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Research Article

# Regional Variation and Factors Associated with Fetal Macrosomia in Ethiopia

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## ABSTRACT

**Background:** Globally, there is an increase in the prevalence of high birth weight. In Sub-Sahara African countries, including Ethiopia, weighting newborns at birth are not well addressed thereby awareness of high birth weight is limited. In this paper, we aimed to assess the between-region variability of the prevalence and identify the associated factors with high birth weight in Ethiopia.

**Methods:** The study is based on the Ethiopian Demographic and Health Survey which is conducted in 2016. A total of 2110 newborns across all regions of Ethiopia are included in the study. The multilevel logistic regression model is applied to identify the associated factors of high birth weight and to evaluate the variation of the prevalence of high birth weight across the regions of Ethiopia.

**Results:** The prevalence of high birth weight in Ethiopia was 10.4%. Based on our analysis, mother's age, residence, mother's educational level, mother's body mass index gestational age, socio-economic class, and the sex of the newborn baby were the significant factors associated with high birth weight. With inter-class correlation of 14%, there is a significant variation of high birth weight among the regions of Ethiopia.

**Conclusion:** Controlling mother's BMI, strengthening follow up for elder women and women in high socio-economic class, and prevention of post maturity (≥ 40 weeks) gestational age could be effective personal and public health measures to combat high birth weight in Ethiopia.

**Keywords:** High birth weight; Multilevel; Gestational age; Regional variation

**Abbreviations:** BMI; Body Mass Index; CI: Confidence Interval; CSA: Central Statistical Agency; ICC: Interclass Correlation; DHS: Demographic Health Survey; EDHS: Ethiopian Demographic and Health Survey; OR: Odds Ratio; WHO: World health organization.

## INTRODUCTION

The term high birth weight is used to describe a newborn with excessive birth weight. A baby who is diagnosed as having high birth weight weighs more than 4,000 grams, regardless of his or her gestational age [1,2]. High birth weight may be caused by genetic factors, maternal obesity and/or excessive gestational weight gain, or other preexisting diseases like diabetes that were not adequately controlled [3].

From kinds of literature, the prevalence of high birth weight in the world varied from country to country and it ranges from 1.6% to 28% [4-7]. The prevalence of high birth weight is higher in industrialized nations and among women of high socio-economic status within a given population. In developed countries, the magnitude of high birth weight ranges from 5% to 20%, while this value is between 0.6% to 15.2% for low and middle-income countries. In Africa, the prevalence of high birth weight is varying between 2% (in Nigeria) to 15.2% (in Algeria) [8]. In other African countries, such as the Democratic Republic of Congo, Angola, Kenya, Niger, and Uganda, the percentage of high birth weight from all newborn babies is estimated as 2.7%, 3.1%, 3.9%, 8%, and 9.1%, respectively. Based on the Ethiopian Demographic Health Survey (EDHS) of 2011, the prevalence of high birth weight was about 10.46% [9].

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Globally, high birth weight affects about 15% of all pregnancies. Delivering a high birth weight baby is distressing for the mother, her baby, obstetrician, and neonatologist. There are many maternal complications associated with high birth weight, including emergency cesarean section, postpartum hemorrhage, and perinatal trauma. It may also have neonatal complications such as clavicular or humerus fracture, shoulder dystocia, brachial plexus injuries, neonatal asphyxia, hypoglycemia, increased risk of neonatal infection, and perinatal death [10,11].

There are several potential risk factors associated with high birth weight. These include; mother's age, sex of newborn, the place of residence, mother's educational level, socio-economic class, mother's Body Mass Index (BMI), gestational age (in weeks), the presence of diabetic mellitus, and previous history of high birth weight [12].

Only fewer data are available for lower-income countries, particularly in Sub-Saharan Africa, where the prevalence of overweight and obese adults is also on the rise. To our knowledge, there is no countrywide study on the risk factors of high birth weight in Ethiopia. In this paper, we aimed to identify the risk factors of high birth weight and assess the between-region variation using EDHS 2016.

