ORİJİNAL ARAŞTIRMA ORIGINAL RESEARCH

DOI: 10.5336/biostatic.2016-54437

Multilevel Logistic Regression Analysis of the Determinants of Stillbirth in Ethiopia Using EDHS 2011 Data

EDHS 2011 Verilerini Kullanarak Etiyopya'daki Ölü Doğum Etkenlerinin Çok Düzeyli Lojistik Regresyon Analizi

Kidanemariam Alem BERHIE,[a]
Habtamu Gebremariam GEBRESILASSIE[b]

[a]Department of Statistics, University of Gondar, College of Natural and Computational Sciences, Gondar
[b]Department of Statistics, Dilla University, College of Natural and Computational Sciences, Dilla

Geliş Tarihi/Received: 03.01.2017
Kabul Tarihi/Accepted: 13.03.2017

Yazışma Adresi/Correspondence:
Kidanemariam Alem BERHIE
University of Gondar, College of Natural and Computational Sciences, Department of Statistics, Gondar, ETHIOPIA
kidanemariam2012@gmail.com

ABSTRACT Objective: Stillbirth is often defined as fetal death after 24 weeks of gestation, but a fetus greater than any combination of 16, 20, 22, 24, or 28 weeks gestational age and 350g, 400g, 500g, or 1000g birth weight may be considered stillborn depending on local law. Once the fetus has died, the mother may or may not have contractions and undergo childbirth or in some cases, a Caesarean section. Most stillbirths occur in full-term pregnancies. If all causes of stillbirth are taken together, the new estimates would place stillbirths fifth on the list of causes of deaths (COD) worldwide. Each year, about 3 million families worldwide will experience a stillbirth. This study has intended to model determinants of experiencing stillbirth among women in child bearing age group of Ethiopia using the Ethiopian demographic and health Survey data. **Material and Methods:** First, the bivariate chi-square test of association was fitted to the data and significant variables were considered for further investigation in binary logistic regression model. Lastly, the multilevel models were fitted. **Results:** This study revealed that the rate of experiencing stillbirth among women of child bearing age was about 25.5 per 1000 deliveries in Ethiopia. From binary logistic regression, region of residence, maternal age, place of residence, education level, parity, antenatal care utilization, place of delivery, body mass index (BMI) and anemia level were found to be significantly associated with experiencing stillbirth. From multilevel logistic regression, it was found that the random intercept model provided the best fit for the data under consideration. The variance of the random component related to the intercept term was found to be statistically significant implying differences in prevalence of experiencing stillbirth among the regions. And in this random intercept model, age group, type of place of residence, antenatal care visit and delivery place were found to be statistically significant factors for experiencing stillbirth among regions. **Conclusion:** Mothers should prefer and people who are around them should advise them to give birth at health centers than delivering at home. Especially older age women, above 35 years, should be more careful for difficulties that come with age, like hypertension and should visit antenatal care during pregnancy. Further studies should be conducted to identify other correlates of stillbirth that are not included and confirm the variables which are insignificant in this study because of many reasons and since regional variation are found significant spatial models can be applied to investigate spatial variations of experiencing stillbirth.

Keywords: Stillbirth; antenatal care visit; multilevel logistic regression; Ethiopia

ÖZET Amaç: Ölü doğum sıklıkla, hamileliğin 24. haftasından sonra yaşanan cenin ölümü olarak tanımlanmaktadır ancak hamilelik dönemlerinden 16, 20, 22, 24 veya 28 hafta ve 350 g, 400 g, 500 g veya 1000 g doğum kilosunun herhangi bir kombinasyonundan büyük olan cenin, yerel yasalara göre ölü doğmuş olarak düşünülebilir. Cenin öldüğünde, annede kasılmalar olabilir veya olmayabilir. Bu durumda anne ölü doğum yapabilir ya da cenin sezaryenle alınabilir. Ölü doğumların birçoğu terme ulaşan hamileliklerde ortaya çıkmaktadır. Eğer ölü doğumların nedenleri birlikte ele alınırsa, yeni tahminler ölü doğumları dünya çapındaki ölüm nedenleri listesinde 5. sıraya koymaktadır. Her yıl, dünya çapında yaklaşık 3 milyon aile ölü doğum tecrübesini yaşamaktadır. Bu çalışma Etiyopya'daki doğurganlık yaş grubunda bulunup ölü doğum yapmış kadınların özelliklerini Etiyopya'nın demografik ve sağlık araştırmaları verilerini kullanılarak modellemeyi amaçlanmıştır. **Gereç ve Yöntemler:** İlk olarak, iki değişkenli ki kare test bağlantısı veriye uyarlandı ve önemli değişkenler iki bileşenli lojistik regresyon modelinde ileriki araştırmalar için dikkate alındı. Sonrasında, çok düzeyli modeller uygulandı. **Bulgular:** Bu çalışma Etiyopya'daki doğurganlık yaş grubunda bulunan her 1000 doğumdan yaklaşık 25,5'inin ölü doğum yaptığını açıklığa kavuşturmuştur. İki bileşenli lojistik regresyonda yaşanan bölge, annenin yaşı, yaşanan ortam, eğitim seviyesi, doğum sayısı, hamilelik bakımından yararlanma, doğum yeri, vücut kütle indeksi (VKİ) ve anemi seviyesi ölü doğum için önemli derecede bağlantılı bulunmuştur. Çok düzeyli lojistik regresyonda rastlantısal kesişim modeli incelenen veriler için en uygun modeldir. Kesişim dönemleriyle ilgili rastlantısal bileşenin varyansı istatistiksel olarak önemli bulunmuştur ve bu bölgelerde ölü doğum sıklığına işaret etmektedir. Ayrıca bu rastlantısal kesişim modeli, yaş grubunun, yaşam alanı tipinin, hamilelik bakım visitlerinin ve doğum yerinin bölgeler arasındaki ölü doğum deneyimleri açısından istatistiksel olarak önemli faktörler olduğu bulunmuştur. **Sonuç:** Anneler evde doğum yapmak yerine sağlık merkezlerinde doğum yapmayı tercih etmelidir ve çevrelerindeki kişiler bunu onlara tavsiye etmelidir. Özellikle 35 yaş üstü kadınlar, hipertansiyon gibi ileri yaşla birlikte gelen zorluklarda daha dikkatli olmalı ve hamilelik süresince hamile bakım servislerine gitmelidir. İleride yapılacak çalışmalar, bu çalışmada dahil edilmeyen diğer ölü doğum korelasyonlarını tanımlamalı ve pek çok sebepten dolayı bu çalışma için önemli görülmeyen değişkenlerin doğruluğunu teyit etmelidir. Bölgesel değişkenler önemli bulunduğundan dolayı ölü doğum yapmanın mekansal değişkenlere göre değişimini araştırmak için mekansal modeller uygulanabilmelidir.

Anahtar Kelimeler: Ölü doğum; hamilelik bakım vizitleri; çok düzeyli lojistik regresyon; Etiyopya

Stillbirth is often defined as fetal death after 24 weeks of gestation, but a fetus greater than any combination of 16, 20, 22, 24, or 28 weeks gestational age and 350g, 400g, 500g, or 1000g birth weight may be considered stillborn depending on local law.[1,2] Once the fetus has died, the mother may or may not have contractions and undergo childbirth or in some cases, a Caesarean section. Most stillbirths occur in full-term pregnancies. The cause is often unknown.

The 2011 Lancet Stillbirths Series reviewed the global status of stillbirths and presented the case for a triple return on investment in stillbirth prevention that also prevents newborn and maternal deaths. That Series received widespread media attention and an unprecedented response.[3] However, despite progress this new Series shows that more must be done to integrate stillbirth prevention within global and national agendas for high quality health care for women, adolescents, and babies. This message resonates with other Lancet Series, notably on maternal health, early child development, and Every Newborn.

