Assessment of the Serum Zinc Status of Expectant Mothers Visiting the Antenatal Care (ANC) Clinic At Embu Level Five Hospital in Embu County, Kenya

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ABSTRACT

Introduction: Micronutrient deficiencies (MND) are of great concern in public health and affect at-risk populations in low-and Middle income and developing countries, including pregnant women. Zinc deficiency, is significant in pregnant women. In particular, zinc deficiency is prevalent among pregnant women in resource-limited households. This is largely attributed to overreliance on cereal- and legume-based diets rich in phytates that inhibit zinc absorption. In Kenya, nearly 68.3% of pregnant women are zinc-deficient, yet County-level data remain limited.

Objective: This study assessed the serum zinc status among expectant mothers who visited the Antenatal Care (ANC) clinic at Embu Level Five Hospital in Embu County, Kenya

Methodology: This was a cross-sectional analytical design, involving pregnant women (n=156) systematically sampled pregnant women attending antenatal care at Embu Level Five Hospital. Data was collected through structured questionnaires and focus group discussions. Serum zinc was measured using atomic absorption spectrophotometry. Data analysis was conducted using descriptive and regression statistical methods with SPSS version 26. The chi-square test was applied to determine whether significant associations existed between selected variables. To determine whether there were differences in the dependent variable and serum zinc concentration across the various independent variable groups, one-way analysis of variance (ANOVA) and the independent samples t-test were applied**.** Data obtained from focus group discussions (FGDs) were transcribed and analyzed through NVIVO for identification and classification of emerging themes.

Results: Most participants were young mothers (20-24 years), with three or fewer parities, and 63.5% reported supplement use summarized in frequencies and proportionsMean serum zinc concentration was 67.50±10.90 µg/dl, with significant trimester-based declines: 76.28 µg/dl (first), 65.87 µg/dl (second), and 56.40 µg/dl (third) (p=0.000). Regression analysis showed dietary zinc intake and supplementation explained 67.2% of serum zinc variation.

Conclusion: This is one among the few studies that focus on the serum zinc status among expectant mothers who visit the Antenatal Care (ANC) clinic at Embu Level Five Hospital in Embu County, Kenya.The study concludes that zinc deficiency remains a nutritional concern in Embu County, driven by plant-based diets.

Recommendation: Promoting home-based food processing techniques and dietary diversification may enhance zinc bioavailability and improve maternal nutrition.

Keywords: Serum zinc status, expectant mothers, visiting the Antenatal Care (ANC) clinic at Embu Level Five Hospital in Embu Bioavailability

INTRODUCTION

Globally, an estimated 1.5 to 2 billion people suffer from one or more chronic micronutrient deficiencies (MNDs), with about 90% of those affected residing in Africa and Asia (Kumar, et al., 2017). These deficiencies remain a significant public health concern, particularly among resource-scarce households in sub-Saharan Africa (Agengo et al. 2020). A major contributing factor is the frequent consumption of foods high in anti-nutritional compounds, which reduce overall diet quality and hinder the absorption of essential nutrients (Gupta, Brazier & Lowe, 2020; Hess, 2017). In addition, the diets of most populations in these regions are deficient in animal-based products (Agengo, et al., 2020), which are important sources of micronutrients such as zinc (Abu-Saad & Fraser, 2010).

Currently, the estimated prevalence of insufficient zinc intake is 17.3% with nearly 59.9% of pregnant women in sub-Saharan Africa at risk due to high consumption of phytate-rich diets (Berhe, Gebrearegay & Gebremariam, 2019). The situation is even more severe in Kenya, where nearly 68.3% of pregnant women experience zinc deficiency, with the highest prevalence of 69.4% occurring among those in their second and third trimesters (MoH, 2011).

Dietary zinc plays a critical role during pregnancy, and its deficiency has been linked to severe outcomes, including intrauterine growth retardation, pregnancy-induced hypertension, abortion, preterm delivery, and stillbirth (Wang et al., 2015; Chaffee & King, 2012; Gupta, Gangoliya & Singh, 2015; Wessells & Brown, 2012). Low zinc levels are linked to adverse outcomes such as premature birth, prolonged labour, and impaired newborn growth (Ota et al., 2015). To ensure adequate nutrient intake, the inhibitory effects of phytates can be mitigated through food-processing techniques that employ enzymes or thermal treatments to hydrolyze phytic acid (Saunders, Craig & Baines, 2013).

