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Research Article

Serum Calcium Levels of Pregnant Women Utilizing Antenatal Care in Primary Health Centres (PHC) in Urban and Rural Areas in Uyo Senatorial District of Akwa Ibom State

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Abstract

Background: Calcium is a necessary for so many physiological processes in the body, especially during pregnancy. Insufficient calcium intake and consequent hypocalcemia poses risks to both fetus and mother including intrauterine growth restriction, low birth weight, poor bone mineralization, preterm birth, maternal hypertension, and preeclampsia. The World Health Organization recommends calcium supplementation for populations with low dietary intake of calcium which necessitates the assessment of serum calcium levels among pregnant women to determine populations that may benefit from calcium supplementation. This study, therefore, aims to compare the serum calcium levels and associated factors of pregnant women utilizing antenatal care in primary health centres (PHC) in urban and rural areas in Uyo senatorial district of Akwa Ibom State.

Methods: This study was a cross-sectional study carried out in 6 primary health care (3 urban and 3 rural) facilities in Uyo senatorial district of Akwa Ibom, selected by simple random sampling. An interviewer administered semi-structured questionnaire was used to obtain information on respondents' characteristics, 24-hour dietary recall and dietary supplements intake. Serum ionized calcium was measured using an Ion selective electrolyte analyzer LW E60B. Descriptive statistics were presented in tables and figures. Chi square test and Fisher's exact were performed to examine the relationship between outcome variable and respondents' characteristics. Statistical significance was set at a *p* value of 0.05.

Result: A total of 180 pregnant women (90 urban and 90 rural) were enrolled into this study. The average age of respondents was 27.39 ± 4.69 years. Only 10.6% respondents reported receiving calcium supplements during the index pregnancy (rural 16.7% vs urban 4.4%; p = 0.013). However, the average 24-hour dietary protein was 1,331.6 mg (110.9% of Recommended nutrient intake [RNI]), with rural respondents having higher intake (116.0% of RNI) compared to urban respondents (107.1% of RNI). The average serum ionized calcium levels of both urban (1.251 ± 0.129) and rural (1.274 ± 0.06) respondents were within the normal range, and only 7.8% and 13.3% of rural and urban respondents respectively had hypocalcemia. Only gestational age of rural respondents showed significant association with serum ionized calcium level.

Conclusion: Majority of the pregnant women had adequate intakes of dietary calcium with rural respondents having higher intakes compared to urban respondents. And most participants had normal levels of serum ionized calcium, with the mean serum ionized calcium being slightly higher among rural respondents compared to urban respondents. We recommend that high quality controlled trials be carried out in our environment to determine the effect of calcium supplementation on maternal and fetal outcomes in our population considering the already adequate dietary calcium intake and serum calcium levels.

Keywords: Calcium; Parathyroid Hormone (PTH); Hypertension

Introduction

Calcium is necessary for so many physiological process in the body and a delicate balance is required in pregnancy to cope with the high demand placed by the fetus for growth and maturation [1]. Although part of the demand is met by means of increased intestinal calcium absorption [2], adequate calcium intake by the mother remains important as total serum calcium levels fall during pregnancy and lactation [3,4]. Insufficient calcium intake and consequent hypocalcemia poses risks to both fetus and mother. Fetal risks include intrauterine growth restriction, low birth weight, poor bone mineralization, and preterm birth, while maternal risks include hypertension, preeclampsia and long term consequences from bone resorption [5-8].

The total requirement of calcium for fetal development has been reported to range between 25-30g with an increase from 2-3 mg/day in first trimester to 250 mg/day in the final trimester. This demand, during pregnancy, is met by increased intestinal reabsorption of calcium under the influence of 1,25- dihydroxy vitamin D (OH). The hormone, which is under the regulation of Parathyroid Hormone (PTH), increases during pregnancy by 50-100% while PTH itself remains the same or decreases. The net effect is a fall in serum total calcium as pregnancy progresses due to the above factors in addition to plasma volume expansion and hypoalbuminemia [2,9].

Dietary intake of calcium accounts for majority of total calcium intake [10]. The World Health Organization (WHO) recommends a dietary intake of 1200 mg/day of calcium for pregnant women [2]. Studies show that in many low- and middle-income countries (LMICs) the daily calcium intake in pregnancy is well below recommendations [11-13]. Furthermore, calcium intake and serum calcium levels have been found to be higher in pregnant women in urban areas and those of higher socio-economic class compared to those in rural areas and those of lower socioeconomic status [14,15].

