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Maternal and Infant Factors Associated with Child Growth in the First Year of Life

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Abstract: *Aim:* To assess the predictors associated with infant length-for-age Z-score (LAZ) in the first year of life. This paper presents the relative contribution of maternal and child factors to child growth among children aged 6-12 months in an urban area of Northern Region of Ghana. *Methods:* This was a retrospective cohort study design in which systematic random sampling technique was used to select study participants, who sought post natal care services in selected hospitals within Tamale Metropolis. The association between LAZ and explanatory variables (maternal height, birth weight, infant and child feeding practices) was assessed using both bivariate and multiple linear regression analyses. *Results:* The mean age of the children was 8.6±1.9 months and 53.8 % were in the 6-8 months age group. The mean dietary diversity score (DDS) was 4.18±1.69 for children aged 6-12 months. Nearly 70.0 % of the children had adequate meal frequency, 73.0 % met the minimum dietary diversity (≥ 4 food groups) and 57.5 % of the children met the minimum acceptable diet. The greatest predictors of mean LAZ were maternal height, low birth weight (LBW), whether child is wasted or not and the consumption of specific foods groups by the child. A 1-unit increase in weight for length z-score (WLZ) was associated with 0.156 decrease in length for age z-score (LAZ) [beta = -0.156 (95% CI: -0.26, -0.03)] among infants 6 to 8 months of age after controlling for LBW and maternal height. Among children 9-12 months, a unit increase in weight for length z-score (WLZ) was associated with 0.182 decrease in length for age z-score (LAZ) [beta = -0.182 (95% CI: -0.32, -0.04)]. The nature and strength of association between LBW and mean LAZ was different according to the age group of the child. Among children aged 6-8 months, the mean LAZ of LBW children were significantly higher than that of children whose birth weight was normal. For children aged 9-12 months, LBW children had lower mean LAZ compared to children with birth weight of at least 2.5 kg (beta coefficient = -0.320, $p < 0.001$). *Conclusion:* In conclusion, the effect of birth weight and maternal height on LAZ depended on the age of the child. The data do suggest that between the ages of 6-8 months, LBW babies may be growing faster in length than non-LBW babies. However, from 9-12 months non-LBW babies grow faster than LBW babies.

Keywords: Child Growth, Maternal Height, Low Birth Weight, Intrauterine Growth Restriction, Northern Ghana

1. Introduction

Childhood under nutrition is a recognized public health problem that is associated with high levels of childhood illness and death in many developing countries including Ghana. The causes of under nutrition are multi-factorial and they vary from place to place but in most cases relate to poor quality or quantity of dietary intake, suboptimal feeding practices, and high rates of infectious diseases (Caulfield et al., 2006, Keller, 1988).

Under nutrition manifests as intrauterine growth restriction (IUGR), stunting (a deficit of length relative to age) or wasting (a deficit in weight relative to length). Acute under nutrition (wasting) occurs as a consequence of short-term response to inadequate intake or an infectious disease episode, whereas chronic under nutrition (stunting) emanates from a longer term response to a sustained poor dietary intake or repeated illnesses. The causes of these two forms of under nutrition are not exactly the same and the association between them in children is also less understood (Gorstein et al., 1994, Keller, 1983, Martorell, 1985, Victora, 1992).

Generally, both maternal and infant factors contribute to the growth of children. Poor maternal nutrition impairs foetal growth and contributes to low birth weight (LBW) and subsequently stunting. The birth weight of a child is the result of intrauterine growth as well as the length of gestation age at birth. The mother's health, nutritional status before and during pregnancy is also a key determinant of pregnancy outcome including birth weight. LBW defined as a birth weight less than 2,500 g (UNICEF/WHO, 2004) is of public health significance in the Northern Region of Ghana. Little information is however available about the independent contribution of IUGR to the persistent high levels of child under nutrition. LBW is a manifestation of IUGR and it is a potential risk factor for stunted growth, of which the empirical evidence is lacking in Northern Ghana. This study was therefore designed to investigate the relative contribution of child factors and maternal anthropometric characteristics to child growth during the period 6-12 months of life in an urban area of Northern Region of Ghana. The child factors considered in this study are foetal growth and infant feeding practices.

