



LOGISTIC REGRESSION ON THE PRIMIPARAL AGE OF WOMEN IN GOMBE, GOMBE STATE

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Abstract:

Failure of women to undergo a successful first child delivery is becoming one of the most challenging problem and a major concern to most of our healthcare providers. In this paper, we apply the binary logistic regression analysis to investigate whether age of women at first birth have a relationship with the outcome of their delivery (Success or failure). The data was collected from Gombe Town Maternity and was subjected to analysis. From the result of the analysis, we observed that most of the women at tender age (12-17) are classified to fail (69%) during their first child delivery while most of the women at higher age (19 and above) have a better chance of succeeding during their first parturition. Also, the result shows that the average age at which women ought to conceive successfully is 19 years. The Wald statistics result also shows that the logistic regression model fits the data very well.

Keywords: Age; Primipara; Logistic Regression.

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1. Introduction

Age at first birth (**primiparal age**) is the age of mothers at the birth of their first child or the age at which a woman gives birth to her first offspring or child. It is the useful indicator for gauging the success of family planning programs aiming to reduce the ever increasing maternal mortality, increase contraceptive use particularly among unmarried adolescents, delay age at first marriage and improve the health of newborns.

Failure of women (especially those at their tender ages) to undergo a successful delivery during their first childbirth is one of the most challenging problems nowadays. Early maternal age at first birth may have long-term consequences for the health of women as they age. It is a known risk factor for obstetrical complications with lifelong associated morbidities. It may also be related to diabetes and cardiovascular disease development which surely needs to be addressed. The younger the mother is the greater risk to her and her child/baby. The risk of maternal failure related to the pregnancy and childbirth for adolescent girls between 13 and 18 years of age accounts for numerous sorts of problems during parturition (World health organization, 2007). For adolescents under 13 years of age these risks increase substantially. Girls who give birth before age 15 are five

times more likely to have complications in childbirth than women in their twenties (Meekers, 2002).

Although some of the women give birth at a matured age, most teenage girls would have given birth for the first child at age 18 or so regardless of their religious belief, custom, tradition, family values, economic strength (wealthy or impoverished) and perhaps family strata in the community (WHO, 2010).

2. Literature Review

In this section we discuss discusses the relevant literature which highlight on the definition, history of age at first birth at well as reviews of some scholars and methods they used to analyze the age at first birth of women.

2.1. Meaning of Age at First Birth

Maliki (2012) defines age at first birth of is the age a woman gives birth to her first offspring after conceiving. Mean age of women at fist birth means the mean age of women delivering their first child (live birth).

For a given calendar year, the mean age of women at first child can be calculated using fertility rates for first births by age (in general, the reproductive period is conventionally defined between 14 and 50 years of age). While birth is defined as the start of life when a child emerges from the body of its mother, the total number of births includes both live births and stillbirths (Salako et al., 2006).

Therefore, age at first birth of women has a lot to do with the ups and downs and the ever increasing failure of women that causes death, relapse or the development of a given disease or an unwanted situation during delivery, (Parturition).

2.2. Effects of Age at First Birth

It is believed that pregnancy can take place as soon as a female gets to the age of puberty, with menarche (first menstrual period) normally taking place around age 12 or 13 (Onyiriuka, et al., 2012). Sixty percent (60%) of girls have their first sexual intercourse before their 13th birthday (Guttmacher Institute, 2004 and Maliki, 2012). Studies have shown that substantial numbers of teenagers have a positive or ambivalent attitude towards pregnancy (Jaccard et al., 2003, Condon et al., 2001, Stevens-Simon et al., 1996). Teenage pregnancies and births during adolescence are considered risky and the teenage birth rate is deemed an indicator of reproductive health politics (Kirchengas, 2009). However, teenage pregnancy and its attendant problems are more prevalent in developing countries than in the developed nations. More than one third of women from developing countries gave birth before the age of 20 (Hanna, 2001; Furstenberg, 1998; Singh and Darroch (2000). Adolescents who have completed at least 7 years of schooling (in developing countries) are more likely to delay marriage until after the age of 18 years (Salako et al., 2006), and this possibly increases the length of time that they are exposed to the risk of adolescent pregnancy.

Although sexual activities among the adolescents are widespread around the world, the determinants and consequences are likely to vary from one region to another. Early pregnancies are more pronounced and detrimental in Sub-Saharan African (SSA) countries, most of which experience high levels of poverty (Maureen Were, 2007). Nigeria has been one of the countries where the prevalence of teenage pregnancy is high. Studies have documented results on this from various part of the country.

2.3. Risks Associated with Birth at Tender Ages

Teenage pregnancy or pregnancy during adolescence (aged 10-19 years) has been a public health concern both in developed and developing countries (Sayem and Nury, 2011). The rates of adolescent pregnancy have been on the increase, particularly in the poorest countries (World Health Organization, 2008), and this has posed a great threat and danger to child development. According to the American College of Obstetricians and Gynecologist,

Approximately 750,000 of 15-19-year-olds become pregnant each year (Langham, 2010).

