Dietary diversity during pregnancy is associated with reduced risk of maternal anemia, preterm delivery, and low birth weight in a prospective cohort study in rural Ethiopia[1]

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ABSTRACT

Background: Anemia during pregnancy is a leading nutritional disorder with serious short- and long-term consequences for both the mother and the fetus.

Objective: The objective was to investigate the association between dietary diversity during pregnancy and maternal anemia, low birth weight (LBW), preterm birth (PTB), and stillbirth in rural Ethiopia.

Design: We conducted a prospective cohort study and enrolled 432 pregnant women in their first antenatal care visit (24–28 gestational weeks); 374 women completed the follow-up. By using the FAO Women's Dietary Diversity Scores (WDDSs), subjects were categorized into "inadequate" (WDDS <4) and "adequate" (WDDS ≥ 4) groups and were followed until delivery. Primary outcomes were maternal anemia, birth weight, term delivery, and stillbirth.

Results: The attrition rate was 13.7% and was balanced across the 2 groups. The proportion of women consuming dairy, animal-source foods, fruits, and vegetables including vitamin A–rich ones was higher in the adequate than in the inadequate WDDS group ($P < 0.05$). The overall incidence of maternal anemia increased from 28.6% to 32.4% during the follow-up period. The overall proportion of LBW, PTB, and stillbirth were 9.1%, 13.6%, and 4.5%, respectively. After control for baseline differences, women in the inadequate group had a higher risk of anemia [adjusted RR (ARR: 2.29; 95% CI: 1.62, 3.24], LBW (ARR: 2.06; 95% CI: 1.03, 4.11), and PTB (ARR: 4.61; 95% CI: 2.31, 9.19) but not of stillbirth (ARR: 2.71; 95% CI: 0.88, 8.36) than women in the adequate group ($P < 0.05$).

Conclusions: A WDDS of ≥ 4 food groups during pregnancy was shown to be associated with lower risk of maternal anemia, LBW, and PTB. Population-based controlled trials of various options to improve dietary diversity are needed before conclusive recommendations can be made. This trial was registered at clinicaltrials.gov as NCT02620943. *Am J Clin Nutr* 2016;103:1482–8.

Keywords: anemia, low birth weight, dietary diversity, pregnancy outcome, preterm, stillbirth

INTRODUCTION

Maternal and child undernutrition accounted for 45% of all child deaths in 2011 (1). Poor maternal nutrition, both before and during pregnancy, is associated with adverse pregnancy outcomes including intrauterine growth restriction, which greatly increases the risk of neonatal deaths (2), low birth weight (LBW),[5] preterm birth (PTB), and stunting (3). Thus, improving the dietary pattern and nutritional status both before and during pregnancy can play a major role in preventing anemia, intrauterine growth restriction, and the associated short- and long-term adverse effects (4, 5). This is in line with the current emphasis on the first 1000 d of life (conception through 24 mo of age) as a window of opportunity to promote healthy child growth.

Unfortunately, diets of pregnant women in low- and middle-income countries (LMICs) are monotonous and predominantly plant-based with little consumption of micronutrient-dense animal-source foods, fruits, and vegetables (6, 7). Recognizing that such poor diets are likely to be deficient in multiple micronutrients, supplementation, particularly with iron or iron-folic acid (IFA), has been the mainstay of nutrition interventions targeting pregnant women. Despite the WHO's clear recommendation, the coverage and compliance of iron and IFA supplementation remain unsatisfactory in most LMICs including Ethiopia (8, 9). Therefore, in these settings, complementary strategies that address the underlying poor dietary practices are needed.

Very few studies have investigated the effect of improved diets in reducing the risk of maternal anemia and adverse pregnancy outcomes in a LMIC setting (10–12), and those that did came up with inconsistent findings showing positive as well as no effects. In a recent cross-sectional study among pregnant women, Agrawal et al. (12) showed that IFA supplementation and dietary diversity, measured by the use of the food groupings described

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[5] Abbreviations used: ANC, antenatal care; ARR, adjusted RR; IFA, iron folic acid; LBW, low birth weight; LMIC, low- and middle-income country; MUAC, midupper arm circumference; PTB, preterm birth; WDDS, Women's Dietary Diversity Score.