2. Methodology

2.1. Study Design

This was a retrospective cohort study design in which systematic random sampling technique was used to select study participants, who sought post natal care services in selected hospitals within Tamale Metropolis.

2.2. Data Collection

Variables known to be associated with linear child growth (e.g. maternal anthropometric measurements, infant feeding practices, child morbidity) were measured. Information about the mother's reproductive history was also obtained.

To qualify for recruitment, the mother's last delivery should be full term (≥ 37 weeks gestation) single live birth.

All anthropometric measurements were taken following standardized procedures. Weight was measured on electronic Seca scale accurate to within 10 g with the baby minimally clothed. The crown-heel length was taken using an infantometer (a flat wooden surface with head and foot boards).

2.3. Statistical Analysis

Using the WHO AnthroPlus software, weight and height measurements were converted to the three nutritional indicators of height-for-age, weight for-height and weight-for-age Z-scores. Before testing for associations between independent variables and the dependent outcomes, the data were cleaned and outliers removed. Z-scores which were outside the WHO flags: WHZ -5 to 5; HAZ -6 to 6; and WAZ -6 to 5 were excluded from the data set.

The association between length-for-age Z-score (LAZ) and explanatory variables (maternal height, birth weight, infant and child feeding practices) was assessed using both bivariate and multiple linear regression analyses.

Two regression models (one for children 6-8 months and the other for children 9-12 months) were constructed to cater for the different growth patterns. Confounding variables controlled for included sex of the child, number of food groups consumed during the previous 24 hours, diarrhoeal infection, maternal height, parity, maternal education, and birth weight.

3. Results

3.1. Socio-Demographic Characteristic of Respondents

Table 1. *Comparison of baseline characteristics of study groups.*

	N	Unexposed Group (birth weight ≥ 2.5 Kg) n (%)	Exposed Group (birth weight < 2.5 Kg) n (%)	Test Statistic
Age of mother (years)				
Under 25	187	74 (39.6)	113 (69.4)	
25-34	190	109 (57.4)	81 (42.6)	$\chi2 = 17.5$, $p < 0.001$
35+	23	17 (73.9)	6 (26.1)	
Age of child (months)				
6-8	215	96 (44.7)	119 (55.3)	$\chi2 = 5.3$, $p = 0.02$
9-12	185	104 (56.2)	81 (43.8)	
Maternal education				
None	120	58 (48.3)	62 (51.7)	
Low (Primary & JHS)	143	69 (48.3)	74 (51.7)	$\chi2 = 0.90$, $p = 0.64$
High (At least SHS)	137	73 (53.3)	64 (46.7)	
Frequency of ANC visits during previous pregnancy				
Less than 4	47	15 (31.9)	32 (68.1)	$\chi2 = 6.9$, $p = 0.008$
At least 4	353	185 (52.4)	168 (47.6)	
Trimester of first ANC visit				
First	279	138 (49.5)	141 (50.5)	$\chi2 = 0.11$, $p = 0.74$
Second	121	62 (51.2)	59 (48.8)	
Timely initiation of breastfeeding				
No	257	134 (52.1)	123 (47.9)	$\chi2 = 1.32$, $p = 0.25$
Yes	143	66 (46.2)	77 (53.8)	
Child had Malarial infection in the past two weeks				
Yes	124	58 (46.8)	66 (53.2)	$\chi2 = 0.75$, $p = 0.39$
No	276	142 (51.4)	134 (48.6)	

In all, 400 mother/pairs were recruited for the study. The mean maternal age was 25.9±5.1 with a range of 18-45 years. Most of the respondents 95.3 % (363) were married. The mean age of the children was 8.6±1.9 months and 53.8 % were in the 6-8 months age group. Of the 400 infants participating in this study, 51.5 % (206) were males, and 48.5 % (194) were females.