Globally, According to the WHO/PMNCH fact sheet on stillbirth 2011 report, each year, about 3 million families worldwide will experience a stillbirth, with 2.65 million stillbirths occurring in late pregnancy.[4] Of these, 1.46 million occur prior to birth and another 1.19 million occur during labour; every day more than 7,300 babies are stillborn, a death that occurs just when parents expect to welcome a new life. The number of third trimester stillbirths worldwide has declined by only 1.1 percent per year, from 3 million per year in 1995 to 2.6 million in 2009. This is slower than reductions for child and maternal mortality. These deaths are directly related to the lack of skilled care at this critical time for mothers and babies.[5] Stillbirths are often not registered systematically in many low-income countries. This leads to underestimation of stillbirths in these countries, in which 98% of all stillbirths occur. Reliable registrations exist only in countries with minor number of deaths.[5] India, Pakistan, Nigeria, China, Bangladesh, Democratic Republic of the Congo, Ethiopia, Indonesia, Tanzania and Afghanistan are ten countries that account for two-thirds of all third trimester stillbirths. Ethiopia is ranked number seven out of these ten.[5]

Stillbirth rate is an important indicator of access to and quality of antenatal and delivery care. Stillbirth prevalence at community level is typically less than 1% in more developed parts and could exceed 3% in less developed regions. A large review of data for 190 countries estimated a stillbirth rate of 32/1000 deliveries in South Asia and Sub-Saharan Africa.[6]

The world health statistics 2013 revealed that the stillbirth rate globally is 19 per 1000 deliveries, in the African region is 28 per 1000 deliveries, 26/1000 for low income countries, 21/1000 for low middle income countries and less than one percent for the high income countries. In Ethiopia, the world health statistics 2013 revealed a stillbirth rate of 26/1000 deliveries which is third highest in the east African countries next to Djibouti and Somalia (with stillbirth rates of 34 & 30 per 1000 births, respectively).[7] In Ethiopia, the world health statistics 2013 revealed a stillbirth rate of 26/1000 deliveries which is third highest in the east African countries next to Djibouti and Somalia (with stillbirth rates of 34 & 30 per 1000 births, respectively).[7] A study conducted on four low and middle income countries revealed a stillbirth rate of 30/1000 deliveries.[8]

A study reported that the prevalence of stillbirth is 19/1000 births.[9] A study done at Tikur Anbessa Hospital has shown a stillbirth rate of 53.3/1000 births and contributed to 77.2% of gross perinatal mortality.[10] The Ethiopian Demographic and Health Survey (EDHS) 2005 data indicated that the still birth rate is 1.8%.[11] The Addis Ababa city administration health bureau 2005/06 annual activity report revealed that the rate of stillbirth is 2.5%.[12] A study done, recently, on prenatal outcomes in Addis Ababa in 2010, also indicates that the rate of stillbirth is 3.1%.[13]

A large review of data for 190 countries estimated a stillbirth rate of 32/1000 deliveries in South Asia and Sub-Saharan Africa [6] which is tenfold greater than that of the developed countries.[14]

Most of the mothers and grandmothers associated the causes of stillbirth and neonatal death with malevolent spirits. As one Oromiya grandmother observed, "Families lose their new born because of an evil spirit." (Wukabi is a type of malevolent spirit that, when offended, will attack the beholder or his/her family).[15]

At least half of all stillbirths in low income countries are associated with a maternal condition before delivery. 'Make every mother and child count', was the name of a WHO report from 2005.[16] The Second Development Goal (SDG) aims to improve maternal health by 2015. Meeting the SDG indirectly reduces the stillbirth rate.

Goal by 2020; For countries with a current stillbirth rate of more than 5 per 1000 births, the goal by 2020 is to reduce their stillbirth rates by at least 50% from the 2008 rates.[17] For countries with a current stillbirth rate of less than 5 per 1000 births, the goal by 2020 is to eliminate all preventable stillbirths and close equity gaps.

Therefore, this study attempts to investigate the major socio-economic, demographic, medical, behavioral and environmental factors of stillbirth in Ethiopia so that the SDG and goal by 2020 for stillbirth will be met. Researches done on the literature review are all discussing the single level effects on stillbirth. This thesis has tried to fill the gap in that it investigates the regional level effects on stillbirth.

In line with the above reality, the research/study attempted to come up with possible solution and recommendation after having clear understanding upon the situation by giving due emphasis to answer the following research questions.

- What are the socio-economic, demographic, and medical factors associated with stillbirth?
- Does the rate of stillbirth differ between regions?
- What are the factors that may explain the variation of rate of stillbirth between regions?

OBJECTIVE OF THE STUDY

GENERAL OBJECTIVE

The general objective of this study is to assess the determinants of stillbirth in Ethiopia using EDHS 2011 data using multilevel logistic regression.

SPECIFIC OBJECTIVES

- To assess socio-economic, demographic, and medical factors associated with stillbirth.
- To estimate the within-regional and between-regional level of difference for the rate of stillbirth in Ethiopia.
- To identify factors that may explain the variation of rate of stillbirth between regions.

LIMITATIONS OF THE STUDY

The data used in this study was the 2011 EDHS. Thus, the results may not necessarily reflect the current situation of Ethiopia. The stillbirth rate in this study is likely to under-estimate the actual stillbirth rate, since the respondents are mothers and may feel ashamed of telling the truth.

METHODOLOGY

SOURCE OF DATA

This study has used the 2011 Ethiopia Demographic and Health Survey (2011, EDHS).[18] The 2011 EDHS was conducted under the aegis of the ministry of health and was implemented by the Central Statistical Agency and partner organizations from September 2010 through June 2011 with a nationally representative sample of nearly 18,500 households. All women age 15-49 and all men age 15-59 in these households were eligible for individual interview.

The sample for the 2011 EDHS was designed to provide population and health indicators at the national and regional levels. The sample design allowed for specific indicators, such as stillbirth experience, to be calculated for each of Ethiopia's eleven geographic/administrative regions: nine regional states (Tigray, Afar, Amhara, Oromiya, Somali, Benishangul-Gumuz, SNNPR, Gambela and Harari) and two city administrations (Addis Ababa and Dire-Dawa). The sampling frame used for the 2011 EDHS was the Population and Housing Census conducted by the Central Statistical Agency (CSA) in 2007 (2007 PHC). The 2011 EDHS sample was selected using a stratified, two-stage cluster design, and EAs were the sampling units for the first stage sampling. The 2011 EDHS sample included 624 EAs, 187 in urban areas and 437 in rural areas.

Households comprised the second stage of sampling. A complete listing of households was carried out in each of the 624 selected EAs from September 2010 through January 2011. Maps were drawn for each of the clusters and all private households were listed. The listing excluded institutional living arrangements (e.g., army barracks, hospitals, police camps, and boarding schools). A representative sample of 17,817 households was selected for the 2011 EDHS survey. Because the sample is not self-weighting at the national level, all data in this report have been weighted unless otherwise specified. 16,515 women aged 15-49 are interviewed, 12,560 women after adjusting for the missing data have been taken for the analysis.

VARIABLES OF THE STUDY

Variables considered in this study were selected based on literatures which have been conducted at the global level. Potential determinant factors expected to be correlated with stillbirth among mothers of child bearing age are included as variables of the study.

DEPENDENT VARIABLE

The 2011 EDHS asked women to report any pregnancy loss that occurred in the five years preceding the survey. For each pregnancy that did not end in a live birth, the duration of the pregnancy was recorded. Pregnancy losses occurring after seven completed months of gestation are defined as stillbirths. The response variable of this study is the occurrence of stillbirth among mothers of child bearing age.

The response variable for the i^{th} mother (15-49) is represented by a random variable Y_i with two possible values coded as 1 and 0. So, the response variable of the i^{th} mother Y_i was measured as a dichotomous variable with possible values $Y_i = 1$, if i^{th} mother had experienced stillbirth and $Y_i = 0$ otherwise.

STATISTICAL METHODOLOGY

In this study single and multilevel logistic regressions were employed to identify determinant risk factors of stillbirth and to determine the prevalence of stillbirth in Ethiopia. The response variable of the study is experiencing stillbirth prior to the survey. Firstly, we analyzed using single level binary logistic regressions by assuming the occurrence of stillbirth is independent among mothers of child bearing age. And finally we assessed the effect of determinant factors and regional difference on prevalence of stillbirth using multilevel logistic regression model.

TWO-LEVEL MODEL

Multilevel models are statistical models which allow not only independent variable at any level of hierarchical structure but also at least one random effect above level one group.[19] A multilevel logistic regression model can account for lack of independence across levels of nested data (i.e., individuals nested within regions). Conventional logistic regression assumes that all experimental units are independent in the sense that any variable which affects occurrence of stillbirth has the same effect in all regions, but multilevel models are used to assess whether the effect of predictors vary from region to region.

The binary multilevel logistic regression model has a binary outcome (experiencing or not experiencing of stillbirth). In this study the basic data structure of the two-level logistic regression is a collection of N groups (regions) and within-group j ($j = 1,2,\dots,N$), a random sample n_j of level-one units (mothers). The response variables, i.e., we let $Y_{ij} = 1$ if the i^{th} mother in j^{th} region has experienced stillbirth, and $Y_{ij} = 0$ otherwise; with probabilities, $P_{ij} = P(y_{ij} = 1|X_{ij}, u_j)$, is the probability of experiencing stillbirth for mother i in region j and $1 - P_{ij} = P(y_{ij} = 0|X_{ij}, u_j)$ is the probability of not experiencing stillbirth for mother i in region j; where u_j is a random cluster effect and often assumed to be $N(0, \sigma_u^2)$. The standard assumption is that Y_{ij} has a Bernoulli distribution. Let P_{ij} be modeled using a logit link function. The two-level model is given by:

$$\text{logit}(p_{ij}) = \log\left(\frac{p_{ij}}{1 - p_{ij}}\right) = \beta_{oj} + \sum_{l=1}^{k} \beta_{lj} x_{lij}\,; \qquad l = 1,2,\dots,k \qquad [1]$$

Where $\beta_{0j} = \beta_0 + U_{0j}, \beta_{1j} = \beta_1 + U_{1j}, \dots, \beta_{kj} = \beta_k + U_{kj}$

The two-level model (3.11) can be rewritten as:

$$\text{logit}(\text{p}_{\text{ij}}) = \log\left(\frac{p_{ij}}{1-p_{ij}}\right) = \beta_o + \sum_{l=1}^{k} \beta_l x_{lij} + U_{oj} + \sum_{l=1}^{k} U_{lj} x_{lij} \quad [2]$$

Where $\text{X}_{ij} = (\text{X}_{1ij}, \text{X}_{2ij}, \dots, \text{X}_{kij})$ represent the covariates, $\beta = (\beta_0, \beta_1, \dots, \beta_k)$ are regression coefficients, $U_{0j}, U_{1j}, \dots, U_{kj}$ are the random effects of model parameter at level two. It is assumed that the $U_{0j}, U_{1j}, \dots, U_{kj}$ follow a normal distribution with mean zero and variance δ_u^2 .