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in the WHO infant and young child feeding guidelines (13), are associated with reduced symptoms suggestive of pre-eclampsia or eclampsia. However, to our knowledge, no longitudinal study has investigated the association of the FAO's scoring system for measuring Women's Dietary Diversity Score (WDDS) with maternal anemia and adverse pregnancy outcomes. The WDDS is a simple, rapid, and useful proxy measure of micronutrient intake adequacy (14, 15), which, if found to be associated with reduced risk of maternal anemia and pregnancy outcomes, can easily be integrated in public health interventions targeting pregnant women.

Therefore, to investigate the association between dietary diversity during pregnancy and maternal anemia, LBW, PTB, and stillbirth, we conducted a prospective cohort study that followed pregnant women from their first antenatal care (ANC) visit to term, in a rural, low-income setting in Ethiopia. The women were separated into adequate (WDDS $\geq$4) and inadequate (WDDS $<$4) dietary diversity groups, and the relative risks of maternal anemia, LBW, PTB, and stillbirth were estimated.

METHODS

Study setting

The present prospective cohort study was conducted in 8 randomly selected health centers in 4 rural districts that were representative of the different agroecologic zones of the Arsi zone, Oromia region, Ethiopia. The Arsi zone is one of the surplus-producing agricultural areas of Ethiopia, with major production of wheat and barley.

Study design, sample size, and sampling procedure

The study was designed to investigate the association of dietary diversity during pregnancy with pregnancy outcomes. The study was a longitudinal, prospective cohort study with 2 arms at a ratio of 1:1 adequate (unexposed) and inadequate (exposed) WDDSs. Sample size was calculated by use of the Open Epi Kelsey statistical software available at http://www.openepi.com/SampleSize/SSCohort.htm with the following parameters and assumptions: a 95% significance level (2-sided), 80% power, and 37% anemia prevalence (16) among exposed pregnant women and an anticipated 10% lower prevalence of anemia among unexposed pregnant women. This yielded a total of 168 subjects/arm, and to allow for $\leq$20% attrition by the end of the study, a sample size of 420 was required. The inclusion criteria for the study were as follows: pregnant women who are permanent residents of the study area, with no known medical, surgical, or obstetric problems and who were willing to attend routine ANC visits.

Ethics

Verbal informed consent was obtained from the eligible participants in the presence of local *kebele* (smallest administrative unit) administrators after a detailed explanation of the purpose and methods of the study. The study procedures were in accordance with the Helsinki Declaration of 1975 as revised in 1983. The study protocol was approved by the institutional review boards of the College of Natural Sciences of Addis Ababa University and the Oromia Regional Health Bureau.

Allocation to study arms

Pregnant women in Ethiopia start ANC late, usually in their second trimester (17); hence, although the study enrolled women attending their first ANC visit, all were already in their second trimester (24–28 gestational weeks). At enrollment, a 24-h WDDS was collected from the pregnant women by use of the FAO guidelines (14), and subjects were then divided into "adequate" (WDDS $<$4) or "inadequate" (WDDS $\geq$4) groups (**Figure 1**). Briefly, the pregnant women were asked to recall the foods they had consumed in the previous 24 h, first spontaneously followed by probes to ascertain that no meal or snack was left out. A detailed list of all the ingredients of the dishes, snacks, or other foods consumed was generated to enable better classification of mixed dishes. The foods were then categorized into 9 food groups: *1*) cereals, roots and tubers; *2*) vitamin A–rich fruit and vegetables; *3*) other fruit; *4*) other vegetables; *5*) legumes and nuts; *6*) meat, poultry, and fish; *7*) fats and oils; *8*) dairy; and *9*) eggs. Overall, four 24-h WDDSs from a typical day were collected each month from enrollment to delivery, meaning data were also collected in the preharvest (August–October) and postharvest (November–January) seasons.

A pregnant woman was assigned and remained in the adequate or inadequate group if her WDDS remained in that category for $\geq$3 of the 4 visits. Otherwise, the woman was excluded from the analysis (n = 8, 4/group).

