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Prevalence and influence of maternal undernutrition on intra uterine growth restriction (IUGR) among beninese newborns

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Abstract
This study aimed to identify the contribution of maternal undernutrition, characterized by maternal weight status and short stature, on the risk of Intra Uterine Growth Restriction. During June 2007 and July 2008, we carried out a cross-sectional study in three health centers in Benin. Mothers and newborns characteristics and anthropometric measurements were collected at delivery. IUGR was defined as a birth weight below the 10th percentile of William's sex-specific reference curve of birth weight-for-gestational-age. Logistic regression was performed for statistical analysis. A total of 526 mothers and their newborns were enrolled. The prevalence of IUGR was 25.3%. Maternal low weight status and short stature (<155cm) accounted for 29.8% and 26.2% respectively. Maternal low weight status (OR=2.53, p<0.000), primiparity (OR=1.98, p=0.01) and Male gender (OR=1.68, p=0.01) were significantly associated with a higher risk of IUGR. Maternal short stature was related to the risk of IUGR in univariate analysis (p=0.02) but no longer in multivariate (p=0.13). Maternal stature and weight status (i.e pre pregnancy weight and gestational weight gain) are main determinants of IUGR in LMIC's. This result confirms the urgent need of public health interventions to improve nutritional status of women of childbearing age before pregnancy, or during initial stages of pregnancy.

Keywords: Maternal low weight status-maternal short stature-intra uterine growth restriction-risk factors-Benin.

Introduction
Intra Uterine Growth Restriction (IUGR) still has severe adverse outcomes on newborns' health and even later in life, especially in Low and Middle-Income Countries (LMICs). IUGR is a principal contributor to low birth weight (LBW) defined by a birth weight lower than 2,500 g.[1] LBW is widely known as a negative determinant of child's health.

IUGR is generally defined as a birth weight below the tenth percentile of a reference birth weight distribution according to gestational age.[2] The prevalence of IUGR varies considerably in LMICs and appears to be higher in Asia (e.g. 62% in South India, 50% in Bangladesh) than in Africa (e.g. 29-35% in rural Burkina Faso, 22-25% in rural Tanzania).[3] In the republic of Benin, rates are similar as for others African countries, but we do not have recent national data from Public Health Ministry.

IUGR is mainly caused by placental insufficiency[4,5] with vascular dysfunctions leading to a chronic decrease of oxygen and nutritional supplies to the growing of the fetus. According to literature, chromosomal defects, primiparity, multiple births, maternal infections during pregnancy, maternal chronic pathologies like hypertension are well-known determinants of intrauterine growth restriction.[6] Moreover, in developed countries, some individual factors like maternal smoking and alcohol consumption are the main causes of IUGR, whereas, in LMICs, chronic maternal nutritional disorders play an important role.[4,7-11]

Maternal nutritional deficits can take various forms such as low weight gain during pregnancy, low body mass index before pregnancy, small maternal size or micronutrient deficiencies.[12-15]

In Benin, people living in rural areas are often disadvantaged and have limited resources. Insufficient caloric and nutrient intake in these people remains a problematic reality and certainly leads to nutritional deficits chronically installed. This question arises with greater intensity in pregnant women living in these areas. The nutritional disorders to which they are exposed have harmful consequences, on the one hand, on the course of pregnancy, fetal growth is affected, and other parts of neonatal morbidity. It is therefore relevant to study this problem.

Moreover, in Benin, there is no public health strategy to prevent maternal undernutrition. Sometimes, supplementation with iron and vitamin B12 is proposed in cases of anemia during pregnancy, which is mainly due to gestational malaria since Benin is located in a malaria-endemic area. But anemia can also be due to poor dietary intake and fit into a global context of nutritional deficiency in pregnant women. This work will provide scientific results on which the Ministry of Public Health will rely to more easily identify women at risk of undernutrition and secondly to initiate in the future, interventions to improve the nutritional status of pregnant women in general and those living in rural areas in particular.

The main objectives of the present study were to determine the prevalence of IUGR among a population living in rural area, to describe the characteristics of IUGR newborns and finally to explore the contribution of maternal undernutrition on the risk of IUGR.

Materials and Methods

Study Area

We carried out a cross-sectional study in Tori Bossito located 40 km North-East of Cotonou, Southern Benin. The study area included nine villages and three health centers with a maternity ward (Tori Avame, Tori Cada, and Tori Gare).

Population

We included all women living in the villages and attending to one of the maternity wards for delivery between June 2007 and July 2008. During this period, 656 newborns were registered. Multiple births (twenty-five pairs of twins and 1 triplet) and stillbirths (n=10) were excluded. Very preterm newborns (n=18) were automatically sent to a bigger and better equipped hospital for proper care. Subjects whose birth weight, gestational age or gender was not informed with accuracy were also excluded. A total of 526 newborns were finally included.