The WHO recommends calcium supplementation (1.5 to 2g oral elemental calcium) for populations with low dietary intake of calcium [2], however, this is not routinely practiced in Nigeria, and particularly in Akwa Ibom state. This necessitates the assessment of serum levels of calcium among pregnant women to determine populations that may benefit from calcium supplementations. This study will help provide information needed to facilitate the implementation of the WHO guideline on calcium supplementation in pregnancy. This would allow the evidence-based prioritization of calcium supplementation, and would inform the development of policies and strategies. The aim of this study is therefore to assess and compare the serum calcium levels and associated factors of pregnant women utilizing antenatal care in primary health centres (PHC) in urban and rural areas in Uyo senatorial district of Akwa Ibom State.

Methods

- **Study setting:** The study was conducted in Uyo, Akwa-Ibom State located in the coastal South-South geopolitical zone of Nigeria. The state has a projected population of 6 million based on the National population commission census figures of 2006 and 85% live in the rural areas [16]. There are 31 Local Government Areas (LGAs) in Akwa Ibom, grouped into three senatorial districts: North East (Uyo senatorial District), North West (Ikot Ekpene Senatorial district) and South (Eket senatorial district). Uyo senatorial district comprises of nine LGAs. Uyo is the State capital, and is located between the coordinates 05^0 00N and $07^0$50E [16].
- **Study design and population:** This study used a cross sectional, comparative study design. This study was part of a larger study carried out to assess the dietary intake, prevalence of anemia and serum calcium levels of Pregnant women in the study location.

All pregnant women between 18 and 49 years of age, at any stage of gestation utilizing antenatal care services within the selected primary health centres, who gave consent to participate in the study were included in the study. Participants had to have been resident in Akwa Ibom State, for at least six months. All pregnant women with known diagnosis of haemoglobinopathies and other chronic infectious diseases that could result in anaemia such as HIV/AIDs, tuberculosis, chronic kidney diseases were excluded from this study.

Sample size

As this study was part of a larger study carried out to assess the dietary intake, prevalence of anemia and serum calcium levels of pregnant women in the study location, the sample size for the study was determined using the formula for the comparison of two independent proportions [17].

$$N = \frac{2 \times (Z_\alpha + Z_\beta)^2 \times [p_1(1-p_1) + p_2(1-p_2)]}{(p_1 - p_2)^2}$$

Where:

N = the sample size (for each group); Z_α = the standard normal deviate for the desired confidence level; Z_β = the standard normal deviate for the desired statistical power; p_1 and p_2 = the anticipated values of the proportions in the two populations; (p_1 - p_2) = the minimum expected difference between the two proportions.

Z_α = 1.96 for α = 0.05 (two tailed); Z_β = 0.84 i.e., power of 80%; p_1 - Proportion of rural pregnant women with anaemia; p_2 - Proportion of urban pregnant women with anaemia.

Therefore, using the prevalence of anaemia in rural pregnant women (48%) and urban pregnant women (20%) from a previous study in Calabar, Nigeria [18].

p_1 = 0.48

p_2 = 0.20

$$N = \frac{2 \times (1.96 + 0.84)^2 \times [0.48(1-0.48) + 0.20(1-0.20)]}{(0.48 - 0.20)^2}$$

$$N = \frac{2 \times 7.84 \times [0.4096]}{0.0784}$$

$$N = \frac{6.3898}{0.0784}$$

N = 81.5

With a non-response rate of 10% added, the minimum sample size for the study was:

Therefore, the minimum sample size of 90 participants was required for rural pregnant women and 90 participants for urban pregnant women. A total of 180 pregnant women were studied in all.

Sampling Technique: Multistage sampling was used for this study. This was done with the following stages:

- **Stage 1:** This involved selecting three LGAs out of the nine LGAs present in Uyo senatorial district by simple random sampling (balloting). This resulted in the selection of Uruan, Itu and Uyo LGAs.
- **Stage 2:** 3 rural and 3 urban PHCs out of a total of 11 rural and 6 urban PHCs present in the three selected (Uruan, Itu and Uyo) LGAs were selected by simple random sampling (balloting). The selected PHCs were: Urban - PHC Base, Uyo; PHC Aka Offot; PHC West Itam, Itu. Rural - PHC Ndon Ebom, Uruan; PHC Ikot Otoinyie, Uruan; PHC Ntak Inyang Itam, Itu.
- **Stage 3:** Selection of Study participants- Respondents were recruited consecutively into the study provided they met the inclusion criteria of the study and consented to the study. For the urban facilities, two/ (2) ANC clinic days per facility was used with an average of twenty (20) respondents seen per ANC clinic day. While, in the rural facilities, an average of four (4) ANC days per facility was used with an average of eight (8) respondents seen per ANC clinic day.