Maternal socioeconomic, dietary, and anthropometric characteristics

Data on the socioeconomic characteristics and food consumption patterns were collected by using a pretested questionnaire that was adapted from the Ethiopian Demographic and Health Survey and the FAO (14, 17). The questionnaires were pretested in a similar setting. The data were collected by 24 well-trained and experienced midwives who work permanently in the antenatal care service provision units of health centers in the community.

The pregnant women were weighed at each visit from enrollment to delivery following the standardized procedures recommended by WHO (18). Pregnant women were weighed to the nearest 100 g on electronic scales with a weighing capacity of 10–140 kg. Their height was measured to the nearest millimeter with a portable device equipped with calibrated and standardized height gauges (SECA 206 body meter). The midupper arm circumference (MUAC) of the left arm was measured to the nearest millimeter with a nonstretch measuring tape.

Outcome assessment

Hemoglobin measurements were taken twice: once at enrollment and once before delivery (term) by use of a portable HemoCue (AB Leo Diagnostics). The readings were adjusted for altitude (19), and pregnant women with values $<$11.0 g/dL were considered to be anemic.

Gestational age was estimated by midwives at the health center, by counting from the last menstrual period and fundal palpation during ANC visits. Birth weight was measured and recorded by the midwives immediately after delivery. Stillbirth (no signs of life at birth after 24 completed weeks of gestation) and PTB ($<$37 wk of gestation) were ascertained by the same professionals at birth.

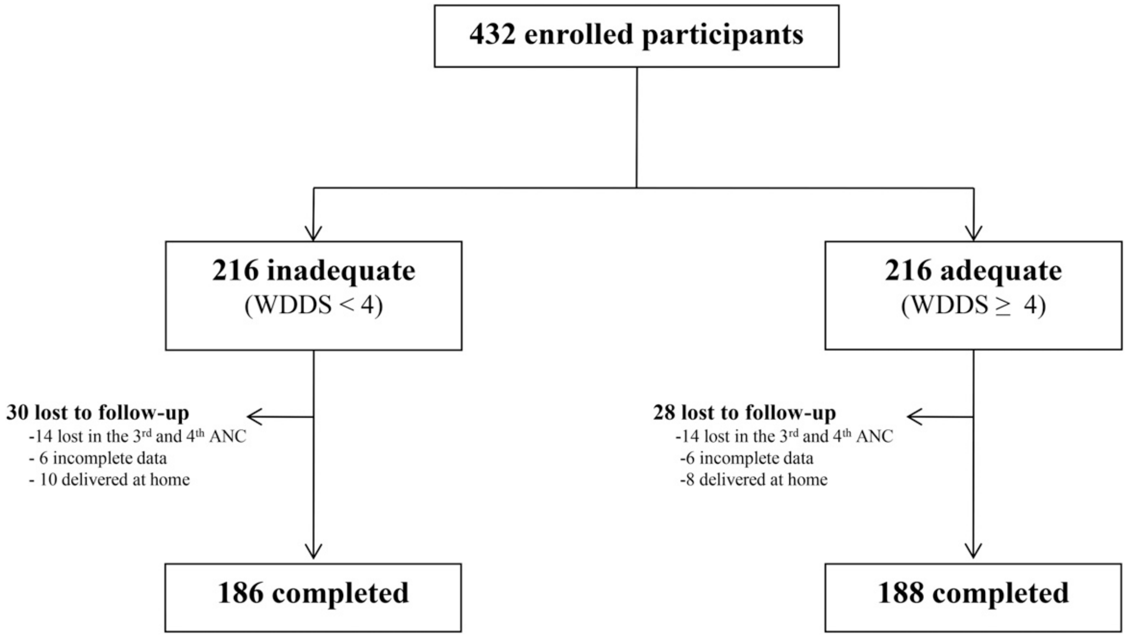

FIGURE 1 Study participant flow of the prospective cohort of pregnant mothers in rural Arsi, Central Ethiopia. ANC, antenatal care; WDDS, Women's Dietary Diversity Score.

Quality control

All data collectors were experienced (≥4 y) midwives with at least a diploma in nursing. They also received 5-d training on participants' enrollment, follow-up, anthropometric measurements, and the use of a HemoCue for hemoglobin measurements. The training was conducted just before the study and was followed by practical tests to ensure the skills were transferred.

