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Original article

# Nutritional status among women whose pregnancy outcome was afflicted with neural tube defects in Tigray region of Ethiopia

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**Abstract**

*Background:* Nutritional deficiency in pregnant women is a confirmed cause of neural tube defects (NTDs). Alongside to this background, We sought to determine the nutritional status and level of awareness on the issue of the NTDs as well as folic acid (FA) utilization among women who born infants with NTDs in Tigray region of Ethiopia.

*Method:* A standard interviewer and a food frequency questionnaire was used to obtain information from mothers of cases with neural tube defects ($n = 205$) and their controls ($n = 412$). Demographic information, weekly food frequency consumption, information on awareness on the issue of the NTDs as well as folic acid (FA) use was collected.

*Result:* The mean age of the mothers of the cases and controls was 26.5 years (range 17–43 years) and 26.05 years (range 18–40 years), respectively. Approximately 92.2% (189/205) of the cases and 90.5% (373/412) control mothers do not know the term folic acid (FA). Notably, all participant mothers (100%) did not understand that NTDs are a serious health problem associated with inadequate intake of FA and none of them used FA prior to conception. Food frequency analysis revealed that except for cereals ($p = 0.12$) and milk products ($p = 0.8$), the proportion of the consumed food type within seven days recalls period showed a statistically significant difference ($p < 0.05$) as compared with controls. The dietary diversity score assessment showed those attained low and high dietary diversity score were a statistically significant difference ($p = 0.0003$) and ($p = 0.0002$) respectively) as compared with controls, but the medium dietary diversity score no significant variation was found ($p = 0.35$).

*Conclusion:* This study has shown none of the study participants do understand that NTDs are a serious health problem associated with inadequate intake of FA. Dietary diversity score was significantly associated with incidence of NTDs. This Ethiopian study also highlighted the need of considering the basic food in future programs of food fortification with folic acid, preconceptional

*Abbreviations:* NTDs, neural tube defects; FA, folic acid; PFA, preconceptional folic acid; MU, Mekelle University; NORAD, Norwegian Agency for Development Cooperation

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folic acid supplementation and adequate dietary intake counseling. Advance research is required to find out the gene-nutrient and gene environment interactions, as well as particular causative factors associated with NTDs in Ethiopia.


*Keywords:* Neural tube defects; Nutritional status; Folic acid; Knowledge; Practice

## 1. Introduction

Neural tube defects (NTDs) occur when the neural tube of a fetus fails to close properly, thus impairing the development central nervous system. NTDs defects form early in a pregnancy, at roughly 28 days after conception [1]. Worldwide NTDs affect 0.5–2 in every 1000 pregnancies [1]. The precise cause of NTDs is not fully realized, but researchers expect that a combination of genetic, health and environmental factors are involved [2,3]. In dietary deprived populations, maternal nutritional status could to be an important determinant of neural tube defects and that dietary diversity score can serve as useful predictive indicator of maternal nutrition during pregnancy and the likelihood of delivering NTDs affected infants [4,5]. Maternal nutrition appears to play a crucial role in influencing pregnancy outcome growth, but the evidence is far from consistent [6,7]. In contrast to the prudent diet users, pregnant mothers with poor nutritional status increased the risk of having birth defects [8]. Embryonic development depends on the mother's body composition, size and total store of nutrients. [9]. Poor maternal nutritional status has been related to adverse birth outcomes; however, the association between maternal nutrition and pregnancy outcome is complex and is influenced by many biologic, socioeconomic, and demographic factors, which vary widely in different populations [6,7,8]. Understanding the correlation between maternal nutrition and pregnancy outcomes may provide a basis for developing nutritional interventions that will improve pregnancy outcomes and long-term quality of life and reduce mortality, morbidity, and health-care costs.