UNICEF (2001) reports that more than 10% of all births worldwide occur to adolescent mothers. Every year over 500,000 women die from pregnancy and childbirth complications (WHO, 2007). For every woman who dies, approximately 20 more develop infections and severe disabling problems – adding up to more than 10 million women affected each year. Access to and use of family planning services could prevent many of these complications and disabilities.

The younger the mother is, the greater the risk to her and her baby. The risk of maternal death related to pregnancy and childbirth for adolescent girls between 15 and 19 years of age accounts for some 70,000 deaths each year. For adolescents under 15 years of age these risks increase substantially. Girls who give birth before age 15 are five times more likely to die in childbirth than women in their twenties (Meekers, 2002).

3. Methodology

The selection of variables was done using the method of logistic regression analysis. Logistic regression analysis consists of several models and the use of each model depends on the nature of data. For the purpose of this study binary logistic regression models was adopted. These models are appropriate when the response takes one of only two possible values representing success and failure, or more generally the presence or absence of an attribute of interest.

Generally, the dependent or response variable in logistic regression is dichotomous, such as presence/absence or success/failure but the multinomial logistic regression also exists to handle situations with more than two dependent variables such as low/medium/high. (McCullough, & Nelder, 1989).

The logistic regression model assumes that the log-odds of an observation y can be expressed as a linear function of the K input variables x :

$$\log \frac{P(\mathbf{x})}{1 - P(\mathbf{x})} = \sum_{j=0}^K b_j x_j$$

Let's take the exponent of both sides of the logit equation.

$$\begin{aligned} \frac{P(\mathbf{x})}{1 - P(\mathbf{x})} &= \exp\left(\sum_{j=0}^K b_j x_j\right) \\ &= \prod_{j=0}^K \exp(b_j x_j) \end{aligned}$$

We can also invert the logit equation to get a new expression for P(x):

$$\begin{aligned} P(\mathbf{x}) &= \frac{\exp z}{1 + \exp z}, \\ z &= \sum_{j=0}^K b_j x_j \end{aligned}$$

The right hand side of the top equation is the sigmoid of z , which maps the real line to the interval $(0, 1)$, and is approximately linear near the origin. A useful fact about $P(z)$ is that the derivative $P'(z) = P(z)(1 - P(z))$. Here's the derivation:

$$\begin{aligned} P(z) &= \frac{\exp z}{1 + \exp z} = (\exp z)(1 + \exp z)^{-1} \\ P'(z) &= (\exp z)(1 + \exp z)^{-1} + (\exp z)(-1)(1 + \exp z)^{-2}(\exp z) \\ & \hspace{15em} \text{(by chain rule)} \\ &= \frac{(\exp z)(1 + \exp z)}{(1 + \exp z)^2} - \frac{(\exp z)^2}{(1 + \exp z)^2} \\ &= \frac{\exp z}{(1 + \exp z)^2} \\ &= \frac{\exp z}{1 + \exp z} \cdot \frac{1}{1 + \exp z} \\ &= P(z)(1 - P(z)) \end{aligned}$$

Later, we will want to take the gradient of P with respect to the set of coefficients \mathbf{b} , rather than z . In that case, $P'(z) = P(z)(1 - P(z))z'$, where $'$ is the gradient taken with respect to \mathbf{b} .

The solution to a Logistic Regression problem is the set of parameters that maximizes the likelihood of the data, which is expressed as the product of the predicted probabilities of the N individual observations.

$$L(X|P) = \prod_{i=1, y_i=1}^N P(\mathbf{x}_i) \prod_{i=1, y_i=0}^N (1 - P(\mathbf{x}_i))$$

(X, y) is the set of observations; X is a $K+1$ by N matrix of inputs, where each column corresponds to an observation, and the first row is $\mathbf{1}$; y is an N -dimensional vector of responses; and (\mathbf{x}_i, y_i) are the individual observations.

It's generally easier to work with the log of this expression, known (of course) as the log-likelihood.

$$\mathcal{L}(X|P) = \sum_{i=1, y_i=1}^N \log P(\mathbf{x}_i) + \sum_{i=0, y_i=0}^N \log(1 - P(\mathbf{x}_i))$$

Maximizing the log-likelihood will maximize the likelihood. As a side note, the quantity $-2 \times \log$ -likelihood is called the *deviance* of the model. It is analogous to the residual sum of squares (RSS) of a linear model. Ordinary least squares minimize RSS; logistic regression minimizes deviance.