Data collection and study instruments

A pre-tested, semi-structured and interviewer-administered questionnaire was used to obtain information on the sociodemographic characteristics and dietary intake of the respondents. The questionnaire was written in English language and communicated verbally in English and the local language where necessary by the trained interviewers. For the section on 24 hours dietary recall data collection, the required information on the approximate weight (grams) of every food consumed within 24 hours by the study participants was recorded by showcasing an approximated size of various food using premeasured and weighed food models during the data collection to enable the study participants quantify the size and weight of the different foods consumed within the 24 hours duration.

An Ion selective electrolyte analyzer LW E60B, in the Chemical pathology laboratory at University of Uyo Teaching Hospital, Uyo, Akwa Ibom State was used for assessing serum calcium. Blood sample for calcium analyses was gotten from respondents with minimal use of tourniquet, this is because iodized calcium in blood depends on the pH, which changes if a tourniquet is applied for a long duration of time leading to hemostasis. Serum heparinized plasma calcium ion measurement was done in duplicate copies and the average gotten by one trained chemical pathologist.

Data management

Measurement of variables

The outcome (dependent) variables are daily dietary intake of calcium of both rural and urban women in this study, and the serum ionized calcium levels of the pregnant women.

The calcium content of the quantified and recorded food intake of each participant was obtained by entering using the validated Total Dietary Assessment Software [19]. This was then compared to the recommended nutrient intake for each nutrient [20,21].

Blood sample for calcium analyses was gotten from respondents with minimal use of tourniquet, this is because ionized calcium in blood depends on the pH, which changes if a tourniquet is applied for a long duration of time leading to hemostasis. Serum heparinized plasma calcium ion measurement was done in duplicate copies and the average gotten by a trained chemical pathologist. Serum ionized

calcium less than 1.16 mmol/L was considered hypocalcemia, while more than 1.31 mmol/L was considered hypercalcemia [22].

Data analysis

Data was coded and entered into IBM SPSS version 22.0.

- **Descriptive statistics:** Frequencies, proportions and means were calculated and presented as tables and charts and compared between the two groups.
- **Inferential statistics:** Fisher's exact and Chi-square test were used to test for association between categorical variable, while Mann-Whitney U test was used for comparison of median. Level of significance was placed at 0.05.
- **Ethical Concerns:** Ethical approval was obtained from the Ministry of Health, Akwa Ibom (MH/PRS/99/VOL.V/641) and the Health Research and Ethics Committee of University of Uyo Teaching Hospital (UUTH/AD/S/96/VOL.XXI/282). Approval was also obtained in writing from the council authorities of the selected LGAs. Written informed consent was obtained from each participant with respect to voluntary participation and freedom to discontinue the interview at any stage. The rights, anonymity and confidentiality of the respondents were respected at all phases of the study by the interviewers, and no identifying information was obtained from the participants.

Result

Sociodemographic characteristics of respondents

A total of 180 pregnant women were recruited to participate in this study, 90 from rural primary health centers, and 90 urban primary health centers. As shown in table 1, most respondents were below 30 years, with a mean age of 27.39 ± 4.69. majority were married (93.9%), had obtained secondary level of education (61.7%) and were mostly business owners (48.9%). Majority of the spouses also attained secondary level of education (58.9%) and were business owners (48.3%). Most of the respondents reported an average monthly household income of less than ₦40,000 (70.6%). The result further reveals that pregnant women in the urban and rural areas were comparable in age, marital status, main occupation, and household income. However, they differed in educational status (p = 0.004). About 31% of urban versus 13.1% of rural respondents had at least a tertiary education. Educational level and main occupation of the spouses were not significantly different across the two groups.