Data Collection

When mothers came to the maternity ward for delivery, a questionnaire was administered to gather their personal information. Obstetric history and current pregnancy history included parity (primipara/multipara), number of antenatal care visits (ACV, < 4 or ≥ 4), and use of malarial Intermittent Preventive Treatment during pregnancy (IPTp). Socio-demographic data concerned ethnic group (Tori, Fon, other), maternal age, education status of the mother (schooled/unschooled) and marital status (polygamous/monogamous). Mother's hemoglobin rate was measured at delivery on capillary blood samples with a Hemocue analyzer (Hemocue@AB®, Sweden); and the mother's anemia was defined as a hemoglobin level less than 110 g/L. Before delivery mother's anthropometrics characteristics were measured: weight was measured to the nearest 100 g using a mechanical scale (SECA® type 761) and maternal height was measured to the nearest mm using a body meter (SECA® type 206). Maternal short stature was defined as height less than 155cm. Body mass index (BMI: defined as weight (in Kg) / square of height (in m²) at the end of pregnancy was then computed. As women's weight before pregnancy was not known, we have estimated it based on method recommended by the World Health Organization Commission on Nutrition.[16]

This calculation takes into account two parameters: a minimal recommended pre-pregnancy BMI of 20 kg/m² and a theoretical minimal gestational weight gain of 1 kg per month from the 4th month until delivery. Calculation example for a woman 59 kg at delivery and 1.67 m tall: using the minimal recommended pre-pregnancy BMI of 20 kg/m², corresponds a minimal weight before pregnancy of 55.78 kg. If this woman delivered after 9 months of gestation, her gestational weight gain should be 6 kg and her calculated minimum weight at delivery is therefore 61.78 kg. As her actual measured weight at delivery (59 kg) is strictly less than the calculated minimum weight at delivery (61.78 kg), this woman is then classified in "low weight status" category.[16] It has to be noticed that this indicator include either low pre-pregnancy weight or low weight gain during pregnancy, or both.

Newborn's anthropometric measurements at birth (weight, length) were performed by midwives with methods recommended by the World Health Organization (WHO).[17] Weight was recorded to the nearest 10 g using mechanical baby scales (SECA® type 745). The length was measured to the nearest millimeter with a locally made wooden board equipped with two metal measuring tapes. Estimation of the gestational age of the newborn was carried out by trained field supervisors, using the Ballard method.[18] IUGR was defined as a birth weight below the tenth percentile of William's reference curve of birth weight-for-gestational-age [19] which is sex-specific as recommended by WHO.[17]

Variables

Our dependent variable was the presence of IUGR coded as a dichotomic variable: 1 = presence of IUGR; 0 = absence of IUGR.

We had two main covariates representing maternal undernutrition: maternal stature and maternal weight status

Statistical Analyses

To explore the potential link between maternal undernutrition and IUGR, we performed univariate and multivariate analyses. Univariate analyses were conducted using chi-square tests or Fisher's exact test to compare percentages, and T student test to compare means. All variables that were linked to the outcome at $P \leq 0.20$ in the univariate analysis were then introduced in a multivariate logistic regression model. In case of colinearity between maternal age and parity in the model, we chose to retain only parity because it is known to be important risk factor according to the literature. Furthermore, all analyses were adjusted for the place of delivery. Statistical analyses were performed using Stata®, version 11.0 (StataCorp LP, College Station, TX, USA). Statistical significance was set at $P<0.05$ in the final model.

Ethics

The study protocol was read and explained to pregnant women in their native language during outreach sessions. The signing of a free, informed and written consent document was required before the enrollment in the research project was definitively accepted. All women who participated in this study were able to withdraw their consent at any time during the study.

Results

Description of Mothers' Population

Deliveries took place in Tori Cada (50.8%), 30.4% in Tori Avame and 18.8% in Tori Gare. The mean age and standard deviation, of mothers were 27.5 and 5.6 years respectively, and 13.5% of them were younger than 20 years. Close to 30% of mothers had a low weight status. Maternal mean height (SD) was 158.7 and 6.3 cm respectively with 26.2% had a short stature (height <155 cm). Around 40% of the mothers were anemic at delivery with hemoglobin level less than 110g/L. Primipara mothers accounted for 14.8%. In the sample, 56.6% have respected more than four antenatal care visits and the great majority, 82.8%, has received at least one dose of Intermittent Preventive Treatment of malaria in pregnancy. Most women were unschooled and lived in a monogamous household.

Description of Newborns' Population

The newborns' mean (SD) birth weight and height along with their standard deviations were 2985g (384) and 48.7cm (2.2), respectively, and the sex-ratio (M/F) was 0.96. There were 25.3% of IUGR babies in the sample. Mothers and newborns characteristics are summarized in Table 1.