In each of the health centers selected, one supervisor (usually the head) was assigned to oversee data collection. In addition, the investigator made a weekly visit to check the completeness and quality of the data collected.

Anthropometric measurements were taken only by trained personnel, and all equipment was calibrated with standard weights and length rods on a daily basis. Neither the pregnant women nor the data collectors were aware of the allocation into groups.

Statistical analyses

Data were entered by use of Epi-data statistical software (version 20). The data were double entered and cleaned and then exported to SPPS (version 20.0) for statistical analyses. All data on singleton pregnancies were analyzed according to their categorization by WDDS. All continuous variables were checked for normality by use of the Kolmogorov-Smirnov test. Variables not normally distributed were log-transformed. Means and SEMs were used to describe continuous variables. An independent Student's *t* test was used to compare means in the adequate and inadequate groups. A χ^2 test or a Fisher's exact test was used to test for independence in distribution of categorical variables between the 2 study groups. In all comparisons, differences were considered statistically significant at $P < 0.05$.

The association between adequacy of WDDS and pregnancy outcomes (anemia, LBW, PTB, and stillbirth) was investigated after adjusting for baseline differences. A log-binomial model adjusting for baseline group differences MUAC, level of education, hemoglobin, age, height, and gestational age was run, and the adjusted RRs (ARRs) and 95% CI values are reported.

RESULTS

A total of 432 eligible pregnant women (216 from each group) were enrolled, of whom 373 completed the study. The reasons for dropping out were mainly discontinuation of the ANC visits (n = 28), incomplete data (n = 12), or not delivering in a health facility (n = 18) (Figure 1). Overall, the dropout rate was 13.7% and was balanced across the 2 groups. The baseline characteristics of the dropouts and the women who completed the study were not statistically different (data not shown).

At enrollment, the mean duration of pregnancy was 25–27 wk, but women in the adequate group had their first ANC ∼1 wk before those in the inadequate group ($P < 0.05$) (**Table 1**). The 2 groups had similar monthly income, land size, parity, and rate of previous abortions ($P > 0.05$). However, women in the adequate WDDS group had a higher number of completed school years, had higher hemoglobin concentrations and MUAC values, and were taller and younger than their counterparts in the inadequate WDDS group ($P < 0.05$). Women in the adequate WDDS group consistently consumed more dairy, animal-source foods, fruit, and vegetables throughout the follow-up period than those in the inadequate group (**Figure 2**).

At the end of the follow-up, several of the outcome variables differed across groups (**Table 2**). Pregnant women in the adequate group had significantly higher weight, higher weight gain, longer duration of follow-up, and higher hemoglobin concentration and gave birth to heavier babies ($P < 0.05$). The proportion of pregnant women taking IFA tablets was very low, and although the number was slightly higher in the adequate group, the difference was not statistically significant. In addition, very few IFA tablets were taken by any of the women, and the number did not differ across the groups.

TABLE 1
Baseline sociodemographic, anthropometric, and biochemical characteristics of a cohort of pregnant women in rural Arsi, Ethiopia[1]

	WDDS[2]		
Characteristics	Inadequate (n = 186)	Adequate (n = 188)	P value
Maternal age, y	25.54 ± 0.347	24.44 ± 0.30	0.017*
Educational status, y	3.9 ± 0.288	5.7 ± 0.355	<0.001*
Proportion of nulliparous women, %	21.7	23	0.66[3]
Previous deliveries or parity, n	2.34 ± 0.09	2.14 ± 0.08	0.147
Previous abortions, n	0.11 ± 0.02	0.08 ± 0.02	0.369
Monthly income[4]	1507 ± 212	1566 ± 264	0.767
Land size, hectare	1.62 ± 0.12	1.36 ± 0.08	0.079
MUAC, cm	22.43 ± 0.12	22.97 ± 0.14	0.001*
Height, cm	158 ± 0.11	159.24 ± 0.39	0.039*
Weight, kg	51.95 ± 0.43	52.59 ± 0.52	0.358
Gestational age, wk	26.59 ± 0.22	25.32 ± 0.26	<0.001*
Hemoglobin,[5] g/dL	10.95 ± 0.12	11.73 ± 0.12	<0.001*

[1]Values are means ± SEMs. *Different between groups, $P < 0.05$ (independent t test). MUAC, midupper arm circumference; WDDS, Women's Dietary Diversity Score.
[2]Inadequate means a WDDS <4, and adequate means a WDDS ≥4.
[3]Value determined by Fisher's exact test.
[4]Ethiopian currency (*birr*).
[5]Hemoglobin concentration was adjusted for altitude.