Characteristics	Urban (N/%) N = 90	Rural (N/%) N = 90	Total (N/%) N = 180	Test statistics/p value
Age (years)				
<30	58 (64.4)	64 (71.1)	122 (67.8)	χ^2 = 0.900
≥30	32 (35.6)	26 (44.8)	58 (32.2)	P = 0.638
Mean (x) ± SD	27.48 ± 4.48	27.31 ± 4.91	27.39 ± 4.69	t = 0.916; p = 0.339
Marital status				
Single	6 (6.7)	5(5.6)	11(6.1)	χ^2 = 0.097
Married	84(93.3)	85 (94.4)	169(93.9)	P = 0.756
Respondents' Level of education				
Primary or less	9 (10.0)	20 (22.2)	29 (16.1)	χ^2 = 8.229
Secondary	53 (58.9)	58 (64.4)	111 (61.7)	P = 0.005*
Tertiary and above	28 (31.1)	12 (13.3)	40(22.2)	
Respondents' Main occupation				
Business owner	48 (53.3)	40 (44.4)	88 (48.9)	χ^2 = 3.304
Civil servant	9 (10.0)	7 (7.8)	16 (8.9)	p = 0.347
Technician/Agric worker	21 (23.3)	32 (35.6)	53 (29.4)	
Unemployed	12 (13.3)	11 (12.2)	23 (12.8)	
Husbands' Level of education				
Primary or less	8 (8.9)	11 (12.2)	19 (10.6)	χ^2 = 3.168
Secondary	49 (54.4)	57 (63.3)	106 (58.9)	p = 0.075
Tertiary and above	33 (36.7)	22 (24.4)	55 (30.6)	
Husbands' Main occupation				
Managers/Business owner	42 (46.7)	45 (50.0)	87 (48.3)	Fishers exact
Civil servant	21 (23.3)	11 (12.2)	32 (17.8)	p = 0.053
Technician/Agric worker	21 (23.3)	32 (35.6)	53 (29.4)	
Unemployed	6 (6.7)	2 (2.2)	8 (4.4)	
Monthly household income (₦)				
<40,000	58 (64.4)	69 (76.7)	127 (70.6)	χ^2 = 3.236
>40,000	32 (35.6)	21 (23.3)	53 (29.4)	p = 0.072

Table 1: Socio-demographic Characteristics of the Respondents by Place of Residence.

* = statistically significant.

Pregnancy Related Characteristics of Respondents

Majority of the urban respondents were in their second trimester (48.9%), while majority of rural respondents were in their third trimester (47.7%). Most respondents commenced antenatal clinic in their second trimester (45.0%) and had received nutrition education (57.8%). Majority had singleton pregnancies (79.4%), had received supplements during the current pregnancy (79.4%), however, only 10.6% had received calcium supplements in particular. A higher proportion of rural (68.9%) versus 46.7% of urban respondents had received nutritional education(p = 0.003). Similarly, significantly more rural respondents had received any supplements and calcium supplement (p = 0.017 and 0.013 respectively).

Pregnancy related characteristics	Urban (N/%) N = 90	Rural (N/%) N = 90	Total (N/%) N = 180	Test statistic/p value
Gestational age (months)				
1-3	9 (10.0)	14 (15.6)	23 (12.8)	
4-6	44 (48.9)	33 (36.7)	77 (42.8)	$\chi^2 = 3.108$
7-9	37 (41.1)	43 (47.7)	80 (44.4)	p = 0.211
Parity				
0	35 (38.9)	40 (44.4)	75 (41.7)	$\chi^2 = 0.895$
1-3	45 (50.0)	39 (43.3)	84 (46.7)	p = 0.667
4-6	10 (11.1)	11 (12.3)	21 (11.6)	
Gestational age at booking (month)				
1-3				
4-6	44 (48.9)	35 (38.9)	79 (43.9)	$\chi^2 = 2.025$
7-9	36 (40.0)	45 (50.0)	81 (45.0)	p = 0.363
	10 (11.1)	10 (11.1)	20 (11.1)	
Received nutrition education during current pregnancy.				
Yes	42 (46.7)	62 (68.9)	104 (57.8)	$\chi^2 = 9.109$
Not sure	48 (53.3)	28 (31.1)	76 (42.2)	p = 0.003*
Singleton or multiple pregnancy				
Singleton	71 (78.9)	70 (77.8)	141 (78.3)	$\chi^2 = 0.129$
Multiple	19 (21.1)	20 (22.2)	39 (21.7)	p = 0.720
Receive any Supplements during this Pregnancy				
Yes	68 (75.6)	75 (83.3)	143 (79.4)	$\chi^2 = 5.724$
No	22 (24.4)	15 (16.7)	37 (20.6)	p = 0.017*
Receive calcium supplement.				
Yes	4 (4.4)	15 (16.7)	9 (10.6)	Fisher's exact
No	86 (95.6)	75 (83.3)	161 (89.4)	p = 0.013*

Table 2: Pregnancy Related Characteristics of Respondents by Place of Residence.

* = statistically significant.