The baseline characteristics of the study participants in the study groups were significantly different with respect to age distribution of the children and the frequency of ANC visits during previous pregnancy. The unexposed group had a significant higher proportion of women who attended ANC at least four times and also had the greatest proportion of children aged 9- 12 months (Table 1).

3.2. Nutritional Status and Dietary Intake of Children Aged 6-23 Months

Table 2. *Nutritional status and dietary intake of children aged 6-12 months.*

Characteristics	Mean ± SD	Frequency (n)	Percentage (%)
Nutritional status			
Height-for Age-z-score (mean ± SD)	-0.002±0.9		
Weight-for-Height-z-score (mean ± SD)	-0.11±1.0		
Weight-for-Age-z-score (mean ± SD	-0.007±0.9		
Stunted (HAZ < -2)		3	0.8
Wasted (WHZ < -2)		1	0.3
Underweight (WAZ < -2)		7	1.8
Diarrhoea infection the past 14 days		130	32.5
Currently breastfeeding		394	98.5
Prevalence of bottle feeding		61	15.3
Met minimum meal frequency		274	68.5
Met minimum dietary diversity		292	73.0
Met minimum acceptable diet		230	57.5
Appropriate complementary feeding rate		178	44.5

The mean dietary diversity score (DDS) was 4.18±1.69 for children aged 6-12 months. Nearly 70.0 % of the children had adequate meal frequency, 73.0 % of children 6-23 months met the minimum dietary diversity (≥ 4 food groups) and 57.5 % of the children met the minimum acceptable diet. Children who met the acceptable diet and started complementary feeding at six months were considered to have appropriate complementary feeding. Therefore the overall appropriate complementary prevalence was only 44.65% (Table 2). The prevalence of chronic, acute and underweight was quite low at 0.8 %, 0.3 % and 1.8 % respectively among children 6-12 months in the study population.

3.3. Predictors of Mean LAZ Among Children Aged 6-23 Months

The predictors of mean length for age Z-score (LAZ) is shown in Table 3. Bivariate analyses showed that there was no significant association between minimum dietary diversity of the child and mean LAZ. However, consumption of certain specific food groups including egg, dairy products and legumes was positively associated high LAZ. When the ages of the children were lumped together, neither baby weight at birth nor increasing maternal height was associated with mean LAZ among this group of virtually normal children. The other predictors of high LAZ were the age of child and non-bottle feeding. Other variables that were tested but were not in any way associated with LAZ were the educational level of the mother, initiation and frequency of ANC attendance.

3.4. Relationship Between Birth Weight and Infant Growth Indicators

Among children 6-8 months, the mean LAZ was significantly higher for LBW compared to normal weight infants though there was no significant difference with respect to LWZ and WAZ. Among children 9-12 months, the mean LAZ, LWZ and WAZ were significantly higher for normal weight babies, compared to LBW infants (Table 4).

The effect of birth weight and maternal height on LAZ depends on the age of the child. Table 5 shows how birth weight and maternal height associate with LAZ in different categories of children.

Table 3. *Relationship between mean LAZ and selected variables among children aged 6-12 months.*

Indicator	N	Mean LAZ	Std. Deviation	95% Confidence Interval for Mean		Test Statistic
				Lower Bound	Upper Bound	
Child MDD						
Low (< 4)	108	-0.15	1.05	-0.35	0.05	F (1, 399) = 3.23,
High (≥ 4)	292	0.05	0.97	-0.06	0.16	p = 0.07
Child is bottle fed						
Yes	61	-0.42	0.93	-0.66	-0.18	F (1, 399) = 13.1,
No	339	0.07	0.99	-0.03	0.18	p < 0.001
Classification of birth weight						
Normal (≥ 2.5 kg)	200	0.004	1.01	-0.14	0.15	F (1, 399) = 0.01,
Low birth weight (< 2.5 kg)	200	-0.007	0.98	-0.14	0.13	p = 0.91
Age of child (months)						
6-8	215	-0.28	0.95	-0.41	-0.15	F (1, 399) =
9-12	185	0.32	0.95	0.19	0.46	40.58, p < 0.001
Consumption of legumes in the past 24 hours prior to study						
No	239	-0.09	0.97	-0.21	0.04	F (1, 399) = 4.33,

