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# A Health Facility-based Analytical cross sectional Assessment of Factors Influencing Birth weight in Kwaebibirem

Brainard Ayisi Asare[1], Grace Asare [2]

[1]Eastern Region, Kwaebibirem, Ghana

[2]Ghana Health Service, Kade

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***Abstract:*** **Objective: Birth weight (BW) is associated with increased risk of perinatal mortality when < 2.5kg. Despite the underlying role of a complex interplay of genetic and environmental factors of unclear proportionate distribution, reduction of the global burden remains a priority. This study analyses maternal and environmental factors influencing BW.**

**Methodology: This analytical cross sectional review inferentially compared parturients who delivered singleton babies with BW above or below < 2.5kg across hypothesized risk variables. A total 4,027 singleton live births, from 2015 to 2020 were retrospectively studied.**

**Results: The overall mean BW was 3.05kg ± 0.4. About 90% of babies weighed 2.5-3.9kg, 5.9% weighed < 2.5kg while 3.8% weighed ≥ 4kg. Adolescent parturients (21.9%) recorded the highest prevalence of BW < 2.5kg. Urban and peri-urban residents recorded a comparatively lower prevalence of BW < 2.5kg. Primiparous parturients recorded a lower mean BW and a commensurately higher prevalence of BW < 2.5kg. Mean Hb concentration was higher among parturients with babies weighing ≥ 2.5kg while mean systolic and diastolic BP were inversely lower among this same category of parturients. Maternal adolescence (POR=2.1, 95% CI=1.2-3.6), rural residence (POR=2.0, 95% CI=1.15-3.5), primiparity (POR=2.4, 95% CI=1.4-4.0), prematurity (POR=8.4, 95% CI=4.7-14.9) and early term (POR=2.4, 95% CI=1.4-4.2) increased risk for BW < 2.5kg.**

**Conclusion: Efforts to reverse adolescent pregnancy rates, (inextricably linked to high risk for BW < 2.5kg and prematurity), should be enhanced. Research to further investigate mechanisms underlying the role of primiparity, maternal hemoglobin concentration and maternal gestational or chronic hypertension should be prioritized.**

***Keywords:*** **Birth weight, factors, maternal, environmental.**

## 1. INTRODUCTION

Birth weight (BW), the body weight of a baby at its birth, (varying by mean across various geographical regions), is of medical importance as BW < 2.5kg is associated with increased risk of perinatal mortality.[1, 2] The prevalence of BW < 2.5kg, (i.e. Low birth weight or LBW), slightly decreased from 7.9% in 1970 to 6.8% in 1980. A slight increase to 8.2% was observed in 2006 and further slightly trended upwards from 2012 to 2019.[2, 3, 4] Extant evidence has widely investigated factors that likely causally predict BW above or below 2.5kg. Two genetic loci, (i.e. ADCY5 and CCNL1), as well four that show some evidence, (i.e. CDKAL1, HHEX-IDE, GCK, and TCF7L2), have been strongly linked with BW.[5, 6, 7] The estimated heritability of BW ranges between 25-40 % while complex relationships further exist between a baby's genes and the maternal environment in which the baby develops.[8, 9] Other important factors linked with BW include maternal health status during pregnancy, environmental factors (e.g. maternal nutrition, smoking and genital infection), among others.[10, 11, 12, 13]

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BW, (also an indicator of the mother and baby's health), is characterized by variations between continents, countries, and cities.[14] Despite estimates indicating ≥ 20 million babies, (or ≥ 16% of all babies globally), are born each year with BW < 2.5kg, consistent acquisition of accurate estimates remains difficult. Significant proportions of babies delivered in low income countries are not weighed.[14] LBW country estimates are therefore adjusted to account for underreporting resulting from poor surveillance and questionable data quality in low income countries.[15] South Asia accounted for the highest burden of babies not weighed at birth with 66% and commensurately the highest LBW prevalence at 28% between 2008-2012 while West and Central Africa ranked second with 14%.[15]

BW, like growth, is determined by a complex interplay of genetic and environmental factors whose proportionate interplay remains unclear.[16] The influence of environmental factors is strongly pronounced by BW variations within genetically similar populations, secular changes and a characteristic reverse social gradient where increasing disadvantage is associated with decreasing BW.[16] The role of maternal stress and exposure to some occupations during pregnancy remains inconclusive while the role of other factors, (e.g. maternal age), though not themselves environmental, are strongly influenced by the social environment.[16]