Studies done in 1970's and 1980's have discovered a link between folate deficiency and the occurrence of NTDs [4]. In addition to congenital abnormalities represented by neural tube defects, folate deficiency is associated with many acquired problems that have significant impact on public health. These include anemia [10], myelopathy [11], and neuropathy [12]. By 1991s' several studies, including 33 centers, 7 countries double-blind prospective study showed that periconceptional folic acid (PFA) supplementation reduced the risk of having infants afflicted with NTDs by 72% [5]. Though PFA supplementation, food fortification with folic acid (FA) and better dietary intake counseling significantly reduces the prevalence of neural tube defects in the developed world [4,13], the use of PFA supplementation, as well as sufficient dietary intake in the developing world, can still be enhanced. The changing clinical and epidemiological pattern of NTDs could be an effect of improving knowledge of the demand to attempt health care by people in developing countries and changing the cultural and traditional belief as a cause of diseases to the internationally accepted causation of diseases [14]. The non-consumption, delayed consumption or low consumption of FA among African reproductive age women [15,16], could reveal that there is a lack of awareness and knowledge of the population concerning health consequences [14]. Awareness on the importance of FA consumption and sufficient food intake in preventing NTDs has been variously shown to exhibit social and tribal differences with the more prosperous women being aware of it and more possibility to practice it more than their less-prosperous counterpart [17,18]. Aligned with this background, we aimed to determine the level of awareness on the issue of the neural tube defects as well as the use of PFA supplementation, food fortified with folic acid (FA) and nutritional status among pregnant mothers who delivered at eight randomly selected hospitals of the Tigray region of Ethiopia.

## 2. Subjects and methods

### 2.1. Study area

The study was conducted at the labor ward of the eight randomly selected hospitals including Mekelle Hospital, Ayder Comprehensive Specialized Hospital, Lemelem Karl Hospital, St. Mary Hospital, Sihul Hospital, Adigrat hospital, Wukro Hospital and Kahsay Abera Hospital. These hospitals are the major public hospitals found in six administrative zones of the Tigray region of Ethiopia, serving populations with diverse demographic characteristics as well as health-related behaviors. The study was carried out between October 2016 and June 2017.

### 2.2. Study design and population

This is a cross-sectional and descriptive study comprised 617 pregnant mothers who delivered in eight ran-

domly selected hospitals. During the study period a total of 14,903 deliveries assessed for possible occurrence of the NTDs. Out of the total of 14,903 deliveries examined during the study period, a total of 205 mothers who born infants with NTDs were identified and registered [19]. Hence, for the purposes of this study, all cases were compared to a group of controls derived randomly from the same representative hospital during the study period. Accordingly, all NTDs cases (n = 205) were compared to their controls (n = 412) (case: control ratio of 1:2). A control is defined as apparently healthy infant born immediately after delivery of a NTDs case in the same hospital where cases were recruited. Prior to the beginning of the data collection, appropriate ethical clearance was obtained from Mekelle University College of Health Sciences; Health Research Ethics Review Committee (registration number: ERC 0837/2016). Then for purposes of obtaining an informed consent of the respondents, every mother, on an individual basis, was furnished with detailed information concerning the research objectives, benefits and the importance of mothers' participation and their newborn babies. Detail written consents and their agreement to participate in the study was approved by signature on the prepared consent form. Then accordingly, information regarding socio-demographic, dietary diversity and food frequency questioner (FFQ) assessment were done by the trained research assistant under the supervision of gynecologists, embryologist, and a neurosurgeon.

### 2.3. Data collection tool

A standard interviewer and food frequency questionnaire were used to collect data for this study. Standardized face-to-face interviews were conducted with the mothers' shortly after delivery by specially trained registered nurses and midwife in the representative hospital. The dietary diversity data collection was made using a food frequency questionnaire (FFQ) by the method of assessment according to the technique explained by Liu [20]. Individual dietary diversity (DD) method of evaluation was made based on the technique used by Kennedy [21] and these methods were used by adapting to our local context and the outcome scored according to the method used by Ajani [22]. Demographic information and information concerning the knowledge and practice on PFA supplementation and awareness on the issue of NTDs was collected.