The DHS survey often follows a hierarchical structure and the survey utilizes the multistage stratified cluster sampling technique. Due to a resulting nested structure of the data, it would be inappropriate to apply the regression analysis without considering a potential correlation of subjects within a region. For this reason, we apply the multilevel logistic regression model to identify the risk factors of high birth weight and to assess variations among the regions of Ethiopia.

We will proceed as follows. Section 2 describes the data set and methods of data analysis. Section 3 presents the result of our analysis. Section 4 discusses the results of the study. Section 5 concludes the main findings.

## METHODS

### Sources of data

EDHS 2016 is the fourth Demographic and Health Survey (DHS) of Ethiopia. It was implemented by the Central Statistical Agency (CSA) of Ethiopia and other stakeholders; processed and organized by ICF International into different datasets. The authors obtained these public datasets from the MEASURE DHS website by their permission. The standard protocols and three types of tools were used for collecting DHS data, namely the man's, the women's, and household questionnaires. Further, the standardization of the questionnaires was also done by governmental and nongovernmental shareholders to maintain the validity of the tools and datasets.

DMEM high sugar medium (Gibco,#11965092), Penicillin-Streptomycin (Gibco,#15070063), fetal bovine serum (FBS,Gibco,#10099133),Tissue ROS detection kit (Beibo Biological,#BB-470532),cell reactive oxygen detection kit(Biyuntian,#S0033S),cell apoptosis detection kit (KGI Bio, #KGA108-1), CCK8 reagent (Dongren Chemical, #CK04), superoxide Substance detection kit (Biyuntian,S0060), autophagy staining detection kit (Solebao, #G0170-100T), Lyso-Tracker Red(Solebao,#L8010-50 μl); Goat Anti-Rabbit IgG H&L (HRP) (Jackson,#111-035-003),Beclin-1 (D40C5) Rabbit mAb (CST,#3495T), mTOR (7C10) Rabbit mAb (CST, #2983T), Phospho-mTOR (Ser2448) (D9C2) Rabbit (CST, #5536T), LC3A/B (D3U4C) XP® Rabbit mAb(CST,#12741T), Cleaved Caspase-3 (Asp175) Antibody (CST, #9661T), 3-MA(MCE, #HY-19312), Endonuclease SgrAI(NEB, #R0603S), Endonuclease EcoRI(NEB, #R3101V).

### Study population and sampling procedures

Ethiopia has nine regions and two administrative towns. Regions are subdivided into Zones, and Zones are also subdivided into administrative units known as Weredas. Each Wereda is further subdivided into the smallest administrative units, called Kebele. During the 2007 census, each kebele was subdivided into census Enumeration Areas (EAs), which were convenient for the implementation of the census and subsequent surveys [13].

EDHS 2016 followed a two-stage sampling design with stratification into urban and rural. At the first stage of the sampling, 645 EAs, 443 from rural and 202 from urban were selected based on the 2007 Ethiopian population and housing census sampling frame called EA. For the women's questionnaire, women aged from 15-49 in the selected EAs of the selected households were eligible. The second stage of the sampling involved selection from the complete listing of households in each selected EAs by a probability proportionate to the size (based on the 2007 Population and Housing Census) of each cluster. Approximately, 28 households from each cluster (giving a total of 18,008 households of which 16,650 households were interviewed). A total of 16,583 eligible women and of them, 15,683 women were interviewed. From the total number of 34,596 newborns included in EDHS 2016, only 2,110 were weighted at birth. Therefore, 2,110 newborns were included in this study for analysis.

### Variables description

The authors assessed the birth weight of the newborn baby as a dependent variable, which is classified as macrosomic (weights more than 4,000 grams) or not. The independent variables considered for analysis include; the region, residence, sex of newborn baby, mother's age, mother's education level, marital status, father's education level, socio-economic class, mother's BMI, gestational age (in weeks), and type of birth (singleton or multiple birth).