HETEROGENEOUS PROPORTIONS

Consider a population having two-levels. A random sample of n_j level-one (mothers) units is collected from level two groups ($j = 1,2, \dots, N$). The outcome variable is dichotomous and denoted by $\text{Y}_{ij}(i = 1,2,\dots,\text{nj}; j=1,2,\dots,N$ for level-one unit *i* nested in level-two group *j*. The outcome is coded as 0 and 1: 0 for "not experiencing stillbirth", 1 for "experiencing stillbirth". The total sample size is $M = \sum_{j=1}^{N} n_j$. If one does not take explanatory variables into account, the probability of success is assumed constant in each group. Let the success probability in group j be denoted by p_j. The dichotomous outcome variable for the individual *i* in group *j*, Y_{ij}, can be expressed as the sum of the probability in group *j*, p_j (the average proportion of *j* levels in group *j*, E (y_{ij}) = p_j) plus some individual dependent residual ε_{ij}, that is,

$$\text{Y}_{\text{ij}} = \text{p}_\text{j} + \varepsilon_{\text{ij}}$$

The residual term is assumed to have mean zero and variance, $Var(\varepsilon_i) = \text{p}_j(1 - \text{p}_j)$.

Since the outcome variable is coded 0 and 1, the group sample average is the proportion of successes in group j given by:

$$\hat{\text{p}}_j = \frac{1}{n_j} \sum_{i=1}^{n_j} \text{Y}_{\text{ij}} \quad [3]$$

$\hat{\text{p}}_j$ is an estimate for the group-dependent probability p_j. Similarly, the overall sample average is the overall proportion of successes, $\hat{\text{p}}$, and is given by:

$$\hat{\text{p}} = \frac{1}{\text{M}} \sum_{\text{j}=1}^{\text{N}} \sum_{\text{i}=1}^{\text{n}_\text{j}} Y_{\text{ij}} \quad [4]$$

This is an estimate for the overall probability of success, p.

TESTING HETEROGENEITY OF PROPORTIONS

For the proper application of multilevel analysis the first logical step is to test heterogeneity of proportions between groups. Here we present two commonly used test statistics that are used to check for heterogeneity. To test whether there are indeed systematic differences between the groups, the well-known chi-square test for contingency table can be used. In this case the chi-square test statistic is:

$$\chi^2 = \sum_{j=1}^{N} n_j \frac{(\hat{p}_j - \hat{p})^2}{\hat{p}(1-\hat{p})} \quad [5]$$

This statistic follows approximately a chi-square distribution with N-1 degrees of freedom. This chi-squared distribution is an approximation valid if the expected number of success ($n_j\hat{p}_j$) and of failures ($n_j(1-\hat{p}_j)$) in each group all are at least one while 80 percent of them are at least 5.[20] This condition will not always be satisfied, and the chi-square test then may seriously lead to wrong conclusions.

A second test of heterogeneity of proportions was proposed by Commenges and Jacqmin (1994).[21]. The test statistic is:

$$Z = \frac{\sum_{j=1}^{N}\{{n_j}^2(\hat{p}_j - \hat{p})^2\} - M\hat{p}(1-\hat{p})}{\hat{p}(1-\hat{p})\sqrt{2\sum_{j=1}^{N} n_j(n_j-1)}} \quad [6]$$

The statistic, Z, follows the standard normal distribution for large value of M. Thus, large calculated values of this statistic are indication of heterogeneous proportions. In the statistic Z, the numerator contains a weight of ${n_j}^2$ whereas chi-square test uses a weight n_j. This shows that the two tests combine the groups in different ways. Hence, when the group sizes n_j are different, it is possible that the two tests may lead to different outcomes. The test statistic Z is shown to have high power over the chi-square test and can be applied whenever there are many groups, even with small group sizes, provided that no single group dominates.[22]

THE EMPTY MULTILEVEL LOGISTIC REGRESSION MODEL

The empty two-level model for a dichotomous outcome variable refers to a population of groups (level-two units) and specifies the probability distribution for group-dependent probabilities p_j in $Y_{ij} = p_j + \varepsilon_{ij}$ without taking further explanatory variables into account. We focus on the model that specifies the transformed probabilities $f(p_j)$ to have a normal distribution. This is expressed, for a general link function $f(p)$, by the formula

$$f(p_j) = \beta_o + U_{oj} \quad [7]$$

Where β_o is the population average of the transformed probabilities and U_{oj} is the random deviation from this average for group *j*. If $f(p)$ is the logit function, then $f(p_j)$ is just the log-odds for group *j*. Thus, for the logit link function, the log-odds have a normal distribution in the population of groups, which is expressed by:

$$logit(p_j) = \beta_o + U_{oj} \quad [8]$$

For the deviations U_{oj} is assumed that they are independent random variables with a normal distribution with mean zero and variance σ_0^2. This model does not include a separate parameter for the level-one variance.[22] This is because the level-one residual variance of the dichotomous outcome variable follows directly from the success probability which is given by:

$$Var(\varepsilon_i) = P_j(1-P_j)$$

Denote by π_0 the probability corresponding to the average value β_0, as defined by

$$f(\pi_0) = \beta_0$$

For the logit function, the so-called logistic transformation of β_0, is defined by

$$\pi_0 = logistic(\beta_0) = \frac{\exp(\beta_0)}{1+\exp(\beta_0)} \quad [9]$$

Note that due to the non-linear nature of the logit link function, there is no a simple relation between the variance of probabilities and the variance of the deviations U_{0j}.[22] An approximate variance of the probability given by:

$$var(P_j) \approx (\pi_0(1-\pi_0))^2\sigma_0^2 \quad [10]$$

Note that an estimate of population variance $var(P_j)$ can be obtained by replacing sample estimates of π_0 and σ_0^2 . The resulting approximation can be compared with the nonparametric estimate,$\hat{t}^2$.

THE RANDOM INTERCEPT MODEL

In the random intercept model the intercept is the only random effect meaning that the groups differ with respect to the average value of the response variable, but the relation between explanatory and response variables cannot differ between groups. We assume that there are variables which potentially explain the observed success and failure. These variables are denoted by $X_h, (h = 1,2,\dots,k)$ with their values indicated by X_{hij}. Since some or all of those variables could be level-one variables, the success probability is not necessarily the same for all individual in a given group.[22] Therefore, the success probability depends on the individual as well as the group, and is denoted by P_{ij}. The outcome variable is split into an expected value and residual as:

$$Y_{ij} = P_{ij} + R_{ij}$$

The random intercept model expresses the log-odds, i.e. the logit of P_{ij}, as a sum of a linear function of the explanatory variables. That is,

$$\text{logit}(P_{ij}) = \log\left(\frac{p_{ij}}{1-p_{ij}}\right) = \beta_{oj} + \beta_1 x_{1ij} + \beta_2 x_{2ij} + \cdots + \beta_k x_{kij}$$

$$= \beta_{oj} + \sum_{h=1}^{k} \beta_h x_{hij} \quad [11]$$

Where the intercept term β_{oj} is assumed to vary randomly and is given by the sum of an average intercept β_o and group-dependent deviations U_{oj}, that is

$$\beta_{oj} = \beta_o + U_{oj}$$

As a result we have:

$$\text{logit}(P_{ij}) = \beta_o + \sum_{h=1}^{k} \beta_h x_{hij} + U_{oj} \quad [12]$$

Solving for P_{ij} we have:

$$P_{ij} = \frac{e^{\beta_o + \sum_{h=1}^{k} \beta_h X_{hij} + U_{oj}}}{1 + e^{\beta_o + \sum_{h=1}^{k} \beta_h X_{hij} + U_{oj}}} \quad [13]$$

Thus, a unit difference between the X_h values of two individuals in the same group is associated with a difference of β_h in their log-odds, or equivalently, a ratio of $\exp(\beta_h)$ in their odds. Equation [11] does not include a level-one residual because it is an equation for the probability P_{ij} rather than for the outcome Y_{ij}. Note that in the above equation, $\beta_o + \sum_{h=1}^{k} \beta_h x_{hij}$ is the fixed part of the model.[11] The remaining U_{oj} is called the random part of the model. It is assumed that the residual U_{oj} are mutually independent and normally distributed with mean zero and variance $\sigma_o{}^2$.