Intrauterine growth and development, (invariably largely assessed by BW in developing countries), constitutes a vulnerable process in the human life cycle whose aberrations bear lasting profound influences in later life.[17] BW therefore comprises a reliable index of intrauterine growth and also a sensitive predictor of survival, growth and long term physical and psychosocial development.[17] LBW babies, (distinctly defined by BW < 2.5kg regardless of gestational age), are 40 times more likely to die within the first four weeks of life than normal weight (or NBW) babies. An estimated 50% of all perinatal and about 34% of all infant mortalities occur among babies with BW < 2.5kg while their survival is further associated with significantly high risk for lower IQ and adult onset obesity and diabetes.[18] Reduction of the LBW burden is therefore long recognized as a public health priority that calls for global commitment.[18] Attainment of targets for reduction would positively impact perinatal mortality and expedite progress towards attainment of other nutrition targets, (e.g. reducing stunting, wasting and other forms of malnutrition).[18] While progress in reducing LBW has stagnated since the year 2000 and particularly between 2010-2015, meeting the World Health Assembly's targets for reduction remain a remote reality globally.[18] Interventions targeting LBW reduction therefore call for comprehensive understanding (of the modifiability) of the contextual fetal, maternal, environmental and socio-demographic factors. This study analyses maternal and environmental factors influencing BW.

## 2. METHODOLOGY

This health facility-based analytical cross sectional study was completed with data on obstetric and newborn care services abstracted from the maternity/labor suit of the Kade Government hospital. The hospital comprises the primary referral health facility in the Kwaebibirem municipality serving an estimated municipal population of 146,346 and an estimated 35, 123 women of fertility age. Five-year data on 4,027 singleton live births covering the years 2015-2020 were abstracted from delivery registers i.e. the registers for mandatory entry of particulars on all institutional births. Parturients who delivered babies with BW < 2.5kg were inferentially compared with parturients who delivered babies with BW ≥ 2.5kg across various hypothesized risk variables. Observations were included in the study within the context of a retrospective data review completed through non-probability convenience sampling of available records on singleton births. All multiple deliveries were excluded.

The primary source document for information for the study, the delivery register, was arbitrarily divided into four parts; the first part contains parturients' personal information, (i.e. age, urban/peri-urban or rural community of residence, highest level of education attained and gravidity and parity). The delivery register secondly records information on antenatal clinic-relevant indicators, i.e. maternal hemoglobin (Hb) concentration level, antenatal clinic (ANC) attendance, gestational age at delivery, intermittent preventive therapy with sulfadoxine-pyremethamine (IPTp-SP) doses during pregnancy and maternal ABO phenotypical blood groups. Additionally documented in this part of the register is information on maternal syphilis, hepatitis B and HIV infection status and maternal systolic and diastolic blood pressure (BP). HIV information is captured within the programmatic context of 'Prevention of Mother to Child Transmission' (PMTCT) services.

The register thirdly records neonatal information, (i.e. APGARS, fetal heart rate, fetal respiration within 30 minutes, fetal presentation and measures of fetal dimensions). It lastly records information on complications following delivery, (i.e. postpartum hemorrhage, antepartum hemorrhage, obstructed labor etc.). Variables analyzed in this study were mainly

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abstracted from the first and second parts of the delivery register coupled with BW information from the third part of the register. BW, the primary measure of interest, (analyzed in two levels independently of GA), was recoded into two mutually exclusive binary outcome variables of < 2.5kg and ≥ 2.5kg; the latter includes 2.5-3.9kg and ≥ 4kg classified as normal BW or NBW and high BW or HBW respectively.[20] Definitions of preterm (i.e. < 37 gestational weeks), early term (i.e. 37-38 gestational weeks), full term (i.e. 39-40 gestational weeks), late term (i.e. 41-42 gestational weeks) and post term (i.e. ≥42 gestational weeks) were adopted from specifications of the American College of Gynecologists (ACOG).[21] Singleton babies delivered at ≤ 28 completed gestational weeks were excluded irrespective of the documented survival status or APGAR scores. Definition of urban/peri-urban and rural communities were consistent with the conveniently used threshold population size for determining localities that can be considered as urban or rural.[19] Based on this convenience, Ghana has over the years defined an urban area to include all localities with ≥ 5,000 population.[19] Peri-urban communities comprised those adjoining urban areas, i.e. communities or settlements around urban areas whose dynamics varied negligibly from that of the adjoined urban area.