Dietary calcium intake

The average 24-hour dietary calcium intake of all respondents was 1,331.6 mg (158.2-3,651.8 mg). Among urban respondents, the average 24-hour dietary calcium intake was 1,285.0 mg (266.9-3,652.8 mg), while that of rural respondents was 1,392 mg (158.2-3,100.6 mg). This difference was not statistically significant (Mann-Whitney U: -1.113; p = 0.266). Hence, using the recommended nutrient intake of 1200, urban respondents had an average of 107.1% of the RNI, rural, 116.0% of the RNI.

Serum calcium level of respondents

Study subjects who attended antenatal care at rural primary health centres had a slightly higher mean serum ionized calcium level (1.274 ± 0.06) compared to those who attended antenatal care at urban primary health centres (1.251 ± 0.129).

Figure 1: Bar chart showing distribution of rural and urban respondents according to their serum ionized serum calcium levels.

Figure 1 showed that over three quarters of urban respondents (78.8%) had normal ionized calcium levels, while 73.3% of rural respondents had normal ionized calcium levels. More rural respondents had high ionized calcium levels compared to urban respondents. This relationship was statistically significant (χ^2 = 5.270; p = 0.049)

Table 3 displays the relationship between serum ionized calcium levels and sociodemographic characteristics of rural and urban participants. None of these relationships was noticed to be statistically significant.

Characteristics	Serum Ionized Calcium of urban respondents		Serum Ionized Calcium of rural respondents	
	Inadequate; n = 12 (13.3%)	**Adequate; n = 78 (86.7%)**	**Inadequate; n = 7 (7.8%)**	**Adequate; n = 83 (92.2%)**
Age (years) <30 >30	 9 (15.5) 3 (9.4)	 49 (84.5) 29 (90.6)	 5 (7.8) 2 (7.7)	 59 (92.2) 24 (92.3)
Test statistic/p value	Fisher's exact; p = 0.527		Fisher's exact; p = 1.000	
Respondents' Level of education Primary Secondary Tertiary and above	 0 (0.0) 8 (15.1) 4 (14.3)	 9 (100.0 45 (84.9) 24 (85.7)	 3(15.0) 4 (6.9) 0 (0.0)	 17 (85.0) 54 (93.1) 12 (100.0)
Test statistic/p value	Fisher's exact; p = 0.255		Fisher's exact; p = 0.282	
Respondents' Main occupation Managers/Business owner Civil servant Technician/Agric worker Unemployed	 7 (14.6) 1 (11.1) 3 (14.3) 1 (8.3)	 41 (85.4) 8 (88.9) 18 (85.7) 11 (91.7)	 2 (5.0) 0 (0.0) 3 (9.4) 2 (18.2)	 38 (95.0) 7 (100.0) 29 (90.6) 9 (81.8)
Test statistic/p value	Fisher's exact; p = 1.000		Fisher's exact; p = 0.329	
Monthly household income (₦) <40,000 >40,000	 8 (13.8) 4 (12.5)	 50 (86.2) 28 (87.5)	 7 (10.1) 0 (0.0)	 62 (89.9) 21 (100.0)
Test statistic/p value	Fisher's exact; p = 1.000		Fisher's exact; p = 0.193	

Table 3: Serum Ionized Calcium Levels by Sociodemographic Characteristics of Respondents.

Table 4 shows that among rural respondents, gestational age was significantly related to serum ionized calcium of rural respondents (p = 0.028). Those with a gestational age of 7-9 months had the highest proportion of subjects with adequate ionized calcium levels compared to other gestational age groups. Among urban participants, none of these relations were significant.

