

# Prevalence and Associated Factors of Zinc Deficiency Among Pregnant Women Attending Antenatal Care at Gambella Hospital, Gambella, Ethiopia, 2018

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**Abstract:** It has been evidenced that zinc deficiency has an adverse effect on both mother and fetus, and subsequent birth outcomes and child survival. However, data on the prevalence and determinants of zinc deficiency among pregnant women are scanty in the country. Thus, this study was aimed to assess the prevalence of zinc deficiency and its associated factors among pregnant mothers attending antenatal care in the study setting in particular and the country in general. Hospital based cross-sectional study was done in Gambella Hospital, Southwest Ethiopia from January to March, 2016. A randomly selected 246 pregnant women were included in this study. Blood samples were collected to analyze biochemical indicators of zinc deficiency. A multivariable logistic regression analysis was done to assess the effect of various explanatory variables on the serum zinc level. The mean serum zinc concentration was 58.75µg/dl (95%CI: 56.10-61.41). The overall prevalence of zinc deficiency among pregnant women was 55.3% (95% CI: 50.0-61.3). Zinc deficiency was positively associated with short birth interval (AOR=2.6; 95% CI: 1.08-6.27), the third trimester (AOR=3.76; 95% CI: 1.49-9.49), failure to consume diet of animal source (AOR=2.4; 95% CI: 1.01-5.74), inadequate dietary diversity (AOR=3.59; 95% CI: 1.45-8.96), low serum albumin level (AOR=3.05; 95%CI: 1.31-7.08), and anemia (AOR=3.09; 95%CI: 1.19-7.95). More than half (55.3%) of pregnant women had biochemical evidence of zinc deficiency. Moreover, the magnitude of zinc deficiency was pronounced among pregnant mothers with short birth interval, advanced gestational age, minimal intake of animal food sources, inadequate dietary diversity score, low serum albumin level, and low hemoglobin level (anemia). Therefore, effort should be made to encourage pregnant mothers to consume balanced diet including animal food sources particularly in their third trimester, to monitor their hemoglobin and serum albumin levels, and strengthening family planning implementations to prevent the occurrence of zinc deficiency.

**Keywords:** Cross Sectional Study, Gambella, Pregnant Women, Zinc Deficiency

## 1. Introduction

Zinc is one of the essential trace element for all forms of life and vital micronutrients with diverse physiologic and metabolic functions. [1] The total body zinc content of human subjects is 1.5-3.0 grams and it is the second most abundant trace element in the body next to iron (4 grams). [2]

This mineral is an essential cofactor for more than 300 enzymes participating in the metabolism of macromolecules as well as micronutrients. Thus, zinc is important in regulating basic cellular functions such as Deoxyribonucleic acid (DNA) replication, ribonucleic acid (RNA) transcription, cell division and activation. However, too extreme zinc level can lead to these abnormal body function.

[3, 4]

ZD in humans is resulted from reduced dietary intake, inadequate absorption, increased zinc loss, or increased zinc demands by the body system. However, the most common cause is reduced dietary intake. In the United States, the Recommended Dietary Allowance (RDA) is 8 mg/day for women and 11 mg/day for men. [5]

Zinc Deficiency (ZD) during pregnancy can negatively affect both the mother and fetus and thus complicated birth outcomes. Major problems associated with ZD are: increased maternal morbidity, pregnancy induced hypertension, fetal neural tube defects, premature rupture of membrane, low birth weight, poor neurobehavioral development, cognitive impairment, intrauterine growth retardation, impaired glucose tolerance, congenital malformations, stillbirths, preterm labor, postpartum hemorrhage, prolonged or non-progressed labor and delivery, inefficient uterine contraction, abnormalities in gene replication, delayed immune system development which leads to increased neonatal morbidity and mortality rate. [3, 6, 7] ZD has also serious consequences for health including impairment of the immune system and as a result increasing the prevalence of childhood infections such as diarrhea and pneumonia, and impaired maternal health and poor pregnancy outcome. [7, 8]