Access to hospital data was granted by the hospital's medical superintendent. All data were analyzed with epi info 3.5.4. Descriptive statistics were used to describe the baseline maternal and new born characteristics. Categorical data are presented in proportions and the differences in maternal, socio-economic and socio-demographic characteristics, (analyzed by BW), were examined using Yates corrected Chi-squared test. Yates corrected Chi-squared value was quoted to avert the risk for biased upwards adjustment of 2 x 2 contingency tables (associated with Pearson's chi-square and McNemar's test) making results higher than they should be.[22] Statistical significance of computed point estimates was interpreted at the conventional significance level of ≤ 0.05, (i.e. 5% or 1 of 20), at the confidence level of 95%. Where the expected value of a cell was < 5, Fisher exact test value for significance of the point estimate was used. Prevalence odds ratios (PORs) were analyzed as point estimates of primary interest and not as estimates of risk ratios (RR), odds ratios (OR) or prevalence ratios PR).[23, 24]

## 3. RESULTS

BW varied significantly by prevalence among babies delivered 2015-2020. BW of 2.5-3.9kg remained most prevalent at 90.3%. The overall prevalence of babies with BW < 2.5kg remained comparatively low at 5.9% while babies with BW ≥ 4kg were observably represented by a lower still prevalence of 3.8%. The mean BW of all babies delivered in Kwaebibirem was 3.05kg ± 0.4. BW was not recorded for about 91 babies i.e. 2.2% of the observations. Parturients aged ≤ 20 years, (the third most prevalent sub population of parturients), accounted for the highest proportion of babies with BW < 2.5kg. This observably reduced along the gradient of advancing parturient age above > 20 years. Urban and peri-urban residents recorded a lower prevalence of BW < 2.5kg as compared with rural residents. Parturients, unexposed to formal education together with those exposed to primary school education, (i.e. nil education and ≤ 6 years of formal education), comprised the second largest sub population of parturients. They recorded a comparatively higher prevalence of babies with BW < 2.5kg as compared with those documented to have higher levels of education. The prevalence of BW < 2.5kg notably decreased along the gradient of increasing parturient level of education with parturients of tertiary educational backgrounds recording the lowest burden. BW did not vary significantly by formal or informal maternal occupation status. Primiparous parturients, the second largest sub population of parturients, recorded a lower mean BW and a commensurately higher prevalence of BW < 2.5kg. This was observably characterized by a steady downward trend in the LBW burden along the gradient of increasing parity. [Table 1]

**Table 1. Baseline characteristics of parturients analyzed by birth weight above or below 2.5kg**

| Characteristic | Characteristic - % | Mean Birth weight - kg | Standard Deviation ± | Birth weight | |
|---|---|---|---|---|---|
| | | | | <2.5kg | >2.5kg |
| **Age** | | | | | |
| ≤ 20 years | 21.9 | 2.89 | 0.4 | 8.9 | 90.2 |
| 21-30 years | 46.0 | 3.06 | 0.4 | 5.1 | 94.9 |
| 31-40 years | 28.2 | 3.13 | 0.4 | 4.7 | 95.3 |
| ≥ 41 years | 3.8 | 3.16 | 0.5 | 2.4 | 97.6 |
| **Area of residence** | | | | | |
| Urban | 42.6 | 3.08 | 0.4 | 3.8 | 92.5 |
| Rural | 57.7 | 3.02 | 0.4 | 7.5 | 96.2 |
| **Education** | | | | | |
| ≤ Primary | 19.0 | 3.06 | 0.4 | 7.5 | 92.5 |