In particular, home-based food processing methods such as soaking, fermentation, germination, and malting are strongly recommended for pregnant women as key approaches to alleviating zinc deficiency (Samitya, Aluko & Dhewa, 2020). These methods reduce phytate levels, thereby enhancing the body's ability to absorb zinc and other essential nutrients from the diet (Kumar et al., 2010).

Despite such evidence, county-specific data remain limited in Kenya, particularly concerning zinc nutrition among vulnerable groups such as pregnant women. Embu County, for example, is agriculturally productive and receives a considerable amount of rainfall. However, the micronutrient malnutrition remains high, with stunting among children under five reported at 26.8% (Kenya Demographic Health Survey (KDHS, 2022), highlighting the urgency of targeted nutritional interventions.

While the KDHS report provided useful insights into child nutrition, it did not capture the zinc status of pregnant women in the county. Furthermore, Getu et al. (2015) indicated that although food consumption in Embu has improved to meet daily caloric requirements, diets remain dominated by cereals and pulses with minimal animal-source foods, resulting in low bioavailability of zinc (Gupta, Gangoliya & Singh, 2015).

In addition, there are significant gaps in understanding the home-based food processing techniques practiced among pregnant women and how these influence their serum zinc status. Findings from this study would provide vital data in the county level to guide dietary counseling, home-based nutrition interventions and antenatal supplementation strategies aimed at optimizing zinc and overall micronutrient status of pregnant women.

To address these gaps, this study assessed the serum zinc status among pregnant women in Embu County, Kenya.Against this backdrop, there is a need for an assessment the serum zinc status among expectant mothers who visited the Antenatal Care (ANC) clinic at Embu Level Five Hospital in Embu County, Kenya

MATERIALS AND METHODS

Study Area: The study was conducted at Embu Level Five Hospital, focusing on pregnant women attending the Antenatal Care (ANC) Clinic at Embu Level Five Hospital in Embu County, Kenya. Embu County and the hospital were purposively selected due to the predominant reliance on plant-based diets in the region and the hospital's role as the main referral facility for the former Eastern Province.

Study Design: The study employed a cross-sectional analytical design, which made it possible to gather data at a specific moment in time (Mitheko, Kimiywe & Njeru, 2013; Schmidt & Brown, 2017), to assess serum zinc status among expectant mothers who visited the Antenatal Care (ANC) clinic at Embu Level Five Hospital in Embu County, Kenya.This design was appropriate as it enabled the identification of trimester-specific differences while examining serum zinc status among the pregnant**.**

Sample size calculation: Study Population and Sample

The number of pregnant women who participated in the study was determined using Cochran's (1967) formula, as cited by Peters and Bostley (2023).

$$\mathrm{n} = \frac{Z^2 pq}{e^2}$$

Therefore;

$$\mathrm{n} = \frac{1.96^2 \; x \; 0.683 \; x \; 0.317}{0.074^2}$$

$$= 150$$

To account for potential non-responses, the sample size was increased by 10% (Israel, 1992), resulting in a total of 165 pregnant women included in the study.

Inclusion Criteria:

1. The study targeted pregnant women attending the Antenatal Care (ANC) clinic during the research period
2. They must have lived in Embu County for at least one year prior to the study
3. Only those who consented to participate

Exclusion Criteria:

1. Those had chronic ailments at the time of the study
2. Those enrolled in programs designed to improve nutritional status, such as supplementary feeding programs
3. Those who had conflict-of-interest and or unwilling to provide objective input
4. Those declined to participate in the study at any stage during the study

Data Collection Tools

Data were collected using a structured questionnaire and an observation checklist. Serum zinc was measured using atomic absorption spectrophotometry.

In addition, a focus group discussion was held to gather deeper insights on commonly consumed foods, preparation methods, and culture-specific dishes (FAO, 2018), as well as the attitudes and beliefs of pregnant women regarding home-based food processing techniques.