### Method of data analysis

Extraction of variables, data exploration, cleaning, coding, and recoding, descriptive statistics were performed using IBM SPSS version 23, whereas the inferential part of our analysis were done using STATA version 15.

We deliberate the application of the multilevel logistic regression model to assess the regional variation, and to identify the factors associated with high birth weight. This is because, the DHS surveys often follow a hierarchical data structure are based on multistage stratified cluster sampling, and hence our data might be correlated within regions. If we apply the classical logistic regression model for this data, the standard errors might be underestimated, because the model does not take into account for the similarity observations within the same region. This underestimation of standard errors results an inflation if type I error rate, which implies a higher possibility of concluding that obtained results are significant, even though they may not be [14].

Multilevel models were developed to correct the dependency of observations within a cluster and to assess interclass correlation (the amount of dependency among individuals) [15,16]. Multilevel models incorporate random components of cluster effects in the statistical model. The consideration of random effects at the cluster level in the multilevel model makes it possible to estimate correct standard errors. In multilevel models, dividing the total variance in the dependent variable into between-cluster and within-cluster parts, the variability of random effects across clusters and the importance of clusters can also be evaluated [16-18]. Again, both observation level and cluster level covariates can be included in multilevel models. Also, multilevel models separate the estimated effects in the covariates into different levels, which can be interpreted as observation level effects (i.e., within a cluster) and cluster level effects (i.e., across clusters), respectively.

Thus, the authors apply the multilevel logistic regression model that takes into account the correlation of individual within the region. The hierarchy for this study follows individuals as level-1 and regions as level-2.

## RESULTS

### Descriptive summaries

For analysis, we have considered all 2110 newborn babies obtained from EDHS 2016. Of all babies, 219 (10.4%) were macrosomic. The majority 129 (6.1%) of macrosomic babies were males (Table 1). Of the total newborns included in the study, 1276 (60.5%) were born in urban areas, and of them, 112(5.3%) were macrosomic. The highest number of high birth weight 189 (8.9%) observed among married families. About 109 (5.2%) of high birth weight were from mother's age of 25-34 years. The highest number of high birth weight 94 (4.5%) were occurred among women who had primary education while the smallest 60 (2.8%) were observed among women who had no education. The frequency of high birth weight among the poor, middle, and rich families were 57 (2.7%), 65 (3.1%), and 97 (4.6%), respectively.

**Table 1:** Socio- demographic and Obstetric characteristics of high birth weight, EDHS 2016.

| | Normal weight of newborns | | High birth weight | |
|---|---|---|---|---|
| Covariates | Number | Percent | Number | Percent |
| Sex of newborn | | | | |
| Male | 949 | 45 | 129 | 6.1 |
| Female | 942 | 44.6 | 90 | 4.3 |
| Place of residence | | | | |
| Urban | 1164 | 55.2 | 112 | 5.3 |
| Rural | 727 | 34.4 | 107 | 5.1 |
| Marital status | | | | |
| Single | 187 | 8.9 | 30 | 1.4 |
| Married | 1704 | 80.8 | 189 | 8.9 |
| Mother's age | | | | |
| 15-24 | 509 | 24.1 | 58 | 2.7 |
| 25-34 | 1031 | 48.9 | 109 | 5.2 |
| 35-49 | 351 | 16.6 | 52 | 2.5 |
| Mother's educational level | | | | |
| No-education | 504 | 23.9 | 60 | 2.8 |
| Primary | 693 | 32.8 | 94 | 4.5 |
| Secondary/above | 694 | 32.9 | 65 | 3.1 |
| Father's educational level | | | | |
| No-education | 387 | 18.3 | 93 | 4.4 |
| Primary | 891 | 41.2 | 77 | 3.6 |
| Secondary/above | 619 | 29.2 | 49 | 2.3 |
| Socio-economic class | | | | |
| Poor | 945 | 44.8 | 57 | 2.7 |
| Middle | 563 | 26.7 | 65 | 3.1 |
| Rich | 383 | 18.1 | 97 | 4.6 |
| Gestational age(wks) | | | | |
| Pre-maturity(<40 wks) | 1665 | 78.9 | 103 | 4.9 |
| Post-maturity(≥ 40 wks) | 226 | 10.7 | 116 | 5.5 |
| Mother's body mass index | | | | |
| Underweight | 287 | 13.6 | 27 | 1.3 |
| Normal | 1164 | 55.2 | 135 | 6.4 |
| Overweight | 440 | 20.8 | 57 | 2.7 |
| Type of birth | | | | |
| Singleton | 1825 | 86.5 | 197 | 9.3 |
| Multiple | 66 | 3.1 | 22 | 1.0 |

