

Levels of Serum Micronutrient Deficit Concentrations in Pregnant Women from Kisangani, Democratic Republic of the Congo

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Summary

Objectives: The objectives of this research were to determine the micronutrients deficient in the sera of pregnant women in Kisangani, and the profile of these women with deficient status.

Methods: We had conducted a cross-sectional study with a prospective data collection in 8 health structures in the city of Kisangani in non-pregnant and pregnant women from October 05, 2023, to January 05, 2024. Statistical data analysis was done using R software version 4.3.0.

Results: The average age of the respondents was 26.3 ± 6.7 years. 52% of the pregnant women were housewives; The mean calcium and zinc in pregnant women were 1.49 ± 0.29 mmol/L and 8.42 ± 0.61 micromol/L. The selenium mode was 0.41 micromol/l. The micronutrients deficient were calcium (0.94-2.22 mmol/l), selenium (0.31-0.78 micromol/l) and zinc (7.29-12.72 micromol/l).

Conclusion: Micronutrient deficiency during pregnancy remains a common problem in obstetrical practice in our settings. Most pregnant women live in precarious social conditions exposing them to the risk of nutritional deficiency and requiring dietary supplementation.

Keywords: Pregnant women, Trace element, Calcium, Zinc, Selenium, Kisangani.

INTRODUCTION

Deficiencies in maternal trace elements are the result of poor-quality diets, high fertility rates, repeated pregnancies, short birth intervals, and increased physiological needs. These factors are compounded by often inadequate and weak capacity health systems, poverty and inequality, as well as socio-cultural factors such as early marriage and teenage pregnancy, as well as some traditional dietary practices (1,2).

Maternal nutrition has profound effects on fetal growth and development, on the infant's subsequent birth weight, and on the health and well-being of the woman herself (3).

Currently, the consequences of the lack or insufficiency

of micronutrients are becoming increasingly important on maternal, fetal and child health. Inadequate food intake, lack of food availability, inequitable distribution of food within households, lack of understanding of the importance of dietary diversity, and the frequent incidence of infectious diseases make pregnant women vulnerable to multiple micronutrient deficiencies (4). Micronutrient deficiencies are a major public health problem in many low- and middle-income countries (5).

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Complications or morbidities related to multiple micronutrient deficiencies during pregnancy would be avoidable if the identification and management of at-risk pregnant women were done early during prenatal consultations. This can only be possible by determining the micronutrient status of pregnant women in this region to correct the micronutrient deficiency missing for a good evolution of these pregnant women (6).

The latest WHO reports have reported multiple micronutrient deficiencies observed in several pregnant women around the world (7). The global burden of disease caused by micronutrient deficiencies during pregnancy is relatively modest on a global scale, however its cumulative individual impact can be considerable. This is particularly true for pregnant women with low socio-economic status or low or middle incomes (4).

Micronutrient deficiency remains a recurrent public health problem in the United States, where 28% of pregnant women are affected overall. 50-65% of pregnant women in the Mediterranean region have multiple micronutrient deficiencies each year despite organized mass supplementation during pregnancy (7).

During demographic and nutritional surveys initiated as part of the improvement of prenatal care for women at risk of chronic malnutrition and hidden hunger, multiple micronutrient deficiency statuses in the first trimester of pregnancy were found in 59% of pregnant women in Iran(8). According to a systematic review study, 56% of pregnant women in Ethiopia, 70% of pregnant women in Kenya and 46% of pregnant women in Nigeria had micronutrient deficiencies at very low values requiring follow-up outside of pregnancy and breastfeeding (9). Based on Ethiopia's 2017 HRE report, the maternal mortality ratio was estimated at 401 per 100 000 live births due to multiple micronutrient deficiencies, and inappropriate practices lead to complications such as undernourishment and non-communicable diseases (10).

Data on micronutrient deficiencies during pregnancy are scarce in the Democratic Republic of Congo, and in Kisangani in particular. Most often, micronutrient supplementation is done randomly without knowing the deficiencies or possible needs of these pregnant women. This is why we initiated this research with the aim of determining the trace elements that are deficient in pregnant women in Kisangani.

We asked ourselves what are the trace elements that are deficient in pregnant women in Kisangani?