At enrollment, 37.6% of women in the inadequate group were anemic compared with 19.7% in the adequate group (**Figure 3**). The proportion of anemia in the inadequate group continued to increase and reached 44.6% of anemic women at the end of the follow-up, whereas it remained fairly stable in the adequate group (20.2% at term). After control for baseline differences, pregnant women in the inadequate WDDS group had a ∼2-fold higher risk of being anemic (ARR: 2.29; 95% CI: 1.62, 3.24), a 4.7-fold higher risk of PTB (ARR: 4.61; 95% CI: 2.31, 9.19), and a 2-fold risk of LBW (ARR: 2.06; 95% CI: 1.03, 4.11) than their counterparts in the adequate WDDS group (**Table 3**). There were no differences in the risk of stillbirth between the 2 groups

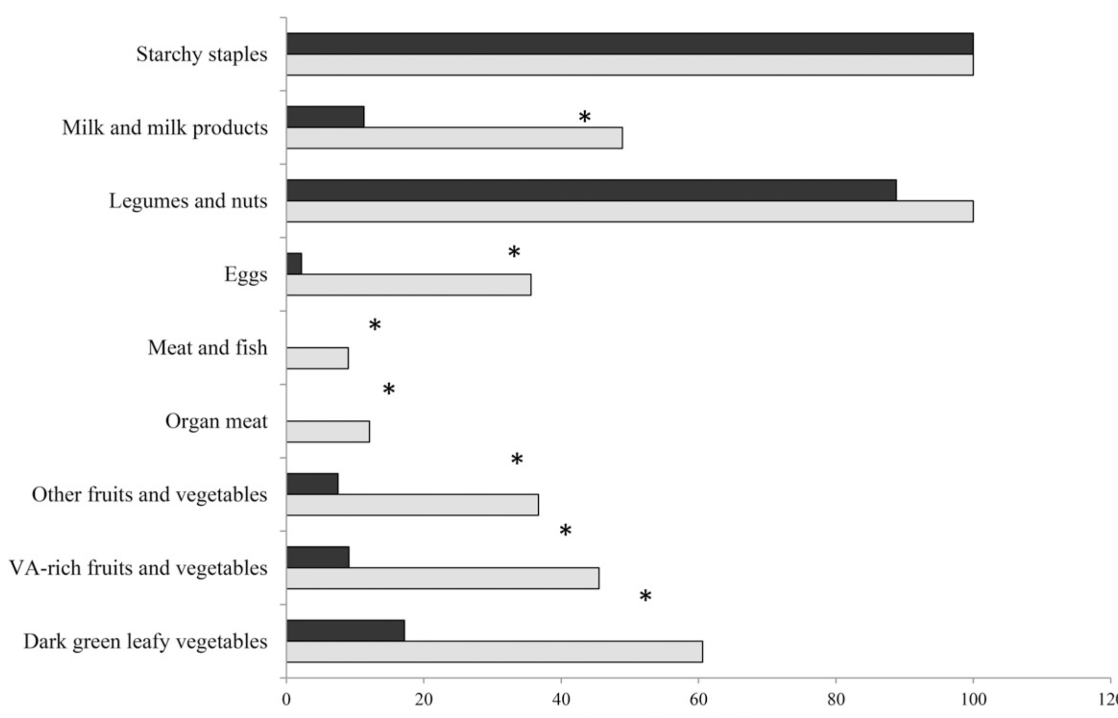

FIGURE 2 Food groups consumed by category of WDDS. Dark shaded bars indicate inadequate diet (WDDS <4), and light shaded bars indicate adequate diet (WDDS ≥4). *Statistically significant difference between adequate and inadequate groups measured by use of Fisher's exact test (P <0.05). VA, vitamin A; WDDS, Women's Dietary Diversity Score.

