or encephalocele⁽¹⁴⁾ was labelled to have NTD. Both groups were recruited from obstetrics/gynaecology department in the same facilities. All women who gave written informed consent were included in the study. Women, who were seriously ill, emotionally upset or who died shortly after childbirth, and cases that are difficult to identify were excluded. The case group was defined as women who gave birth to newborns with NTD, while the comparison group was defined as women who gave birth to an apparently healthy and alive neonate. The comparison group was randomly selected from the same hospital.

Sample size determination

The sample size was calculated assuming an equal number of cases and comparison group (1:1), odds ratio of 3.0, power of 80 %⁽¹⁵⁾, significance level of 5 % and non-response rate of 5 %. The final sample size was 276 (138 cases and 138 comparisons).

Data collection and measurements

Data were collected through a face to face interview using interviewer administered pre-tested structured questionnaire. Trained midwives were involved in data collection. The questionnaire included socio-demographic, dietary and anthropometric data. The questionnaire was initially prepared in English language and translated into the local language. A previously validated Food Frequency Questionnaire (FFQ) was used⁽¹⁶⁾, and the questionnaire included 125 locally available items that are most commonly consumed in the community after consultation with key informants. The FFQ was pre-tested and necessary modifications were made before actual data collection.

Minimum Dietary Diversity for Women (MDD-W)^(17,18) was determined using the following ten food groups, including starchy and staple foods and grains, beans and peas, nuts and seeds, dairy, fleshy foods, eggs, vitamin A-rich dark green leafy vegetables, other vitamin A-rich fruits and vegetables, other vegetables and other fruits^(19–21). Meal frequency, dietary diversity score (DDS), food variety score (FVS) and animal source food (ASF) score were used to assess dietary practice. The FVS was calculated by counting the frequency of individual foods consumed by the mother during a week period. The mean FVS of pregnant women was calculated, and pregnant women with FVS greater than the mean were marked as having a 'high' FVS. The sum of each food group consumed by pregnant women during one week was calculated for DDS analysis and converted to tertiles, with the highest tertile used to mark the 'high' DDS. ASF consumption was estimated by calculating the frequency of each animal-derived food consumed by women during the reference period. ASF scores were also converted to tertiles, with the highest tertile defined as 'high'.

Values for each of the four indicators were summed and dietary practice was categorised as good when mothers have meal frequency greater than four, high FVS, high DDS and high ASF score, while the rest were labelled as having poor dietary practices^(18,22–24).

Women's height, weight and mid arm circumference (MUAC) were measured after calibration of the device and standardization of the data collectors. Acute malnutrition among pregnant women was defined as having MUAC of <21 cm^(25,26).

Quality control measures

In order to maintain the quality of the data, the questionnaire was adapted from validated and pretested data collection instruments. Data collectors and supervisors were trained for three days. The supervisors and principal investigator



Table 1. Socio-demographic data among the case group and the comparison group in Eastern Ethiopia

Variables	Case group (n 138)		Comparison group (n 138)		P
	n	%	n	%	
Living area					
Urban	81	58.7	78	56.5	0.71*
Rural	57	41.3	60	43.5	
Maternal age					
15–24	57	41.3	37	26.8	0.036*
25–34	67	48.6	86	62.3	
>34	14	10.1	15	10.9	
Educational status					
No formal education	23	16.7	30	21.7	0.0123*
Primary (1–8)	70	50.7	65	45.7	
Secondary (9–12)	37	26.8	28	20.3	
Tertiary education	8	5.8	17	12.3	
Occupational status					
Governmental	13	9.4	9	6.5	0.695*
Housewife	90	65.2	89	64.5	
Private	15	10.9	20	14.5	
Daily worker	20	14.5	20	14.5	
Family size					
1–3	48	34.8	53	38.4	0.29*
4–6	41	29.7	48	34.8	
>7	49	35.5	37	26.8	

All results are described as Pearson's chi square and all *p* values are *p* < 0.05 (*).

overhauled the data collection process and feedback was given on the data daily.

Data processing and analysis

Chi-square tests and independent sample *t*-tests were used to determine any statistically significant differences in prevalence and means between the two groups. Multivariable logistic regression model was fitted to isolate independent

predictors of dietary practices. The best-fitting model was determined using Akaike's information criterion (AIC). A lower AIC indicates a better fit model. AOR with 95 % CI were used to measure association. All assumptions were checked and a standard errors of >2.0 was used to test the presence of multicollinearity. All tests were two-sided and statistical significance was determined using a *P*-value of 0.05.

