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# Modeling Birth Registration in the Savannah Region of Ghana

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**Abstract**

Accurate birth registration plays a vital role in national development planning and organizational decision-making. The Births and Deaths Registry is a key provider of demographic information, offering insights into the composition, magnitude, growth, and spatial distribution of a country's population across different administrative divisions. Inaccurate birth records can lead to misallocation of resources, such as immunization supplies, educational funding, and child protection initiatives. This research examines the factors influencing birth registration in the Savannah Region of Ghana, based on secondary data obtained from the regional Births and Deaths office for the years 2020 and 2021. The analysis was conducted using negative binomial regression model. The results indicate that month of registration, employment status, the identity of the informant, place of delivery, District registered, maternal age, parent's occupation, and religion of father significantly impact birth registration outcomes. The model adequacy was assessed using $G^2$ and McFadden's Pseudo $R^2$. The findings highlight an urgent need to improve public awareness, especially within rural areas and communities with low literacy levels, in order to increase birth registration rates.

**Keywords:** Negative binomial regression, Occupation, District, Registration of birth, Educational level of parents.

## 1. Introduction

The act of registering a birth is an essential legal right that ensures every child is officially recognized and assigned a nationality. It serves as the first legal acknowledgment of a child's identity, recording both the child's and parents' names. These records function not only as legal evidence of age, nationality, and identity but also as a critical statistical resource.

For individuals, they are essential for enrolling in school, obtaining travel documents, and accessing other civic rights. For the state, birth records inform the planning and allocation of services such as education, healthcare, and infrastructure development across different levels of governance (Pais, 2009).

Generally, in the developed countries births and deaths registry is the main source of data for planning purposes (Anaduaka, 2020; Brown, 2021; Abay and Gebre-Egziabher, 2020). In Ghana, vital registration practices date back to 1888, initially focusing only on deaths, governed by the Cemetery Ordinance. This regulation, primarily concerned with public health, sought to manage the handling of deceased individuals. Birth registration was later added in 1912. However, until 1895, these responsibilities were not housed under any formal institutional structure, until they were placed under the Department of Medical Services (DMS), Sanitary Department (Bwalya et al., 2021).

In contrast, developed nations have long institutionalized birth and death registration as part of their development agenda. Countries including the United States, Japan, and Russia transitioned from paper-based to digitized systems to improve accuracy and efficiency. For example, in Ireland, death registration began as far back as 13$^{th}$ century through the efforts of the Church, while formal civil registration commenced in 1864. The practice of recording births and deaths in India started under colonial administration and was officially codified with the enactment of the 1969 Registration of Births and Deaths Act (Anaduaka, 2020; Lovie, 1995).

Ghana's civil registration framework has evolved significantly, with various legislative reforms aimed at enhancing its effectiveness. Initially, the Registry of Births and Deaths operated under the Medical Department between 1912 and 1926, and later moved to the Registrar General Department from 1948 to 1960. The 1926 registration ordinance remained in effect until it was replaced in 1965 by Act 301. The most recent legislative update occurred in October 2020 with the passage of Act 1027 (Tobin et al., 2013; Bwalya et al., 2021). The Local Government Act 462 of 1993, mandates Unit Committees to document and report vital events as they happen. Some jurisdictions employ a continuous registration model, considered part of the active registration methods (Lovie, 1995). As a reliable source of demographic and socio-economic data, civil registration supports national policy development and long-term planning.

In light of its relevance, the study focuses on identifying the critical elements that shape birth registration practices in the Savannah Region of Ghana. The registration system helps compile vital statistics critical for understanding population changes and supporting informed decision-making. While the registry is recognized as a crucial agency in this process, further investigation is required to better understand the factor affecting registration trends. Accordingly, this study applies a linear mixed effects modelling framework to evaluate how both fixed and random factors especially those related to parental demographics impact birth registration outcomes in the region. The materials and methods are presented in Section 2, Results are presented in Section 3, and conclusion in Section 4.

