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RESEARCH ARTICLE

EVALUATION OF ZINC DEFICIENCY AND ITS ASSOCIATED FACTORS AMONG PREGNANT WOMEN ATTENDING ANTENATAL CARE AT THE SUB DISTRICT HOSPITAL CHIMUR, CHANDRAPUR, MAHARASHTRA, INDIA

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ABSTRACT

Background: Zinc deficiency during pregnancy has far-reaching consequences on both mother and fetus and subsequent child survival. However, data on the prevalence and determinants of zinc deficiency among pregnant women are scanty and inconclusive. The aim of this study was to assess the prevalence of zinc deficiency and associated factors among pregnant women attending antenatal care at the Sub District Hospital Chimur, Distrct Chandrapur, Maharashtra, India.
Methods: Institution based cross-sectional study was conducted at the SDH Chimur from July 2015 to April 16. A total of 377 pregnant women were selected by systematic sampling technique. Data on socio-demographic factors, reproductive history and nutrition related factors were collected using a structured questionnaire. Blood sample were collected to analyze biochemical indicators. Statistical analysis was done using logistic regression analysis method. P-value < 0.05 at 95 % confidence interval was considered as statistically significance.
Results: The prevalence of zinc deficiency among pregnant women was 57.4 % (95 % CI: 52.2 %–62.9 %). Living in rural area [AOR = 1.92; 95 % CI (1.04, 3.56)], too close birth [AOR = 3.97; 95 % (1.30, 12.13)], low intakes of diet of animal origin [AOR = 2.29; 95 % CI (1.35, 3.89)], inadequate dietary diversity [AOR = 2.09; 95 % CI (1.24,3.51)], lack of nutrition education [AOR =1.78; 95 % CI (1.10,2.86)], low serum albumin [AOR = 2.55; 95 % CI (1.40,4.63)]were significantly associated with zinc deficiency.
Conclusion: Zinc deficiency is of public health concern in the study area. To combat the problems, nutrition education to increase knowledge as well as practices concerning the consumption of zinc rich foods and optimal dietary diversity, use of home based phytate reduction techniques and agricultural based approaches should be considered.

INTRODUCTION

Zinc deficiency (ZD) during pregnancy has an adverse effect on both mother and fetus. Zinc has an essential role in the maintenance of cell and organ integrity, in the process of genetic expression and as an antioxidant and anti-inflammatory agent. Zinc (Zn) is an essential trace mineral element vital for many physiological functions and plays an important role in growth, reproduction and immune system (Prasad, 2013; DiSilvestro, 2000; Khalid, 2014; Bhaskaram, 2002 and Joint, 2005). Major problems associated with zinc deficiency include growth retardation, delayed immune system development, cognitive impairment, impaired glucose tolerance, low birth weight, congenital malformations, pregnancy-induced hypertension and increased risk of abortion, miscarriage, stillbirths, preterm labour, postpartum hemorrhage and prolonged labor (Prasad, 2013; Khalid, 2004; Brown, 2009; Mahomed, 2007; Roohani, 2013). World Health Organization (WHO) estimates that zinc deficiency affects 31 % with the prevalence rates ranging from 4 to 73 % in various regions of the world's population (Caulfield, 2004). In developing countries zinc deficiency is one of the ten significant factors contributing to burden of disease (Khalid, 2014). Although ZD is increasingly being recognized as a widespread problem, currently, there is no precise data regarding the magnitude and severity of ZD in pregnant women (Walker, 2009). Almost nothing is being done in India to address zinc deficiency of this magnitude except for the short-term zinc supplementation targeting children with diarrhea. The present study aims at assessing the prevalence and factors associated with ZD among pregnant women.

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MATERIALS AND METHODS

Study design, area and population: An institution based cross-sectional study was conducted from July 2015 to April 2016. The study was conducted at the Sub District Hospital

(SDH) Chimur, District Chandrapur. The Hospital is service-rendering institution that provides health service to over 1.7 Lakh people in Chimur. The study populations were all pregnant women in Chimur Tahsil and the surrounding area who attend antenatal care (ANC) at SDH Chimur.

Sample size and sampling technique: A systematic random sampling technique was used to select the study subjects. According to the Hospital report, around 1080 pregnant women have been enrolled to ANC. On average, 30–40 pregnant women visit ANC clinic weekly. Since the sample size was determined as 377, hence a sampling interval of 3 was used to select study participants. Of the first three subjects, one woman was randomly selected by lottery method, and then every 3rd pregnant women was selected to participate in the study until the required sample size of 377 pregnant women was obtained. To avoid double enumeration the client chart number was used and after data was collected code was given to the client chart.