| | | | | | |
|---|---|---|---|---|---|
| Junior High School | 61.5 | 3.03 | 0.4 | 5.9 | 94.1 |
| Senior High School | 14.4 | 3.06 | 0.4 | 5.3 | 94.7 |
| Tertiary | 5.0 | 3.18 | 0.3 | 1.9 | 98.1 |
| **Occupation** | | | | | |
| Formal | 13.1 | 3.03 | 0.4 | 6.0 | 94.0 |
| Informal | 86.9 | 3.07 | 0.4 | 5.3 | 94.7 |
| **Parity** | | | | | |
| Primipara | 29.5 | 2.88 | 0.4 | 9.9 | 90.1 |
| Bipara | 19.8 | 3.04 | 0.4 | 5.9 | 94.1 |
| Multipara | 40.9 | 3.14 | 0.4 | 3.7 | 96.3 |
| Grand multipara | 9.9 | 3.14 | 0.4 | 3.9 | 96.1 |
| **Antenatal care** | | | | | |
| Yes | 81.0 | 3.06 | 0.4 | 5.8 | 94.2 |
| No | 19.0 | 3.01 | 0.4 | 6.6 | 93.4 |
| **Term status** | | | | | |
| Preterm (≤ 36 weeks) | 9.3 | 2.67 | 0.5 | 27.3 | 72.7 |
| Early term (37-38 weeks) | 25.0 | 2.93 | 0.4 | 11.0 | 89.0 |
| Full term (39-40 weeks) | 47.0 | 3.12 | 0.4 | 1.9 | 98.1 |
| ≥ Late term (≥ 41 weeks) | 18.7 | 3.22 | 0.4 | 1.1 | 98.1 |
| **IPTp-SP doses** | | | | | |
| Nil dose | 3.6 | 2.98 | 0.4 | 11.8 | 88.2 |
| One dose | 22.7 | 3.02 | 0.4 | 7.6 | 92.4 |
| Two doses | 34.5 | 2.99 | 0.4 | 6.4 | 93.6 |
| Three doses | 26.4 | 3.18 | 0.5 | 3.4 | 96.6 |
| ≥ Four doses | 12.7 | 3.23 | 0.4 | 1.7 | 98.3 |
| **Anemia status** | | | | | |
| Yes | 71.2 | 3.07 | 0.4 | 5.6 | 94.4 |
| No | 28.8 | 3.08 | 0.4 | 8.6 | 91.4 |
| **Severity of anemia** | | | | | |
| Mild | 36.5 | 3.10 | 0.4 | 7.2 | 92.8 |
| Moderate | 61.6 | 3.06 | 0.4 | 4.6 | 95.4 |
| Severe | 1.9 | 2.64 | 0.5 | 11.1 | 88.9 |
| **ABO Blood Group** | | | | | |
| A | 21.9 | 3.04 | 0.4 | 4.7 | 95.3 |
| AB | 3.5 | 3.23 | 0.5 | 7.7 | 92.3 |
| B | 18.1 | 3.09 | 0.4 | 6.9 | 93.1 |
| O | 56.5 | 3.09 | 0.4 | 4.5 | 95.5 |
| **Syphilis** | | | | | |
| Positive | 3.0 | 3.23 | 0.5 | 3.2 | 96.8 |
| Negative | 94.6 | 3.05 | 0.4 | 6.1 | 93.9 |
| Not done | 2.4 | 3.04 | 0.4 | 0.0 | 100.0 |
| **Hepatitis B** | | | | | |
| Positive | 4.3 | 3.05 | 0.4 | 4.4 | 95.6 |
| Negative | 92.2 | 3.05 | 0.4 | 6.0 | 94.0 |
| Not done | 2.5 | 2.95 | 0.32 | 0.0 | 100.0 |
| **PMTCT** | | | | | |
| Positive | 1.9 | 2.90 | 0.2 | 0.0 | 100 |
| Negative | 96.9 | 3.05 | 0.4 | 6.3 | 93.7 |
| Not done | 1.2 | 3.17 | 0.4 | 0.0 | 100 |
| **Sex** | | | | | |
| Male | 52.4 | 3.09 | 0.4 | 5.7 | 94.3 |
| Female | 47.6 | 2.99 | 0.4 | 6.1 | 93.9 |

Despite a wide standard deviation of SD ± 7.4 and variance, mean maternal age remained comparatively lower among parturients who delivered babies with BW < 2.5kg. Mean parity was marginally lower among parturients who delivered babies with BW < 2.5kg. Mean ANC, IPTp-SP and gestational age, (all conceivably interlinked variables), remained comparatively higher among parturients who delivered babies with BW ≥ 2.5kg. While mean Hb concentration was observably higher among parturients who delivered babies with BW ≥ 2.5kg, mean systolic and diastolic BP were inversely lower among this same category of parturients. Systolic and diastolic maternal BP were characterized by wide SD ± and variance. [Table 2]

**Table 2. Mean parturient characteristics analyzed by delivery of babies above or below 2.5kg**

| Characteristics | Parturients with babies < 2.5kg N (%) | | | Parturients with babies ≥ 2.5kg N (%) | | |
|---|---|---|---|---|---|---|
| | Mean | Std. deviation ± | Variance | Mean | Std. deviation ± | Variance |
| Maternal age | 24.8 | 7.4 | 56.0 | 27.3 | 7.0 | 50.2 |
| Parity | 1.2 | 1.6 | 2.7 | 1.8 | 1.7 | 3.0 |
| ANC visits | 4.5 | 2.1 | 5.8 | 5.8 | 2.6 | 6.8 |
| Gestational age | 36.3 | 3.0 | 9.6 | 39.1 | 1.7 | 3.2 |
| IPTp-SP Doses | 1.7 | 0.9 | 0.9 | 2.2 | 1.1 | 2.2 |
| Hb concentration | 10.2 | 1.3 | 1.7 | 10.4 | 4.7 | 22.9 |
| Systolic BP | 125.9 | 25.8 | 665.6 | 118.6 | 17.1 | 294.5 |
| Diastolic BP | 78.6 | 18.6 | 345.9 | 74.9 | 28.9 | 836.2 |