### 1.1 Negative Binomial Regression

The binomial regression is used for modeling count data, especially over-dispersed data. It is particularly necessary in situations where there is significant over-dispersion with little or no zeros that makes impossible for Poisson regression or the huddles models to be used. The general form of the negative binomial distribution is given by

$$ln\ (\mu_i) = \beta_0 + \beta_1 x1_i + \beta_2 x2_i + \cdots + \beta_k xk_i\ . \quad (1)$$

The conditional variance of the negative binomial regression is given by

$$var(Y_i|x_i) = \mu_i(1 + \theta\mu_i). \quad (2)$$

The $x_i$ are predictors, $\beta_0, \cdots, \beta_k$ are the coefficients, and $\theta$ is the over-dispersion parameter (Long, 1997).

## 2. Results

### 2.1 Birth Registration Overview

An analysis of the birth registration data from 2020 and 2021 showed that out of the total 21,750 recorded births, 53% were male (11,453) and 47% were female (10,297), indicating a slightly higher registration rate for boys across both years. Monthly registration trends are summarized in Table 1. The figures in 2020 show a dip in February following January's count, a rebound in March, and variable trends through the rest of the year. The highest peak occurred in November, attributed to intensified registration campaigns by staff and volunteers. The decline observed in December might be due to the holiday season, during which fewer people prioritize registration.

**Table 1: Monthly Birth Registrations in 2020 and 2021**

| Month of Registration | Registered Births (2020) | Registered Births (2021) |
|---|---|---|
| January | 537 | 970 |
| February | 385 | 1,066 |
| March | 436 | 1,276 |
| April | 603 | 1,030 |
| May | 582 | 1,470 |
| June | 781 | 1,209 |
| July | 979 | 1,056 |
| August | 884 | 846 |
| September | 725 | 812 |
| October | 1,212 | 948 |
| November | 738 | 1,599 |
| December | 318 | 1,288 |
| **Total** | **8,180** | **13.570** |

In terms of delivery locations, 30% of births occurred at home, followed by hospitals and health centres (each at 24%), CHPS compounds or clinics (22%), and maternity homes (0.3%). Regarding who attended the deliveries, 67.5% were assisted by midwives, 30% by Traditional Birth Attendants (TBAs), and only small portions by doctors (2%) or nurses (0.5%). Across the seven administrative districts, North Gonja led with 27% of registrations, followed by Bole (20%). The Sawla-Tuna-Kalba District recorded the fewest, at just 6% (Table 2).

**Table 2: Monthly Birth Registrations by District**

| Administrative Districts | Number of Births Registered | Proportion (%) |
|---|---|---|
| North Gonja | 5,790 | 27 |
| Bole | 4,307 | 20 |
| North East Gonja | 3,683 | 17 |
| West Gonja | 2,702 | 12 |
| Central Gonja | 2,418 | 11 |
| East Gonja | 1,540 | 7 |
| Sawla Tuna Kalba | 1,310 | 6 |
| **Total** | **21,750** | **100** |

The data by mother's age group showed that most births were registered by mothers aged 25-29 years (32%), followed by those aged 20-24 years (29%), and 30-34 years (21%). Only 0.5% of registered births were from mothers aged 45-49, indicating a steep drop with increasing maternal age (Table 3).

**Table 3: Distribution of Registered Births by Maternal Age Category**

| Age Category | Number of Births Registered | Proportion (%) |
|---|---|---|
| 15-19 | 1,576 | 7 |
| 20-24 | 6,285 | 29 |
| 25-29 | 6,862 | 32 |
| 30-34 | 4,584 | 21.1 |
| 35-39 | 1,608 | 7.4 |
| 40-44 | 734 | 3 |
| 45-49 | 101 | 0.5 |
| **Total** | **21,750** | **100** |

Registered births by mothers from outside Ghana included 51 from Burkina Faso and 45 from other countries, making up less than 1% combined. Regarding maternal occupation, housewives dominated with 72%, while traders made up 14%, and students and teachers accounted for 3% each. Other occupations comprised 8% (Table 4).