Pregnant women in developing countries are susceptible to multiple micronutrient deficiencies including ZD. Pregnancy is associated with physiological changes and increased metabolic demands that results in increased plasma volume of blood, decreased concentrations of circulating nutrient-binding proteins and micronutrients, poor bio-absorption. All these conditions are obvious and most common to pregnant women. [3, 9] Increased nutritional demands during pregnancy predispose pregnant women to develop ZD. Because zinc requirements for fetal growth are high, Pregnant women are more susceptible to ZD, particularly in 2nd and 3rd trimesters. [6] Globally, It is estimated that 82% of pregnant women likely have inadequate zinc consumption. [8] However, the deficiency of zinc is more prevalent in women from poor socioeconomic groups. [10]

In 2004 International Zinc Nutrition Consultative Group (IZiNCG) estimated that 21.1% of Ethiopian population was at risk of inadequate dietary zinc intake. Where diets are plant based rich in phytate, a compound which is known to inhibit zinc absorption and bioavailability. [3] In light of this fact, in most areas of Ethiopia consumption of animal sources is mostly limited to occasional public holidays, which indicated inadequate intake. [11] Hence, this might be the reason for the expected high ZD prevalence in the country. The hot climatic condition of the region may also increase zinc loss from the body. [3]

ZD is increasingly being recognized as a major public health problem and the risk factors for low serum zinc level concentration believed to exist. However, there is no regionally representative figure on zinc status of the population. Nothing is being done so far in Ethiopia to address ZD except for the short-term zinc supplementation targeting children with diarrhea. However, the extents of ZD

among pregnant women are not fully understood in the study setting in particular and the country in general and this challenges us in the expansion of prevention strategies to control ZD in the population. Therefore, this study was aimed to assess the magnitude and associated factors of ZD among pregnant women attending Antenatal care (ANC) at Gambella Hospital, Gambella, Ethiopia.

## 2. Materials and Methods

### *Study design and setting*

A hospital based cross-sectional study was conducted at Gambella Hospital, Gambella, Southwest Ethiopia from January to March, 2016. It is located at 768 km far southwest from the capital of Ethiopia, Addis Ababa. The city has an elevation ranging from 400 to 600 meters above sea level and largely hot climatic zone. The hospital provides surgical, medical, pediatric, gynecologic, and obstetric including ANC service among many other services to the community and displaced people from South Sudan. According to the 2014 annual plan and performance report of Gambella Hospital, 15 to 20 pregnant women visited the hospital's ANC clinic daily on average and thus 700 pregnant women had ANC follow up during two months attendance in the hospital.

### *Sampling size determination and Sampling technique*

The sample size was determined by using single population proportion formula using EPI info version7 assuming the prevalence of zinc deficiency among pregnant women was 57.4% [12], 5% margin of error, and 5% level of significance. There were finite number of mothers attending the ANC clinic at the hospital and thus, the final sample size was estimated to be 268 by adding 10% for non-response rate. The study subjects were selected by systematic random sampling one for every three mothers visited the ANC clinic in the hospital during the study period and to avoid redundancy client card numbers were coded.

### *Data collection procedures and Variable measurements*

Data were collected using pretested structured questionnaire that was adopted from different similar literatures. It was used to collect data on serum zinc concentration and its associated risk factors based on the conceptual framework of the study. It was prepared first in English then translated into Amharic and Agnuac languages. Finally, the questionnaires were administered in both Amharic and Agnuac languages. Trained Diploma midwives and laboratory technicians were involved in the data collection and supervisions were also supervised by two nursing professionals.

DDS Assessment: The DDS assessment tool was adopted from Food and Nutrition Technical Assistance (FANTA) indicator guide for measuring household and individual DDS. [13] The women dietary diversity level was assessed using 24 hour recall method. Respondents were asked whether they had taken any foods or liquids from predefined 9 food groups in the previous day of the survey. Based on a set list of nine food items (Starchy staples, dark-green leafy vegetables, vitamin A rich fruits and vegetables, other fruits and

vegetables, organ meat, meats and fish, eggs, legumes, nuts and seeds, milk and milk products), DDS less than four out of nine score was categorized as inadequate otherwise it was categorized as adequate DDS. [13]