THE RANDOM COEFFICIENT MULTILEVEL LOGISTIC REGRESSION MODEL

In logistic regression analysis, linear models are constructed for the log-odds. The multilevel analogue, random coefficient logistic regression, is based on linear models for the log-odds that include random effects for the groups or other higher level units.

Consider explanatory variables which are potential explanations for the observed outcomes. Denote these variables by $X_1, X_2, \ldots, X_k$. The values of $X_h (h = 1, 2, \ldots, k)$ are indicated in the usual way by X_{hij}. Since some or all of these variables could be level-one variables, the success probability is not necessarily the same for all individuals in a given group. Therefore, the success probability depends on the individual as well as the group, and is denoted by P_{ij}.

Now consider a model with group-specific regressions of logit of the success probability, $\text{logit}(P_{ij})$, on a single level one explanatory variable X,

$$\text{logit}(P_{ij}) = \log\left(\frac{p_{ij}}{1-p_{ij}}\right) = \beta_{oj} + \beta_{1j} x_{1ij} \qquad [14]$$

The intercepts β_{oj} as well as the regression coefficients or slopes, β_{1j} are group dependent. These group dependent coefficients can be split into an average coefficient and the group dependent deviation:

$\beta_{oj} = \beta_o + U_{oj}$

$\beta_{1j} = \beta_1 + U_{1j}$

Substitution into [14] leads to the model

$$\text{logit}(P_{ij}) = \log\left(\frac{p_{ij}}{1-p_{ij}}\right) = (\beta_o + U_{oj}) + (\beta_1 + U_{1j}) x_{1ij}$$

$$= \beta_o + \beta_1 x_{1ij} + U_{oj} + U_{1j} x_{1ij} \qquad [15]$$

There are two random group effects, the random intercept U_{oj} and the random slope U_{1j}. It is assumed that the level two residuals U_{oj} and U_{1j} have both zero mean given the value of the explanatory variable X. Thus, β_1 is the average regression coefficient like β_o is the average intercept. The first part of equation [15], $\beta_o + \beta_1 x_{1ij}$, is called the fixed part of the model whereas the second part $U_{oj} + U_{1j} x_{1ij}$ is called the random part of the model.

The term $U_{oj} + U_{1j} x_{1ij}$ can be regarded as a random interaction between group and predictors (X). This model implies that the groups are characterized by two random effects: their intercept and

their slope. These two groups effects U_{oj} and U_{1j} will not be independent. Further, it is assumed that, for different groups, the pairs of random effects (U_{oj}, U_{1j}) are independent and identically distributed. Thus, the variances and covariance of the level-two random effects (U_{oj}, U_{1j}) are denoted by:

$Var(U_{oj}) = \sigma_{00} = {\sigma_0}^2$

$Var(U_{1j}) = \sigma_{11} = {\sigma_1}^2$

$Cov(U_{oj}, U_{1j}) = \sigma_{01}$

The model for a single explanatory variable discussed above can be extended by including more variables that have random effects. Suppose that there are k level-one explanatory variables $X_1, X_2, \dots, X_k$, and consider the model where all predictor variables have varying slopes and random intercept. That is

$$\text{logit}(P_{ij}) = \log\left(\frac{p_{ij}}{1-p_{ij}}\right) = \beta_{oj} + \beta_{1j}x_{1ij} + \beta_{2j}x_{2ij} + \cdots + \beta_{kj}x_{kij} \quad [16]$$

Letting $\beta_{oj} = \beta_o + U_{oj}$ and $\beta_{hj} = \beta_h + U_{hj}$ where $h = 1, 2, \dots, k$, we have:

$$\text{logit}(P_{ij}) = \log\left(\frac{p_{ij}}{1-p_{ij}}\right) = \beta_o + \sum_{h=1}^{k}\beta_h x_{ij} + U_{oj} + \sum_{h=1}^{k} U_{hj}x_{ij} \quad [17]$$

The first part $\beta_o + \sum_{h=1}^{k}\beta_h x_{ij}$ is called the fixed part of the model, and the second part, $U_{oj} + \sum_{h=1}^{k} U_{hj}x_{ij}$ is called the random part of the model. The random variables or effects, $U_{0j}, U_{1j}, \dots, U_{kj}$, are assumed to be independent between groups but may be correlated within groups. So the components of the vector $(U_{0j}, U_{1j}, \dots, U_{kj})$ are independently distributed as a multivariate normal distribution with zero mean vector and variances and co-variances matrix Ω given by:

$$\Omega = \begin{pmatrix} \sigma_0^2 & . & \dots & . \\ \sigma_{01} & \sigma_1^2 & \dots & . \\ \vdots & \vdots & \ddots & \vdots \\ \sigma_{0k} & \sigma_{1k} & \cdots & \sigma_k^2 \end{pmatrix}$$

INTRA-CLASS CORRELATION COEFFICIENT (ICC)

The other fundamental reason for applying multilevel analysis is the existence of intra-class (intra-regional) correlation arising from similarity of prevalence of stillbirth in the same region compared to those of different regions. The intra-class correlation coefficient (ICC) measures the proportion of variance in the outcome explained by the grouping structure. ICC can be calculated using an intercept-only model. This model can be derived from "Eq. [16]" by excluding all explanatory variables, which results in the following equation: $(\text{logit}(p_j) = \beta_o + U_{0j})$. The ICC is then calculated based on the following formula:

$$ICC = \frac{\delta_{uo}^2}{\delta_{uo}^2 + \delta_e^2} \quad [18]$$

Where δ_e^2 variance of individual (lower) level units

In multilevel logit model, level one residual variance $\delta_e^2 = \pi^{2/3} \approx 3.29$ [22] this formula can be reformulated as:

$$ICC = \frac{\delta_{uo}^2}{\delta_{uo}^2 + 3.29} \quad [19]$$

RESULTS AND DISCUSSION

We analyzed data from women of child bearing age from the EDHS 2011 sample. The initial population consisted of 16,515 women of child bearing age. Out of this 12,560 (76%) of women with complete information were selected and studied in the analysis. From the sampled women, the proportion of experiencing stillbirth was about 2.55% (25.5 per 1000) in Ethiopia.

The analysis is carried out in three parts. In the first part, we present the bivariate analysis with its chi-square test of association and then selecting the significant variables, we analyze the data using ordinary logistic regression, for both the analyses we used SPSS 20 software. Finally, we identify determinant factors of experiencing stillbirth and variation in experiencing stillbirth across regions using multilevel logistic regressions model using MLwiN 2.30 software.

RESULT OF BIVARIATE ANALYSIS

Among the factors, region of residence, maternal age, place of residence, education level, parity, antenatal care utilization, place of delivery, mode of delivery, body mass index (BMI), and anemia level were found to have a significant association with experiencing stillbirth at 1% level of significance (p-value=0.01), while having job was significant at the 5% level of significance (p-value=0.05).

Experiencing stillbirth has varied from one region to the other. The result in Table 1 shows that region of residence is significantly associated with experiencing stillbirth (p-value < 0.001). Somali region had the highest (5.26%) percentage of experiencing stillbirth followed by Tigray region (3.73%). Gambela and Addis Ababa had the lowest percentages (1.49%, 1.54%) respectively, for experiencing stillbirth in Ethiopia.

Of the 12,560 women with complete information, 50.7% were 15-24 years old, 33.3% were 25-34 years old and the rest (16.1%) were 35 or above. Maternal age was significantly associated with experiencing stillbirth and it was found that mothers with higher age were found to be with higher probability to experience stillbirth. Place of residence was also significantly associated with experiencing stillbirth and of the 71.1% rural area resident women 4.62% had experienced stillbirth and only 2.37% urban area residents had experienced stillbirth.

Education level is also associated with experiencing stillbirth. 47.4% of the women were with no educational achievement and, of this, those who had experienced stillbirth were 3.53% as compared to that of those who completed their primary education (1.68) and to that of those who completed secondary or higher education level (1.64). 41.2% of the women were nulliparous, having no child, with 1.01% proportion of experiencing stillbirth as compared to 3.63% proportion of experiencing stillbirth among multiparas.

TABLE 1: Distribution of factors analyzed with experiencing stillbirth among women of child bearing age in Ethiopia (EDHS, 2011).