The objectives of this research are to determine the trace elements deficient in the sera of pregnant women in Kisangani, and the profile of women with micronutrient deficiency status.

METHODS

This research took place in the city of Kisangani, located in the north-east of the Democratic Republic of Congo, capital of the province of Tshopo, in the Democratic Republic of Congo. The choice of this city is justified by its technical platform capable of conducting the determination of trace elements useful for this research, and the presence of a HUB KISANGANI deconcentrated repository with a cold chain at Hypercold (from -50 to -120°C) that can keep the serums in a stable state at -80°C.

Indeed, this study was multi-site, conducted within the 8 health structures of Kisangani. These are the University Clinics of Kisangani, the Kabondo General Referral Hospital, the Foyer Referral Health Center, the Saint Joseph Health Center, the Matete Referral Health Center, the Mangobo General Referral Hospital, the Lubanga General Referral Hospital, the Makiso-Kisangani General Referral Hospital. These hospitals were selected because of their high attendance by pregnant and non-pregnant women. All these health facilities have outpatient, antenatal and maternity services; and there are medical biologists who are able to take venous blood samples.

Population and Study Period

The study population for this research was non-pregnant women and pregnant women living in the city of Kisangani. This study took place from 05 October 2023 to 05 January 2024.

Sampling

To calculate this sample size, we used the article "First trimester microelement and their relationships with pregnancy outcomes and complications" in Poland in 2020 published by Lewandowska M. et al. (11). We used the G-Power software version 3.1.9.7. at the α threshold of 0.05 and a power of 95%, an effect size of 0.1. The minimum sample size was 1180 individuals, including 590 women who were not pregnant and 590 pregnant women. Our sampling was non-exhaustive.

Selection Criteria

Inclusion Criteria

1. Be a woman of genital age living in the city of Kisangani;
2. Be a pregnant woman living in the city of Kisangani;
3. Be in apparent good health;

4. Have voluntarily consented to participate in the study by signing the informed consent form;
5. Have agreed to the blood sample being taken, and the personal data being recorded (Noted).

Criteria for Non-inclusion

1. Breastfeeding or menopausal women living in the city of Kisangani;
2. Woman of childbearing age who is inpatient or outpatient;
3. Pregnant women with inpatient or outpatient morbidity;
4. Non-pregnant or pregnant woman who does not live in Kisangani.

Exclusion criteria

-Non-pregnant woman or pregnant woman whose personal data has been incorrectly noted, or the blood sample has been hemolyzed, or the sample (serum) had not been frozen at -80°C within 3 hours of collection.

-The case where the quantity of blood collected was not sufficient for all laboratory analyses.

Study Type

We conducted a cross-sectional study with a prospective data collection on all the sites selected for this research.

Data Collection Process

Data collection was prospective in outpatient and antenatal clinics in selected hospitals.

At the end of the sampling, the samples were sent to the laboratory of the university clinics of Kisangani. The tubes containing blood were centrifuged at 5,000 rpm for 5 minutes. After the sera were collected and divided by 2, placed in 2 different cryotubes, marked (each cryotube had a female identifier code according to the identification sheet, i.e. each woman had two cryotubes bearing her identifier or code). The cryotubes were stored in the Hub-Kisangani at -80°C. Half of these cryotubes were sent to the large biochemistry laboratory of the Faculty of Life Sciences of the University of Strasbourg in collaboration with the laboratory of the Chemistry and Biochemistry Section of the Faculty of Science of the University of Geneva for comparative assays of trace elements. The sera were transported in a container of liquid nitrogen to the laboratory of the University of Strasbourg.

Micronutrient concentrations in sera were analyzed using an inductively coupled plasma mass spectrophotometer (ICP-MS Agilent 7700X).

Data Processing and Analysis Plan

1. Manual data analysis and categorization.
2. Data analysis.

Data were entered on a computer using Microsoft Excel 2021 software. Statistical data analysis was done using R software version 4.3.0.

Percentage calculations were used for qualitative variables, mean, median, standard deviation, variance, minimum, maximum, first and third quartile, and mode for quantitative variables. We tested normality with the Kolmogorov-Smirnov test and we tested the homogeneity of variances with the Levene test. We used the Kruskal Wallis test and the Wilcoxon Mann-Whitney test to compare the means between the different groups.