#### *Anthropometric measurements*

To assess nutritional status of pregnant women, measurements of Mid Upper Arm Circumference (MUAC) was taken from all selected pregnant women using a non-stretchable MUAC tape. It is done after study subjects removed their jackets. A triplicate measurement of MUAC was taken at the same day from each study subject using standardized techniques. All measurements had been taken twice and the average had been computed. When the two measurements differ by one unit, the measurement had been repeated. Checking accuracy of the scale and frequent calibrating of the scale was done. Calibration was done before and after weighing every pregnant woman setting it to zero. Those with a MUAC value less than 22 cm were considered as malnourished and above 22 are well nourished.

#### *Blood sample collection, Processing and Transportation*

A venous blood sample of 5 milliliters (5 ml) was collected from the median-antecubital vein under aseptic conditions using a sterile trace elements-free evacuated blood collection tube. The same day, the serum samples were kept frozen at  $-20^{\circ}\text{C}$  at Gambella regional laboratory until it is transported to the laboratory of the Ethiopian Public Health Institute (EPHI). Serum was kept in an ice box during transportation.

#### *Serum zinc determination and zinc deficiency*

Both non-fasting and fasting blood samples were collected following standard procedures for serum zinc analysis. Serum zinc concentration was determined at EPHI using Shimadzu Flame Atomic Absorption Spectroscopy (AA 6800 model, Japan). The pregnant woman is zinc deficient if the serum zinc level is less than  $56\mu\text{g/dl}$  during the first trimester or less than  $50\mu\text{g/dl}$  during the second or third trimester. [3]

#### *Hemoglobin and albumin levels determination*

Hemoglobin was determined at Gambella Hospital. Hemoglobin concentration was estimated by Hemo Cue haemoglobinometer. This device is non-invasive requiring only a small volume of blood ( $10\mu\text{l}$ ) and confers high sensitivity, specificity, and positive predictive value for evaluation of blood hemoglobin. [14] Albumin was also determined at Gambella hospital. Albumin level was measured by Roche cobas intgera® 400 plus chemistry analyzer machine. Albumin deficiency is defined as a serum albumin level less than  $3.2\text{ g/dl}$  during pregnancy [15]. In addition, Anemia among pregnant women is defined as a hemoglobin level of (at sea level) less than  $11.0\text{ g/dl}$  during the first or third trimester or less than  $10.5\text{ g/dl}$  during the second trimester. [13]

#### *CRP determination and HIV status screening*

CRP was determined qualitatively using CRP-Latex following the procedure provided with the kit. In addition, rapid test for HIV (1/2) antibody from whole blood was also performed by serial testing algorithm. The algorithm includes KHB as a screening test, Stat pack as a confirmatory test and

Uni-gold as a tie breaker test.

#### *Data processing and statistical analysis*

The collected data were coded and entered using EPI-Info version-7 software. The data were exported to SPSS version 20 statistical software for further cleaning and analysis. The descriptive statistics show the distribution of respondents by the key variables. Descriptive statistics such as frequencies with percentages and mean with standard deviation were used to present categorical and continuous variables, respectively. Bar graphs are also used to summarize categorical variables. Multivariable binary logistic regression analysis was used to assess the effect of different explanatory variables on the zinc status and to control potential confounders. Finally, multivariable analysis was run for significant variables in the bivariate analysis of logistic regression and thus, variables with  $P\text{-value} \leq 0.05$  (5%) were considered as statistically significant predictors of ZD prevalence in the final logistic regression model. Moreover, the Adjusted Odds Ratio (AOR) and 95% Confidence Interval (CI) were interpreted and discussed for the statistically significant predictors of ZD prevalence in the study.

#### *Ethics approval and consent to participate*

Ethics approval was issued by Institutional Review Board (IRB) of Mekelle University, College of Health Sciences (Protocol Reference: ERC 06104/2016) and a written informed consent was obtained from the study subjects prior to data collection after explaining the purpose and procedures of the study. Health care workers read out and explained the information to illiterate participants and obtained written consent on their behalf. While, for subjects who were less than 18 years of age, assent was sought from their spouse as legal guardian for those who were not married and thus, parental consent was also considered in this situation. Moreover, the privacy, anonymity, voluntary participation and confidentiality were ensured.