TABLE 2
Pregnancy and birth outcomes of pregnant women by dietary diversity group at end line (term)[1]

Outcome variable	WDDS[2] Inadequate (n = 186)	WDDS[2] Adequate (n = 188)	P value
Birth weight, g	2690.9 ± 20.65	3192.3 ± 33.3	<0.001*
Weight, kg	61.32 ± 0.51	62.65 ± 0.53	0.072
Changes from baseline	9.42 ± 0.16	10.02 ± 0.18	0.01*
Gestational age, wk	36.86 ± 0.07	37.39 ± 0.08	<0.001*
Duration of follow-up, wk	10.76 ± 0.25	12.05 ± 0.27	<0.001*
Hemoglobin,[3] g/dL	10.96 ± 0.14	12.19 ± 0.13	<0.001*
Changes from baseline	0.00 ± 0.11	0.46 ± 0.13	0.009*
Number of IFA tabs taken	35.39 ± 4.38	41.72 ± 3.25	0.345
IFA, proportion taking[4]	23.7	33.7	0.659

[1]Values are means ± SEMs. *Different between groups, $P < 0.05$ (independent t test). IFA, iron-folic acid; WDDS, Women's Dietary Diversity Score.
[2]Inadequate means a WDDS <4, and adequate means a WDDS ≥4.
[3]Hemoglobin concentration was adjusted for altitude.
[4]Value determined by Fisher's exact test.

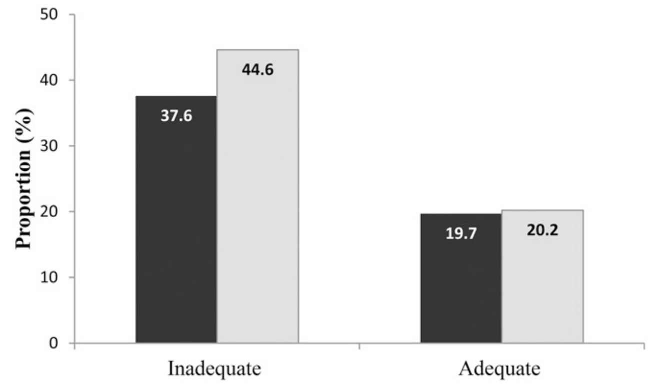

FIGURE 3 Incidence of anemia by WDDS category at baseline and endpoint. Dark shaded bars indicate baseline measurements, and light shaded bars indicate measurements at endpoint. Inadequate means a WDDS <4, and adequate means a WDDS ≥4. WDDS, Women's Dietary Diversity Score.

(ARR: 2.71; 95% CI: 0.88, 8.36). The incidence of LBW, PTB, and still birth at the end of the follow-up period was significantly higher in the inadequate than in the adequate group **(Figure 4)**.

DISCUSSION

The present multicenter prospective cohort study was conducted in a rural setting in Ethiopia. The study enrolled pregnant women from their first ANC visit (second semester) and followed them until delivery to investigate the association between the dietary diversity of pregnant women and the risk of LBW, PTB, stillbirth, and anemia during pregnancy. To our knowledge, this is the first study to examine the relation between the FAO WDDS and maternal anemia and pregnancy outcomes in a developing country setting. After adjustment for baseline differences, the study found that pregnant women in the inadequate WDDS group had a higher risk of anemia. Compared with their counterparts in the adequate WDDS group, women in the inadequate group had also a higher risk of LBW and PTB but not of stillbirth.

The higher risk of anemia among pregnant women in the inadequate WDDS group is not surprising and can be partly explained by a lower energy and nutrient intake than in the adequate group. Studies conducted among women of reproductive age and young children in various countries showed nutrient intakes increased with an increase in dietary diversity (15, 20). This was the basis for the validation and operationalization of dietary diversity tools as proxy indicators of dietary quality. Although we were unable to find any such studies among pregnant women, the nutrient adequacy of the diets is similarly expected to improve with dietary diversification, especially because the women in the adequate WDDS group consumed more nutrient-dense foods such as animal-source foods, fruits, and vegetables.