Adolescent parturients were about twice as likely to deliver babies with BW < 2.5kg. This risk decreased with advancing maternal age despite generation of PORs that did not attain statistical significance. Parturients resident in urban or peri-urban communities were significantly less likely to deliver babies with BW < 2.5kg as compared with those documented to be resident in rural communities. Rural residents were about twice as likely to deliver babies with BW < 2.5kg. Point estimates defining associations between parturients' documented level of education and occupations, albeit suggestively protective, were statically insignificant. The increased risk of being significantly over thrice as likely to deliver babies with BW < 2.5kg among primiparous parturients was eliminated by advancing parity i.e. ≥ bipara. Parturients documented to be ≥ multiparous had a significantly reduced risk of delivery of babies with BW < 2.5kg. Babies delivered preterm, (i.e. < 37 completed gestational weeks), together with those delivered early term, (i.e. between 37-38 completed gestational weeks), consistently with hypothesized expectations, had significantly increased risk for BW < 2.5kg. Advanced gestational age at delivery ≥ 39 completed gestational weeks significantly eliminated the risk of BW < 2.5kg. PORs defining associations between BW and exposure to IPTp-SP doses during pregnancy did not attain statistical significance. [Table 3]

**Table 3. Assessment of maternal and environmental factors influencing birth weight**

| Characteristic | Parturients with babies < 2.5kg N (%) | | Parturients with babies ≥ 2.5kg N (%) | | POR (95% CI) | p-value |
|---|---|---|---|---|---|---|
| | Yes | No | Yes | No | | |
| **Maternal age** | | | | | | |
| ≥20 years | 23 | 212 | 40 | 788 | 2.1 (1.2-3.6) | 0.007 |
| 21-30 years | 25 | 463 | 38 | 537 | 0.7 (0.4-1.2) | 0.3 |
| ≥31-50 years | 15 | 325 | 48 | 675 | 0.6 (0.6-1.1) | 0.19 |
| **Area of residence** | | | | | | |
| Urban residence | 17 | 427 | 46 | 577 | 0.4 (0.2-0.8) | 0.02 |
| Rural residence | 45 | 555 | 18 | 449 | 2.0 (1.15-3.5) | 0.01 |
| **Maternal education** | | | | | | |
| Nil | 4 | 66 | 58 | 915 | 0.9 (0.3-2.7) | 0.8 |
| Primary | 11 | 118 | 51 | 863 | 1.5 (0.7-3.1) | 0.2 |
| Junior High School | 38 | 604 | 24 | 377 | 0.9 (0.5-1.6) | 0.9 |
| ≥ Senior High School | 9 | 193 | 53 | 788 | 0.6 (0.3-1.4) | 0.4 |
| **Maternal occupation** | | | | | | |
| Formal occupation | 7 | 109 | 56 | 895 | 1.0 (0.4-2.3) | 0.8 |
| Informal occupation | 42 | 765 | 21 | 248 | 0.6 (0.3-1.1) | 0.1 |
| **Parity** | | | | | | |
| Primipara | 31 | 282 | 32 | 708 | 2.4 (1.4-4.0) | 0.0008 |
| Bipara | 12 | 191 | 51 | 799 | 0.9 (0.5-1.8) | 0.9 |
| ≥ Multipara | 20 | 517 | 43 | 473 | 0.4 (0.2-0.7) | 0.002 |
| **Term status** | | | | | | |
| Preterm (≤ 36 weeks) | 24 | 64 | 38 | 857 | 8.4 (4.7-14.9) | 0.0000001 |
| Early term (37-38 weeks) | 27 | 218 | 35 | 703 | 2.4 (1.4-4.2) | 0.0008 |
| Full term (39-40 weeks) | 9 | 458 | 53 | 463 | 0.17 (0.08-0.3) | 0.000001 |
| ≥ Late term (≥ 41 weeks) | 2 | 181 | 60 | 740 | 0.13 (0.03-0.5) | 0.002 |
| **IPTp-SP doses** | | | | | | |
| Nil dose | 2 | 15 | 23 | 414 | 2.4 (0.5-11.1) | 0.2 |
| One dose | 8 | 97 | 17 | 332 | 1.6 (0.6-3.8) | 0.4 |
| Two doses | 10 | 147 | 15 | 282 | 1.2 (0.5-2.9) | 0.7 |
| Three doses | 4 | 113 | 21 | 316 | 0.5 (0.1-1.5) | 0.3 |
| ≥ Four doses | 1 | 57 | 24 | 372 | 0.2 (0.03-2.0) | 0.1 |

Maternal anemia, defined by Hb concentration of ≤ 10.9g/dl, was not significantly associated with BW. Further assessment of maternal anemia along the clinical gradient of severity (from mild to severe) also further yielded PORs that did not attain statistical significance. Maternal ABO phenotypical blood groups and syphilis, hepatitis B, PMTCT positive status were not significantly associated with BW. Neonatal male or female sex status did not impact BW. [Table 4]