## 3. Results

#### *Background characteristics of the study participants*

Of the total 268 pregnant women (15-49 years of age) selected, 246 (91.4%) were interviewed with an acceptable non-response rate less 8.6%. One hundred sixty-five (67.1%) of the study participants were urban dwellers. Slightly more than half (51.6%) of the study participants were youth (25-34 years old). Approximately, 46.0% of study subjects were Protestants. Regarding the educational status, 56 (22.8%) of pregnant women were illiterate. Nearly half (47.5%) of the pregnant women were housewives. Almost all of the study participants (95.5%) had married marital status. Almost two-third (67.1%) of the study subjects were urban dwellers and 165 (66.3%) of pregnant women had family size of 4-5. Source of drinking water for more than half (54.9%) of study participants was tap water. Unlikely, more than one fifth (20.7%) of pregnant women had well water source of drinking (Table 1).

**Table 1.** Background characteristics of the pregnant women attending ANC at Gambella Hospital, Gambella, Southwest Ethiopia, 2016 (n=246).

Variables	Frequency	Percentage
Age (in years)		
15-24	73	29.7
25-34	127	51.6
35-49	46	18.7
Religion		
Orthodox	92	37.4
Protestant	112	45.5
Muslim	26	10.6
Catholic	16	6.5
Ethnicity		
Agnuac	53	21.5
Amhara	52	21.1
Oromo	46	18.7
Nuer	39	15.9
Others*	56	22.8
Marital status		
Married (living with a partner)	235	95.5
Others**	11	4.5
Residence		
Urban	165	67.1
Rural	81	32.9
Educational status		
Illiterate	56	22.8
Can write and read	23	9.3
Primary education (1-8)	83	33.7
Secondary education (9-12)	41	16.7
Higher education***	43	17.5
Occupation		
House wife	116	47.2
Governmental employed	36	14.6
Farmer	27	11
Merchant	25	10.2
Self-employed	18	7.3
Others****	24	9.8
Family size		
≤3	67	27.2
4-5	163	66.3
≥6	16	16.5
Family monthly income		
≤1000 Ethiopian birr	77	31.3
1001-2000 Ethiopian birr	90	36.6
>2001 Ethiopian birr	79	32.1
Latrine availability		
Yes	199	80.9
No	47	19.1
Source of water		
Tape water	135	54.9
Spring water	60	24.4
Well water	51	20.7

\*Opo/kemo/Tigray/Kemba/Wolayita/Gurage/Kafa; \*\*Single/Divorced/Widow; \*\*\*College /University; \*\*\*\*Day laborer/student

*Reproductive health and health care related characteristics of the study participants*

Seventy four (30.1%) of the study participants had first ever pregnancy in the study. More than one third (37.8%) and almost two-fifth (40.2%) of pregnant women had inadequate birth interval and were in the third trimester of pregnancy respectively. In addition, 117 (47.6%) of the study participants were received nutritional education during their ANC follow-up. Among those pregnant women who attended ANC, 65 (26.4%) of them were received iron

supplementation as medication during their pregnancy period. The reproductive health and health care characteristics of the study subjects were presented in (Table 2).

**Table 2.** Reproductive health and health care related characteristics of pregnant women attending ANC at Gambella Hospital, Gambella, Southwest Ethiopia, 2016 (n=246).

Variables	Frequency	Percentage
Parity		
0	74	30.1
1-2	101	41.0
3-4	57	23.2
≥5	14	5.7
Birth interval		
0 (no birth)	74	30.1
6-23 months	93	37.8
≥24 months	79	32.1
Period of pregnancy in trimesters		
First trimesters (0-12 week)	56	22.8
Second trimesters (13-28 week)	91	37.0
Third trimesters (29-40 week)	99	40.2
Received nutrition education during pregnancy		
Yes	117	47.6
No	129	52.4
Received iron supplementation during pregnancy		
Yes	65	26.4
No	181	73.6
Suffered any illness during pregnancy		
Sick	107	43.5
Not sick	139	56.5
Types of illness during pregnancy period*		
Acute fever illness /malaria, typhoid/	28	11.4
Pregnancy related disorder	29	11.7
Others**	50	20.3
Type of treatment/medications given*		
Haven't received	21	8.5
Anti-malaria	19	7.7
Other treatment***	67	27.4

\*multiple response were possible; \*\* Helimentasis/pneumonia; \*\*\*Pain killer/traditional remedies.