Variables	Levels	N	N%	Experienced Stillbirth%		d.f	Chi-square	p-value
				No	Yes			
Region	Addis Ababa	1167	9.3	98.46	1.54	10	53.262	< .001
	Tigray	1368	10.9	96.27	3.73			
	Affar	1034	8.2	98.26	1.74			
	Amhara	1554	12.4	98.13	1.87			
	Oromiya	1705	13.6	96.48	3.52			
	Somali	703	5.6	94.74	5.26			
	Benishangul-Gumuz	975	7.8	97.23	2.77			
	SNNP	1640	13.1	97.62	2.38			
	Gambela	872	6.9	98.51	1.49			
	Harari	742	5.9	98.38	1.62			
	Dire Dawa	800	6.4	98.00	2.00			
Maternal age	15-24	6363	50.7	98.88	1.12	2	144.68	< .001
	25-34	4179	33.3	96.84	3.16			
	35+	2018	16.1	94.20	5.80			
Place of residence	Rural	8924	71.1	95.38	4.62	1	8.407	.004
	Urban	3636	28.9	97.63	2.37			
Education Level	No education	5955	47.4	96.47	3.53	2	43.691	< .001
	Primary	4835	38.5	98.32	1.68			
	Secondary & Higher	1770	14.1	98.36	1.64			
Wealth Index	Poor	4924	39.2	97.42	2.58	2	1.439	.487
	Middle	1784	14.2	97.09	2.91			
	Rich	5852	46.6	97.59	2.41			
Parity (Total children ever born)	Nulliparous	5169	41.2	98.99	1.01	1	84.097	< .001
	Multiparas	7391	58.8	96.37	3.63			
Antenatal care utilization	No antenatal visits	4101	32.7	93.34	6.66	2	97.417	< .001
	Visited atleast once	3290	26.2	96.41	3.59			
	Never given birth	5169	41.2	98.99	1.01			
Place of Delivery	HOME	6166	49.1	92.40	7.60	2	138.53	< .001
	Health center	1225	9.8	96.24	3.76			
	Never given birth	5169	41.2	98.99	1.01			
Mode of Delivery	Normal	7169	57.1	94.42	5.58	2	85.725	< .001
	Caesarean section	222	1.8	96.05	3.95			
	Never given birth	5169	41.2	98.99	1.01			
Body mass index (BMI)	Thin	3541	28.2	95.83	4.17	2	134.32	< .001
	Normal	8248	65.7	97.37	2.63			
	Overweight/Obese	771	6.1	93.63	6.37			
Marital status	Never Married	4017	32.0	97.13	2.87	2	4.067	.131
	Married/Living with partner	7640	60.8	96.32	3.68			
	Divorced/separated/Widowed	903	7.2	96.46	3.54			
Had any STI	No	12498	99.5	97.46	2.54	1	0.115	.471
	Yes	62	.5	96.77	3.23			
Smokes cigarettes	No	12513	99.6	97.44	2.56	1	1.233	.297
	Yes	47	.4	100.0	0.00			
Anemia level	Not anemic	10010	79.7	97.65	2.35	1	11.953	< .001
	Anemic	2550	20.3	94.67	5.33			
Has job	No	12340	98.2	97.51	2.49	1	6.190	.013
	Yes	220	1.8	96.09	3.91			
Alcoholic drink	Never	8454	67.3	97.60	2.40	3	3.669	.299
	Sometimes	2945	23.4	97.32	2.68			
	Usually	683	5.4	96.93	3.07			
	Always	478	3.8	96.44	3.56			

Table 1 displayed also that among the women of child bearing age 26.2% has made their antenatal care visit at least once during their pregnancy times and 3.59% of these had experienced stillbirth, which is less than that of those (32.7%) who made no antenatal care visit during their pregnancies which was 6.66%. 41.2% of the women had no child and among the women who delivered a child, 49.1% had delivered at home in which 7.6% were stillbirth, only 9.8% had delivered at any health center in which 3.76% were stillbirth, 57.1% had delivered normally in which 5.58% were stillbirth and 1.8% of the women delivered with caesarean section in which 3.95% of those delivered with caesarean section had given to stillbirth.

Body mass index was found to be another significantly associated predictor with experiencing stillbirth. The result indicates that 28.2% of the women were thin (BMI < 18.5), 65.7% were normal (weight) (BMI 18.5-24.9) and 6.1% were overweight or obese (BMI ≥ 25). The proportion of experiencing stillbirth among women who are thin, normal and overweight were 4.17%, 2.63% and 6.37% respectively. 79.7% of the women were not anemic and with less proportion of experiencing stillbirth than those (20.3%) with anemia whose proportion is 5.33%. 98.2% of the women were having no job while 1.8% had any job. The proportion of experiencing stillbirth among those who had no job was 2.49% which is less than that of those who had any job (3.91%).

RESULTS OF BINARY LOGISTIC REGRESSION ANALYSIS

Multiple logistic regression models were fitted using the categorical predictor variables which were found to be significant in the bivariate analysis using enter selection (Likelihood ratio) method.

ASSESSMENT OF GOODNESS OF FIT OF THE MODEL

For categorical data, after we fit the logistic model, it is necessary to see the appropriateness, adequacy and usefulness of the fitted model. To overcome this we have several techniques. The most commonly used techniques are Pearson's Chi-square, the likelihood ratio tests (LRT) and Hosmer and Lemeshow Goodness of fit test.

The result presented in Table 2 showed a likelihood ratio test statistic $G^2 = 277.041$ which is distributed as chi-square with 11 degree of freedom. The tabulated value was $X^2_{0.05}(11) = 19.675$. Since $G^2 > X^2_{0.05}(11)$, we reject the null hypothesis and conclude that at least one of the predictors was significantly related with experiencing stillbirth among mothers of child bearing age.

TABLE 2: Overall Model Evaluation Using Likelihood Ratio Test (EDHS, 2011).

	-2 Log likelihood	Likelihood ratio (G^2)	d.f	$X^2_{\alpha}(16)$
Null model	3043.857	277.041	11	19.675
Full model	2766.816			

Based on the results in Table 3, the null hypothesis that there is no difference between the model with only a constant and the model with independent variables was rejected.

The Hosmer-Lemeshow goodness-of-fit test is found to be not significant (χ^2= 7.424, d.f = 8, p-value = 0.72). Thus, we do not have an evidence to reject the null hypothesis that the model fitted the data well.

The Nagelkerke R-square was 8.0% indicating that explanatory variables were useful in predicting experiencing stillbirth. But, it doesn't give the meaning of variance explained as in linear regressions.[23]

TABLE 3: Omnibus Tests of Model Coefficients (EDHS, 2011).

	Chi-square	d.f	Sig.
Step	213.727	23	0.000
Block	213.727	23	0.000
Model	213.727	23	0.000

TABLE 4: Classification Table of Model with Predictor Variables (EDHS, 2011)

Observed		Predicted		
		Experienced stillbirth		
		No	Yes	Percentage Correct
Experienced still birth	No	12240	0	100.0
	Yes	59	261	81.6
Overall Percentage				99.5

VALIDATION OF PREDICTED PROBABILITIES

The degree to which predicted probabilities agree with actual outcomes is expressed as a classification table. Classification table documents the validity of predicted probabilities. According to the classification presented in Table 4, prediction for women who had not experienced stillbirth was more accurate than that for those who had experienced stillbirth. This observation is supported by the magnitude of sensitivity (81.6%) compared to that of specificity (100.0%). Sensitivity measures the proportion of correctly classified events (i.e., those women who had experienced stillbirth), whereas specificity measures the proportion of correctly classified nonevents (those women who had not experienced stillbirth). The overall correct prediction was 99.5%, an improvement over the chance level.

INTERPRETATION OF LOGISTIC REGRESSION COEFFICIENTS

A multiple logistic model was fitted to the data to test the research hypothesis regarding the relationship between the likelihood that experiencing stillbirth of woman is related with the predictor variables. Result displayed in Table 5 revealed that region of residence, maternal age, place of residence, education level, parity, antenatal care utilization, place of delivery, body mass index (BMI) and anemia level were found to be significantly associated with experiencing stillbirth.

Experiencing stillbirth was significantly associated with geographical regions. The odds of experiencing stillbirth in Tigray, Amhara, Oromiya, SNNP, Gambela, Harari, and Dire-Dawa were not significantly different from that of experiencing stillbirth in Addis Ababa. Experiencing stillbirth in Benishangul-Gumuz was 2.451 times more likely than that in Addis Ababa city. Women who live in Afar and Somali were more likely to experience stillbirth than women who live in Addis Ababa (Table 5).

According to the model, the log of the odds of a woman to experience stillbirth was positively related to maternal age group 25-34 (p = 0.000) and 35+ (p-value = 0.000) when compared with age group 15-24. Indicating that the older the woman the more likely to experience stillbirth. The odds of a woman in age group (25-34) of experiencing stillbirth were 3.49 times the odds of woman with age group 15-24 and the odds of a woman in age group (35+) of experiencing stillbirth were 6.80 times that of a woman with age group 15-24. This further indicates that women of older ages are vulnerable to experiencing stillbirth.

TABLE 5: Logistic Regression Results of experiencing stillbirth among women, in Ethiopia.