3.1. Case of Success and Failure

We consider the first case where the response y_i is binary (Binomial distribution), assuming only two values that for convenience we code as one or zero. For example we could define

$$y_i = \begin{cases} \mathbf{1} & \text{if the } i^{\text{th}} \text{ woman deliver successfully} \\ \mathbf{0} & \text{otherwise (referred)} \end{cases}$$

Successful means the number of women that underwent a perfect and complication-free delivery.

Referred means the number of women that could not deliver on their own. That is they met numerous sort of problems that include failure to progress which may lead to Cs, excessive blood loss, perennial lacerations, abnormal fetal heart rate, amniotic cavity issues and eventual Death. etc.

$$\text{Now, } Y_i \sim B(n_i, \pi_i).$$

The probability distribution function of Y_i is given by

$$\Pr \{Y_i = y_i\} = \binom{n_i}{y_i} \pi_i^{y_i} (1 - \pi_i)^{n_i - y_i},$$

$$\text{For } y_i = 0, 1, \dots, n_i.$$

Here $\pi_i^{y_i} (1 - \pi_i)^{n_i - y_i}$ is the probability of obtaining y_i successes and $n_i - y_i$ failures in some specific order, and the combinatorial coefficient is the number of ways of obtaining y_i successes in n_i trials.

The mean and variance of Y_i can be shown to be

$$E(Y_i) = \mu_i = n_i \pi_i$$

$$\text{Var}(Y_i) = \sigma_i^2 = n_i \pi_i (1 - \pi_i)$$

3.2. Odds and Logits Transformation

The odds function is the strategy that is often used to streamline the work of logistic regression. The odds function makes use of which odds of an event is defined as the ratio of the probability that an event occurs to the probability that it fails to occur.

Thus,

$$\text{Odds (case=1)} = \frac{p(\text{case}=1)}{1-p(\text{case}=1)} = \frac{\pi_i}{1-\pi_i}$$

If Odds >1 it means the underlined event is more likely to be success

If Odds <1 it means the underlined event is less likely to be failure

If Odds =1 it means both events have the same chance of occurring

For logits transformation,

$$\text{We Let } \mathbf{Y} = \frac{e^{a+bX}}{1+e^{a+bX}}$$

$$\text{Where } \ln(\text{ODDS}) = a+bX = \frac{\pi_i}{1-\pi_i}$$

$$\text{And } e^{a+bX} = \text{the ODDS ratio}$$

$$\text{Then, } \mathbf{Y} = \frac{\text{odds}}{1+\text{odds}} \text{ is the predicted probability of success or failure.}$$

4. Data Analysis

The data collected was a secondary data collected from the Records section of Gombe State primary Health care (Town Maternity). The data includes the various ages of women, Outcome of their delivery (Successful or Referred), weights, blood pressure, educational background etc that attended the hospital during the period of the past 12 months. But only women that came for first delivery were considered.

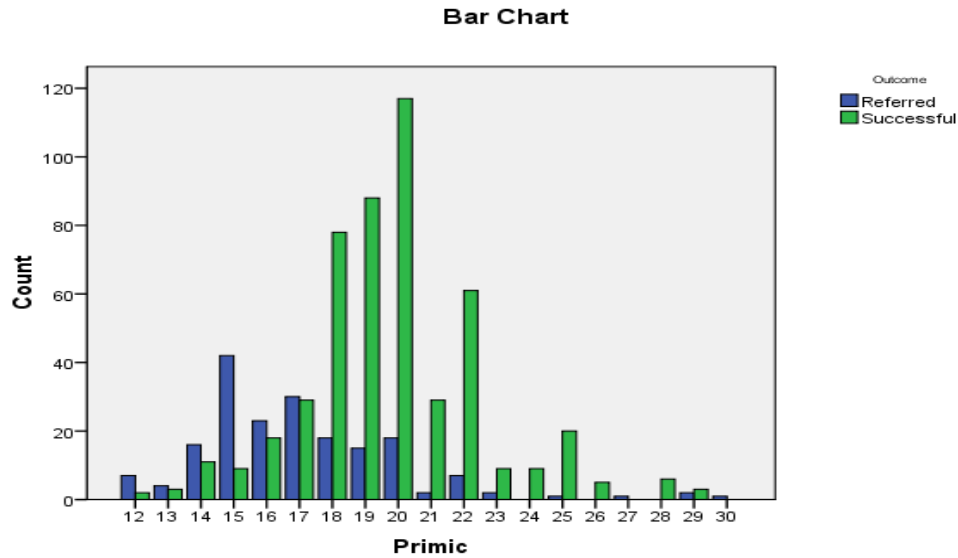


Figure 1: Bar Chart Showing the Rate of Outcome of Delivery at Each Respective Age

The green bars shows the rates of successful women during delivery according to their ages while the blue bars shows the rates of women that failed to deliver successfully (Referred). The x-axis entails the primiparal ages of the women while the y-axis entails the respective rates of success and failure.