*Nutrition related characteristics of the study participants*

The staple diet for the majority (44.5%) of the study participants was Teff. More than three-fourth (81.7%) of the study subjects were consuming coffee. Regarding the DDS of the pregnant women, the more than half (52.4%) of study participants had inadequate DDS. Only ninety-three (37.8%) of pregnant women were consumed diet of animal origin. The highly consumed food groups by the study participants, 244 (99.2%) were starchy and cereal based foods composed of Teff, Wheat, Sorghum, and Millet and 53.1% of the study subjects consumed diet of legumes, nuts and seeds in the previous 24 hours. However, only few (12.2%) of the study participants were provided with organ meat and eggs. Moreover, the nutritionally related characteristics of the study participants were summarized in (Table 3).

**Table 3.** Nutrition related characteristics of pregnant women attending ANC at Gambella Hospital, Gambella, Southwest Ethiopia, 2016 (n=246).

Variables	Frequency	Percentage
Types of staple diets*		
Millet	37	15.0
Teff	109	44.5
Maize	96	39.0
Others**	4	1.5
Consumed animal source foods		
Yes	93	37.8
No	153	62.2
Types of consumed animal source food		
Fish	92	37.4
Meat	36	14.6
Others***	22	9.0
Frequency of animal source food		
Very rare/ holidays	106	43.1
once per weeks	37	15.0
3-6 per weeks	87	35.4
2 per months	16	6.5
Dietary diversity score		
Adequate	117	47.6
Inadequate	129	52.4
Frequency of meal intake per day		
≥3 times	182	74.0
<3 times	64	26.0
Frequency of coffee intake per day		
No take coffee	45	18.3
≤3 cup of coffee	165	67.1
>3 cup of coffee	36	14.6

\*\*Wheat/Sorghum/rice; \*\*\*Milk and its product/eggs /organ meat.

#### Clinical characteristics of the study participants

The lower proportion, 14 (5.7%) of the study participants were positive for HIV. Nearly one-third, 79 (32.1%) of the pregnant women had anemia on the basis of their hemoglobin levels (<11g/dl). A substantial proportion, 105 (42.7%) of the pregnant women had low serum albumin level (<3.2 g/dl). More than one-third of the study participants (38.2%) were undernourished (Table 4).

**Table 4.** Clinical characteristics of pregnant women attending ANC at Gambella Hospital, Southwest Ethiopia, 2016 (n=246).

Variables	Frequency	Percentage
HIV Status		
Positive	14	5.7
Negative	224	91.1
Refuse	8	3.2

**Table 5.** Risk factors associated with zinc deficiency among pregnant women attending ANC at Gambella Hospital, Southwest Ethiopia, 2016 (n=246).

Predictors	Zinc status		COR (95%CI)	AOR (95%CI)
	ZD Freq. (%)	Normal Freq. (%)		
Birth interval				
<24 months	70 (75.3)	23 (24.7)	3.28 (1.72-6.26)*	2.6 (1.08, 6.27)**
≥24 months	38 (48.1)	41 (51.9)	1	1
Trimester				
First	36 (64.3)	20 (35.7)	1	1
Second	35 (38.5)	56 (61.5)	1.06 (0.56, 2.11)	0.84 (0.31-2.22)
Third	65 (65.7)	34 (34.3)	3.06 (1.69, 5.53)**	3.76 (1.49, 9.49)**
Consumed animal source of food				
Yes	44 (47.3)	49 (52.7)	1	1
No	92 (60.1)	61 (39.9)	1.68 (0.99, 2.83)	2.40 (1.01, 5.74)**
Dietary diversity score				