	B	S.E.	Wald	Df	Sig.	Exp(B)	95% CI for Exp(B)	
							Lower	Upper
AGE (15-24 ref.cat)			49.686	2	.000			
25-34	1.250	.183	46.463	1	.000	3.49	2.438	4.996
35+	1.917	.333	33.140	1	.000	6.8	3.541	13.062
REGION (Addis Ababa ref.cat)			41.254	10	.000			
Tigray	-.035	.359	.009	1	.922	0.966	0.478	1.952
Affar	.851	.304	7.822	1	.005	2.342	1.291	4.250
Amhara	-.089	.357	.063	1	.803	0.915	0.454	1.842
Oromiya	.103	.328	.099	1	.754	1.108	0.583	2.108
Somali	.782	.300	6.794	1	.009	2.185	1.214	3.935
Benishangul-Gumuz	.897	.314	8.167	1	.004	2.451	1.325	4.538
SNNP	.478	.332	2.074	1	.150	1.613	0.841	3.092
Gambela	.358	.317	1.276	1	.259	1.431	0.768	2.663
Harari	-.109	.387	.079	1	.779	0.897	0.420	1.915
Dire Dawa	-.063	.389	.026	1	.871	0.939	0.438	2.013
ResidPlace (Rural ref.cat)								
Urban	-.478	.176	7.370	1	.007	0.62	0.439	0.875
EucationLevel (No Educ. ref.cat)			8.254	2	.016			
Primary	-.291	.252	1.342	1	.247	0.748	0.456	1.225
Secondary & Higher	-1.728	.239	7.230	1	.007	0.178	0.111	0.284
PARITY (Nulliparous ref.cat)								
Multipara	1.168	.362	10.385	1	.001	3.215	1.582	6.537
ANC (No ANC visit ref.cat)			5.953	1	.015			
Visited atleast once	-.729	.299	5.953	1	.015	0.482	0.268	0.867
Delivery Place (Home ref.cat)			.201	1	.654			
Health center	-1.417	.435	10.611	1	.001	0.242	0.103	0.569
Delivery Mode (Normal ref.cat)			1.894	1	.169			
Caesarean section	-.498	.362	1.894	1	.169	0.608	0.299	1.236
BMI (Thin ref.cat)			7.757	2	.021			
Normal	-.729	.152	4.796	1	.029	0.482	0.358	0.650
Overweight/Obese	.417	.230	1.815	1	.178	1.518	0.967	2.382
Anemia (Not anemic ref.cat)								
Anemic	.916	.436	4.414	1	.036	2.499	1.063	5.874
Occupation (No ref.cat)								
Yes	-.492	.319	2.379	1	.123	0.611	0.327	1.143
Constant	-1.522	.532	8.188	1	.004	0.218	0.077	0.619

ref.cat = reference category, SNNP = South Nations Nationalities and Peoples

Table 5 has also revealed that place of residence was significantly associated with experiencing stillbirth. The likelihood of experiencing stillbirth for those women residing in urban area is 0.620 times that of those women residing in rural area. Educational level was also found to be significantly associated with experiencing stillbirth. Though women having only primary education have no significant difference in experiencing stillbirth with those having no educational attainment, women with secondary and higher education were less likely (OR = 0.178) to experience stillbirth than those with no educational attainment.

The above table (5) is trying to tell us that the multipara women, those having at least one child, were 3.215 times more likely vulnerable to experience stillbirth than the nulliparous women, those having no

children. Women who have made antenatal care visit for at least once during their pregnancy times were less likely (OR = 0.482) to experience stillbirth than those who haven't visited antenatal care. Women who delivered their babies at any health center were 75.8% (0.242-1, OR = 0.242) less likely to experience stillbirth than those who preferred to deliver at home.

Experiencing stillbirth is significantly associated with the body mass index (BMI) of women. The normal weight women were found to be less likely (OR= 0.482) to experience stillbirth than those women who were thin (BMI <18.5). Although not significant, those women who were overweight/obese (BMI ≥25) were more likely (1.518) to experience stillbirth than those women who were thin. Thus, normal weight women were found to be less likely to experience stillbirth than abnormal weight women. Women who were anemic are 2.499 times likely to experience stillbirth than those who were not anemic.

RESULTS OF MULTILEVEL LOGISTIC REGRESSION ANALYSIS

In this study we consider multilevel models to allow for and to explore between-region variance of experiencing stillbirth. The data have a two-level hierarchical structure with 12,560 women at level 1, nested within 11 regions at level 2. We used the MLwiN software to analyze the data, which uses a linearization method based on a Taylor series expansion and since the likelihood is not reliable, we are not able to use the AIC and BIC to compare the models.

The multilevel process was stepwise. The first step examined the null model of overall probability of experiencing stillbirth without adjustment for predictors. Second step included both the analysis of single and multilevel model for random intercept and fixed slope multilevel analysis. Third step considered a model for two level random intercept and random slope (random coefficient) multilevel logistic regression analysis. The Wald χ^2 test was used to determine significance of random part as well as to determine significance of individual β coefficients.

TEST OF HETEROGENEITY

A chi-square test statistic was applied to assess heterogeneity in the proportion of women who experienced stillbirth within regions. The test yield χ^2 = 53.262, d.f=10, P-value < 0.001. Therefore, regions are indeed significantly heterogeneous. Thus, the significance of this test gives us an evidence of heterogeneity of experiencing stillbirth across regions in Ethiopia.

RESULTS OF EMPTY LOGISTIC REGRESSION MODEL

Intercept only model, as is being seen in the output below, is the simplest hierarchical linear model in which only the intercept varies between level two units and no explanatory variables are entered in the model. The empty model is considered as a parametric version of assessing heterogeneity of regions for experiencing stillbirth. According to the result, the variance of the random factor is 6.694 with its standard error 0.411 and the Wald test statistic is 256.411, which is compared with a chi-squared distribution on 1 degree of freedom, gives a p-value less than 0.001. Therefore, we conclude that there is significant variation between regions in experiencing stillbirth among regions.

As can be seen from the output (Table 6), The Intra-class (Intra-region) correlation coefficient or, in other words, variance partition coefficient, which measures the proportion of the total variance that is

TABLE 6: Result of Multilevel Empty model.

$$\boldsymbol{StillbirthExp_{ij}} \sim \boldsymbol{Binomial(denom_{ij}, \pi_{ij})}$$
$$logit(\pi_{ij}) = \beta_{0j} cons$$
$$\beta_{0j} = \mathbf{-3.416(0.064)} + u_{0j}$$
$$[u_{0j}] \sim N(0, \Omega_u) \; : \; \Omega_u = [\mathbf{6.694(0.411)}]$$
$$var(StillbirthExp_{ij} \backslash \pi_{ij}) = \pi_{ij}(1 - \pi_{ij})/denom_{ij}$$

Bold are those variables which are significant at α = 0.05.

due to differences between regions, can be calculated as $ICC = \frac{\delta_{uo}^2}{\delta_{uo}^2 + 3.29} = \frac{6.694}{6.694 + 3.29} =$ 0.671. The result shows that 67.1% of the residual variation in the propensity to experience stillbirth is attributable to differences between regions. This implies that between regions variations are higher than within region variations for experiencing stillbirth.

The intercept βo = -3.416 interpreted as the odds of experiencing stillbirth in an average region. That is the intercept informs us that the average probability of experiencing stillbirth everywhere in Ethiopia is exp (-3.416)/ [1+exp (-3.416)] = 0.032 which is somewhat similar with the descriptive result (0.0255).

RESULTS OF RANDOM INTERCEPT LOGISTIC REGRESSION MODEL

The random intercept and fixed slope logistic regression model is a multilevel model which have random intercept and fixed coefficient of predictors. As can be seen from the output below, the analysis of multilevel logistic regression revealed that experiencing stillbirth varied among regions. The variance of the random factor is 5.081 with its standard error 0.384 and the Wald test statistic is 175.366, which is compared with a chi-squared distribution on 1 degree of freedom, gives a p-value less than 0.001 besides the between region variance decreased from 6.694, in the empty multilevel model, to 5.081. So some of the variation in experiencing stillbirth between regions is explained by differences in their fixed predictor variables and this indicates that the random intercept multilevel model is found to give a better fit as compared to the empty model for predicting experiencing stillbirth among regions in Ethiopia.

The fixed part, in the output (Table 7), shows that age group (p-value = 0.000), type of place of residence (p-value = 0.014), antenatal care visit (p-value = 0.039) and delivery place (p-value = 0.047) were found to be statistically significant factors for experiencing stillbirth. The result is trying to tell also that those women aged above 35 years are more likely to experience stillbirth than those at lower age. Women who are from urban societies in Ethiopia are found to experience fewer stillbirths than those from rural area. Visiting antenatal care for at least once is found to decrease the probability of experiencing stillbirth. And delivering at health center rather than delivering at home brought about less likely to experience stillbirth.