Results

A total of 138 pairs of participants were identified, among which 30 (21.7 %), 22 (15.9 %) and 86 (62.3 %) of cases with NTD delivery were reported from Dil Chora Referral Hospital, Hiwot Fana Specialization Hospital and Adama Hospital Medical College, respectively. The overall maternal age ranged from 17 to 40 years and the mean (\pm SD) maternal age was 26.2 (\pm 5.9) years. As indicated in Table 1, 58.7 % of cases with NTD and 56.5 % of those without NTD were from urban areas. Regarding educational status, 50.7 % of the NTD cases had primary education (grades 1–8) followed by secondary education (9–12) accounting for 26.8 %. Similarly, 45.7 % of the comparison group had primary education followed by secondary level which accounted for 20.3 % (Table 1).

Fig. 1 shows the contribution of each food group to the dietary practices as measured by the different indicators shown earlier by the status of delivering a newborn with NTD (case group) or not (comparison group). All subjects in both groups consumed more starch and group staples. Consumption of beans, peas, dairy products, meat, vitamin A-rich foodstuffs and other vegetables and fruits was higher in the corresponding group than in the case group, while nuts, seeds and eggs were relatively higher in the case group (Fig. 1).

There were significant differences in the intake of beans and peas (*P* = 0.005), meat group (*P* = 0.028), eggs (*P* = 0.046),

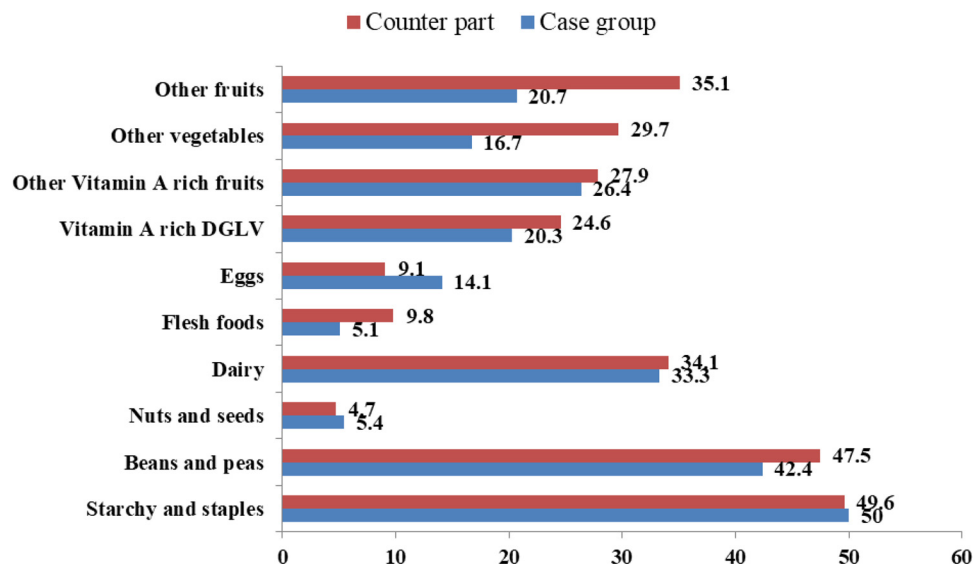


Fig. 1. Percentage of foods groups consumed by the case and comparison groups of cohort pregnant women in eastern Ethiopia.

**Table 2.** Food groups consumed during the 3-month dietary recalls, among participant women's case and comparison group in Eastern Ethiopias

Characteristics	Case group (n 138)	Comparison group (n 138)	Mean difference	P
	Mean (sd)	Mean (sd)		
Starchy and staple foods	5.5 (2.13)	5.4 (2.11)	0.00725	0.31
Beans and peas	5.5 (3.75)	5.7 (3.5)	0.10145	0.005*
Nuts and seeds	0.1 (0.3)	0.1 (0.3)	0.01449	0.42
Dairy	1.01 (1.0)	1.16 (0.89)	-0.01449	0.6
Flesh foods	0.18 (0.38)	0.13 (0.4)	-0.0942	0.028*
Eggs	0.25 (0.43)	0.19 (0.39)	0.10145	0.046*
Vitamin A-rich DGLV	0.64 (0.49)	0.83 (0.5)	-0.08696	0.14
Other vitamin A-rich fruits and vegetables	0.73 (0.9)	0.76 (0.89)	0.26087	0.36
Other vegetables	0.54 (0.51)	0.55 (0.6)	0.26087	<0.0001**
Other fruits	0.57 (0.49)	0.41 (0.49)	0.28986	<0.0001**

DGLV, dark green leaf and vegetables.

p values denotes as $p < 0.05$ (χ^2 test), $p < 0.01$ ** (Independent Sample t-test) and $p < 0.001$ ***.

other vegetables and other fruits ($P < 0.001$) between case and control groups. Women who delivered newborns without NTDs consumed more meat and fruit than controls (Table 2).