Table 2 shows that Subjects referred at tender/higher age were coded as (0) while Subjects that were successful at tender/higher age as (1).

Dependent Variable Encoding	
Original Value	Internal Value
Referred	0
Successful	1

Let “a” denote the given constant, “b” denote the intercept-only model and let “X” be the outcome of the delivery (Success=1, Refer=0).

Table 3: The respective values of a constant and that of the slope

Variables in the Equation							
		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1 ^a	Primic	-1.62	.040	94.122	1	.000	.198
	Given Constant	.83	.727	72.777	1	.000	2.293

Then the variables in the equation output (table 3) shows that the Logistic regression equation is given by;

$$Y = \frac{e^{a+bX}}{1 + e^{a+bX}}$$

Where e^{a+bX} = the ODDS ratio

$$\begin{aligned} \therefore \ln(\text{ODDS}) &= a+bX \\ &= e^{a+bX} \text{ or} \\ \text{ODDS} &= \frac{\pi}{1-\pi} \end{aligned}$$

Where a, b and X are as defined above, while (ODDS) means the ratio of success to failure and vice versa (logit).

We can now use the model to predict the *ODDS* that a subject of a given age (tender/higher) will deliver successfully or fail.

The *ODDS* prediction equation is as stated above, therefore;
If our subject is in her tender ages then (Refer = 0);

$$\begin{aligned} \text{ODDS} &= e^{a+bX} \\ \text{Where} \\ a &= 0.83, b = -1.62 \text{ and } X = 0, \text{ Now} \\ &e^{0.83 + (-1.62)(0)} \\ &= e^{0.83} = 2.2933. \end{aligned}$$

That is, a woman at her tender ages is 2.2933 times more likely to fail (to be referred) as she is to make a successful delivery.

Also, if our subject is in her tender ages then (Successful = 1)

$$(\text{ODDS}) = e^{a+bX}$$

Where

$$\begin{aligned} a &= 0.83, b = -1.62 \text{ and } X = 1, \text{ Now} \\ &e^{0.83 + (-1.62)(1)} \\ &= e^{-0.79} = 0.4538. \end{aligned}$$

That is, a woman at her tender ages is only 0.4538 times more likely to succeed as she is to fail during her first delivery.

We can therefore simply convert our *ODDS* into probabilities using the formula

$$Y = \frac{e^{a+bX}}{1 + e^{a+bX}}$$

Where $e^{a+bX} = \text{ODDS}$,

$$\therefore Y = \frac{ODDS}{1+ODDS}, \text{ Now}$$

For Referred Subjects at tender ages we have;

$$Y = \frac{ODDS}{1+ODDS} = \frac{2.2933}{1+2.2933} = \frac{2.2933}{3.2933} = 0.69.$$

That means our model predicts that 69% of women giving their first birth at tender ages will fail to deliver successfully (will be referred).

Also, for Successful Subjects at tender ages we have;

$$Y = \frac{ODDS}{1+ODDS} = \frac{0.4538}{1+0.4538} = \frac{0.4538}{1.4538} = 0.31.$$

That means our model predicts that only 31% of the women giving their first birth at tender ages will deliver successfully without complications.

Table 4.5: Average Age Needed for Women to Highly Likely Succeed During First Parturition

Descriptive Statistics						
	N	Minimum	Maximum	Mean	Std. Deviation	Variance
Primipara	686	12	30	18.99	3.040	9.239

Table 4.5 shows that the maximum number of age out of the 686 women surveyed were 30 while least is 12. So also the average age 18.99~19 which means the average years that women ought to conceive from the underlined normal distribution of the ages should not be less than 19.

4.1. Discussion of the Result

From the result obtained in the analysis, the *odds* ratios shows that women at tender age are more likely to fail and less likely to succeed during parturition (2.2933) while women at higher age have a better chance of succeeding and are far less likely to fail (0.4538) during child delivery.

Correspondingly, the predicted/classified percentage of women at tender (12-17) ages to fail or succeed during parturition is 69% or 31% respectively and the reverse is the case for women at higher ages (19-30).

Therefore, the average age (out of the 686) women ought to get pregnant for the first time should be from age of 19 and above in order to avoid the first childbirth rapid-rising problems as shown in the analysis.

Also, the **Wald** statistic was found to be 94.122 which means the model fits the data very well.

5. Conclusion

The analysis of **primiparal age** of women using logistic regression shows that women at tender age (12-17) are more likely to fail and less likely to succeed during parturition while women at higher age (19 and above) have a better chance of succeeding and are far less likely to fail during child delivery. So also Wald statistics shows that model fits the available data really well. We can therefore generalize and conclude that women at tender age have a greater risk of failure during their first child delivery and the percentage for their rate of success and failure is 31% and 69% respectively. Also the average age for first birth is 19 for highly likely complication-free parturition.

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