Variables	Frequency	Percentage
Nutritional status (MUAC)		
Undernourished (<22cm)	94	38.2
Normal (≥22cm)	152	61.8
Serum albumin level (g/dl)		
<3.2	105	42.7
≥3.2	141	47.3
Hemoglobin level (g/dl)		
≤11	79	32.1
>11	167	67.9

#### Prevalence of Zinc deficiency among the study participants

The majority of the blood samples 190 (77.2%) were collected in the morning. Nearly half of the participants, 121 (49.2%) were non-fasting. The overall prevalence of zinc deficiency was 55.3% (95% CI: 50.0-61.3). The mean serum zinc concentration of pregnant women in this study was 58.75 (95% CI: 56.10-61.41) with SD of 21.11µg/dl. The prevalence of ZD during the first, second and third trimesters were 64.3%, 38.5%, and 65.7%, respectively.

#### Factors associated with zinc deficiency in multivariable logistic regression analysis

Birth interval, trimester (gestational age), animal source food, dietary diversity score, serum albumin and hemoglobin level were significantly associated with zinc deficiency (Table 5). The odds of zinc deficiency was 2.6 times higher among pregnant women with short birth interval (<24 months) as compared to those with optimal (≥24 months) birth interval (AOR=2.60; 95% CI: 1.08-6.27) keeping effect of other risk factors constant. The odds of ZD was 3.7 times higher among third trimester women as compared to those in first trimester (AOR=3.76; 95%CI: 1.49-9.49). The odds of ZD were more than 3 times higher among pregnant women with anemia than pregnant women who had no anemia (AOR=3.09; 95% CI: 1.19-7.95). The odds of ZD were 3 times higher among pregnant women with albumin deficiency than pregnant women who had adequate serum albumin levels (AOR=3.05; 95% CI: 1.31-7.07). Generally, the statistically significant predictors of ZD prevalence among pregnant women in the current study were summarized in (Table 5).

Predictors	Zinc status		COR (95%CI)	AOR (95%CI)
	ZD	Normal		
	Freq. (%)	Freq. (%)		
Adequate	62 (53.0)	55 (47.0)	1	1
Inadequate	74 (57.4)	55 (42.6)	1.91 (0.72, 1.96)	3.59 (1.45, 8.96)**
Receive nutrition education				
Yes	47 (40.2)	70 (59.8)	1	1
No	89 (69.0)	40 (37.0)	3.31 (1.96, 5.6)**	2.41 (0.91, 6.43)
Albumin deficiency				
No	63 (44.7)	78 (55.3)	1	1
Yes	73 (69.5)	32 (30.5)	2.82 (1.66, 4.81)**	3.05 (1.31, 7.07)**
Anemia				
No	77 (46.1)	90 (53.9)	1	1
Yes	59 (74.7)	20 (25.3)	3.45 (1.91, 6.23)*	3.09 (1.19, 7.95)**

\* Significant at p-value: ≤ 0.05; \*\* P-value≤0.01; 1 =Reference

#### 4. Discussion

In the current study, more than half (55.3%) of pregnant women had biochemical evidence of zinc deficiency based on their low serum zinc concentration. According to the IZiNCG, ZD is a public health concern when the prevalence is greater than 20%. [3] Thus, the study provides the evidence for the public health concern of ZD in the study setting. [1]

The finding of the current study is in line with similar studies conducted in Sidama (53%) [16], Gondar (57.4%) [12], India (55.5%) [17], and China (51.5%). [18] The possible explanation could be similarity in soil zinc levels and feeding style though it needs further investigations. Conversely, the findings were much lower than that of the prevalence of ZD reported from the Southern Ethiopia (72%, 74% and 76%) [19-21], Northwest Ethiopia (66.7%) [21], Nigeria (97.2%) [22], Kenya (66.9%) [23], Cameroon (82%) [24], Turkey (72.3%) [25] and India (64.6% and 72%). [26, 27] This discrepancy may be due to socio-economic difference and seasonal variation in the study period. Moreover, most of the other studies included different population by culture and geographical area which may contribute for the difference in prevalence unlike the current study. [3, 8, 28] Furthermore, in the study setting, consumption of animal food source especially fish is very common even considered as staple food which are good source of zinc. [3, 4] Moreover, the prevalence may be overestimated as only pregnant women from rural areas in the third trimester were included in the study from Sidama and India, unlike the present study which targeted all pregnant women of urban and rural dwellers.