Operational Definitions

Socio-economic levels were determined using the Household Economic Well-Being Index as constructed by Tchamda and Nkabkob [21](12). This index considers households' ownership of certain durable goods and certain characteristics of the dwelling. For our study, in relation to household durable goods, we looked for the possession or not of: television, radio, vehicle and refrigerator and mobile phone; And with regard to the characteristics of the housing, we asked about the availability of electricity, the supply of drinking water, the use of modern toilets, the construction of walls in sustainable materials and the use of embers or stoves as fuel for cooking.

We first assigned a score to each of the properties or characteristics of the dwelling: 1 for the "yes" answer and 0 for the "no" answer. Then, we assigned a total score in each household corresponding to the sum of all the scores obtained by property or dwelling characteristic. Thus, households were ranked in ascending order of total score and divided into 5 categories called quintiles: poorest (total score = 1-2), second or poor (total score = 3-4), medium (total score = 5-6), fourth or rich (total score = 7-8) and richest (total score = 9-10).

-Private sector official: employee in an NGO, Independent contractor.

-Pregnant or pregnant woman: A woman with a pregnancy whose diagnosis has been confirmed by the rapid urine pregnancy test and an ultrasound.

Ethical Considerations

The Ethics Committee of the University of Kisangani has given us its approval by Letter No. of Approval: UNIKIS/CER/025/2022 of 26/12/2022 to start with the effective collection of data. The research was carried out in accordance with the ethical standards set out in

the Declaration of Helsinki of 1964 and its amendments in 2013. All subjects provided written informed consent prior to inclusion in the study.

Anonymity was guaranteed during the collection, analysis and dissemination of this data. The latter were only collected when the woman had signed the informed consent form according to the language she mastered.

RESULTS

Socio-Demographic Characteristics of the Respondents

A reading of Table I shows that 75% of pregnant women were aged 20-34 compared to 64.4% of non-pregnant women. The average age was 26.3 ± 6.7 years. The extreme ages were 15 years and 47 years. 52% of pregnant women were housewives compared to 45.6% of non-pregnant women; And 7% of pregnant women were state agents compared to 4.8% of non-pregnant women. 87% of

Table I. Distribution of non-pregnant women and pregnant women according to their socio-demographic characteristics

Characteristic	Pregnancy		Total N = 1,189
	Not N = 598	Yes, N = 591	
Age (years)			
< 20	112 (18,7%)	59 (10,0%)	171 (14,4%)
20 to 34	385 (64,4%)	445 (75,3%)	830 (69,8%)
≥ 35	101 (16,9%)	87 (14,7%)	188 (15,8%)
Address (Municipality)			
Kabondo	85 (14,2%)	103 (17,4%)	188 (15,8%)
Kisangani	98 (16,4%)	46 (7,8%)	144 (12,1%)
Lubunga	101 (16,9%)	28 (4,7%)	129 (10,8%)
Makiso	119 (19,9%)	111 (18,8%)	230 (19,3%)
Mangobo	126 (21,1%)	166 (28,1%)	292 (24,6%)
Tshopo	69 (11,5%)	137 (23,2%)	206 (17,3%)
Profession			
State agent	29 (4,8%)	45 (7,6%)	74 (6,2%)
Merchant	54 (9,0%)	76 (12,9%)	130 (10,9%)
Dressmaker	24 (4,0%)	33 (5,6%)	57 (4,8%)
Farmer	12 (2,0%)	23 (3,9%)	35 (2,9%)
Student	51 (8,5%)	16 (2,7%)	67 (5,6%)
Teacher	13 (2,2%)	23 (3,9%)	36 (3,0%)
Nurse	16 (2,7%)	22 (3,7%)	38 (3,2%)
Housewife	278 (46,5%)	308 (52,1%)	586 (49,3%)
Pharmacist	1 (0,2%)	0 (0,0%)	1 (0,1%)
Private sector employee	19 (3,2%)	18 (3,0%)	37 (3,1%)
Marital Status			
Bachelor	175 (29,3%)	74 (12,5%)	249 (20,9%)
Bride	423 (70,7%)	517 (87,5%)	940 (79,1%)
Level of education			
Illiterate	3 (0,5%)	0 (0,0%)	3 (0,2%)
Primary	19 (3,2%)	17 (2,9%)	36 (3,0%)
Secondary	406 (67,9%)	446 (75,5%)	852 (71,7%)
Academic	170 (28,4%)	128 (21,7%)	298 (25,1%)
Socio-economic level			