Validity and Reliability

The accuracy and consistency of the data collection tools were assessed through pre-testing (Bolarinwa, 2015). In addition, experts from the Foods, Nutrition, and Dietetics Department at Kenyatta University reviewed the tools and provided feedback for necessary revisions. To further establish reliability, the test-retest method was applied to the pre-test sample after three days (Bolarinwa, 2015). A reliability coefficient of 0.7 was considered acceptable (Taber, 2018).

Data collection techniques

Quantitative interviews participants- Data were collected daily from Monday to Friday over one month. With assistance from the ANC nurse, participants were recruited after providing written consent. Biochemical zinc status was assessed using non-fasting venous blood samples collected by a skilled phlebotomist with zinc-free equipment and stored in trace element-free vacutainers (IZiNCG, 2012). Samples were analyzed at Embu University using a Shimadzu AA-2000 atomic absorption spectrophotometer, with zinc deficiency defined as serum levels below 56 μg/dl in the first trimester and below 50 μg/dl in the second and third trimesters (Berhe et al., 2019; Chaffee & King, 2012).

Qualitative interviews participants-An FGDs was held: one with ten purposively selected pregnant women at different trimesters based on factors such as pregnancy status, Zinc serum status, nutritional knowledge (Etikan, Musa & Alkassim, 2016), and another with ANC healthcare providers at Embu County Level Five Hospital. Each 45-minute session was moderated by the researcher, recorded, and later transcribed, coded, and analyzed together with field notes, with all information treated in strict confidentiality.

Procedure and Methods: For Quantitative A systematic sampling technique was then applied to determine the required sample size. This involved listing all pregnant women attending the ANC clinic, assigning numbers based on their clinic attendance records to create a sampling frame Creswell, J. W. (1994) and selecting every kth participant (Thomas, 2020) until the desired sample size was obtained.

The study population (N) was 480, based on the monthly ANC clinic attendance at Embu Level Five Hospital, while the required sample size (n) was 165. Accordingly, every 3rd pregnant woman was selected to participate in the study.

Piloting: Pre-Testing; The questionnaire was pre-tested to ensure clarity, determine the time required for completion, and assess content validity. The pre-test was conducted with 17 pregnant women (10% of the study population) who attended the Dallas Dispensary, Embu County with similar background characteristics.

Reliability and Validity: The accuracy and consistency of the data collection tools were assessed through pre-testing (Bolarinwa, 2015). In addition, experts from the Foods, Nutrition, and Dietetics Department at Kenyatta University reviewed the tools and provided feedback for necessary revisions. To further establish reliability, the test-retest method was applied to the pre-test sample after three days (Bolarinwa, 2015). A reliability coefficient of 0.7 was considered acceptable (Taber, 2018).Double-blind assessment of the research tools was done by two experts and their judgment of the tools content as relevant or irrelevant was determined using content validity index.

Member checking was conducted, where preliminary interpretations are shared with a subset of participants to confirm accuracy and resonance for qualitative data collection tools. The data collection process was undertaken in two weeks.

Statistical Analyses: Data were organized, coded, and analyzed using SPSS version 26. The socio-demographic characteristics of the study population were summarized using descriptive statistics, and Pearson's correlation was applied to assess associations between quantitative variables. Chi-square tests

evaluated relationships between categorical variables and ANOVA with independent t-tests compared serum zinc levels across groups based on factors such as dietary intake and food processing practices. The statistical significance of the variables was tested at $P \leq 0.050$. For qualitative data, audio tape recordings were all together transcribed verbatim, coded and uploaded qualitative data analysis software Non-Versional Information Versatile Outcome (NVIVO) version 12.

Ethical Approval: Permission to conduct the study was first obtained from Kenyatta University Graduate School, followed by ethical clearance from Kenyatta University Ethical Review Committee (KUERC). Final approval was then granted by the National Council for Science, Technology, and Innovation (NACOSTI). Informed consent was also sought from all respondents, and their information was treated with strict confidentiality and used exclusively for academic purposes. The permit was then used to secure an authorization letter from Embu County's Ministry of Health department.