### 2.4. Statistical data analysis

Simple descriptive statistics were used to characterize the study subjects. The data collected was coded; cleaned and analyzed using Statistical Packages for Social Sciences (SPSS version 20). Comparison of the data proportion was calculated using MedCalc version 17.9.7 statistical software. And the analyzed statistical results were compared using their counterpart reference ranges, to decide whether they are in normal range or not and also to find if any significant differences ($p < 0.05$).

## 3. Result

The comprehensive clinical and socio-demographic description of the study subjects was published elsewhere [23]. Briefly, this study has shown the maternal mean age of the cases were 26.5 years (range 17–43 years) and mean age of the controls was 26.05 years (range 18–40 years), respectively. The educational status of the cases were having no formal education followed by elementary school, high school and college or above respectively. The majority of mothers of controls attained high school, followed by No formal education, attended elementary school, and college or above, respectively. The obstetric history has shown most of the respondents were primigravida to gravida two followed by gravida three to four and gravida above four (Table 1).

### 3.1. Knowledge and practice of the preconceptional folic acid consumption among mothers of cases with neural tube defects and their controls

This study has shown the awareness of the folic acid utilization in the preconception period was terribly poor among the respondents. Approximately 92.2% (189/205) of the cases and 90.5% (373/412) control mothers do not know the term folic acid (FA). None of the respondents had a practice of folic acid consumption prior to conception. Only 4% (9/205) of the cases and 8.7% (36/412) control had taken folic acid during 4th to 6th month of their pregnancy period. None of the respondents had eaten food fortified with folic acid at any time during their pregnancy. Notably, all study participants (100%) did not understand that NTDs are a serious health problem associated with inadequate intake of FA (Table 1).

### 3.2. Nutritional status among mothers of neural tube defects cases and their controls

The data in the Table 2 showed that the most consumed food groups in seven day period were; cereal/grain products, legume, seeds (bean, peanut or sunflower), milk product, oil and fats and miscellaneous drinks accounting for 98.5% (202/205), 76.1% (156/205), and 43.4% (89/205), 52.7% (108/205), 48.8% (100/205), and 77.1% (158/205), of the mothers born infants afflicted with NTDs respectively. While the least consumed food types were root or potato type, vegetables, fruits, flesh meat, organ meat, chicken, egg, vitamin A

Table 1
Knowledge and practice of the preconceptional folic acid consumption among mothers of cases with neural tube defects (n = 205) and their controls (n = 412) (Berihu et al. [23]).

| Characteristics | | Frequency: n (%) | |
|---|---|---|---|
| | | Cases (N = 205) | Controls (N = 412) |
| Maternal age (years) | | | |
| Mean age | | 26.5 | 26.05 |
| Level of education | | | |
| No formal education | | 70(34.1) | 109(26.5) |
| Primary school (Grade 1–8) | | 53(25.9) | 78(18.9) |
| Secondary school (Grade 9–12) | | 52(25.4) | 119(28.9) |
| Tertiary | | 3(1.5) | 12(2.9) |
| Gravidity | | | |
| Primigravida to gravida 2 | | 134(65.4) | 217(52.6) |
| Gravida 3 to 4 | | 43(21) | 135(32.8) |
| Gravida above 4 | | 28(13.6) | 60(14.6) |
| Know folic acid | | | |
| No | | 189(92.2) | 373(90.5) |
| Yes | | 16(7.8) | 39(9.5) |
| Took recommended 400ug folic acid supplement prior to conception | | | |
| No | | 205(1 0 0) | 412(1 0 0) |
| Took recommended 400ug folic acid supplement | | | |
| No | | 196(95.6) | 376(91.3) |
| Yes | 4th to 6th month of pregnancy | 9(4) | 36(8.7) |
| Ate food fortified with folic acid | | | |
| No | | 205(1 0 0) | 412(1 0 0) |
| Know about neural tube defects and its link with folic acid deficiency | | | |
| No | | 205(1 0 0) | 412(1 0 0) |