The prevalence of the good dietary practice in the study population was 29 % (95 % CI 23.6 %, 34.3 %) (Fig. 2).

As shown in Table 3, dietary practice ($P = 0.034$) showed a significant difference between the two groups. In addition, the FVS ($P = 0.01$) and the DDS ($P = 0.045$) were significantly different between the case and comparison groups (Table 3).

On the multivariable logistic regression model, after adjusting for background variables, women living in the rural areas were 71 % less likely to have good dietary practice than urban women [adjusted odds ratio (AOR) = 0.29, 95 % CI, 0.1, 0.7]. Likewise, illiterate women were 84 % less likely to adhere to good dietary practices than women with higher education (AOR = 0.16, 95 % CI 0.03, 0.8). Mothers in the comparison group were more likely to have a good dietary practice than women who delivered newborn with NTD (AOR = 2.1, 95 % CI 1.07, 4.1) (Table 4).

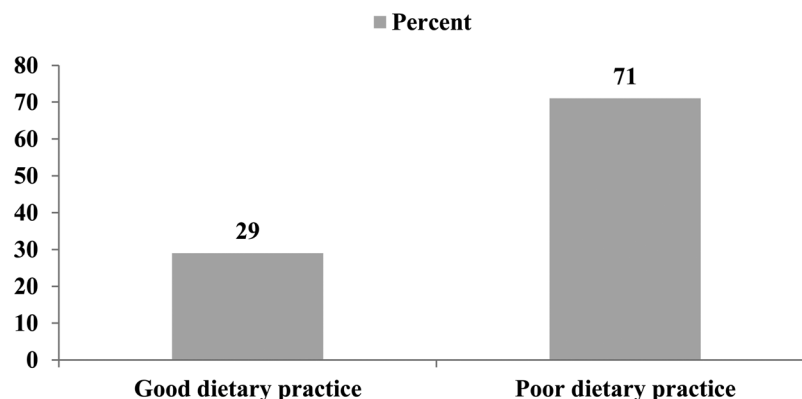
Discussion

The present study compared the dietary practice of women who gave birth to newborns with NTD with the ones who delivered apparently healthy newborn. Dietary practices were assessed based on meal frequency, FVS, DDS and ASF consumption. The overall proportion of good dietary practice was low, 29 %

(95 % CI 23.6 %, 34.3 %), which is higher than that of a study in the Haramaya region of eastern Ethiopia (15.18 %) (27) and in the West Gojjam Zone, Ethiopia (19.9 %) (23).

The present study showed that the case group had a poorer dietary practice than the comparative group (40 %) and that there was a significant difference in dietary practice between the two groups ($P = 0.034$). The poor dietary practice of pregnant mothers can have a significant impact on fetal health and birth outcomes (28–30). It also contributes to micronutrient deficiency (31,32) such as folate deficiency (33), which could lead to the occurrence of NTDs.

In the present study, nearly half of the case group (50 %) and of the comparison group (49.6 %) of women consumed starches and staple foods, while meat, nuts and seeds were the lowest food items taken by both groups (5.1 % of the case group and 5.4 % of the comparison group). This finding suggests that study participants rarely ate foods that consisted of folic acid. There were statistically significant differences in the intake of beans and peas ($P = 0.005$), meat group ($P = 0.028$), other fruits and vegetables ($P < 0.001$) between the case group and the comparison groups, which is consistent with the reports of other studies conducted in Ethiopia (23,34). The fact that flesh foods, nuts and seeds are good sources of folic acid (35), could explain the difference in the risk potential of NTDs between the two groups. Folic acid has been shown to have health benefits through its important role in one-carbon metabolism with its deficiency

**Fig. 2.** Prevalence of dietary practice study participants in eastern Ethiopia.

**Table 3.** Dietary practice and anthropometric indices, between case group and counterpart

Characteristics	Case group (n 138)	Comparison group (n 138)	P
	n (%)	n (%)	
Dietary practice			
Poor	106 (76.8)	90 (65.2)	0.034*
Good	32 (23.2)	48 (34.8)	
Food variety score			
Low	70 (50.7)	49 (35.5)	0.01*
High	68 (49.3)	89 (64.5)	
Dietary diversity score			
Low	39 (14.1)	25 (9.1)	0.045*
Medium	64 (23.2)	68 (24.6)	
High	35 (12.7)	45 (16.3)	
Animal source food			
Low	27 (9.8)	34 (12.3)	0.79
Medium	80 (29)	69 (25)	
High	31 (11.2)	35 (12.7)	
Body mass index			
Under weight	8 (2.9)	4 (1.4)	0.49
Normal weight	126 (45.7)	131 (47.5)	
Over weight	4 (1.4)	3 (1.1)	
MUAC			
Under-nourished	75 (27.2)	82 (29.7)	0.39
Well-nourished	63 (22.8)	56 (20.3)	