Data Collection Method

Questionnaire

Data on potential determinants of ZD were collected using structured and pretested questionnaire through interview. Two data collectors (one staff nurse and a laboratory technician) were recruited. Training was given for them by the principal investigator. The data collection process was followed daily by the principal investigator. The questionnaire was administered in local language.

Laboratory Analysis

Blood collection, Serum separation and zinc level determination

About 5 ml of venous blood was collected from each pregnant women, using sterile trace element-free evacuated blood collection tubes. The blood was allowed to clot for 20 minutes, centrifuged at 3000 rotations per minute for 10 minutes, and sera were separated from the cells following standard procedures. Serum were kept frozen at −20 °C at the ICTC Laboratory of Sub District Hospital Chimur until transported to the laboratory of the Path Care centre, Hyderabad. Zinc deficiency was defined as a serum zinc level of less than 56µg/dl during the first trimester, or less than 50µg/dl during the second or third trimester (IZiNCG, 2004).

Hemoglobin level determination: Hemoglobin level was determined using hematological analyzer. Anemia was defined as a hemoglobin level of less than 11.0 g/dl during the first or third trimester or less than 10.5 g/dl during the second trimester (Gebremedhin, 2011).

HIV status determination: Rapid test for HIV (1/2) antibody from whole blood was performed by serial testing algorithm at ICTC unit of SDH Chimur.

Data processing and analysis: Analysis was carried out using SPSS version 20 statistical program. Descriptive analysis was carried out using mean, frequency and percentage. Wealth index quintiles (poor, middle and rich) were computed using Principal component analysis. P-value < 0.05 at 95 % CI was considered statistically significant. Written informed consent was obtained from each study participant after the purpose of the study explained. Needle safety procedures were in line with WHO standard. Nutrition education was given to all study participants. Anemic women were given iron supplementation.

RESULTS

Socio-demographic characteristics of the study subjects Of 377 pregnant women recruited, 364 were willing to take part in the study. The mean age of the mothers was 26.7 years (±4.7 years) of standard deviation, with a range of 25 (16, 41). A relatively small proportion of the participants, 73(20.1 %) had no formal education and more than half, 199 (54.7 %) were housewives. The mean monthly household income was 2519 INR. The average family size was 3.36 (±1.7) (Table 1).

Table 1 Socio-demographic characteristics of pregnant women attending antenatal care at Sub District Hospital Chimur, Chandrapur, Maharashtra, India

Characteristics	Frequency (n)	Percent (%)
Age (year)		
15 – 24	113	31
25 – 34	224	61.5
≥35	27	7.4
Educational status		
Unable to read and write	73	20.1
Grade 1-4	25	6.9
Grade 5-8	57	15.7
Grade 9-10	74	20.3
Grade 11-12	26	7.1
Certificate and above	109	29.9
Occupation		
House wife	199	54.7
Farmer	12	3.3
Merchant	50	13.7
Government employee	83	22.8
Daily laborer	11	3.0
Student	9	2.5
Wealth Index		
Low	121	33.2
Middle	243	66.8

Environmental and sanitation factors

The vast majority of participants, 344(94.5 %) had toilet facilities. The greater number of study subjects, 259(75.3 %) use pit latrine. Source of drinking water for majority, 324(89 %) of study participants was tap water. Among pregnant women who used other sources of drinking water other than tap water the risk of zinc deficiency tend to increase. Among 12 pregnant women who consumed well water, 9(75 %) were zinc deficient. Similarly among 28 pregnant women who consumed spring water, 22(78.6 %) were zinc deficient (Table 2).

Clinical factors and Zinc deficiency

Small proportion, 13(3.6 %) of the pregnant women were positive for HIV. Among 13 pregnant women who were positive for HIV, 10(76.9 %) were zinc deficient. The mean zinc levels for HIV positive and negative samples were 40.3(±15.2) and 48.3(±21.8) µg/dl, respectively. Of all pregnant women, 79(21.7 %) were taking iron supplement at least once in the preceding four weeks of the survey. Small proportion, 24(6.6 %) of the respondents had diarrhea; of whom more than three-fourth, 19 (79.2 %) were zinc deficient. One - third, 119(32.7 %) of the pregnant women had anemia on the basis of their hemoglobin levels. Among anemic women, more than two third, 78(65.5 %), were zinc deficient.

Similarly, among zinc deficient women, 78 (37.3 %) had anemia. Nearly one - fifth, 83(22.8 %) of the pregnant women were undernourished (MUAC ≤ 21 cm). The findings of the present study showed that, 88(24.2 %) of the pregnant women had low serum albumin level (<3.2 g/dl). Among albumin deficient women, three-fourth, 66(75 %) were zinc deficient (Table 3).