Very poor	14 (2,3%)	0 (0,0%)	14 (1,2%)
Poor	139 (23,2%)	25 (4,2%)	164 (13,8%)
Medium	243 (40,6%)	415 (70,2%)	658 (55,3%)
Rich	149 (24,9%)	139 (23,5%)	288 (24,2%)
Very rich	53 (8,9%)	12 (2,0%)	65 (5,5%)

Trace Element Status of All Respondents in General

The micronutrients deficient in pregnant women were calcium (0.94-2.22 mmol/l), selenium (0.31-0.78 micromol/l) and zinc (7.29-12.72 micromol/l). (see table II on page 9)

Table 2. Micronutrient status in women overall and in Pregnant Women

	Average	Variance	Standard deviation	Minimum	P 25	Median	P 75	Maximum	Mode
women overall									
Calcium (mmol/l)	1,9031	0,2428	0,4927	0,94	1,49	1,99	2,31	2,98	2,31
Cuivre (μmol/l)	13,0686	4,473	2,115	0,53	11,48	12,41	14,37	20,42	12,31
Magnésium (mmol/l)	0,9401	0,5905	0,7685	0,082	0,79	0,83	0,92	1,15	0,87
Selenium (μmol/l)	0,7306	4,4383	2,1067	0,2	0,46	0,54	0,76	1,26	0,54
Zinc (micromol/l)	11,1396	9,532	3,0874	2,41	8,42	9,71	13,79	16,43	7,49
Pregnant Women									
Calcium (mmol/l)	1,4896	0,0827	0,2876	0,94	1,24	1,49	1,69	2,22	1,54
Cuivre (micromol/l)	12,5796	1,2805	1,1316	11,04	11,71	12,33	13,24	14,99	12,31
Magnésium (mmol/l)	1,0334	1,0723	1,0355	0,082	0,82	0,87	0,94	1,05	0,87
Selenium (micromol/l)	0,4713	0,0044	0,0665	0,31	0,42	0,47	0,53	0,78	0,41
Zinc (micromol/l)	8,4199	0,3772	0,6141	7,29	7,87	8,42	8,81	12,72	7,49

Table III. Comparison of micronutrient means between pregnant and non-pregnant women

The table III shows that pregnant women had lower levels of trace elements (calcium (1.5 ± 0.3 mmol/l), selenium (0.5 ± 0.1 micromol/l) and zinc (8.4 ± 0.6 micromol/l) than women who were not pregnant. The differences are statistically significant. (see table III on page 10)

Trace elements		Pregnancy		p-value
		Non N = 598	Oui N = 591	
Calcium (mmol/l)	Mean (standard deviation)	2,3 (0,3)	1,5 (0,3)	<0.001
Cuivre (micromol/l)	Mean (standard deviation)	13,6 (2,7)	12,6 (1,1)	<0.001
Magnésium (mmol/l)	Mean (standard deviation)	0,8 (0,3)	1,0 (1,0)	<0.001
Selenium (micromol/l)	Mean (standard deviation)	1,0 (2,9)	0,5 (0,1)	<0.001
Zinc (micromol/l)	Mean (standard deviation)	13,8 (2,0)	8,4 (0,6)	<0.001

pregnant women were married and 70.2% were of average socio-economic status. (see table I on page 8)

DISCUSSION

Deficiency Trace Elements in Pregnant Women

During this research, we found three trace elements that

were deficient in pregnant women in Kisangani. These were calcium with a mean of 1.5 ± 0.3 mmol/l (p-value < 0.001); selenium: 0.5 ± 0.1 micromol/l (p-value < 0.001); and zinc: 8.4 ± 0.6 micromol/l (p-value < 0.001).

These results are like those of studies carried out in South Africa by Robb Liska et al (13); and in Ethiopia by Samson Gebremedhin et al. (14), even though we observe

variations in different values depending on the country or study environment.

However, Mie S et al. in Japan (15), Duntas L H et al. in Greece (16), did not make observations like ours. Among them, pregnant women had serum micronutrient statuses or averages that remained within the norms despite some observed variations, not like the general population and non-pregnant women in particular.