**Table 4: Distribution of Birth Registrations by Maternal Occupational Status**

| Occupational Category | Number of Births Registered | Proportion (%) |
|---|---|---|
| Housewives | 15,580 | 71 |
| Traders | 2,983 | 14 |
| Teaching Staff | 558 | 3 |
| Students | 692 | 3 |
| Public/Civil Sector Workers | 150 | 1 |
| Other Categories | 1,787 | 8 |
| **Total** | **21,750** | **100** |

Looking at maternal education, 60% of the registered births were from mothers with no formal education. Those with primary, JHS, secondary, and tertiary education contributed 17%, 9%, 11%, and 3% respectively. Among fathers, 34 were from Burkina Faso and 45 from other nations representing 0.4% combined. The majority (59%) had never attended school. Those with primary (15%), secondary (13%), and tertiary education (7%) followed. Data by father's age group indicated that the majority fell between 30-34 years (33%) and 35-39 years (20%), with very few above ages 50. This is shown in Table 5.

**Table 5: Distribution of Registered births by father's Age Category Status**

| Age Category (Years) | Number of Births Registered | Proportion (%) |
|---|---|---|
| 15-19 | 28 | 0.1 |
| 20-24 | 1,372 | 6.3 |
| 25-29 | 3,649 | 17 |
| 30-34 | 7,202 | 33 |
| 35-39 | 4,386 | 20 |
| 40-44 | 3,328 | 15 |
| 45-49 | 1,253 | 6 |
| 50-54 | 409 | 2 |
| 50-55 | 79 | 0.4 |
| 60+ | 44 | 0.2 |
| **Total** | **21,750** | **100** |

Concerning father's occupation, farmers constituted 68% of the registered births, followed by traders (9%), teachers (7%), drivers (3.7%), public servants (3%), and other groups (Table 6).

**Table 6: Distribution of Birth Registrations by father's Occupational Status**

| Occupation Category | Number of Births Registered | Proportion (%) |
|---|---|---|
| Farmers | 14,902 | 68 |
| Traders | 1,873 | 9 |
| Teachers | 1,611 | 7 |
| Drivers | 802 | 3.7 |
| Doctors/Nurses | 61 | 0.3 |
| Public/Civil Sector Workers | 586 | 3 |
| Students | 479 | 2 |
| Others | 1,436 | 7 |
| **Total** | **21,750** | **100** |

In terms of religious affiliation, the majority of fathers were Muslim (82%), followed by Christians (17%), and traditionalists (1%). When considering the person reporting the birth, 59% were fathers, while 40.2% were mothers, with a minor fraction (less than 1%) being other relatives (e.g., uncles, aunties). Lastly, 60% of births were registered in urban areas, while 40% came from rural locations, pointing to urban areas having better access or awareness.

Preliminary analysis of the data revealed that the Negative binomial regression produced a theta value of 1.4314 with standard error of 0.0128. This represents a clear indication of over-dispersion and indication that the Poisson regression is unsuitable to be used for analysis of this data. The *AIC* for the binomial regression is 256183 smaller than that of the Poisson regression (1834482). This clearly makes the binomial regression the best candidate model for the analysis of the data. The following result in Table 7 contains results of the negative binomial regression.