**Table 4. Assessment of maternal and environmental factors influencing neonatal birth weight**

| Characteristic | Parturients of babies <2.5kg N (%) | | Parturients of babies ≥2.5kg N (%) | | POR (95% CI) | p-value |
|---|---|---|---|---|---|---|
| | Yes | No | Yes | No | | |
| **Maternal Anemia** | | | | | | |
| Yes | 26 | 437 | 37 | 567 | 0.9 (0.5-1.5) | 0.8 |
| No | 16 | 168 | 47 | 836 | 1.6 (0.9-3.0) | 0.11 |
| **Anemia severity** | | | | | | |
| Mild | 12 | 154 | 14 | 280 | 1.5 (0.7-3.4) | 0.3 |
| Moderate | 12 | 272 | 13 | 162 | 0.5 (0.2-1.3) | 0.2 |
| Severe | 1 | 8 | 25 | 426 | 2.1 (0.2-17.7) | 0.4 |
| **Maternal Blood Group** | | | | | | |
| Group A | 8 | 162 | 32 | 583 | 0.8 (0.4-1.9) | 0.9 |
| Group AB | 2 | 24 | 38 | 721 | 1.5 (0.3-6.9) | 0.3 |
| Group B | 10 | 135 | 30 | 610 | 1.5 (0.7-3.1) | 0.3 |
| Group O | 20 | 424 | 20 | 321 | 0.7 (0.4-1.4) | 0.4 |
| **Maternal Syphilis** | | | | | | |
| Positive | 1 | 30 | 60 | 939 | 0.5(0.06-3.8) | 0.4 |
| Negative | 60 | 919 | 1 | 50 | 3.2 (0.4-24.0) | 0.17 |
| **PMTCT** | | | | | | |
| Positive | 0 | 18 | 61 | 923 | Undefined | 0.31 |
| Negative | 61 | 913 | 0 | 28 | Undefined | 0.16 |
| **Sex** | | | | | | |
| Male | 32 | 525 | 31 | 475 | 0.5 (0.9-1.5) | 0.8 |
| Female | 32 | 525 | 31 | 475 | 0.9 (0.5-1.5) | 0.8 |

## 4. DISCUSSION

Birth weight (BW), the body weight of a baby at its birth, varied by various maternal, socio-economic and socio-demographic variables in Kwaebibirem. This is consistent with established evidence indicating that BW is characterized by variations between continents, countries, cities and communities.[14] While BW, like growth, is determined by a complex interplay of genetic and environmental factors, the proportionate interplay of these factors remains unclear.[16] The overall prevalence of LBW babies at 5.9% was significantly lower than the World bank Ghana estimates of 15% in 2004 and 14% in 2016 and also lower than the estimates of the multiple cluster indicator survey country estimates of 10.7%.[25, 26] Male babies were generally heavier than female babies by 0.4kg, a wider difference than detected by Agorinya A. I. *et al* who reported a male-female BW difference of 0.1kg.[27] A study that consistently identified this male-female BW variation posited that paternal BW significantly influences male but not female weight and further suggested the existence of a genetic regulation along the male line.[27] Health facility-based LBW estimates of this study remain considerably lower than the 2018 administrative regional estimates of 14.5% in the Upper East region, 7.9% in Dodowa, 9.9% in the Greater Accra region and in Northern region.[27] About 91 or 2.2% of babies did not have documented BW in the delivery register. Other corresponding source documents, (i.e. parturients' personal folder, labor summary sheets etc.), were however not traced to ascertain whether these babies were weighed or not. Defining this inconclusive finding to be consistent with the challenge of significant proportions of babies in developing countries not weighed at birth therefore remains difficult.

While BW remained largely normal among parturients aged ≥ 20 years, younger maternal age or adolescence significantly increased the risk of LBW. This risk was eliminated along the gradient of advancing maternal age. Mean maternal age was commensurately lower among parturients who delivered babies with LBW. This finding lends credence to widely established associations between increased risk of LBW among adolescent parturients.[27] Adolescent parturients also however notably recorded the highest burden of preterm deliveries likely and conceivably partly underlying their increased LBW risk. While Restrepo-Méndez C. M. *et al* attribute this to possible confounding from individual socioeconomic status (SES), Widiyanto J. *et al* site the associated role of maternal anemia and not only lower age.[28, 29] Dennis J. A. *et al* reported differential impact of maternal age by race between African Americans, whites and foreignand U.S.-born Hispanics. They conclusively posited that LBW disparities by maternal age are a complex product of socioeconomic disadvantage and current social and behavioral factors, such that LBW risk may not operate uniformly by race, ethnicity or maternal age.[30, 31]

While parturients in the study were largely rural residents, babies of parturients resident in urban and peri-urban communities were generally heavier by mean difference of 0.02kg. This was defined by a significant prevalence difference between urban/peri-urban and rural LBW burdens of 3.7%. While urban and peri-urban residence reduced risk of LBW delivery by 60%, rural residence contrarily increased the risk by 80%. This corroborates with findings of other studies.[17] Kaur S. *et al* attributed this variation to a less sedentary lifestyle and higher participation in household/caregiving activities, sports activities among rural residents and less occupational activity than urban women.[32]