TABLE 7: Result of Multilevel Random intercept model.

$$\boldsymbol{StillbirthExp_{ij}} \sim \boldsymbol{Binomial(denom_{ij}, \pi_{ij})}$$
$$logit(\pi_{ij}) = \beta_{0j} cons + \mathbf{0.590(0.168)25\text{-}34_{ij}} + \mathbf{1.190(0.184)35+_{ij}} + \mathbf{-0.398(0.181)Urban_{ij}} + -0.236(0.153) Normal + 0.207(0.279)\, Overweight/Obese_{ij} + -0.217(0.151) Primary_{ij} + -0.370(0.250)\, Secondary \,\&\, Higher_{ij} + 0.350(0.303) Multiparas_{ij} + \mathbf{-0.950(0.223)Visited\ ANC\ at\ least\ once_{ij}} + \mathbf{-0.912(0.232)\ Delivered\ at\ Health\ center_{ij}} + 0.489(0.369) Caesarean\ section_{ij} + 0.122(0.149) Anemic_{ij} + 0.486(0.330) Job\ Yes_{ij}$$
$$\beta_{0j} = \mathbf{-4.800(0.229)} + u_{0j}$$
$$[u_{0j}] \sim N(0, \Omega_u) \; : \; \Omega_u = [\mathbf{5.081(0.384)}]$$
$$var(StillbirthExp_{ij} \backslash \pi_{ij}) = \pi_{ij}(1 - \pi_{ij})/denom_{ij}$$

Bold are those variables which are significant at α = 0.05.

The Intra-class (Intra-region) correlation coefficient or, in other words, variance partition coefficient can be calculated as $ICC = \frac{\delta_{uo}^2}{\delta_{uo}^2 + 3.29} = \frac{5.081}{5.081 + 3.29} = 0.607$. The result shows that 60.7% of the residual variation in the propensity to experience stillbirth is attributable to differences between regions the rest 39.3% variation were due to variations within regions or women factors. This implies that between regions variations are higher than within region variations for experiencing stillbirth.

RESULTS OF RANDOM COEFFICIENT LOGISTIC REGRESSION MODEL

The random coefficient logistic regression model is a multilevel model which has random intercept, like the random intercept model, and random coefficient of predictors, unlike the random intercept model. In random intercept model we allowed the intercept only to vary across regions by fixing explanatory covariates, But the relation between explanatory and dependent variables can differ between groups (regions in our case) in many ways, for example, in experiencing stillbirth (nesting structure: women within regions) it is possible that the effect of place of residence of a woman on experiencing stillbirth is stronger in some regions than in others. In the analysis of covariance, this phenomenon is known as heterogeneity of regression across groups by covariate interaction. In the hierarchical linear models it is modeled by random slopes.[22]

As can be seen from the output (Table 8), the variance component of the intercept is 5.081 with its standard error 0.384, which is unchanged from the random intercept model, and that of the slope of type of place of residence is 0.000, which is the same to its standard error, thus, this suggests that the effect of type of place of residence is not random. We have also tried to make the other variables random but found none to be significant. This shows that the random coefficient model is not appropriate model. Thus, the random intercept multilevel logistic model is found to best fit the data.

DISCUSSION

This study has intended to model determinants of experiencing stillbirth among women in child bearing age group of Ethiopia using the Ethiopian demographic and health Survey data. Accordingly, different models are fitted to the data to identify potential determinants of experiencing stillbirth among women in reproductive age group. First, the bivariate chi-square test of association was fitted to the data and significant variables were considered for further investigation in binary logistic regression model. Lastly,

TABLE 8: Result of multilevel random coefficient model.

$$StillbirthExp_{ij} \sim Binomial(denom_{ij}, \pi_{ij})$$

$$logit(\pi_{ij}) = \beta_{0j}cons + 0.590(0.168)25\text{-}34_{ij} + 1.190(0.184)35+_{ij} + \beta_{3j}Urban_{ij} + -0.236(0.153)Normal + 0.207(0.279)\ Overweight/Obese_{ij} + -0.217(0.151)Primary_{ij} + -0.370(0.250)\ Secondary\ \&\ Higher_{ij} + 0.350(0.303)Multiparas_{ij} + -0.950(0.223)Visited\ ANC\ at\ least\ once_{ij} + -0.912(0.232)\ Delivered\ at\ Health\ center_{ij} + 0.489(0.369)Caesarean\ section_{ij} + 0.122(0.149)Anemic_{ij} + 0.486(0.330)Job\ Yes_{ij}$$

$$\beta_{0j} = -4.800(0.229) + u_{0j}$$

$$\beta_{3j} = 0.398(0.181) + u_{3j}$$

$$\begin{bmatrix} u_{0j} \\ u_{3j} \end{bmatrix} \sim N(0, \Omega_u) : \Omega_u = \begin{bmatrix} 5.081(0.384) & 0.000(0.000) \\ 0.000(0.000) & 0.000(0.000) \end{bmatrix}$$

$$var(StillbirthExp_{ij} \backslash \pi_{ij}) = \pi_{ij}(1 - \pi_{ij})/denom_{ij}$$

the multilevel models were fitted; the multilevel model was step wise, on the first step the intercept only or the empty model was fitted to check whether multilevel effects or heterogeneity exists among the hierarchies. The next step was fitting random intercept and fixed slope model, usually called random intercept model, and finally the random intercept and random slope (random slope model) is fitted. The results are discussed in the following paragraphs.

This study revealed that the rate of experiencing stillbirth among women of child bearing age was about 25.5 per 1000 deliveries in Ethiopia consistent with the world health statistics 2013 report which revealed a stillbirth rate of 26/1000 deliveries and was also almost consistent with a large review of data for 190 countries which estimated a stillbirth rate of 32/1000 deliveries in South Asia and Sub-Saharan Africa.[6]

Among the factors, mode of delivery and occupation were found to have a significant association with experiencing stillbirth only in the bivariate analysis; And factors like education level, parity, body mass index (BMI) and anemia level were significantly associated with experiencing stillbirth also in binary logistic regression which is consistent with most of the studies in the literature.[24,25,27] But, these factors were not significant in the best model, which is the multilevel random intercept logistic regression model. This might be due to methodological differences, in which the grouping variable, region, was significantly associated with experiencing stillbirth so that we used multilevel analysis, and time gap between the current and earlier surveys, in which some of the factors might be improved. But further studies are required to confirm these findings.

The rate of experiencing stillbirth in Tigray, Amhara, Oromiya, SNNP, Gambela, Harari and Dire Dawa were not significantly differing from that in Addis Ababa. This might be because of most of these regions are similarly developed as Addis Ababa. Women who live in Afar, Somali and Benishangul-Gumuz regions were significantly more likely to experience stillbirth than those women living in Addis Ababa which might be because of they were disadvantaged regions in the past reigns.

This study revealed that experiencing stillbirth among women was significantly associated with the age group they are found in. Women in higher age group, especially those above 35 years, are more likely to experience stillbirth than those at lower age group. This finding was consistent with a study done using available data from 6 study sites of The Newborn Cross-Sectional Study (NCSS), component of Intergrowth-21st, maternal age >40 (OR: 2.52).[25] Review of researches done on five clinical sites in America stated that the stillbirth rate is increased two-fold for women 35–39 years of age, and 3- to 4-fold for women aged forty or older. While some age-associated risk is due to higher rates of maternal complications, in uncomplicated pregnancies there may be a 50 percent increased risk associated only with maternal age ≥35. For older women, stillbirth risk rises more rapidly as gestational age increases beyond 37 weeks.[24] A prospective study done in Nigeria also revealed that 35 years and above pregnancy was important factor contributing to high stillbirth rate.[27] And almost all researchers in the literature agree in that advanced maternal age is contributing factor to high stillbirth rate.

Women's place of residence was found to be significantly associated with experiencing stillbirth. Those women residing in rural areas were found to be more likely to experience stillbirth than those in urban areas which might be for the reason that in rural areas there is lack of a skilled attendant at

delivery, lack of education, lack of full information and so on. This finding was in line with the finding of review of causes, risk factors and prevention strategies of stillbirth in developing countries.[28]

Experiencing stillbirth was also significantly associated with utilization of antenatal care (ANC). Visiting antenatal care for at least once is found to decrease the probability of experiencing stillbirth. This finding has an agreement with a cross-sectional retrospective analysis of stillbirth among women delivering in University of Maiduguri teaching hospital (UMTH), east Nigeria in which lack of antenatal care visit (OR: 1.91) had increased the rate of experiencing stillbirth.[29] A research finding also revealed that lack of antenatal care had positive association with stillbirth.[30] In the binary logistic analysis done in Hawassa University Hospital, southern Ethiopia, both the crude and adjusted analysis showed that the stillbirth rate was highest among mothers who had no ANC follow up.[31]

The best model of the study, random intercept model, found also that place of delivery was significant factor for experiencing stillbirth. Delivering at health center rather than delivering at home brought about less probability to experience stillbirth. This finding was consistent with a prospective study entitled 'Causes of stillbirth in a community survey in Gombe State', Nigeria.[30] This happens because when mothers deliver at home, they might not find skilled attendant and in difficult case there is no other choice like caesarean section in health centers.