Regarding gestational age of baby, 103 (4.9%) of high birth weight had pre-maturity (< 40 weeks), and 116 (5.5%) had post-maturity (≥40 weeks). In this study, the prevalence of high birth weight among women who had underweight, normal, and overweight/obesity BMI were 27(1.3%), 135(6.4%), and 57(2.7%) respectively. Among newborns included in this study, 2022(95.8%) were singleton, whereas, 88(4.2%) were had multiple birth. Among the singleton babies in the study, 197(9.3%) were macrosomic, while, 22(1.0%) of high birth weight were among multiple birth.

Using the Chi-square test, we found that there is a significant ($p<0.001$) variation of the prevalence of high birth weight among the regions in Ethiopia (Table 2). The smallest number of high birth weight 5(0.2%) was observed in the Afar region, while the highest number of high birth weight 37(1.7%) in Addis Ababa.

**Table 2:** The variation of high birth weight among the regions of Ethiopia.

| Region | Normal weight | | High birth weight | | Chi-square value |
|---|---|---|---|---|---|
| | Number | Percentage | Number | Percentage | |
| Tigray | 146 | 6.9 | 15 | 0.7 | $X^2$ : 47.98 df:10 p<0.001 |
| Afar | 118 | 5.6 | 5 | 0.2 | |
| Ahmara | 219 | 10.4 | 28 | 1.3 | |
| Oromia | 267 | 12.6 | 47 | 2.2 | |
| Somali | 209 | 9.9 | 14 | 0.7 | |
| SNNP | 159 | 7.5 | 22 | 1.0 | |
| Benishangul Gumuz | 78 | 3.7 | 10 | 0.4 | |
| Gambela | 87 | 4.1 | 15 | 0.7 | |
| Harari | 38 | 1.8 | 7 | 0.3 | |
| Addis Ababa | 424 | 20.1 | 37 | 1.7 | |
| Dire Dawa | 146 | 6.9 | 19 | 0.6 | |

### Results of the multilevel logistic regression analysis

Based on the multilevel analysis, there is a variation (ICC=14%) of the prevalence of high birth weight among the regions of Ethiopia (Table 3). Among the candidate factors considered in the study; mother's age, place of residence, mother's education level, socio-economic class, mother's BMI, gestational age (weeks), and sex of newborn were statistically significant (p-value<0.05).