Characteristics	Serum Ionized Calcium of urban respondents		Serum Ionized Calcium of rural respondents	
	Inadequate; n = 12 (13.3%)	Adequate; n = 78 (86.7%)	Inadequate; n = 7 (7.8%)	Adequate; n = 83 (92.2%)
Parity 0 1-3 4-6	 8 (22.9) 4 (8.9) 0 (0.0)	 27 (77.1) 41 (91.1) 10 (100.0)	 4 (10.0) 2 (5.1) 1 (9.1)	 36 (90.0) 37 (94.9) 10 (100.0)
Test statistic/p value	Fisher's exact; p = 0.109		Fisher's exact; p = 0.085	
Gestational age (months) 1-3 4-6 7-9	 2 (22.2) 6 (13.6) 4 (10.8)	 7 (77.8) 38 (86.4) 33 (89.2)	 3 (21.4) 0 (0.0) 4 (9.3)	 11 (78.6) 33 (100.0) 39 (90.7)
Test statistic/p value	Fisher's exact; p = 0.671		Fisher's exact; p = 0.028*	
Is pregnancy singleton or multiple pregnancy? Singleton Multiple	 10 (14.1) 2 (10.5)	 61 (85.9) 17 (89.5)	 4 (5.8) 3 (14.3)	 65 (94.2) 18 (85.7)
Test statistic/p value	Fishers exact; p = 1.000		Fisher's exact; p = 0.347	
Have you received nutrition education during this pregnancy? Yes No	 6 (12.5) 6 (14.3)	 36 (85.7) 42 (87.5)	 6 (9.7) 1 (3.6)	 56 (90.3) 27 (96.4)
Test statistic/p value	x^2 = 0.062; P = 0.804		Fisher's exact; p = 0.428	
Did you receive calcium supplements? Yes No	 1 (25.0) 11 (12.8)	 3 (75.0) 75 (87.2)	 2 (13.3) 5 (6.7)	 13 (86.7) 70 (93.3)
Test statistic/p value	Fisher's exact; p = 0.442		Fisher's exact; p = 0.330	
24-hour dietary calcium intake Low Adequate	 2 (10.0) 10 (14.3)	 18 (90.0) 60 (85.7)	 3 (16.7) 4 (5.6)	 15 (83.3) 68 (94.4)
Test statistic/p value	Fisher's exact; p = 1.000		Fisher's exact; p = 0.140	

Table 4: Serum Ionized Calcium Levels by Selected Pregnancy Related Characteristics and Antenatal Care Function Received by Respondents.

*statistically significant.

Discussion

We studied the serum ionized calcium levels in a sample of 180 pregnant women in rural and urban areas. This study presents preliminary information on the serum calcium levels of pregnant women in Akwa Ibom state, Nigeria, and can serve as a guide for further research on the topic, and for local recommendations on calcium supplementation during pregnancy.

The evidence in this study shows that in both rural and urban locations, serum calcium levels were mostly within the normal range. This was similar to an Indian study which reported a 12% prevalence rate of hypocalcemia [23]. Our findings were in contrast with a study in Maiduguri, Northern Nigeria reported a 29% prevalence of hypocalcemia among its pregnant population [24]. This difference may be attributed to the dietary composition of foods in the different locations, as Maiduguri has had long standing insurgency, which may affect the quality and quantity of food available to pregnant women. Similarly, another Nigerian study reported higher prevalence of hypocalcemia (25.6%) compared to our findings [25]. Also, in contrast to our study, A Cameroonian study reported that 58.8% of the pregnant women had hypocalcemia when serum albumin levels were corrected for [26]. Apart from a variance in dietary habits of pregnant women between the two studies, the fact that the study in Cameroon was carried out among pregnant women in their third trimester alone may explain the wide variation observed, as serum calcium levels further decreases in the third trimester due to increasing demand by the fetus [2]. It is worthy of note that while we measured ionized calcium, these other studies measured total calcium levels which is error prone in pregnancy as it is sensitive to the dilutional effect of intravascular expansion seen in pregnancy [3].

A diet deficient in calcium is the leading cause of hypocalcemia in pregnancy [10]. The low prevalence of hypocalcemia in this study reflects the diet of the respondents, where the mean calcium intake was higher than the RNI by over 10%. This may be attributed to the staple diets found in the study location which is rich in leafy vegetables, found to contain high amounts of calcium [27]. This mean intake of calcium was similar to an Indian study where most of the pregnant women had adequate calcium intake, resulting in low levels of hypocalcemia [23]. However, it is higher than the mean intakes in studies in Nigeria, and in China [28,29]. Our study also revealed higher serum calcium levels in rural compared to urban respondents. This can also be explained by the higher dietary calcium intake of rural respondents and the fact that a higher proportion of rural respondents took calcium supplements compared to urban respondents. This finding was similar to results in an Iranian study [30]. It was also seen that a significantly higher proportion of the pregnant women from rural areas reported that they received nutritional education, nutrient supplementation and specifically calcium supplementation which also explains the higher serum calcium levels among rural respondents. While this is unexpected, it may be as a result heightened interest in maternal health in rural areas, leading to improved quality of antenatal care services in these areas.