The high prevalence of ZD in this study as compared to the similar studies conducted in Addis Ababa, Ethiopia (11.3%) [29], Pakistan (27.8%) [30], Eastern and Central Sudan (38% and 45%) [31, 32], Malawi (46%) [33], Iran (29% and 49%) [34, 35], Vietnam (29%) [36], Bangladesh (14.7%) [37], and Uruguay (7-14%) [38] might be explained by the high food insecurity in the study setting is leading to lack of access to adequate, safe, and nutritious food which in turn leads to low zinc concentration. Moreover, crops grown locally will have low zinc content and households who

depend entirely on locally produced crops will be more likely to develop ZD because of the low zinc contents of the Ethiopian soil. [39] Furthermore, the studies may have underestimated the prevalence as they had only included pregnant women in early pregnancy in study from Bangladesh and Vietnam, unlike the present study which targeted all pregnant women as study subjects.

The current study has also revealed that birth interval, gestational age (trimester), DDS, animal food sources, hemoglobin level, and serum albumin level were identified as statistically significant risk factors of ZD among pregnant women.

Birth interval was one of the significant risk factor influencing positively the biochemical zinc status of pregnant women. Too short birth interval was significantly associated with ZD among pregnant women. This might be supported by the understanding that repeated pregnancies deplete maternal nutritional store and this could also positively affect the serum zinc status of the pregnant women as a result of the inter-gestational link. This finding is in line with previous studies conducted in Northwest Ethiopia (Gondar), Southern Ethiopia (Sidama), India, Malawi and Nigeria.[12, 16, 26, 33, 38] Contrary to this study finding, a study from Turkey did not find any statistically significant association between zinc status and birth interval. [25] The variation might be explained by difference in socio-economic and demographic factors and nutritional status prior to and during pregnancy.

Result of the current study also revealed that the trimester (gestational age) of the pregnant women is statistically associated with ZD prevalence. Thus, gestational age was positively associated with ZD in the study. Similar findings were reported from Sidama, Southern Ethiopia. [20, 21] Like wisely, similar studies conducted in Bangladesh, Pakistan and Turkey [25, 30, 37] were also supported the finding. This could be reflecting more about the influence of pregnancy is interacted with physiological changes and increased metabolic demands. Different hypothesis include, changes in protein level secondary to physiological adoption, hormonal effect, increased metabolic demands that result an expansion of plasma volume and red blood cells, and maternal fetal transfer of zinc. [39] It is also decreased concentrations of circulating nutrient-binding proteins and micronutrients, poor bio-absorption and its increased nutritional demands during

pregnancy predispose pregnant women to develop zinc deficiency. Because, zinc requirements for fetal growth are high and thus, pregnant women are more susceptible to zinc deficiency, particularly in second and third trimesters. [6, 7] A common finding during pregnancy is hypoalbuminemia and high levels of estrogens, which may be associated with low concentration of zinc.

Food of animal source was also significantly associated with ZD prevalence among pregnant women. Pregnant mothers who did not consume animal source foods had low serum zinc concentration as compared to those who consumed animal source foods. The finding of the current study is consistent with similar studies conducted in Malawi, Vietnam, Sudan, Northwest Ethiopia (Gondar) and Southern Ethiopia (Sidama). [12, 16, 32, 33, 36] The present study revealed a high dependency on consumption of plants diets: cereals (99.4%) and legumes (53.3%) among pregnant women. Basically, these diets contain high level of phytates, the most potent inhibitors of zinc absorption and bio-availability. [3]