**Table 3:** The multilevel logistic regression model for high birth weight in Ethiopia, 2016 EDHS.

| Covariates | Estimate | SE | p-value | OR(95%CI) |
|---|---|---|---|---|
| Sex of newborn | | | | |
| Female | Ref. | | | |
| Male | 0.324 | 0.151 | 0.002* | 1.383(1.029,1.580) |
| Place of residence | | | | |
| Rural | Ref. | | | |
| Urban | 0.288 | 0.137 | 0.014* | 1.332(1.018,1.742) |
| Mother's age | | | | |
| 15-24 | Ref. | | | |
| 25-34 | -0.073 | 0.086 | 0.031* | 0.929(0.785,1.103) |
| 35-49 | 0.265 | 0.105 | 0.015* | 1.364(1.068,1.592) |
| Mother's educational level | | | | |
| No-education | Ref. | | | |
| Primary | 0.042 | 0.078 | 0.097 | 1.042(0.893,1.217) |
| Secondary/above | 0.102 | 0.097 | 0.299 | 1.108(0.912,1.345) |
| Socio-economic class | | | | |
| Poor | Ref. | | | |
| Middle | 0.196 | 0.086 | 0.011* | 1.217(1.002,1.477 |
| Rich | 0.282 | 0.102 | 0.001* | 1.325(1.086,1.616) |
| Gestational age(wks) | | | | |
| Pre-maturity(<40 wks) | Ref. | | | |
| Post-maturity(≥ 40 wks) | 0.182 | 0.091 | 0.003* | 1.210(0.987,1.458) |
| Mother's body mass index | | | | |
| Underweight | Ref. | | | |
| Normal | 0.163 | 0.337 | 0.004* | 1.171(0.628,2.265) |
| Overweight/obesity | 0.524 | 0.391 | 0.018* | 1.681(0.784,2.627) |
| Region | | | | |
| Var(_cons) | 0.512 | | | (0.215,0.624) |
| ICC=0.14* | | | | |

**Note:** *Significant at 5%, OR: Odd ratio, Ref.: Reference group

Males are more likely to be macrosomic as compared to females (OR=1.383; 95% CI [1.029, 1.580]). The odds of being macrosomic among urban area is higher than the rural area (OR=1.332; 95%CI [1.018, 1.742]. Mothers aged between 35 and 49 years were 36.4% (OR=1.364; 95%CI [1.068, 1.592]) times more likely to deliver macrosomic newborns than women aged between 15 and 24 years, whereas women aged between 25 and 34 years had less likely to deliver macrosomic newborns than women aged between 15 and 24 years (OR=0.929; 95%CI [0.785, 1.103]).

Mothers with primary and secondary/above educational levels were 4.2% (OR=1.042; 95% CI [0.893, 1.217]) and 10.8% (OR=1.108; 95% CI [0.912, 1.345) times more likely to deliver macrosomic newborns than mothers with no education level, respectively. The body mass index of mothers is also another key factor associated with high birth weight. Mothers having overweight/obesity were 68.1% (OR: 1.681; 95%CI [0.784, 3.627]) times more likely to deliver macrosomic newborns than those who had underweight BMI.

The newborns that have a gestational age of ≥ 40 weeks (post-maturity) were 21.0% (OR: 1.210; 95%CI [0.925, 1.816]) times more likely to be macrosomic than newborns with gestational age of <40 weeks (pre-maturity). Mothers with middle and rich economic class were 21.7% (OR: 1.217; 95%CI [1.002, 1.477]) and 32.5% (OR: 1.325; 95%CI [1.086, 1.616]) more likely to deliver a macrosomic baby as compared to the poor economic class, respectively.

## DISCUSSION

The prevalence of high birth weight was 10.4% in Ethiopia. This finding is in line with the previous studies conducted in Hawassa, Ethiopia (11.86%) [19], and in Ghana (9.69%) [20]. But this prevalence rate is higher as compared to the prevalence reported from some African countries, like Tanzania (2.3%) [21]. The results of our study show that the magnitude high birth weight for male babies is greater than females. This conclusion is supported by the similar studies in Ghana (20) and Tanzania (21).

The ICC of at least 2% is suggestive for the higher-level effect and worth considering of a multilevel setup [22]. The authors had performed the multilevel modeling and thereby found an ICC of 14%, which proofs that applying the multilevel logistic regression model for our data over the classical logistic regression model, was correct. The ICC of 14% indicates a significant variation of high birth weight among the regions of Ethiopia.

The multilevel logistic regression analysis reveals that the age of mothers, the place of residence, the educational level of mothers, the economic class, mother's BMI, gestational age and the sex of the newborn babies were the significant factors associated with high birth weight in Ethiopia.