Table 2. Environmental and Sanitation characteristics of pregnant women attending antenatal care at SDH Chimur

Characteristics	Frequency (n)q	Percent (%)
Latrine availability		
Yes	344	94.5
No	20	5.5
Types of latrine		
Pit latrine	259	75.3
Water flush	83	24.1
Public	2	0.6
Source of drinking water		
Tap	324	89
Well	12	3.3
Spring	28	7.7

Table 3. Clinical factors among pregnant women attending antenatal care at the SDH Chimur

Characteristics	Frequency (n)	Percent (%)
MUAC		
≤21	83	22.8
>21	281	77.2
Diarrhea		
Yes	24	6.6
No	340	93.4
HIV		
Yes	13	3.6
No	351	96.4
Iron supplement		
Yes	79	21.7
No	285	78.3
Anemia (Hgm, g/dl)		
Yes	119	32.7
No	245	67.3
Serum albumin, g/dl		
<3.2	88	24.2
≥3.2	276	75.8

Prevalence of zinc deficiency

The prevalence of zinc deficiency among pregnant women was 57.4 % (95 % CI: 52.2 % – 62.9 %). The mean serum zinc concentration was 48.1(±21.6) µg/dl. The value ranged from 10.5 to 102.8 µg/dl. The prevalence of ZD during the first, second and third trimesters were 15.8, 30.6 and 53.6 %, respectively. The mean serum zinc levels for the first, second and third trimesters were 53.1 (±21.6), 47.2(±21.7) and 46.9 (±21.6) µg/ dl, respectively.

Factors associated with zinc deficiency

Multivariable logistic regression analysis was computed to identify predictors of zinc deficiency among study participants. Variables which significantly associated to the dependent variable in bivariate regression models were exported to a multivariable regression model for adjustment. Independent variables that showed association on the bivariate logistic regression model include: residence, source of drinking water, diarrhea, birth interval, sorghum consumption, coffee intake, animal source food, dietary diversity, nutrition education, serum albumin and intestinal parasite. The multivariable logistic regression analysis revealed that residence, birth interval, animal source food, dietary diversity, nutrition education, and serum albumin were variables which significantly associated to zinc deficiency. Birth interval was also significantly associated with zinc deficiency (P = 0.016). Pregnant women with short birth interval(<2 yr) were four times more likely to be zinc deficient as compared to pregnant women with no birth [AOR = 3.97; 95 % (1.30,12.13)]. Significant associations were also observed between zinc status and diet of animal origin. Compared to pregnant women who consumed animal source foods, the risk of ZD was 2.29 times higher among those who did not consume animal source foods in the reference period [AOR = 2.29; 95 % CI (1.35, 3.89)]. Similarly compared to pregnant women with adequate DD Score (DDS ≥ 4), the risk of ZD was two times higher among those with inadequate DDS (DDS ≤ 3) [AOR = 2.09; 95 % CI (1.24, 3.51)]. Nutrition education and zinc status were positively associated (P = 0.02). Pregnant women who did not receive nutrition education was 1.78 times at greater risk of being zinc deficient compared to those who received nutrition education during pregnancy [AOR =1.78; 95 % CI (1.10, 2.86)]. Serum albumin was also positively associated with zinc status (P = 0.002). Albumin deficient pregnant women had two and half fold [AOR = 2.55; 95 % CI (1.40, 4.63)] greater risk of being zinc deficient compared to those with normal serum albumin levels.

DISCUSSION

In the current study, more than half, (57.4 %) of pregnant women had biochemical evidence of zinc deficiency based on low serum zinc concentrations. According to the International Zinc Nutrition Consultative Group (IZiNCG), the risk of zinc deficiency is of public health concern when the prevalence of low serum zinc concentrations is greater than 20 % (Brown, 2009). Hence, the study provide evidence for the public health significance of zinc deficiency in the study area. The result of the present study was relatively similar with study conducted in Southern Ethiopia 53 % (Gebremedhin, 2011), and Nepal 61 % (Jiang, 2005). However, relatively lower than other reports from Ethiopia; prevalence of ZD was 76 % (Stoecker, 2009). 74 % (Gibson, 2008),and 72 % (Abebe, 2008), in Sidama and 66.7 % [13] in Gondar. It was also relatively lower than study from other countries, Kenya 66.9 % (Mitheko, 2013). Cameroon 82 % (Engle-Stone, 2014). The previous studies reported severe deficiency situation compared to the present study. The variation can be explained by different cut-offs of serum zinc levels that were used and seasonal difference in data collection. The result of the present study was relatively higher than reports from Eastern Sudan (38 %) (Mohamed, 2011). Central Sudan (45 %) (Bushra, 2010) Malawi (36 %) (Gibson, 1998), Vietnam 29 % (Nguyen, 2013). Bangladesh 14.7 % [35], and Iran 49 % (Salimi, 2004). The reason for this difference probably is due to nutritional regiment; cultural differences in food preparation and feeding habit. Further, the studies may have underestimated the problem as they only included pregnant women in early pregnancy in study from Bangladesh and Vietnam. The existence of low biochemical zinc status was attributed to seven major factors: living in rural areas, too close births, inadequate dietary diversity, low intakes of foods of animal origin, lack of nutrition education and low serum albumin each of which is discussed below. Birth interval was one of a significant factor influencing the biochemical zinc status of pregnant women. Pregnant women with short birth interval(<2 yr) had four fold greater risk of being zinc deficient as compared to pregnant women with no birth. The