The administrative leaders of the County, were be brought on board after being adequately briefed on the study and its purpose. The health facility administrators in Embu County were also informed and appropriately engaged in the study for logistics and for participation as key informants. Confidentiality and anonymity were strictly observed throughout data collection and reporting, consistent with ethical guidelines for research involving minors (WHO, 2022).

Study Limitations: The cross-sectional design of the study limited data collection to a single point in time, precluding causal inferences and the assessment of temporal changes. This limitation was addressed by interpreting the findings strictly in terms of associative relationships and situating them within the context of existing longitudinal literature where applicable.

Additionaly, the study focused on a single health facility which may limit the generalizability of the findings to other healthcare facilities. The study has mitigated this by using multiple data collection methods (Questionnaires, KIIs and FGDs) that have helped in cross-validating responses and hence reduced the bias. This has additionally been addressed through spelling out the contexts and situations in which the findings may apply.

RESULTS

Response Rate

A total of 156 pregnant women participated in the study, achieving a 94.5% response rate. This was made possible through effective mobilization, trust-building, clear communication of study benefits, integration with routine antenatal visits and support from local institutions. Since a 50% response rate is generally considered adequate according to Mugenda, A. G. (2008). The achieved rate strengthens the reliability and generalizability of findings on trimester-based differences and the links between home-based food processing, dietary intake, and zinc status

Socio-Demographic characteristics of the respondents

As shown in Table 1, the majority of the pregnant women in this study (27.6%) were in the age bracket of between 20-24 years. The study also found that 51.3% of women were in their second trimester, 17.3% were in the third, and a majority (63.5%) reported taking supplements. Serum zinc concentrations progressively decline as pregnancy advances, reaching their lowest levels in the third trimester. Nearly three-quarters of respondents (72.4%) were married, less than half (47.4%) had a university degree, and 34.0% were business owners.

Table 1: Socio-demographic characteristics of respondents

Variables	Categories	Frequencies (156)	Percentages
Age of the mother	15-19	15	9.6

(Years)	20-24	43	27.6
	25-29	40	25.6
	30-34	38	24.4
	35-39	12	7.7
	Above 40	8	5.1
Parity	0-1	53	34.0
	2-3	82	52.6
	4-5	20	12.8
	6-7	1	0.6
Gestation in weeks	0-12	49	31.4
	13-24	80	51.3
	25-40	27	17.3
Mineral supplements	Yes	99	63.5
	No	57	36.5
Marital Status	Single Mother	33	21.2
	Married	133	72.4
	Divorced	4	2.6
	Separated	5	3.2
	Widowed	1	0.6
Education Level	Completed Primary	4	2.6
	Did not Complete Primary	3	1.9
	Completed Secondary	12	7.7
	Did not Complete Secondary	10	6.4
	College	53	34.0
	University	74	47.4
Respondents Occupation	Housewife	21	13.5
	Business Owner	53	34.0
	Formal Employment	38	24.4

	Farmer	15	9.6
	Casual Labourer	24	15.4
	Domestic Worker	5	3.2
Husband's Occupation	Not Employed	39	25.1
	Business Owner	44	28.2
	Formal Employment	40	25.6
	Farmer	23	14.7
	Casual Labourer	10	6.4

Source: Research Data (2023)

The serum zinc status of expectant mothers who visit the Antenatal Care (ANC) clinic at Embu Level Five Hospital in Embu County, Kenya.

The mean serum-zinc level of pregnant women was 67.50±10.90 μg/dl, ranging from 45.52 to 88.43 μg/dl. Serum-zinc status differed significantly across trimesters (p = 0.000), with levels declining from a mean of 76.28±8.83 μg/dl in the first trimester to 65.87±8.82 μg/dl in the second and 56.40±6.84 μg/dl in the third (Table 2). In this study, all 49 women in their first trimester met the ≥56 μg/dl threshold, while 5 of 80 in the second and 4 of 27 in the third trimester fell below 50 μg/dl.