Description of the IUGR Newborns' Population (Table 2) Among the IUGR infants, the majority were boys, 77, accounting for 57.89%. The mean birth weight (SD) was 2606.85 (208.22) kg; the leanest weighed 1845 kg and the heaviest 3002.5 kg. The mean birth length (SD) was 47.49 (2.24) cm. regarding the birth term, the mean gestational age was 39.28 weeks of amenorrhea. All IUGR neonates were born between 37 and 43 weeks of amenorrhea. It is important to note that they are all born at term, after 37 weeks of amenorrhea which is the threshold of prematurity. These are therefore real IUGR due to real restricted fetal growth and not due to inadequate gestational age.

Determination of Risk Factors of IUGR

During univariate analysis (Table 3), infant's gender, maternal age, stature and weight status, maternal anemia at delivery and parity were factors linked with IUGR with $p \leq 20$.

In the logistic regression model for multivariate analysis (Table 4), low maternal weight status (OR=2.53, p<0.000), infant's male gender (OR=1.68, p=0.01) and primiparity (OR=1.98, p=0.01) were significantly associated with an increased risk of IUGR. Maternal short stature was no longer associated with the risk of IUGR. Maternal anemia at delivery seemed to increase the risk of IUGR but no significant link was found.

Table 1: Description of the study population

	N=526	Mean (SD)	%
Mothers' characteristics			
Age (in years)		27.5 (5.6)	
Age group			
≤ 20	71		13.5
] 20 - 25]	129		24.6
] 25 - 30]	183		34.9
>30	141		26.9
Maternal low weight status	157		29.8
Maternal Height (in cm)		158.7 (6.3)	
Maternal short stature (height<155cm)	138		26.2
Maternal Anemia (Hb≤110g/L)	200		38.5
Parity			
Multipara	448		85.2
Primipara	78		14.8
Number of Antenatal Care Visits			
< 4	217		43.4
≥ 4	283		56.6
Use of Intermittent Preventive Treatment of malaria for pregnant women	433		82.8
Schooling status			
Schooled mothers	77		14.6
Unschooled mothers	449		85.4
Marital status			
Polygamous	153		29.1

Monogamous	373		70.9
Newborns' characteristics			
Birth weight (in gram)		2985 (384)	
Length at birth (in cm)		48.7 (2.2)	
Sex ratio (M/F)		0.96	
Gestational age (in weeks)		38.47 (1.7)	
Intra Uterine Growth Restriction	133		25.3

Table 2: Description of the IUGR newborns population

	IUGR newborns		
	N (%)	**Mean (SD)**	**[Range]**
Infant's gender			
Male	77 (57.89)		
Female	56 (42.11)		
Birth weight (in gram)		2606.85 (208.22)	[1845-3002.5]
Length at birth (in cm)		47.49 (2.24)	[41.6-56]
Gestational age (in weeks)		39.28 (1.23)	[37-43]

Table 3: Risk factors for Intra Uterine Growth Restriction (IUGR). Univariate analysis

	IUGR (N or Mean)		
	Yes	No	P
Infant's gender			**0.02**
Male	77	181	
Female	56	210	
Mother's age (in year)	26.26	27.91	**0.003**
Maternal stature			**0.02**
Normal (≥155cm)	88	299	
Short (<155cm)	45	93	
Maternal weight status			**0.000**
Normal	73	296	
Low	60	96	
Maternal anemia			0.20
No	86	232	
Yes (Hb≤110g/L)	44	156	
Parity			**0.009**
Multipara	104	343	
Primipara	29	49	
Number of antenatal care visits			0.43
< 4	57	159	
≥ 4	66	217	
Use of Intermittent Preventive Treatment of malaria for pregnant women	114	318	0.30
Schooling status			0.89
Schooled	20	57	
Unschooled	113	335	
Marital status			0.95
Polygamous	39	114	
Monogamous	94	278	

Table 4: Risk factors for intra uterine growth restriction (IUGR). Multivariate Analysis (logistic regression)[a]

Covariates	**Adjusted Odds Ratio [95% CI]**	**p-value**
Maternal low weight status	2.53 [1.65-3.88]	**<0.000**
Maternal short stature (<155cm)	1.42 [0.90-2.23]	0.13
Infant's gender male	1.68 [1.11-2.55]	**0.01**
Primiparity	1.98 [1.15-3.39]	**0.01**
Maternal anemia (<110g/L)	0.74 [0.48-1.14]	0.17

[a] Adjustment was made for the place of delivery.