MUAC, middle upper arm circumference.

p values denotes as $p < 0.05^*$ (χ^2 test), $p < 0.01^{**}$ and $p < 0.001^{***}$.

being primarily associated with defects in the development of the fetal nervous system, NTDs and megaloblastic anaemia^(36–38). The fact that none of the pregnant women in the present study took folic acid before and during pregnancy is an issue that requires immediate policy attention.

There was a statistically significant difference in the DDS ($P = 0.01$) and the FVS ($P = 0.045$) between case and comparison groups. Dietary diversity correlates with nutrient adequacy, increased nutrient intake and better nutritional status in pregnant women⁽³⁹⁾. In our study, women living in urban areas had a significant association with good dietary practices, which could be due to the fact that urban residents are more exposed to nutritional information and practice

proper nutrition. In addition, the present study found that women's dietary practices were significantly associated with women's educational status, similar to what was documented by other studies^(22,40–43). The association between educational status and good dietary practice could be explained by the role of education in making people aware of the importance of eating a diverse diet. On the other hand, educated women can have better employment and income opportunities⁽⁴⁴⁾, which may lead to better food security and consumption of a diversified diet.

The findings revealed that women with poor dietary practices have lower folic acid intake among study participants. This requires efforts to activate public health measures aimed at increasing the consumption of foods, especially those rich in folic acid, and generally improving good dietary practice through a food-based approach, which is clearly stated in Ethiopia's newly developed food and nutrition policies and strategies^(45,46).

There are many comparative studies in Ethiopia that determined dietary practices of women in the context of NTD, which is a contribution to the literature pool. We acknowledge the limitations of the study, including the inability to assess the nutrient content of foods as part of the dietary practice. Nevertheless, these qualitative measures such as DDS, ASF and FVS have been shown to strongly correlate with nutrient levels and can be used as surrogate markers of nutrient intakes.

Conclusion

The present study highlighted that a significant proportion of the study participants had poor dietary practices regarding food groups with a source of folic acid. The dietary practice has been significantly associated with the proportion of NTDs. This finding indicates the need to consider fortification of staple food, folic acid supplementation prior to conception and nutritional education intervention. Further research is needed to discover the interactions between genetic, epigenetic and other causative risk factors associated with NTDs.

Table 4. Parameter estimates from multivariate regression predicting dietary practice among participant women

Parameters	Dietary practice status		β	SE	AOR (95% CI)	P
	Poor, n (%)	Good, n (%)				
Mothers group						
Delivered newborn with NTD (case)	106 (54.1)	32 (40)			1.00	
Delivered newborn without NTD (comparison)	90 (45.9)	48 (60)	0.75	0.34	2.1 (1.07–4.1)	0.029
Residence						
Urban	96 (49)	63 (78.8)			1.00	
Rural	100 (51)	17 (21.2)	−1.2	0.49	0.29 (0.1–0.7)	0.013
Educational status of women						
Illiterate	18 (9.2)	23 (28.7)	−1.7	0.8	0.16 (0.03–0.8)	0.02
Primary education (1–8)	102 (52)	22 (27.5)	0.8	0.7	2.2 (0.5–8.9)	0.25
Secondary education (9–12)	67 (34.2)	19 (23.8)	1.07	0.6	2.9 (0.8–10.4)	0.09
Tertiary education	9 (4.6)	16 (20)			1.00	

AOR, adjusted odds ratio; CI, confidence interval; NTD, neural tube defect. Maximum Standard Error (SE) = 0.8, Significant at $P < 0.05$.



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A.B. involved in the development of original idea, study concept, design, analysis and writing original draft preparation. T.F. supervised data collection. T.B. supported analysis, writing, review and editing the whole document.

All methods of the present study were carried out in accordance with the Declaration of Helsinki-Ethical principle for medical research involving human subjects. Before beginning data collection, ethical clearance was obtained from the Institutional Review Board (IRB) with a reference number of IHR PGY/738/21. The purpose of the study was informed with detailed information, benefits and the importance of mothers' participation and their newborn babies, and written informed consent was obtained from participants.

Data cannot be shared for ethical/privacy reasons.

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We declare here that we have no conflict of interest.

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