Table *2*: Mean serum-zinc status

Serum-Zinc Status	**N**	**Minimum**	**Maximum**	**Mean ± SD**	**P value**
1st Trimester	49	58.09	88.29	76.28±8.83	0.03
2nd Trimester	80	45.52	88.43	65.87±8.82	
3rd Trimester	27	48.19	73.30	56.40±6.84	
Total	**156**	**45.52**	**88.43**	**67.50±10.90**	

Source: Research Data (2023)

DISCUSSION

The serum zinc status of expectant mothers who visit the Antenatal Care (ANC) clinic at Embu Level Five Hospital in Embu County, Kenya

The majority of the pregnant women in this study (27.6%) were in the age bracket of between 20-24 years. This aligns with findings by Gebremariam et al. (2023), but contrasts with a study by Mwaniki, Chege & Munyaka (2019) in Embu, Kenya, where the largest proportion (35.4%) was aged 25-29 years. These results indicate that the present study population was made up of relatively young mothers, with the majority being below 25 years.

Correspondingly, more than half (52.6%) had experienced two to three parities, reflecting their younger age. High parity is associated with adverse outcomes such as hypertension, placenta previa, and uterine rupture (Shah, 2010), and has also been linked to reduced serum zinc levels (Wessells et al., 2023).

The study also found that 51.3% of women were in their second trimester, 17.3% were in the third, and a majority (63.5%) reported taking supplements. Serum zinc concentrations progressively decline as pregnancy advances, reaching their lowest levels in the third trimester. The increased use of supplements during the second and third trimesters is therefore likely a response to heightened nutritional demands.

Low zinc levels are linked to adverse outcomes such as premature birth, prolonged labour, and impaired newborn growth (Ota et al., 2015). Nearly three-quarters of respondents (72.4%) were married, less than half (47.4%) had a university degree, and 34.0% were business owners. These findings suggest that many pregnancies were planned, given the women's relatively high literacy levels and sources of income. Similar trends were reported by Hassouni, Ahmed, and Mohammed (2023), who found that 70.7% of respondents were married with no significant effect of marital status on serum zinc levels, and by Mwaniki (2017), where 88.4% were married and engaged in small-scale businesses.

Higher education may enhance zinc status through improved nutritional knowledge and practices (Kumera et al., 2015), while better socio-economic conditions can also contribute to improved maternal zinc status (Ugwuja et al., 2010). These may be linked to increased awareness of the benefits of benefits of zinc that comes with better education. Higher socioeconomic status may enable acquisition of Zinc supplementation to boost te levsls.

The mean serum-zinc level observed was comparable to 66±14 μg/dl reported by Mitheko et al. (2013), but higher than 52.4±9.9 μg/dl reported by Gebremedhin et al. (2011), who also noted a progressive decline across trimesters (57.2±9.4, 53.6±9.8, and 50.1±9.9 μg/dl). In contrast, Ejezie and Nwagha (2011) reported higher corresponding values of 106.82±19.76, 101.65±14.47, and 85.57±15.50. Variations in mean serum zinc levels may be influenced by age, household income, gestational stage, diet, and physiological factors such as infection, inflammation, stress, exercise, fasting, circadian rhythm, and zinc status (Liu et al., 2021).

Notably, pregnant women consuming predominantly plant-based diets often fail to meet the recommended daily intake of 11 mg zinc (Darnton-Hill, 2013). To mitigate this, Gebremedhin, Enquselassie and Umeta (2011) emphasized the importance of combining home-based techniques with livelihood promotion initiatives and targeted agricultural practices to provide a sustainable solution to zinc deficiency.

In this study, all 49 women in their first trimester met the ≥56 μg/dl threshold, while 5 of 80 in the second and 4 of 27 in the third trimester fell below 50 μg/dl. The mean serum-zinc level observed was comparable to 66±14 μg/dl reported by Mitheko et al. (2013), but higher than 52.4±9.9 μg/dl reported by Gebremedhin et al. (2011), who also noted a progressive decline across trimesters (57.2±9.4, 53.6±9.8, and 50.1±9.9 μg/dl). In contrast, Ejezie and Nwagha (2011) reported higher corresponding values of 106.82±19.76, 101.65±14.47, and 85.57±15.50.