The WHO recommends calcium supplementation of 1.5-2g per day for pregnant women in populations with observed low dietary calcium intake in order to reduce the risk of pre-eclampsia [2]. However, it was reported in a systematic review of 13 randomized clinical trials that investigated the effect of daily calcium supplementation in preventing pre-eclampsia and eclampsia, that calcium supplementation reduced the risk of pre-eclampsia by more than half when compared to placebo for all women in the study, irrespective of initial serum calcium levels. This risk reduction was 41% for women at low risk of developing pre-eclampsia and 78% for those at high risk of hypertensive disorders [2]. Due to the fact that pre-eclampsia and eclampsia are a major cause of maternal and perinatal morbidity and mortality in Nigeria [31,32], Ositadinma., *et al*. opined that calcium supplementation be added to routine antenatal medications irrespective of the average serum calcium level of the population [33]. This is however not commonly practiced as evidenced by findings in our study, where calcium supplementation rate was very low for both urban and rural respondents. However, excessive consumption of calcium may increase the risk of urinary stones and urinary tract infection, and reduce the absorption of other essential micronutrients [34]. Hence, caution should be exercised with calcium supplementation in populations with adequate serum calcium levels.

Some studies have reported associations between serum calcium levels and certain characteristics of the pregnant women such as educational level, socioeconomic status and parity [23,24]. This was contrary to our findings as all associations between maternal characteristics and serum calcium levels among urban

respondents were not significant, while among rural respondents, only gestational age showed significant association with serum calcium levels.

Limitations

This study had several limitations including the study design and small sample size. This study was a cross-sectional study with self-reported variables; hence this data was prone to recall bias. Furthermore, the small sample size may affect generalizability to the entire population of pregnant women in Akwa Ibom state. However, this is the first study carried out on this topic in Akwa Ibom state and will serve a vital role as preliminary information on serum calcium levels in the state, serving to inform future research and policy makers.

Conclusion and Recommendation

Majority of the pregnant women had adequate intakes of dietary calcium with rural respondents having higher intakes compared to urban respondents. Hence, although calcium supplementation rate was very low, most participants had normal levels of serum ionized calcium, with the mean serum ionized calcium being slightly higher among rural respondents compared to urban respondents.

Sequel to our findings, we recommend that future studies focus on the effect of low dose calcium supplementation on maternal and child outcomes in populations with adequate serum calcium levels, as this may help avert the side effects of high dose calcium supplementation in these populations. Furthermore, high dose calcium supplementation (>1g) should be given to those with low serum calcium levels, or low dietary calcium intake in our environment. We also recommend that similar studies be carried out on a larger scale in other senatorial districts of Akwa Ibom state Nigeria, in order to be able to generalize the results.

Bibliography

1. Ward KA., *et al*. "Bone status during adolescence, pregnancy and lactation". *Current Opinion in Obstetrics and Gynecology* 17.4 (2005): 435-439.

2. World Health Organization. Guideline: calcium supplementation in pregnant women. Geneva: World Health Organization (2013).

3. Almaghamsi A., *et al*. "Hypocalcemia in Pregnancy: A Clinical Review Update". *Oman Medicine Journal* 33.6 (2018): 453-462.

4. Akhter K., *et al*. "Serum calcium in normal pregnant women". *Mymensingh Medicine Journal* 12.1 (2003): 55-57.

5. Farzin L and Sajadi F. "Comparison of serum trace element levels in patients with or without pre-eclampsia". *Journal of Research in Medical Sciences* 17.10 (2012): 938-941.

6. Ephraim RKD., *et al*. "Serum calcium and magnesium levels in women presenting with pre-eclampsia and pregnancy-induced hypertension: a case-control study in the Cape Coast metropolis, Ghana". *BMC Pregnancy and Childbirth* 14.1 (2014): 390.

7. Scholl TO., *et al*. "Maternal calcium metabolic stress and fetal growth". *The American Journal of Clinical Nutrition* 99.4 (2014): 918-925.

8. Chen Y., *et al*. "Association between maternal vitamin D deficiency and small for gestational age: evidence from a meta-analysis of prospective cohort studies". *BMJ Open* 7.8 (2017): e016404.

9. Katung GK and Akande TS. "The prevalence of hypocalcemia in pregnancy and peurperium in northwestern Nigeria". *Tropical Journal of Obstetrics and Gynaecology* 33.1 (2016): 27-31.

10. Willemse JPMM., *et al*. "Calcium intake from diet and supplement use during early pregnancy: the Expect study I". *European Journal of Nutrition* 59.1 (2020): 167-174.

11. Merialdi M., *et al*. "World Health Organization systematic review of the literature and multinational nutritional survey of calcium intake during pregnancy". *Fetal and Maternal Medicine Review* 16.2 (2005): 97-121.