In the present study, women in the inadequate WDDS group had an increased risk of PTB (ARR: 4.61; 95% CI: 2.31, 9.19) and LBW (ARR: 2.06; 95% CI: 1.03, 4.11) compared with women in the adequate WDDS group. Poor nutrition in general and anemia in particular have been associated with various pregnancy complications including PTB and LBW (21). Most of this evidence comes from trials that involved supplementation with IFA, multiple micronutrients, and, more recently, food supplementation (22, 23). Most of these studies compared multiple micronutrients with iron or IFA and suggested that multiple micronutrient supplementations have several advantages in reducing LBW and preterm. We were only able to find a few observational and randomized controlled trials that investigated the effect of improved diet on birth outcomes (10, 24, 25). Taken together, these studies indicate that diet quality is associated with birth weight and PTB. In a prospective cohort study involving 66,000 pregnant women in Norway, "prudent" dietary patterns that consisted of vegetables, fruits, oils, water as a beverage, whole-grain cereals, and fiber-rich breads were associated with a lower risk of preterm delivery (26). Another prospective cohort study in the United States showed that the Dietary Approach to Stop Hypertension diet, which is also rich in dairy, fruit, and vegetables, was found to be associated with reduced risk of preterm delivery (25).

However, a recent randomized controlled trial in India reported that an intervention that increased consumption of dairy, fruits, and green leafy vegetables before and during pregnancy through a specially formulated snack had no effect on birth weight (11). In contrast, in the present study, the risk of LBW was lower in the adequate than in the inadequate group. Compared with women in the inadequate group, those in the adequate group consumed more dairy, fruits, and vegetable, but also other animal-source foods such as meat and eggs. The latter are rich sources of bioavailable micronutrients and thus may partly explain the difference in findings between the study in India and ours. It should also be noted that unlike the study in India, our study lacks evidence for causality.

It is worth noting that inconsistent findings among studies investigating micronutrients and pregnancy outcomes are common. For instance, the provision of lipid-nutrient supplement rather than IFA or multiple micronutrients during pregnancy in Ghana improved fetal growth (23), whereas it did not in Malawi (27). Such inconsistencies suggest that other factors in addition to improved nutrient intakes can come into play. In our study, baseline differences in maternal age, level of education, hemoglobin concentrations, and anthropometry could all have affected the incidence of maternal anemia and pregnancy outcomes (28). However, the association between dietary diversity, maternal

TABLE 3
Risk of maternal anemia and adverse pregnancy outcomes by dietary diversity group[1]

Outcome assessment	*n*	RR (95% CI)[2]
Anemia		
Anemic		
Inadequate	70	2.29 (1.62, 3.24)
Adequate	37	1
Total	107	
Nonanemic		
Inadequate	116	
Adequate	151	
Total	267	
Birth weight		
LBW		
Inadequate	23	
Adequate	11	2.06 (1.03, 4.11)
Total	34	1
Normal weight		
Inadequate	163	
Adequate	177	
Total	340	
Term delivery		
PTB		
Inadequate	42	4.61 (2.31, 9.19)
Adequate	9	1
Total	51	
Term birth		
Inadequate	144	
Adequate	179	
Total	323	
Birth		
Stillbirth		
Inadequate	13	2.71 (0.88, 8.36)
Adequate	4	1
Total	17	
Live birth		
Inadequate	173	
Adequate	184	
Total	357	

[1]Total $N = 374$: inadequate group, $n = 186$; adequate group, $n = 188$. LBW, low birth weight; PTB, preterm birth.

[2]Values were estimated by using log-binomial regression adjusted for baseline differences: maternal educational status, age, height, midupper arm circumference, and hemoglobin concentration.

anemia, and the birth outcomes remained significant even after adjusting for these baseline differences. Another confounding factor is the IFA supplementation supplied by the health facilities. However, the proportion of women who took IFA supplementation was similarly low in the 2 groups, and those who took the supplements did not take more than a third of the WHO-recommended regimen of minimum 90 tablets. Such low compliance and adherence to IFA supplementation is common among pregnant women in many developing countries including Ethiopia (8, 9). At enrollment, ∼30% of the pregnant women were already anemic, and a closer look at these data showed that 20% more women in the inadequate group were anemic than in the adequate group. Considering the equally low compliance, the inadequate amount of tablets taken, and the late start of IFA supplementation in the 2 groups, we do not think this is the main reason for the observed differences in the risk of maternal anemia and pregnancy outcomes. There was also no reported case of malaria during the follow-up period, and none of the women were smokers.