Indicator	N	Mean LAZ	Std. Deviation	95% Confidence Interval for Mean		Test Statistic
Yes	161	0.12	1.02	-0.03	0.28	p = 0.04
Maternal height (cm)						
<145	3	0.47	1.20	-2.52	3.4603	
145–149	16	0.26	0.70	-0.11	0.6360	
150–154	83	-0.05	0.96	-0.26	0.16	F (4, 399) = 1.09, p = 0.36
155–159	132	0.09	0.97	-0.07	0.26	
≥160	166	-0.08	1.05	-0.25	0.08	
Consumption of dairy products in the past 24 hours prior to study						
No	211	-0.14	1.02	-0.28	-0.006	F (1, 399) = 9.41, p = 0.002
Yes	189	.1579	.94454	.0224	0.29	
Consumption of egg in the past 24 hours prior to study						
No	262	-0.08	1.004	-0.20	0.04	F (1, 399) = 5.09, p = 0.025
Yes	138	0.15	0.96	-0.009	0.31	

***Table 4.** Relationship between birth weight and infant growth indicators (LAZ, WAZ and WLZ stratified by age of child.*

		6-8 months		
Birth weight	**N**	**Mean LAZ**	**Mean LWZ**	**WAZ**
Normal birth weight (≥ 2.5 kg)	96	-0.59±0.88 (CI: -0.76 to -0.41)	-0.07±1.03(CI: -0.28 to 0.14)	-0.24±0.97(CI: -0.44 to -0.04)
Low Birth weight (<2.5 kg)	119	-0.04±0.94 (CI: -0.21 to 0.13)	-0.25±1.04(CI: -0.44 to -0.06)	-0.12±1.01(CI: -0.31 to 0.06)
Test statistic		F (1, 214) = 19.14, p < 0.001	F (1, 214) = 1.67, p = 0.20	F (1, 214) = 0.72, p = 0.40
		9-12 months		
Normal birth weight (≥ 2.5 kg)	104	0.55±0.80 (CI: 0.39 to 0.70)	0.17±1.00 (CI: -0.02 to 0.37)	0.46±.90 (CI: 0.28 to -0.64)
Low Birth weight (<2.5 kg)	81	0.04±1.04 (CI:- 0.19 to 0.27)	-0.30±0.84 (CI: -0.49 to -0.12)	-0.16±0.91 (CI: -0.36 to 0.04)
Test statistic		F (1, 184) = 14.33, p < 0.001	F (1, 184) = 11.70, p = 0.001	F (1, 184) = 21.55, p < 0.001

CI: 95% confidence interval.

***Table 5.** Relationship between mean LAZ, birth weight and maternal height stratified by age of child.*

	Children 6-8 months					
Indicator	**N**	**Mean LAZ**	**Std. Deviation**	**95% Confidence Interval for Mean**		**Test Statistic**
				Lower Bound	**Upper Bound**	
Classification of birth weight						
Normal (≥ 2.5 kg)	96	-0.59	0.88	-0.76	-0.41	F (1, 214) = 19.14,
Low birth weight (< 2.5 kg)	119	-0.04	0.94	-0.21	0.13	p < 0.001
Maternal height (cm)						
<145	3	0.4709	1.20	-2.52	3.46	F (1, 214) = 2.75,
145–149	11	0.4603	0.52	0.11	0.81	p = 0.03
150–154	51	-0.20	0.95	-0.47	0.07	
155–159	52	-0.34	0.87	-0.58	-0.09	
≥160	98	-0.40	0.99	-0.60	-0.20	
	Children 9-12 months					
Classification of birth weight						
Normal (≥ 2.5 kg)	104	0.55	0.80	0.39	0.70	F (1, 184) = 14.33,
Low birth weight (< 2.5 kg)	81	0.04	1.04	-0.19	0.27	p < 0.001
Maternal height (cm)						
<145	-	-	-	-	-	
145–149	5	-0.17	0.90	-1.28	0.95	
150–154	32	0.18	0.96	-0.17	0.53	F (3, 184) = 0.83,
155–159	80	0.37	0.93	0.17	0.58	p = 0.48
≥160	68	0.37	0.96	0.14	0.60	

Multivariable regression analyses showed increasing age of child, not being bottle fed and consumption of egg remained consistent predictors of high LAZ (Table 6a). Birth weight and maternal height were therefore not determinants of LAZ when the children aged 6-12 months were lumped together.