**Table 7: Results based on Negative Binomial Regression**

| Variable | Category | Estimate | Std. Error | Z Value | Pr(> \|t\|) |
|---|---|---|---|---|---|
| | Intercept | 4.4203 | 0.1684 | 26.242 | < 2e-16 |
| Registration Month | February | -0.0317 | 0.03159 | 1.005 | 0.3149 |
| (Ref.: January) | March | 0.0943 | 0.0302 | -3.124 | 0.0018 |
| | April | 0.1396 | 0.0305 | -4.581 | 4.62e-06 |
| | May | 0.1205 | 0.0292 | -4.120 | 3.79e-05 |
| | June | 0.1416 | 0.0295 | -4.796 | 1.62e-06 |
| | July | 0.0678 | 0.0293 | -2.316 | 0.0206 |
| | August | 0.0116 | 0.0304 | -0.383 | 0.7020 |
| | September | 0.0342 | 0.0312 | -1.098 | 0.2724 |
| | October | 0.0153 | 0.0294 | 0.520 | 0.6027 |
| | November | 0.0637 | 0.0288 | -2.214 | 0.0268 |
| | December | 0.0415 | 0.0314 | 1.320 | 0.1867 |
| Gender | Female | -0.0087 | 0.0115 | 0.758 | 0.4486 |
| Type of birth | Twins | -0.0066 | 0.0481 | -0.136 | 0.8915 |
| (Ref.: Single) | Triplets | -0.5669 | 0.3771 | 1.503 | 0.1328 |
| Attendance at birth | Midwife | 0.0365 | 0.0424 | 0.860 | 0.3897 |
| (Ref.: Doctor) | Nurse | 0.0336 | 0.0944 | 0.356 | 0.7219 |
| | TBA | 0.1124 | 0.0646 | 1.740 | 0.0818 |
| | Health Center | 0.1329 | 0.0201 | 6.621 | 3.56e-11 |
| Place of delivery | Maternity home | -0.0264 | 0.1035 | 0.255 | 0.7988 |
| (Ref.: Hospital) | CHIPS compound | 0.1790 | 0.0212 | 8.455 | < 2e-16 |
| | Home | 0.1193 | 0.0564 | 2.115 | 0.0344 |
| District registered | North Gonja | 0.2635 | 0.0266 | 9.922 | < 2e-16 |
| (Ref.: West Gonja) | Bole | 0.2161 | 0.0229 | 9.452 | < 2e-16 |
| | Sawla Tuna Kalba | -0.1748 | 0.0324 | 5.401 | 6.63e-08 |
| | Central Gonja | -0.2736 | 0.0267 | 10.261 | < 2e-16 |
| | East Gonja | -0.1302 | 0.0296 | -4.403 | 1.07e-05 |
| | North East Gonja | 0.0470 | 0.0255 | 1.842 | 0.0654 |
| Maternal age | 20-24 | 0.0237 | 0.02560 | -0.912 | 0.3619 |
| (Ref.: 15-19) | 25-29 | 0.0623 | 0.0280 | -2.226 | 0.0260 |
| | 30-34 | 0.0235 | 0.0312 | 0.754 | 0.4506 |
| | 35-39 | 0.0094 | 0.0385 | 0.246 | 0.8060 |
| | 40-44 | -0.1471 | 0.0484 | 3.040 | 0.0024 |
| | 45-49 | -0.2802 | 0.0941 | 2.977 | 0.0029 |
| Mother Nationality | Burkina Faso | -0.1110 | 0.2057 | -0.540 | 0.5893 |
| (Ref.: Ghana) | Niger | -0.1723 | 0.1919 | 0.897 | 0.3695 |
| Father Age | 21-25 | 0.2812 | 0.1622 | 1.733 | 0.0831 |
| (Ref.: 15-20) | 26-30 | 0.2384 | 0.1624 | 1.469 | 0.1419 |
| | 31-35 | 0.2866 | 0.1626 | 1.762 | 0.0780 |
| | 36-40 | 0.2424 | 0.1630 | 1.487 | 0.1369 |
| | 41-45 | 0.2227 | 0.1633 | 1.363 | 0.1728 |

| | | | | | |
|---|---|---|---|---|---|
| | 46-50 | 0.2048 | 0.1648 | 1.242 | 0.2142 |
| | 51-55 | 0.1932 | 0.1690 | 1.143 | 0.2529 |
| | 56-60 | 0.2061 | 0.1885 | 1.093 | 0.2742 |
| | 61-65 | 0.1900 | 0.2073 | 0.917 | 0.3593 |
| Father Education | Primary | -0.0029 | 0.0247 | -0.119 | 0.9056 |
| (Ref.: Non-formal) | Junior High | -0.0237 | 0.0292 | -0.813 | 0.4161 |
| | Secondary | -0.0120 | 0.0258 | -0.466 | 0.6410 |
| | Tertiary | -0.0007 | 0.0372 | 0.019 | 0.9849 |
| Father's occupation | Trader | -0.0649 | 0.0232 | -2.792 | 0.0052 |
| (Ref.: Farmer) | Employed | -0.0695 | 0.0291 | -2.393 | 0.0167 |
| | Others | -0.1300 | 0.0325 | -4.002 | 6.29e-05 |
| Father's religion | Christian | -0.1109 | 0.0171 | 6.500 | 8.02e-11 |
| (Ref.: Moslem) | Traditionalist | -0.1724 | 0.0581 | 2.966 | 0.0030 |
| Informant | Mother | 0.0769 | 0.0148 | 5.218 | 1.81e-07 |
| (Ref.: Father) | Other | -0.1968 | 0.0834 | -2.361 | 0.0182 |
| Parity | | -0.0049 | 0.0051 | -0.962 | 0.3360 |
| Mother's Education | Basic | 0.0025 | 0.0238 | 0.106 | 0.9155 |
| (Ref.: Non-formal) | Junior high | 0.0311 | 0.0269 | 1.158 | 0.2470 |
| | Secondary | 0.0421 | 0.0270 | 1.559 | 0.1191 |
| | Tertiary | -0.0005 | 0.0519 | -0.010 | 0.9919 |
| Mother's occupation | Trader | -0.0065 | 0.0194 | 0.339 | 0.7343 |
| (Ref.: House wife) | Employed | -0.0879 | 0.0390 | -2.255 | 0.0241 |
| | Others | -0.1147 | 0.0234 | -4.915 | 8.90e-07 |