In the current study, a serum zinc level was found to be depleted among pregnant women with inadequate DDS. On the other hand, pregnant women with inadequate DDS were more likely to develop ZD as compared to those with adequate DDS. This finding is in line with the study conducted in Southern Ethiopia (Sidama) and Northwest Ethiopia (Gondar). [12, 16] Additionally, previous studies conducted in India, Malawi, Kenya, Sudan, and Nepal [19, 23, 26, 40, 41] were also supported the finding. The decreased prevalence of zinc deficiency is justified by the concept that increasing the variety of foods and food groups in the diet helps to ensure adequate intake of essential nutrients including zinc and promotes good health. [42] Another possible justification may be as the number of consumed foods increase the chance of including animal sources of food in the diet is high, which are good sources of zinc. This reason is strengthened by the fact that greater dietary diversification and modification of diets can enhance availability and utilization of foods with a high content of absorbable zinc and it has been associated with better nutritional outcomes and improved micronutrient intake. [3]

Similarly, anemia is identified a statistically significant predictor of ZD prevalence in the current study. Thus, pregnant mothers with anemia diagnosis were more likely to have ZD as compared to those mothers with no anemia diagnosis. The finding of the present study is in-consistent with other similar studies conducted in Sudan. [31, 32, 40] Conversely, the result of this study is in line with other similar studies conducted in Nigeria, Nepal, Northwest Ethiopia (Gondar), Southern Ethiopia (Sidama). [12, 16, 19, 38, 41] Moreover, Iron and zinc deficiencies in pregnant women may occur simultaneously as a result of an increased demand for zinc and iron by pregnant women, and also more likely, poor intake and poor bio-absorption of iron and zinc. On the other hand, as zinc is known to participate in multiple metabolic reactions, it might have causal role in anemia. Zinc is implicated in hemoglobin synthesis through the activity of several zinc dependent enzyme catalysis, including

aminolevulinic acid dehydrase that mediates a step in the synthesis of heme. More recently, the zinc-finger transcription factor has also been confirmed as essential factor for normal erythropoiesis or the common dietary sources of iron and zinc. [19, 40] Other potential mechanisms may involve the stimulation of hematopoiesis by zinc-induced plasma insulin-like growth factor-1 levels and the role of zinc in stabilizing cell membranes. [43]

Finally, the findings of this study indicated that low serum albumin level was positively associated with the serum zinc level of pregnant women. Albumin deficient pregnant women had 3 fold greater risk of being zinc deficient compared to those with adequate serum albumin level. Therefore, the finding of this study was supported by similar studies conducted in Malawi, Northwest Ethiopia (Gondar). [12, 19] The finding strengthens the knowledge that serum zinc concentration declines in relation to serum albumin level during pregnancy, due to expansion in plasma volume. In addition, Serum zinc concentration also falls with the hypoalbuminemia, which positively affects absorption and transport of zinc. [3].

## 5. Conclusion

Overall, the prevalence of ZD among pregnant women in the study was 55.3%. The prevalence was high among pregnant women: with short birth interval, in the third trimester, low intake of animal food sources, low dietary diversity score, low serum albumin level (hypoalbuminemia) and low hemoglobin level (anemia). Therefore, effort should be made to encourage pregnant mothers to consume balanced diet including animal food sources particularly in their third trimester, to monitor their hemoglobin and serum albumin levels, and strengthening family planning implementations to prevent the occurrence of zinc deficiency. However, further prospective follow up studies were recommended to confirm the cause-effect (temporal) relationship between anemia and ZD and population based prospective studies should be also conducted to assess the magnitude, severity and risk factors of ZD in the country.

## Abbreviations

ANC: Antenatal Care AOR: Adjusted Odds Ratio CI: Confidence Interval COR: Crude Odds Ratio CRP: C - reactive protein DDS: Dietary Diversity Score EPHI: Ethiopian Public Health Institute HIV: Human Immunodeficiency Virus IZiNCG: International Zinc Nutrition Consultative Group MUAC: Mid Upper Arm Circumference SD: Standard Deviation WHO: World Health Organization ZD: Zinc Deficiency.

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## Disclosure

We authors declared that we have no competing interests.

## Availability of Data and Materials

The data that support our conclusion of the study are obtained from the corresponding author up on reasonable request. Because, the data set is not shared publicly.

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