CONCLUSION

The purpose of this study has been to assess socio-economic, demographic, and medical factors associated with stillbirth and to estimate the within-regional and between-regional level of difference for the rate of stillbirth in Ethiopia. The descriptive result showed that 25.5 per 1000 deliveries were stillbirth.

In this study single level and multilevel logistic regression were used. In the single level logistic regression model, region of residence, maternal age, place of residence, education level, parity, antenatal care utilization, place of delivery, body mass index (BMI) and anemia level were found to be significantly associated with experiencing stillbirth. Women of older ages are vulnerable to experiencing stillbirth.

Women are considered as nested with in the various regions. Chi-square test of association was done to see if there is association between experiencing stillbirth and region of residence and since it revealed that region of residence was associated with experiencing stillbirth, we are obliged to take multilevel logistic regression as better model to fit the data well.

Fitting the three multilevel logistic regression models, it was found that the random intercept model provided the best fit for the data under consideration. It showed that 60.7% of the residual variation in the propensity to experience stillbirth is attributable to differences between regions the rest 39.3% variation were due to variations within regions or women factors, which implies that between regions variations are higher than within region variations for experiencing stillbirth. The significant determinants of prevalence of stillbirth among regions, using this model, were age group (p-value=

0.000), type of place of residence (p-value= 0.014), utilization of antenatal care visit (p-value= 0.039) and place of delivery (p-value= 0.047).

RECOMMENDATIONS

Based on the findings of this study we forward the following recommendations to whom it my concern:

- First and for most all mothers should take care of their health condition when they become pregnant, during pregnancy and when approaching to labour. This can be made by utilizing antenatal care in health centers.
- Mothers should prefer and people who are around them should advise them to give birth at health centers than delivering at home.
- Those older age women, above 35 years, should be more careful for difficulties that come with age, like hypertension and should visit antenatal care during pregnancy.
- The government should facilitate infrastructures to teach and inform women, especially those residing in rural areas about the silent killer stillbirth that it is not because of an evil spirit called "Wukabi".

Therefore, this study is important in the following ways: First it provides an alternative model that can preferably represent the current data set to model experiencing stillbirth among women in Ethiopia. Secondly, it provides information about factors leading to stillbirth and variations across regions and finally, it points out that further studies should be conducted to incorporate spatial variations in experiencing stillbirth, by utilizing other models such as Spatial Models and Geo-additive models to investigate spatial variations of contraceptives use in the country.

Conflict of Interest

Authors darecled no conflict of interest or financial support.

Authorship Contributions

Habtamu Gebremariam Gebresilassie *made contributions on conceptualized the research problem, designed the study, performed statistical analysis, interpretation of data and revised & drafting the manuscript.*

Kidanemariam Alem Berhie *was involved in, re- vision of the research design, data analysis and revision of the manuscript for publication. All authors read and approved the final manuscript.*

REFERENCES

1. Robinson GE. Pregnancy loss. Best Pract Res Clin Obst Gynaecol 2014;28(1):169-78.
2. Nguyen RH, Wilcox AJ. Terms in reproductive and perinatal epidemiology: 2. perinatal terms. J Epidemiol Community Health 2005;59(12):1019-21.
3. Frøen JF, Friberg IK, Lawn JE, Bhutta ZA, Pattinson RC, Allanson ER, et al; for The Lancet Ending Preventable Stillbirths Series Study Group. Stillbirths: progress and unfinished business. Lancet 2016;387(10018):574-86.
4. Frøen JF, Cacciatore J, McClure EM, Kuti O, Jokhio AH, Islam M, Shiffam J. Stillbirths: why they matter. Lancet 2011;377(9774):1353-66.
5. Lawn JE, Blencowe H, Pattinson R, Cousens S, Kumar R, Ibiebele I, et al. Stillbirths: Where? When? Why? How to make data count? Lancet 2011;377(9775):1448-63.
6. Stanton C, Lawn JE, Rahman H, Wilczynska-Ketende K, Hill K. Stillbirth rates: delivering estimates in 190 countries. Lancet 2006;367(9521):1487-94.

7. Cousens S, Blencowe H, Stanton C, Chou D, Ahmed S, Steinhardt L, et al. National, regional, and worldwide estimates of stillbirth rates in 2009 with trends since 1995: a systematic analysis. Lancet 2011;377(9774):1319-30.
8. Engmann C, Garces A, Jehan I, Ditekemena J, Phiri M, Mazariegos M, et al. Causes of community stillbirths and early neonatal deaths in low-income countries using verbal autopsy: an international, multicenter study. J Perinatol 2012;32(8):585-92.
9. Berhane Y, Hogberg U. Prolonged labor in rural Ethiopia: a community base study. Afr J Reprod Health 1999;3(2):33-9.
10. Daniel B, Hakim LY. Still birth at Tikur Anbessa Hospital a retrospective study. Ethiopian J Health Dev 2008;2(15):25-34.
11. Ethiopia Demographic and Health Survey 2005. Central Statistical Agency Addis Ababa, Ethiopia.Chapter 4, Fertility. ORC Macro Calverton, Maryland, USA. 2005. p.47-55
12. Addis Ababa Health Bureau. Family health team annual report for 2006. Addis Ababa, Ethiopia. 2006.
13. Tegegne BA, Enquoselassie F, Yusuf L. Birth to pregnancy interval and its effect on perinatal outcomes in Addis Ababa, Ethiopia. Ethiop J Repro Health 2010;4(1):37-51.
14. McClure EM, Nalubamba-Phiri M, Goldenberg RL. Stillbirth in developing countries. Int J Gynaecol Obstet 2006;94(2):82-90.
15. Sisay MM, Yirgu R, Gobezayehu AG, Sibley LM. A qualitative study of attitudes and values surrounding stillbirth and neonatal mortality among grandmothers, mothers, and unmarried girls in rural Amhara and Oromiya regions, Ethiopia: unheard souls in the backyard. J Midwifery Womens Health 2014;59 Suppl 1:S110-7.
16. World Health Organization (WHO). The World Health Report 2005. Make Every Mother and Child Count. Geneva: WHO Press; 2005. p.211. Available from: http://www.who.int/whr/2005/mediacentre/slides en.pdf
17. Goldenberg RL, McClure EM, Bhutta ZA, Belizán JM, Reddy UM, Rubens CE, et al; Lancet's Stillbirths Series steering committee. Stillbirths: the vision for 2020. Lancet 2011;377(9779):1798-805.
18. Central Statistical Agency (Ethiopia) and ICF International, 2012. Ethiopia Demographic and Health Survey 2011. Addis Ababa, Ethiopia and Calverton, Maryland, USA: Central Statistical Agency and ICF International; 2012. p.327.
19. Guo G, Zhao H. Multilevel modeling for binary data. Annu Rew Sociol 2000;26(22):441-62.
20. Agresti A. Categorical Data Analysis. 1st ed. New York: John Wiley & Sons; 1990. p.576.
21. Commenges D, Jacqmin H. The intraclass correlation coefficient distribution free definition and test. Biometrics 1994;50(2):517-26.
22. Snijders TAB, Bosker RJ. Multilevel Analysis: An Introduction to Basic and Advanced Multilevel Modeling. Department of Statistics, University of Poone. 1st ed. London: Sage Publications; 1999. p.266.
23. Scott M. Applied Logistic Regression Analysis. Sage University Paper series on Quantitative Applications in the Social Sciencies. No: 07-106. 2nd ed. Beverly Halls, CA: Sage; 2002. p.111.
24. Silver RM, Varner MW, Reddy U, Goldenberg R, Pinar H, Conway D, et al. Work-up of stillbirth: a review of the evidence. Am J Obstet Gynecol 2007;196(5):433-44.
25. Finkton Jr DW. The epidemiology of stillbirth: The INTERGROWTH-21st Newborn Cross-Sectional Study. MSc Research, University of Oxford; 2013.
26. Reddy UM, Laughon SK, Sun L, Troendle J, Willinger M, Zhang J. Prepregnancy risk factors for antepartum stillbirth in United States. Obstet Gynecol 2010;116(5):1119-26.
27. ACOG Practice Bulletin No. 102. Management of stillbirth. Obstet Gynecol 2009;113(3):748-61.
28. McClure EM, Saleem S, Pasha O, Goldenberg RL. Stillbirth in developing countries: a review of causes, risk factors and prevention strategies. J Matern Fetal Neonatal Med 2009;22(3):183-90.
29. Audu BM, Alhaji MA, Takai UI, Bukar M. Risk factors for stillbirths at universty of Maiduguri teaching hospital, Maiduguri, Nigeria: A cross-sectional retrospective analysis. Niger Med J 2009;50:42-6
30. Alkali YS, Jalo I, El-Nafaty AU, Bode-Thomas F. Causes of stillbirth in a community survey in Gombe State. Niger J Paed 2014;41(2):125-8.
31. Bayou G, Berhan Y. Perinatal mortality and associated risk factors: a case control study. Ethiop J Health Sci 2012;22(3):153-62.