From Table 7 above, the months of August, September, October and December have birth registrations significantly higher than January with *p-values* less than 0.05. February on the other hand had significantly lower birth registrations from January. The rest of the months though had positive coefficients and implied having more birth registrations than January were generally having p-values lower than 0.05 which means their difference from January was insignificant. There were fewer female birth registrations with a coefficient of -0.0087 and p-value greater than 0.05.

Compared to deliveries attended by doctors (reference), the coefficients for midwife**,** nurse and TBA attendance are positive with significant difference from that of doctor.

On District of registration, only North East Gonja has a significantly higher number of birth registration than West Gonja with a positive coefficient and p-value greater than 0.05. Bole and North Gonja though had positive coefficients, their p-values were less than 0.05 indicating that their differences were insignificant. Central Gonja, Sawla Kalba Tuna, and East Gonja had negative coefficients with p-values less than 0.05 implying insignificant lower birth registrations from that of West Gonja.

Singleton birth registrations were most prevalent in the district and posted a significantly higher birth registrations than both twins and triplets both negative coefficients and p-values greater than 0.05. Maternity homes have significantly lower birth registrations than hospitals with a negative coefficient and p-value greater than 0.05. Birth registrations in hospitals were generally lower than Health Centers, CHIPS compound and home deliveries all with positive coefficients that were all not significant. On birth registration for maternal age, only intervals 40- 44, and 45-49 had lower birth registrations than the reference age interval of 15-19. The rest of the of the intervals though had positive difference with the reference age category of 15-20, only age interval 25-29 had a p-

value less than 0.05. Mothers' whose children were registered were generally Ghanaians with insignificant registrations from mothers with Burkina Faso and Niger nationalities as their p-values are far greater than 0.05.

On fathers' age, all the age intervals have significantly higher birth registrations than the 15-20 category. Their coefficients were all positive with p-values greater than 0.05. The educational level with the highest birth registration is the non-formal group. All the other levels of the education had lower birth registrations with p-values greater than 0.05 and positive coefficients. All the other occupations have lower birth registrations than those who are farmers. They all have p-values less than the significant level. On fathers' religion, Christian and traditional fathers have a lower birth registration than their Moslem counterparts with both p-values lower than 0.05. The informant reveled that whilst mothers are more likely to present new births for registration than the fathers, other family relatives are less likely to preset a child for registration with both p-values less than 0.05. The results further revealed that, parity is not a significant factor for predicting birth registration. It further revealed that mother's education, those who had basic, junior high school and secondary school education had significantly higher birth registration than those with non-formal education. Those with tertiary education however have a negative coefficient and p-value greater than 0.05. On mother's occupation, those employees in either formal or informal sector have significant effect on birth registration than housewife. Traders however do have significant effect on birth registration.

The $G^2$ statistic based on the likelihood ratio test yield a value of $1.129885e+03$. This large value of $G^2$ which represents difference in the -2 log likelihood values implies that the negative binomial regression significantly fits the data well. The McFadden's Pseudo $R^2$ was obtained as 0.55 indicating that the model explains larger variation in birth registrations in the region.