During pregnancy, the demands for trace elements are accentuated for the maintenance of the metabolism of the maternal organism and to ensure embryonic (and fetal) development. The micronutrient status of the pregnant woman, which, depending on the state of the woman's micronutrient reserves before pregnancy, undergoes all these fluctuations. The latter are then able to plunge the pregnant woman into a deficient state or a significant decrease in the level of these trace elements concerned. Vomiting in pregnancy and hypo or intestinal hyperabsorption of certain trace elements during pregnancy lead to deficiencies that can be significant during this period.

Our respondents live in an environment at risk of nutritional deficiency in general (17). This exposes them to the risk of deficiencies or deficits in certain trace elements even before the onset of pregnancy. For most non-pregnant women with normal trace element values close to the lower bound of normality or below normal, can easily tip into even mild or severe deficiencies when a pregnancy occurs with all its requirements. Our results would be justified by this phenomenon.

However, in countries where the nutritional status of the population is known, their governments or health authorities most often adopt the policy of fortifying foods with nutrient deficiencies, especially among children, lactating women and women of childbearing age. This attitude could justify the results of some research (18) where they did not note deficiencies or deficits of certain trace elements in pregnant women.

Profile of Pregnant Women with Micronutrient Deficiency Status

Most of the pregnant women with micronutrient deficiency status were aged between 20 and 34 years (75.3%), with an average age of 26.3 ± 6.7 years, housewives (52.1%); and shopkeepers (12.9%). Most of them were married (87.5%), with a high school education (75.5%) and with a medium socio-economic level (70.2%).

Research conducted by Ugwuja EL et al. (19) in Nigeria found a predominance of university-level pregnant women

at 59.2%; 64.3% of these respondents were state officials, with an average age of 27.04 ± 2.75 years and the age extremes of 15 and 40 years. Zyambo K et al. (20) found more pregnant women aged 23-32 years (mean age 26 years), unemployed in Zambia.

The research environment most often influences the selection of cases, which would justify the similarity or difference in age in our different studies. Women's schooling continues to be a concern in developing countries, where boys are more likely to attend school than girls.

In addition to women's lack of access to employment, unemployment is a huge problem in sub-Saharan Africa; This could justify the lack of jobs among most of our respondents and those of other African authors (20).

The socio-economic level comparison of respondents from different studies cannot be considered, since we did not all use the same parameters to determine or assess their socio-economic levels. This can lead to confusion in comparison: for example, a poor or low-socio-economic individual in a developed country could be a rich person or of average or even high socio-economic level when assessed in a developing country (A poor person in the north is not necessarily equal to a poor person in the south).

AUTHOR CONTRIBUTIONS

JL : conceptualization, methodology, software, formal analysis, resource, investigation, data curation, writing-original draft, supervision; AT : software, investigation, writing-original draft; AL : formal analysis, writing-review and editing, visualization; EK : validation, investigation; BL : validation, investigation, resource; JJ: conceptualization, investigation, supervision; VB: conceptualization, methodology, resource; GK : methodology, validation, project administration.

All the authors have read and approved of this manuscript.

DISCLOSURE STATEMENT

The authors are employees of the University of Kisangani and the University of Mbuji-Mayi.

ETHICS AND CONSENT

This study was approved by the Ethics Committee of the University of Kisangani (approval no.: UNIKIS/CER/025/2022, dated 26/12/2022). This study was conducted in accordance with the requirements of good clinical practice and the principles of the Helsinki Declaration of the World Medical Association, along with any subsequent relevant amendments. Consent

was obtained from the authorities of the participating institutions, and measures were taken to ensure that no information allowing for patient identification was collected. Anonymity was guaranteed during the data collection and analysis. Data was collected only after signing the document, informed consent, and explanations provided in the local language (Swahili or Lingala), if necessary. As far as minors are concerned, we have obtained the consent of their parents or guardians.

Paper contexte key findings

- Pregnant women had lower levels of trace elements than women who were not pregnant.
- These differences were statistically significant.

Added knowledge

Pregnant women have lower levels of Cu, Ca, Zn, Mg and Se than non-pregnant women.

Declaration of funding

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