Parturients' with ≤ 6 years of formal education and those with nil exposure to formal education accounted for a higher prevalence of LBW babies. This burden decreased along a gradient of advancing years of exposure to formal education. The LBW burden was therefore comparatively lower among parturients with ≥ 9 years of exposure to formal education. Despite this observed inverse relationship between declining prevalence of LBW with increasing level of formal education, the associated PORs did not attain statistical significance. These findings were inconsistent with otherwise widely established associations between BW and individual SES operationalized as maternal education and dichotomized at various levels.[33, 34, 35] Studies that have identified significant associations, contrarily to this study, however posit that the underlying mechanism(s) to the association between BW and formal education remain unclear.[34, 35]

BW varied insignificantly by maternal occupation type dichotomized as formal and informal (i.e. 'white' and 'blue' color jobs respectively). A strong majority of parturients had informal occupations. Other studies, using specific occupations, have reported varied and inconsistent findings that suggest electrical work, metal work etc. significantly influence BW.[36, 37, 38] Efforts to investigate the influence of maternal occupations have sometimes modeled occupation and education as measures of individual SES. Mean BW, lowest among primiparous parturients at 2.88 ± 0.4, increased with advancing parity while the LBW burden inversely decreased with advancing parity. Primiparous parturients were over twice as likely to deliver babies with LBW. This was strongly consistent with findings of extant evidence that identify primiparous parturients as a significantly high risk category for delivery of LBW babies.[39, 40 41, 42] Noteworthy however is the fact that primiparous parturients had a significant composition of adolescents hence also a comparatively higher burden of preterm deliveries.

Though largely attendant, parturients' absolute number of ANC attendances varied significantly i.e. 1-15 attendances. The LBW burden among non-ANC attendants remained marginally higher as compared with that of ANC attendants characterized by a mean difference of 0.05kg. Mean ANC attendance was therefore notably higher among parturients with NBW babies as compared with those who delivered LBW babies i.e. 5.8 ± 2.6 and 4.5 ± 2.1 respectively. This is likely attributable to, (however not invariably), the inextricable links between higher gestational age, higher fetal term status and higher absolute ANC attendances among parturients with heavier babies. These findings lend credence to Zhou H. *et al* who reported increased risk for LBW among women with ≤ 5 ANC visits, non-ANC attendance during the first trimester and lack of access to certain ANC content (e.g. weight, blood pressure, blood test, urine test, ultrasonography and folic acid supplement).[43] Metgud S. C. *et al* implicated late ANC registration as a risk factor LBW while Agorinya A. I. *et al* conclusively pointed to an inherent capacity for only effective and adequate ANC to identify LBW risk factors.[17, 27] This association however remains widely established.28

Findings strongly further corroborated with established associations in extant literature between shorter gestation and LBW infant delivery. Most deliveries occurred at full term (47%) followed by early term (25%), late term (18%) and preterm (9.3%) respectively. Preterm deliveries, characterized by mean BW of 2.6 ± 0.5, mostly occurred among parturients ≤ 20 years of age at 12.8%. This burden steadily decreased to 8.7%, 7.9% and 5.1% among parturients aged 21-30, 31-40 and ≥ 41 years respectively. The high prevalence of LBW among parturients aged ≤ 20 years in this study, decreased steadily on a gradient of advancing maternal age. Hel V. *et al* however contrarily posit that increase in the LBW burden is seemingly driven by reduced fetal growth rate rather than shorter gestation.[44]

IPTp-SP, a policy-prescribed timeous and effective management of malaria during pregnancy, is widely practiced in malaria endemic parts of the world.[45] Exposure to IPTp-SP during pregnancy, (despite the observed inverse steady decrease in the LBW burden with increasing doses), did not attain statistical significance. Mean IPTp-SP doses among parturients who delivered babies with BW < 2.5kg was 1.7 ± 0.9 as compared with 2.2 ± 1.1 among those who delivered babies with BW ≥ 2.5kg. As with ANC attendance and BW, while this relationship may remotely be causal, higher IPTp-SP doses are notably and inextricably linked with more advanced gestation and fetal weight in turn. The WHO global malaria program however strongly posits that IPTp-SP prevents the adverse consequences of malaria on maternal and fetal outcomes such as placental infection, clinical malaria, maternal anemia, fetal anemia, LBW and perinatal mortality.[45]