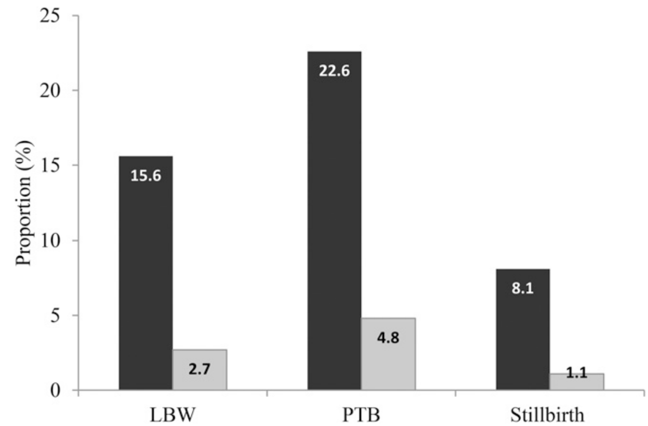

FIGURE 4 Incidence of adverse pregnancy outcomes by WDDS category at the end of follow-up. Dark shaded bars indicate inadequate diet (WDDS <4), and light shaded bars indicate adequate diet (WDDS ≥4). LBW, low birth weight; PTB, preterm birth; WDDS, Women's Dietary Diversity Score.

In addition to improved micronutrient intakes, a plausible way by which dietary diversity could improve pregnancy outcomes would be through improved antioxidant and fiber intakes (29, 30). This is particularly true for women in their second trimester of pregnancy, because oxidative stress reaches a peak at this time (31). Such oxidative stresses and the associated inflammation have been linked to pregnancy complications (32, 33). Therefore, increased dietary diversity could also mean higher intakes of antioxidants and fiber through increased consumption of fruit and vegetables, which could counteract oxidative stress-related pregnancy complications (34).

The present study has several limitations that need to be taken into consideration when interpreting the findings. Although it is recognized that both pre- and early pregnancy nutrition are associated with pregnancy outcomes, we were only able to follow the women starting from their second trimester, mainly because of the late start of ANC visits. Nevertheless, given the consistency of WDDSs in the 4 monthly assessments conducted during the follow-up period, we expect that the pre- and early pregnancy WDDSs would have been similar. We used the FAO WDDS, which included 9 food groups and assumed consumption of ≥4 food groups as the minimum adequate dietary diversity score. Unfortunately, our study was not adequately powered to test several thresholds of WDDS. Neither did we impose a minimum amount restriction in counting food groups. However, our dichotomous categorization of dietary adequacy based on a cutoff point of 4 food groups was a good predictor of maternal anemia and the various adverse pregnancy outcomes. By assessing the dietary diversity of the women at monthly intervals (a total of 4 times) and hence in both pre- and postharvest seasons, this study was able to account for possible seasonal variations. Although efforts were made to control for baseline differences when calculating the relative risks of adverse pregnancy outcomes, the effect of some factors like the level of education cannot be completely controlled. Also, the present finding should be interpreted with caution, because it does not provide evidence for causal relation.

Notwithstanding the above-mentioned limitations, our study is to our knowledge unique in showing that a WDDS ≥4 is associated with reduced risk of maternal anemia, LBW, and preterm among pregnant women in rural Ethiopia. This finding suggests that the FAO WDDS could be used as a simple tool to assess the dietary quality of pregnant women and could thus be used to support programs in further defining recommendations of a "balanced diet" at this vulnerable life stage. However, the present findings suggest association and not causality. Thus, future studies should explore the validity of the WDDS as a predictive tool for maternal anemia and adverse pregnancy outcomes in other low- and middle-income countries.

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