The mean LAZ of children aged 9-12 months was significantly lower than that of children aged 6-8 months (Beta coefficient = 0.277, p < 0.001). The three variables accounted for 11.3 % of the variance in LAZ (Adjusted R Square = 0.113). Children who were not bottle-fed in the past 24 hours prior to the study had a mean LAZ which was 0.134 standard units higher than children who were bottle-fed (Table 6a). Children who consumed egg in the past 24 hours prior to the study had a mean LAZ which was significantly higher than that of children who did not.

Table 6a. *Determinants of LAZ among children 6-12 months.*

Model	Standardized Coefficients	Sig.	95.0% Confidence Interval for β	
	Beta		Lower Bound	Upper Bound
(Constant)		0.000	-2.09	-1.04
Not bottle-fed	0.134	0.005	0.11	0.63
Children aged 9-12 months	0.277	<0.001	0.36	0.74
Consumption of egg in the past 24 hours	0.104	0.028	0.02	0.41

Using analysis of covariance (ANCOVA) that adjusted for bottle feeding and consumption of egg in the past 24 hours, there was a significant interaction between the exposure (whether LBW or normal weight) and age group of the child on mean LAZ, F (2,400) = 19. 1, p < 0.001. The presence of the strong interaction necessitated the presentation of strata-specific estimates instead of summary measures of association. The nature and strength of association between birth weight and mean LAZ were different according to the age group of the child.

When the children were stratified by age, the determinants of LAZ for children aged 6-8 were not the same for children aged 9-12 months (Tables 6b and 6c). Strangely, the mean LAZ for children whose mothers' height was at least 160 cm was significantly lower than that of children whose mothers' height was less than 145 cm. Similarly, the mean LAZ of LBW children was significantly higher than that of children whose birth weight was normal.

Table 6b. *Determinants of LAZ among children 6-8 months.*

Model	Standardized Coefficients	Sig.	95.0% Confidence Interval for β	
	Beta		Lower Bound	Upper Bound
(Constant)		0.151	-1.17	0.18
Low Birth weight (Reference: birth weight ≥ 2.5)	0.252	<0.001	0.24	0.73
WHZ	-0.156	0.017	-0.26	-0.03
Maternal height (≥160.0 cm)	-0.146	0.026	-0.26	-0.02

Table 6c. *Determinants of LAZ among children 9-12 months.*

Model	Standardized Coefficients	Sig.	95.0% Confidence Interval for β	
	Beta		Lower Bound	Upper Bound
(Constant)		<0.001	0.65	1.49
Low Birth weight (Reference: birth weight ≥ 2.5)	-0.320	<0.001	-0.88	-0.34
WHZ	-0.182	0.012	-0.32	-0.04
Consumption of legumes in the past 24 hours prior to study	0.141	0.045	0.01	0.53

For children aged 9-12 months birth weight but not maternal height significantly predicted LAZ. Among this group of children, LBW children had lower mean LAZ compared to children with birth weight of at least 2.5 kg (beta coefficient = -0.320, p < 0.001) (Table 4.6c). Consumption of legumes was positively associated with LAZ among children 9-12 months. Between the ages of 6-8 months, LBW babies may be growing faster than non-LBW babies. However, from 9-12 months non-LBW babies grow faster than LBW babies.

4. Discussion

By virtue of the fact that patterns of physical growth of the child is influenced by both prenatal and postnatal factors including IUGR, morbidity and nutrition (Maleta et al., 2003), it is important to identify which of these factors has the most influence in a given population in order that adequate preventative measures can be taken.