When examined by trimester, average zinc levels were 76.28 ± 8.83 μg/dl for the first trimester, 65.87 ± 8.82 μg/dl for the second, and 56.40 ± 6.84 μg/dl for the third trimester, showing statistically significant differences across these stages of pregnancy ($p = 0.000$). Using the IZiNCG criteria for zinc deficiency, (<56 μg/dl for the first trimester and <50 μg/dl for the second and third trimesters), none of the participants in their first trimester were found to be deficient ($n = 49$; mean 76.28 ± 8.83 μg/dl), whereas 5 women in the second trimester ($n = 80$; mean 65.87 ± 8.82 μg/dl) and 4 women in the third trimester ($n = 27$; mean 56.40 ± 6.84 μg/dl) fell below the recommended levels (2022; Wessells et al., 2023). To ensure accurate assessment of zinc status, zinc reference controls were included in laboratory analyses.

Additionally, serum zinc levels were interpreted alongside levels of C- reactive protein (CPR) and alpha-1-acid glycoprotein (AGP) to explain potential decreases in circulating zinc brought on by infection or inflammation (Liu et al., 2021). The gradual decrease in serum zinc during the trimesters is consistent with typical physiological changes that occur during pregnancy and supports findings in comparable African populations (Gebremedhin et al., 2011; Mitheko, Kimiywe, & Njiru, 2013).

Other factors such as gestational age, nutritional intake, and socio-economic conditions may also contribute to these variations. Overall, most pregnant women in the study maintained adequate zinc status. Nonetheless, a small number in the later trimesters showed signs of deficiency which is still alarming.

CONCLUSION

The study revealed that most pregnant women in Embu County were young mothers with three or fewer parities and were taking dietary supplements. The average serum zinc concentration was 67.50±10.90 μg/dl, ranging from 45.52-88.43 μg/dl, with significant variation across trimesters due to physiological changes, dietary intake, absorption, and socioeconomic factors. Importantly, a strong relationship emerged between home-based processed food consumption and serum zinc status.

The findings underscore the need for women of reproductive age to prioritize nutrition before and during pregnancy, with emphasis on simple food processing techniques such as fermentation to improve the bioavailability of key micronutrients, particularly zinc, from plant-based staples commonly consumed in Kenya and other developing countries. These results emphasize the need for regular monitoring and the importance of considering inflammatory markers when assessing nutritional zinc status.

RECOMMENDATIONS

Recommendations for Policy

Kenya's Ministry of Health, county health departments, and other relevant stakeholders should incorporate interventions targeted at improving zinc status into routine antenatal care (ANC) services across all counties. This could include providing structured dietary counselling on home-based food processing methods that enhance zinc bioavailability, promoting dietary diversity, and ensuring systematic provision and monitoring of micronutrient supplements in line with national ANC guidelines.

Since there is currently limited county-level data on zinc deficiency among pregnant women, establishment of local surveillance and monitoring systems is key in identifying at-risk populations, guiding resource allocation, and evaluating the effectiveness of these interventions. Incorporating these measures into both national ANC protocols and county-level health plans will strengthen maternal nutrition programs and help reduce pregnancy complications related to zinc deficiency.

Embu County health department should consider integrating information on uptake of serum status in the health services during regular hospital (reproductive Health, HIV, Outpatient Department, Maternal and Child Health) among the target groups. This model will integrate vaccination seamlessly into the facilities's complex operations while maintaining quality and accessibility

Recommendations for Practice

Women of reproductive age need to prioritize their health before and during pregnancy. One way to achieve this is by adopting home-based food processing techniques such as fermentation. The focus should be in addressing the decline ias the trimesters progress. This approach can improve the absorption of essential nutrients, including zinc, from plant-based foods, which form the staple diets of many developing countries, such as Kenya.

Recommendation for further research

Mean serum zinc concentration was 67.50±10.90 μg/dl, with significant trimester-based declines: 76.28 μg/dl (first), 65.87 μg/dl (second), and 56.40 μg/dl (third) (p=0. 000.There is an urgent need for research in Kenya to investigate the factors that may be associated with this decline.

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