12. Benali AI and Demmouche A. "Calcium Deficiency among Pregnant Women and their Newborns in Sidi Bel Abbes Region, Algeria". *Journal of Nutrition and Food Sciences* 4.6 (2014).

13. Cormick G., *et al*. "Global inequities in dietary calcium intake during pregnancy: a systematic review and meta-analysis". *BJOG* 126.4 (2019): 444-456.

14. Agueh VD., *et al*. "Dietary Calcium Intake and Associated Factors among Pregnant Women in Southern Benin in 2014". *Food and Nutrition Sciences* 06.11 (2015): 945.

15. Sachan A., *et al*. "High prevalence of vitamin D deficiency among pregnant women and their newborns in northern India". *The American Journal of Clinical Nutrition* 81.5 (2005): 1060-1064.

16. Citypopulation. Akwa Ibom (State, Nigeria) - Population Statistics, Charts, Map and Location. City Population (2020).

17. Scott TA. "Sample Size Planning, Calculation, and Justification". 12.

18. Okafor IM., *et al*. "Iron Status of Pregnant Women in Rural and Urban Communities of Cross River State, South-South Nigeria". *Nigerian Journal of Physiology Science* 31.2 (2017): 121-125.

19. ESHA Research. Total Diet Assessment. Get the software safely and easily. Software Informer (2022).

20. Meija L and Rezeberga D. "Proper Maternal Nutrition during Pregnancy Planning and Pregnancy" (2017).

21. Opara DC. "Fundamentals of Public Health Nutrition". 1st Edition. Uyo: Heritage Digi-Link Int'l (2019).

22. Schafer AL and Shoback DM. "Hypocalcemia: Diagnosis and Treatment". In: Feingold KR, Anawalt B, Boyce A, Chrousos G, de Herder WW, Dhatariya K, et al., editors. Endotext. South Dartmouth (MA): MDText.com, Inc. (2000).

23. Gupta A., *et al*. "Dietary calcium intake, serum calcium level, and their association with preeclampsia in rural North India". *Indian Journal of Community Medicine* 41.3 (2016): 223.

24. Bako B., *et al*. "Prevalence and risk factors of hypocalcemia among pregnant and non-pregnant women in Maiduguri, Nigeria: A cross-sectional study". *Nigerian Journal of Clinical Practice* 24.1 (2021): 75.

25. Eli S., *et al*. "Prevalence of hypocalcaemia and maternal complications among antenatal clinic attendees at the university of Port Harcourt teaching hospital". *Nigerian Journal of Medicine* 26.3 (2017): 208.

26. Ajong AB., *et al*. "Prevalence and correlates of low serum calcium in late pregnancy: A cross sectional study in the Nkongsamba Regional Hospital; Littoral Region of Cameroon". *PLOS ONE* 14.11 (2019): e0224855.

27. Natesh N H., *et al*. "An overview of nutritional and anti nutritional factors in green leafy vegetables". *HIJ* 1.2 (2017).

28. Sholeye OO., *et al*. "Dietary habits of pregnant women in Ogun-East Senatorial Zone, Ogun State, Nigeria: A comparative study". *IJNAM* 6.4 (2014): 42-49.

29. Gao H., *et al*. "Dietary Intake and Food Habits of Pregnant Women Residing in Urban and Rural Areas of Deyang City, Sichuan Province, China". *Nutrients* 5.8 (2013): 2933-2954.

30. Esmaillzadeh A., *et al*. "Dietary patterns among pregnant women in the west-north of Iran". *Pakistan Journal of Biological Sciences* 11.5 (2008): 793-796.

31. Musa J., *et al*. "Incidence and risk factors for pre-eclampsia in Jos Nigeria". *African Health Sciences* 18.3 (2018): 584-595.

32. Onoh R., *et al*. "Severe preeclampsia and eclampsia: A 6-year review at the Federal Teaching Hospital, Abakaliki, Southeast Nigeria". *Tropical Journal of Obstetrics and Gynaecology* 36.3 (2019): 418.

33. Ositadinma O., *et al*. "Evaluation of Serum Calcium Level in Pregnant Normotensive and Pre-eclamptic/Eclamptic Women in Nnewi, Nigeria: A Case Control Study". *Savant Journal of Medicine and Medical Sciences* 1 (2015): 60-64.

34. Hofmeyr GJ., *et al*. "Calcium supplementation during pregnancy for preventing hypertensive disorders and related problems". *Cochrane Database System Review* 10 (2018): CD001059.