The key maternal and child factors that significantly predicted length for age z-score (LAZ) during 6-12 months of life were LBW, maternal height, whether child was wasted or not and the consumption of specific foods groups by the child. The main finding was that effect of birth weight and maternal height on LAZ depended on the age of the child. There was a significant interaction between exposure (whether LBW or normal birth weight) and age group of the child on mean LAZ, F (2,400) = 19. 1, p < 0.001. The nature and strength of association between birth weight and mean LAZ were different according to the age group of the child. This is an important finding that has not been reported in earlier studies.

4.1. Association Between Wasting and Stunting

A 1-unit increase in weight for length z-score (WLZ) was associated with a decrease in length for age z-score among 6 to 8 months of age after controlling for LBW and maternal height. Among children 9-12 months, a 1-unit increase in weight for length z-score (WLZ) was associated with a higher decrease in length for age z-score. These findings suggest that wasted children were less likely to be stunted (that is, protective).

In a review of eight cohort studies involving 1599 children, wasting was associated with a higher risk for linear growth retardation, although instances of wasting may not be the primary cause of stunting in developing countries (Richard et al., 2012). In the same study, children who were wasted only in the first six months of life were not observed to have linear growth deficits at the end of follow up compared with children who were never wasted. This means children who were wasted were unlikely to be stunted.

4.2. Association Between LBW and Mean LAZ

The nature and strength of association between LBW and mean LAZ was different according to the age group of the child. Among children aged 6-8 months, the mean LAZ of LBW children were significantly higher than that of children whose birth weight was normal.

This is an indication that catch up growth during the first eight months of life is very good among LBW babies.

For children aged 9-12 months, LBW children had lower mean LAZ compared to children with birth weight of at least 2.5 kg. The data showed that between the ages of 6-8 months, LBW babies grew faster in length than non-LBW babies. However, from 9-12 months non-LBW babies grow faster than LBW babies. This finding is consistent with some studies that have reported that infants with low birth weight put on weight more rapidly than infants who were heavier at birth and can risk overweight (Mihrshahi et al., 2011, Mohammadzadeh et al., 2010). At the same time, LBW infants at the age of 9-12 months were growing slower compared to children with normal weight at birth and this is equally supported by other studies which have earlier shown that LBW can have difficulties to achieve standard weight or length at 12 months (Hien and Ushijima, 2007, Motta et al., 2005).

4.3. Association Between Maternal Height and LAZ

Maternal height was an important predictor of LAZ among children 6-8 months but not among children 9-12 months. The mean LAZ of children whose mothers' height was at least 160 cm was significantly lower than that of children whose mothers' height was less than 145 cm. Similarly, the mean LAZ of LBW children was significantly higher than that of children whose birth weight was normal. The explanation could be that shorter women gave birth to more LBW and this group of children gained weight or length faster than normal babies.

However, in some other studies, short mothers were more likely to have a child who was stunted at two years, compared with taller mothers (Addo et al., 2013, Hambidge et al., 2012, Hambidge et al., 2014, Varela-Silva et al., 2009). Whereas in previous studies maternal height and infant length-for-age z scores (LAZ) were positively correlated, in this present study these variables were negatively associated.

Bivariate analyses showed that there was no significant association between minimum dietary diversity of the child and mean LAZ. However, consumption of certain specific food groups including egg, dairy products and legumes was positively associated high LAZ.

Conclusion: In conclusion, the effect of birth weight and maternal height on LAZ depended on the age of the child. The data do suggest that between the ages of 6-8 months, LBW babies may be growing faster in length than non-LBW babies. However, from 9-12 months non-LBW babies grow faster than LBW babies.

Limitations of the Study

Our findings are not without limitations. First of all, the design was a cross sectional and as with all such studies it is not possible to ascribe causation between the outcome and exposure variables. Secondly, some responses were based on self-report and so measurement bias cannot also be ruled out. However, it is logical to assume that biases will be minimal as respondents were well informed about the importance of giving accurate responses and also assured the confidentiality of their responses. Finally, recall bias was more likely since women were asked for events which have already happened within the past 12 months prior to this study.

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