Discussion

This study aimed to determine the prevalence of IUGR and to explore the contribution of maternal undernutrition on the risk of IUGR. The prevalence of IUGR was 25.3% among these Beninese newborns. In the sample, maternal low weight status and maternal short stature, characterizing maternal undernutrition, accounted respectively for 29.8% and 26.2%. Maternal low weight status, primiparity, and Male gender were significantly associated with a higher risk of IUGR. Maternal short stature was related to the risk of IUGR in univariate analysis but no longer in multivariate.

To determine IUGR in African populations was problematic due to the reference curves usually used. In Benin, as in many African countries, there is a lack of fetal growth curves, validated at the national level and which can be used as reference for comparison. Different curves are used according to the countries and according to the authors.[6] The fetal growth curve is essential in detecting abnormalities in the course of pregnancy and in fetal growth. Populations are genetically different, the environment and the living conditions are different. Food habits, access to health care and lifestyle are not the same from one country to another. All these factors can interact to induce various trajectories of intrauterine growth. In this study, we used the sex-specific reference curve of birth weight for gestational age of Williams[19] as recommended by WHO.[17] This curve was developed in the United States. However, we took into account only data from black pregnant women. The use of such curve might have led to an overestimation of IUGR in our study. But the prevalence of IUGR observed in our population was corresponding to the global estimate of 24.1% in LMICs [3] and close to figures reported in the literature for African countries, 20.3% in rural Malawi.[20]

In our study, we identified short stature mothers when they were less than 155 cm tall. This threshold has been used by other authors, as Ozaltin pointed out in a review of the literature concerning 54 LMICs between 1991 and 2008, on this subject. From this work different values (<145cm, [145 to 149.9], [150 to 154.9], [155 to 159.9] and <160 cm) were used in different populations and different areas.[21] The stature of the mothers was strongly related to the risk of IUGR in univariate analysis. This result is consistent with what has been described in the literature.[6,15] Its effect decreased in the multivariate model. And this is due to the simultaneous presence in the same model of the 2 variables, maternal stature, and maternal weight status, since height has been used to calculate this last variable. There is indeed a strong correlation between these two variables. Maternal height, therefore, remains a determining factor in the occurrence of IUGR in populations living in a disadvantaged context in the LMICs.

As women were included at delivery in this study, we did not know the women's pre-pregnancy weight. To overcome this, we constructed a specific indicator, maternal weight status, based on a calculation method recommended by the World Health Organization.[16] With this calculation method, the variable includes both women who have low gestational weight gain and those who have low pre-pregnancy weight. This indicator is not perfect but allows us to approximate the prevalence of maternal undernutrition. This prevalence (29.8%) is consistent with the literature in LMICs[15]: indeed in Sub-Saharan Africa, more than 20% of women are undernourished,[12] 30% in Bangladesh, 27% in Ethiopia.[22] This observation provides arguments for the validity of this variable.

In our study, women with low weight status significantly had a higher risk of delivering IUGR newborns. Our results are consistent with those from other authors.[10,11,14,23,24] Maternal low weight status is a main cause of IUGR, especially in LMICs. Maternal undernutrition, which can be expressed by short stature or low weight status during pregnancy was the most important determinants of IUGR. This has been widely demonstrated in literature.[12,23,25-28]

IUGR is the main mechanism inducing low birth weight (birth weight < 2500 grams) in LMICs. By giving birth to IUGR newborns, mothers with low weight status contribute to the cycle of intergenerational transmission of malnutrition. Indeed it has been shown that children who have experienced restricted fetal growth born mostly with low birth weight and are likely them too, in adulthood, to give birth to low birth weight children.[29] Therefore, in order to break this cycle and to ensure the best maternal nutrition status, nutritional interventions should be conducted using high caloric energy dietary supplements and hyper-protein supplements.

The financial cost is high if we consider such interventions in all pregnant women. According to our results, we can propose an evolution in public health policies in Benin: restricting in priority the target population of such nutritional interventions to young primipara women and women presenting low anthropometric status. Concerning young primipara mothers, other authors share this opinion by proposing to intervene before pregnancy in childbearing age, or very early in pregnancy[14,24,30] as proposed by the "1,000-Days Initiative".[31] These 1000 days begin at conception, cover the duration of the pregnancy and go up to the second birthday of the child. Numerous studies have demonstrated the impact of nutritional supplementation during pregnancy[9, 13, 32-35] and some have shown the interest of beginning the supplementation before pregnancy.[36-38] Regarding women with low anthropometric status, during the first antenatal care visit, weight and height should be recorded and two alert criteria must be taken into account: a height of less than 155 cm and a body mass index of less than 20 kg / m^2. These are simple actions, easy to implement, inexpensive that can give positive effects on mother and child health outcomes.

Conclusions and Implications

Finally, this study confirms that in LMICs in general and especially in African Populations, where IUGR's rates are high, maternal undernutrition is a key factor. Pre-pregnancy weight and gestational weight gain can be targeted through nutritional interventions.

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Conflicts of Interest: None.

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