## 3. Discussion

Although registration of birth is a vital means for national development and policy formulation, it is often overlooked in numerous developing and emerging economies. Meeting the targets set by the Sustainable Development Goals (SDGs), particularly in areas such as health, education, and social protection, requires reliable demographic data to support effective resource allocation and future planning. A key principle of the UN 2030 Agenda is to "leave no one behind", underscoring the importance of universal registration. Specifically, SDG Target 16.9 advocates for legal identity for all, including free birth registration. For this reason, the study investigated the patterns and drivers of birth registration in Savannah Region of Ghana. The analysis showed that male births (53%) outnumbered female births (47%), consistent with findings from the 2017/2018 Multiple Cluster Survey and similar observations in Rwanda, where male registrations also exceeded female ones (Brown, 2021). The trend of registrations over time appeared erratic, reflecting short-term fluctuations likely influenced by local activities such as outreach campaigns or seasonal changes. Such irregularities may obscure long-term trends and highlight the need for consistent registration practices. Supporting findings from Dake and Fuseini (2018), the study observed that birth registrations were more common when children were born in health facilities, particularly those assisted by healthcare professionals. In this study, 30% of births occurred at home, with hospitals and CHPS/clinics each accounting for 24%, while maternity homes recorded the lowest share. This may largely be as a result of the fact that there are fewer hospitals and maternal homes in the region than the other places of births. More so, except the maternity homes and home deliveries, there are birth registration officers at the other places of deliveries who educate nursing mother and register them. Deliveries were mostly assisted by midwives (67.5%), followed by Traditional Birth Attendants (30%), with minimal contributions from doctors and nurses. This may be due to the

fact that, except for cesarian section where doctors are responsible for, nurses and doctors are not usually responsible for conducting deliveries and hence their low numbers. The lower number of registered births were associated with mothers age intervals 40-44 and 45-49 years. This means registration rates declined among older mothers. A small percentage of mothers and fathers were non-Ghanaian nationals from neighboring countries, such as Burkina Faso and Niger. In terms of occupation, housewives (71%) and traders (14%) were the most prominent among mothers. Interestingly, a higher proportion of uneducated mothers registered births compared to those with formal education, a finding contrary to the work of Cappa and Wardlaw (2013), who reported a positive relationship between education and registration in India and Nigeria. This may be due to the intensive education by birth registration officers at the health facilities and hence mother's education level did not really matter. For fathers, 53% had no formal education, and most (69%) were engaged in farming. This could negatively affect registration fortunes. Registration peaked among fathers aged 30-34 but declined significantly with age, particularly beyond 40 years. This observation rather defies logic as one would expect that older age intervals comes with experience and should easily translate into higher registrations. Agricultural responsibilities and the rural nature of the region likely contributed to delays or non-registration, especially during farming seasons. Given the region's economic challenges as one of the least endowed regions in Ghana, even basic transportation costs may present barriers to timely registration (Jakperik et al., 2023; Tobin et al., 2013)).

Religious affiliation also played a role: Moslems accounted for 82% of Registered births, followed by Christians (17%), and traditionalists (1%), which is in line with findings from Tigray, Ethiopia ( A b a y a n d Gebre-Egziabher, 2020) . Most of the registrations were initiated by fathers (59%), with mothers accounting for 40%, and the remaining 1% reported by extended family members. This suggests a stronger inclination among fathers to report births.

Geographically, urban areas accounted for 60% of registrations, compared to 40% in rural areas, highlighting the need to expand registration infrastructure and awareness in underserved rural communities. This observation supports earlier findings from UNICEF (Lovie, 1995; Bwalya et al., 2021), who also reported urban bias in birth registrations.

The model results affirmed that variables such as registration month (excluding January), parents' occupations, mother's education, and father's religion had positive associations with birth registration. Conversely, mothers age, fathers age, secondary education among fathers, and non-parent informants were negatively associated with birth registration (Anaduaka, 2020). Additionally, the low registration rates in rural areas relative to the urban centers maybe due to education and other related f a c t o r s but not costs. This is because, birth registration in Ghana under one year is free. Savannah region even though not among the poorest regions of Ghana is not also well endowed (Jakperik et al., 2019; Anaduaka, 2020).

## 4. Conclusion

The study revealed that month of registration, employment status, informant, place of delivery, District registered, maternal age, parent's occupation, and religion of father significantly impact birth registration outcomes. The findings highlight an urgent need to improve public awareness, especially within rural areas and communities with low literacy levels, in order to increase birth registration rates.

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