Table 2
Food groups consumed in seven days dietary recalls, among of participant mothers of cases and controls.

| Characteristics | Food frequency consumed among cases and controls | | P value |
|---|---|---|---|
| | Cases (n = 205) | Controls (n = 412) | |
| Food group | | | |
| Cereals | 202(98.5) | 410(99.5) | 0.12 |
| Legumes | 156(76.1) | 337(81.8) | 0.01 |
| Nuts and seeds | 89(43.4) | 244(59.2) | 0.002 |
| Miscellaneous drinks | 158(77.1) | 371(90) | 0.001 |
| Milk and milk products | 108(52.7) | 213(51.7) | 0.8 |
| Fats and oils | 100(48.8) | 240(58.3) | 0.023 |
| Flesh Meat | 65(31.7) | 213(51.7) | 0.0001 |
| Organ meat | 63(30.7) | 160(38.8) | 0.05 |
| Dark green leafy vegetables | 69(33.7) | 188(45.6) | 0.005 |
| Fruits | 57(27) | 191(46.4) | 0.0001 |
| White roots and tubers | 41(20) | 198(48.1) | 0.0001 |
| Chicken Meat | 50(24.4) | 143(34.7) | 0.001 |
| Egg | 56(27.3) | 173(42) | 0.0004 |
| Vitamin A rich vegetables | 2(1) | 27(6.6) | 0.0021 |

Table 3
Dietary diversity score among of participant mothers of cases and controls.

| Characteristics | | Frequency n (%) | | P value |
|---|---|---|---|---|
| | | Cases n = 205) | Controls (n = 412) | |
| Dietary diversity score | Low | 118(57.6) | 173(42) | 0.0003 |
| | Medium | 58(28.3) | 135(32) | 0.35 |
| | High | 29(14.1) | 104(25.2) | 0.002 |

rich food accounting for 20% (41/205), 33.7% (69/205), 31.7% (65/205), 30.7% (63/205), 24.4% (50/205), 27.3% (56/205), and 1% (2/205), of mothers born infants afflicted with NTDs respectively (Table 2).

The dietary score assessment showed except for cereals ($p = 0.12$) and milk products ($p = 0.8$), the proportion of the consumed food type within seven days recalls period showed a statistically significant difference ($p < 0.05$) as compared with controls (Table 3). The diet-

ary diversity score of cases showed that 57.6% (118/205) lie in low dietary diversity followed by 28.3% (58/205) occurring in the range of medium dietary diversity score and 14.1% (29/205) occurring in the high dietary diversity range. While the control mothers showed that 42% (173/412) of them occurring in the low dietary diversity followed by 32% (135/412) in the range of medium dietary diversity score and 25.2% (25.2/412) fall in the high dietary diversity range. Those found in low and high dietary diversity score were a statistically significant difference ($p = 0.0003$) and ($p = 0.0002$) respectively) as compared with controls, but as compared with a medium dietary diversity score where no significant variation was found ($p = 0.35$) (Table 3).

## 4. Discussion

The literature survey demonstrated that maternal diet and nutritional level have a direct impact on pregnancy outcome [6,7,8,9]. This is confirmed significantly in experimental animals and brought related to the socioeconomic status through surveillance of mothers living in poverty. One good example of a proven relationship between pregnant women whose diets are deficient in folate and congenital malformation are neural tube defects (NTDs) [4,5]. Unlike our country Ethiopia with highest NTDs incidence rate accounting for 131 per 10,000 pregnancy outcomes [19], in most developed countries and many developing countries, the NTDs incidence rate is less than 1/1,000 births, mainly as a result of encouraging reproductive age women to improve their dietary habit and PFA usage [1,5,24].