study finding showed deleterious effect of too close birth on zinc status. This study is in line with previous studies conducted in India (Rathi, 1999), and Southern Ethiopia (Gebremedhin, 2011). The study finding agrees with the understanding that too close births and repeated pregnancies deplete maternal nutritional store. However, study conducted in Turkey did not find any significant association between zinc status and birth interval (Meram, 2003). The variation might be explained by difference in socioeconomic status and nutritional care prior to and during pregnancy. Albumin deficient pregnant women had two and half fold greater risk of being zinc deficient compared to those with adequate serum albumin levels. The current study finding witnessed a highly significant positive association between serum albumin and serum zinc level. Previous study conducted in Malawi also supported the finding (Gibson, 1998). Pregnant women who did not receive nutrition education during pregnancy was at greater risk of being zinc deficient as compared to those who received nutrition education. One recent study in Southern Ethiopia failed to witness any definite trend on the effect of nutrition education on maternal zinc status (Gebremedhin, 2011) However, the present study showed a positive association between nutrition education and zinc status.

Foods of animal origin was also significantly associated with biochemical zinc status of pregnant women. Compared to pregnant women who consumed animal source foods, the risk of ZD was 2.29 times higher among those who did not consume animal source foods in the reference period. Previous studies conducted in Malawi (Gibson, 1998), and Southern Ethiopia (Gebremedhin, 2011), also supported the finding. The present study revealed a high dependency on consumption of cereals, 363(99.7 %) and legumes, 259(71.2 %) in the study community. Such diets contains high level of phytates, which are the most potent inhibitor of zinc absorption (Brown, 2004 and http://www.extranet.elsevier.com/homepage_about/mrwd/nvrn/Zinc%20Deficiency%20in%20Humans.pdf). Only one-third, 124 (34.1 %) of pregnant women were consumed diet of animal origin, which are good sources of bioavailable zinc (Brown, 2004). Thus, the high prevalence of zinc deficiency in the present study could be partially explained by the poor zinc absorption from the plant-based diets. However, inadequate intake of zinc rather than low bioavailability might be the main risk factor for the zinc deficiency in pregnant women from the study area (http://www.extranet.elsevier.com/homepage_about/mrwd/nvrn/Zinc%20Deficiency%20in%20Humans.pdf; Cakmak, 2009 and Lambein, 1994). Our study also showed positive relationship between zinc deficiency and anemia. ZD and anemia tend to occur together. About 73 (34.9 %) of the subjects had both deficiencies. A previous studies also found significant positive association between zinc deficiency and anemia (Gebremedhin, 2011; Gibson, 2008; Mohamed, 2011; Borna, 2009). As the studies are cross-sectional it is not viable to implicate causal inference. Nevertheless, as zinc is known to participate in multiple metabolic pathways, it might have causal role in anemia. This relation between ZD and anemia might be due to the role of zinc in erythropoiesis or the common dietary sources of iron and zinc (Gibson, 2008; De Jong, 2002; Folin, 1994). The major limitation of this study was the study design as cross-sectional study design by its nature limits information about cause and effect relationship in the majority of predictors. Assessment of dietary intake depends on the 24 hour recall method, which may not accurately reflect their past feeding experience.

Conclusion

Zinc deficiency is of a public health concern among pregnant women in the study area. Living in rural areas, too close births, inadequate dietary diversity; low intakes of foods of animal origin, lack of nutrition education, and low serum albumin are key predisposing factors to zinc deficiency. The problem must be combated through implementation of strategies like promoting higher agricultural productivity and diversity, use of zinc containing fertilizers and rural livelihood promotion and empowerment of women. We also suggest sustained nutrition education to increase knowledge as well as practices concerning the consumption of zinc rich foods and optimal dietary diversity, use of home based phytate reduction techniques, homemade water treatment practices especially in rural community and use of effective methods of contraception to reduce frequent reproductive cycling. Multicentric studies in various parts of the country should be conducted to substantiate the data obtained in the present study so that intervention measures can be initiated.

Abbreviations

ANC: Antenatal Care; CRP: C-reactive protein; DD: Dietary Diversity;
DDS: Dietary Diversity Score; MUAC: Mid Upper Arm Circumference;
WHO: World Health Organization; Zn: Zinc; ZD: Zinc Deficiency.

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