While maternal anemia, (consistent with maternal Hb concentration of < 11.0g/dl), did not impact BW, descriptive assessment along the clinical gradient of severity pointed to a higher LBW burden among parturients documented to have had severe anemia. Parturients who delivered babies with LBW further had a lower mean maternal Hb concentration of 10.2g/dl ± 1.3 as compared with 10.4g/dl ± 4.7 among those who delivered babies with NBW and HBW. This association however did not attain statistical significance. Assessment of duration and trimester of detection of maternal anemia was beyond the scope of this study. Extant literature point to considerable increase in maternal and fetal iron needs during pregnancy leading to established increased risk for LBW delivery when unmet.[46]

Findings indicating insignificant associations between maternal ABO phenotypical blood groups and BW corroborated with Beyazit F. *et al* and Phaloprakarn C. *et al* who also identified insignificant associations.[47, 48] Further research on much larger samples however remain relevant as Kothari K. L. *et al* identified babies' blood group AB significantly showing a tendency for the lowest BW despite their comparatively lower prevalence.[49] A homolateral finding in this study also pointed to higher burdens of LBW babies among parturients with AB blood group who coincidentally comprised a significant minority. The prevalence of syphilis among ANC attendants remained low at 3% (despite near universal screening coverage) and did not statistically impact BW. Contrarily however, increased risk of LBW with maternal syphilis remains established in extant literature.[50, 51, 52] Consistent with findings of Mbangiwa. T *et al*, maternal hepatitis B positive status did not statistically influence BW.[53] HIV prevalence of 1.9% among parturients was slightly higher than the national adult estimates of 1.7%.[54] Contrary to established evidence, maternal HIV positive status in this study did not influence BW.[55, 56] Parallel documents indicating antiretroviral and compliance statuses of HIV positive parturients and duration of infection were not sought. While the sex of a baby only weakly influenced BW in this study, other studies have identified significantly increased risk of LBW among female babies.[57] Mean systolic and diastolic maternal BP among parturients who delivered babies with LBW (i.e. 125.9mmHg ± 25.8 and 78 mmHg ± 18.6 respectively) were higher as compared with those who delivered babies with NBW or HBW (i.e. 118.6mmHg ± 17.1 and 74.9mmHg ± 28.9 respectively). While this remains consistent with current evidence, research to distinctly investigate associations between BW and both gestational and chronic (or essential) hypertension should remain a priority.

## 5. CONCLUSION

The prevalence of NBW, HBW and LBW varied significantly with NBW being most prevalent at 90.3%. The overall prevalence of LBW remained comparatively low at 5.9% while HBW was lower still at 3.8%. Overall mean BW was 3.05kg ± 0.4. LBW deliveries mostly occurred among parturients aged ≤ 20 years, a sub population also with significantly increased risk for preterm deliveries. While babies of urban and peri-urban residents were generally heavier and less likely to have LBW, babies of rural residents were significantly likely to have LBW. Exposure to formal education of ≥ 9 years was weakly linked to reduced LBW burdens. Primiparous parturients, twice as likely to deliver babies with LBW, recorded the lowest mean BW at 2.88 ± 0.4. This characteristically lower BW decreased with advancing parity. ANC attendants and parturients exposed to IPTp-SP during pregnancy generally delivered heavier babies, a finding that calls for further investigation. Maternal anemia, (irrespective of the clinical spectrum of severity), positive maternal syphilis, hepatitis B and HIV status and maternal ABO phenotypical blood groups did not influence BW. Mean systolic and diastolic maternal BP remained higher among parturients who delivered NBW and HBW babies.

## 6. RECOMMENDATIONS

Maternal age ≤ 20 years, particularly associated with increased risk of LBW and preterm delivery, comprises a modifiable factor that should be ameliorated to reduce the municipality's high adolescent pregnancy of 21.9%. Multi-sectorial efforts aimed to improve adolescent health and welfare, (e.g. contraception, sustained free and compulsory senior high school education and improved access to information on sexuality, gender-responsive sexual and reproductive health services), should be enhanced and prioritized. Investigation for distinct modifiable factors underlying increased risk of LBW among rural residents will yield comprehensive information for intervention. The positive influence of exposure to formal education of ≥ 9 years on BW should be further researched with larger samples. Research should also further seek to identify specific causal factors predicting increased risk of LBW among primiparous parturients while controlling for the possible role of adolescent pregnancy. Efforts to increase coverage for IPTp-SP should be enhanced as its link to decreased LBW burden may be associated with its capacity for prevention of malaria and anemia, (both comprising established LBW risk factors). ANC's logistic and human resource capacity for timeous detection of elevated maternal BP, (somewhat a modifiable risk factor), should be assessed and duly strengthened. This would facilitate early, effective and appropriate attention to avert its influence on BW. Continued research to distinctly investigate the influence of both gestational and essential/chronic maternal Hypertension on BW should be prioritized.

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