This study has shown that the maternal dietary diversity score was significantly associated with incidence of NTDs. The dietary diversity score assessment in the present study showed most of the study participants attain a low dietary diversity score followed by medium and high dietary diversity range. Similarly, studies conducted in Ethiopia showed that there were poor nutritional health statuses of reproductive women who lived in rural areas indicated by low body weight [13], which may contribute to a higher incidence rate of NTDs suspected in our country. Additionally, this study revealed that the knowledge about the issue of NTDs and the preventive role of sufficient intake of FA are abysmally poor among Ethiopian women. Devastatingly, none of our study participants were consumed folic acid in the preconception period. Though since the late 1970s, evidence has been reported for the link between poor intake of folate and the incidence of NTDs [4], it is disappointing that most Ethiopian women are unaware of the role of FA use and its magnificent means of declining the occurrence of the NTDs which is regularly a social problem in our environment. The literature survey reported that the women who previously gave birth to children with NTDs showed a significant decline in recurrence risk in a subsequent pregnancy if they took folic acid supplement prior to conception and early pregnancy period [4]. Recent reports from the medical research council (MRC) vitamin study group showed that the preconceptional folic acid supplementation for prevention of the NTDs pregnancy of the high-risk patients showed a significant reduction in NTDs incidence. The data convincingly confirmed that the daily 4 mg dose of the folic acid prior to conception and during early pregnancy showed about 72% reduction in the incidence of the NTDs [5].

The fact that PFA usage and improved dietary intake counseling significantly reduces the occurrence of NTDs in the developed world [4,5,24], while our country Ethiopia has not yet launched mandatory PFA supplementation and food fortification with FA, further strengthens their low awareness of the condition observed in our study. PFA supplementation has been shown to decline the incidence of NTDs [5]. For it to be useful, the FA should be taken commonly by reproductive-age women from two months prior to conception up to the end of the first trimester of pregnancy period as recommended by public health initiatives [24,25].

This study revealed that low educational status of the respondents' might influences their awareness of the FA as a preventive measure for the occurrence of NTDs as well as their awareness to select and consume food rich with folate. It is therefore likely that worse level of awareness could be expected from women in the less educated community. This study is comparable with the study from Nigeria, published in 2012, stated the PFA consumption has been indicated that the more educated women were being aware of it and more likely to use it more than their less educated counterparts [26].

A large study in Tanzania uses data from 1999 to 2008 reported that only 17.2% of mothers had taken FA at any time during their pregnancy [27]. Comparable findings were reported from other geographical regions of the world [17]. Thus, many women have not followed PFA recommendation may be because of their unplanned pregnancies, lack awareness, and limited access to supplements [17,18]. In most studies from countries where a folate rich diet is not accessible to all, NTDs showed a social gradient with the low-income population having the highest incidence [28,29]. Even in high-income countries, a lower maternal education status was associated with higher risk of NTDs [28]. The implications of this study for the larger population of Ethiopian women and by extension women in other developing countries are profound. Despite, their overall knowledge of the issues relating to NTDs is poor. It is therefore likely that the low awareness status could be expected from women in the less educated population in the developing world. Public education and interventions to enhance knowledge on the issue of the NTDs have been shown to be effective

in increasing PFA use [30,31]. Based on the aforementioned studies, there are clearly opportunities for African countries to improve the knowledge about FA unique means to improve pregnancy outcomes. Thus, educating women in developing economies and thereby improving their socioeconomic status may positively impact on the incidence of NTDs. Therefore, our study strongly argues the need for quick public enlightenments and interventions to improve adequate dietary intake, awareness on the issue of NTDs and its linkage with FA use in developing nations like Ethiopia.

## 5. Conclusion

The present study has shown none of the study participants do understand that NTDs are a serious health problem associated with inadequate intake of folate. Dietary diversity score was significantly associated with incidence of NTDs. This Ethiopian study also highlighted the need of considering the basic food in future programs of food fortification with folic acid, preconceptional folic acid supplementation and adequate dietary intake counseling. Advance research is required to find out the gene-nutrient and gene environment interactions, as well as particular causative factors associated with NTDs in Ethiopia.

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