The present study assessed that mothers with advanced age i.e. more than 35 years old, delivered more macrosomic babies than those mothers who were below 35 years old. This finding is consistent with several previous studies [23-26]. Similarly, Said et.al and Kenny et.al, reported that the risk of high birth weight increased significantly with advancing maternal age [27].This may be due to the fact that with increasing the age of a mother, there exists the effect on metabolism, thereby accelerating the velocity of growth in the baby. Mothers who were educated more than secondary school was more likely to deliver high birth weight as compared to illiterate mothers. This is in line with the previous study conducted in urban Nigeria [28]. The study also reveals that newborns that their family lived in urban area are more likely to be high birth weight than the rural area. This is finding is compatible with the previous studies done in Ethiopia, and in Nigeria. This may be due to the fact that women in urban area have relatively better living conditions and thus get better access to food but also with more fatty diet which could lead them to get overweight/obesity.

This study revealed that mothers of the higher socio-economic groups had a higher occurrence of macrosomic babies than the lower socio-economic group. The previous study found that the prevalence of high birth weight is more common in mothers who belong to higher socio-economic status than those of lower socio-economic status. The current finding is also in line with some previous studies [29-33].

The mother's BMI is an important factor associated with high birth weight. Our analysis shows that mothers who had overweight/obesity BMI has greater chance to get high birth weight. This is analogous to many previous studies [34].

The newborns who are delivered post maturely (>40 weeks), called post-term, had a higher chance to be high birth weight as compared to the pre-maturely (<40 weeks) born babies. This is consistent to the conclusions reported from Northern Ghana (22), Hawassa (21), and in Tigray (31) regions of Ethiopia. This may be attributable to the period of post-maturity that there could lead to excessive fetal weight gain. Moreover, being a male is associated with an increased risk of being fetal macrosomic. Similar results have been found in many papers [35].

## STRENGTH OF THE STUDY

The sampling methods, methods of data collection, interviewing techniques applied, data processing, and organization are to the standard and the quality of DHS data is unquestionably the most reliable type of data. The authors were weighting the data before doing any kind of analysis to reduce the bias due to clustering. Moreover, multilevel modeling was applied to account for the variation of high birth weight across the regions in Ethiopia.

## LIMITATIONS THE STUDY

According to EDHS 2016 data, only 5% of newborns were weighed during birth in Ethiopia. Hence, the authors were unable to get large data to investigate the approximate magnitude of high birth weight in Ethiopia. Besides, because of the lack of qualitative data on EDHS, the authors were unable to investigate the association between some other important predictors like biological factors, genetics factors, previous history of high birth weight and diabetic status with high birth weight.

## CONCLUSION

The prevalence of high birth weight varies from region to region of Ethiopia. The age of mothers, the place of residence, educational level of mothers, the BMI of mothers, gestational age, socio-economic class, and the sex of newborns are important factors significantly associated with high birth weight. Controlling mother's BMI, strengthening follow up for elder women and women in high socio-economic class, and prevention of post maturity (≥ 40 weeks) gestational age are the critical need for effective personal and public health initiatives designed to decrease high birth weight in Ethiopia.

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## AUTHORS' CONTRIBUTIONS

GN conceived the idea. GN, AB, JA, and DB contributed to the design and extraction of the data; and analysis. GN drafted the manuscript. All authors read and approved the manuscript.

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There is no direct fund for this study.

## AVAILABILITY OF DATA AND MATERIALS

The datasets generated and/or analyzed during the current study are available in the MEASURE DHS repository, [https://dhsprogram.com/data/available-datasets.cfm]

## ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The authors used secondary data which was collected by the Central Statistical Agency (CSA) of Ethiopia. The data we obtained is anonymized data with no personal identifiers. To obtain this data from CSA, we get written ethical approval from the Institutional Research Ethics Review Committee of the College of Natural Sciences, Jimma University.

## CONSENT FOR PUBLICATION

Not applicable.

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