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# Survival Analysis of Time to First Birth after Marriage

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**Abstract**

Of the joy and challenges people face in life, there is none which is more extraordinary than having a first child. The expectation of most women, especially married couples, is to have a child and the longer they keep without a child, the more frustrated they become. By using Non parametric survival analysis techniques and data from the 2008 Ghana Demographic and Health Survey (GDHS), this study considered only women of childbearing age (15-49 years), who went into marriage without a child or a pregnancy. The results showed that, at 0.1% level of significance, whether the wife had ever had an induced abortion or not, and her region of residence, are significant determinants of the waiting time to first birth for married women: Significant educational and family income differentials were also observed in the study. The results also show that, while most women (about 74%) have their first birth within the first three years of marriage, some women have their first child even after 10 years in marriage.

**Keywords**: Fertility, Waiting times, Pregnancy, Marriage, Survival

## 1. Introduction

Fertility is the natural capability of giving life and of all the joy and challenges people face in life, there is none which is more extraordinary than the occurrence of a first child. Being pregnant for the first time creates a lot of expectations in the minds of most women. The birth of the first child is the first visible outcome of fertility and serves as an event of great social and individual significance; its importance is recognized in all human societies. The first birth plays a significant role in the future life of each individual woman and her family; her overall fertility depends on it.

The waiting time to first birth from marriage, which is defined to be the time interval between the time of marriage and the time of occurrence of the first birth, is said to be highly influenced by several socio-economic and demographic factors [1]. Age at first marriage is often used as a proxy for the onset of women's exposure to the risk of pregnancy by some researches, but many women are sexually active before marriage. Therefore the age at which women initiate sexual intercourse marks the beginning of their exposure to reproductive risk more precisely. Others also identified an inverse relation between waiting time and the age at first marriage of a mother [2]. Several studies have shown of faster subsequent child bearing and an increase chance of unwanted births if the first child is born at an early age [3, 4, 5, 6]. On the other hand, delayed birth is shown to reduce completed family size, except perhaps for Russia where Turner [7], found fertility to be low despite early age at first birth and a lack of efficient contraceptives methods. Fundamental social, economic and cultural transformations, which have changed norms relating to family and reproduction, as well as personal values and practices, are shown to influence fertility and thus time to first birth [8, 1, 9, 10, 11]. Several studies have also shown the effect of education on the timing of a first birth [12, 13, 14, 15, 16, 23], these studies identified that high education strongly reduces the likelihood of first birth. The Ghana demographic and Health Survey [18], using basic descriptive statistics, reports that, place of residence (rural or urban), Region of residence, level of education of Mother as well as the wealth index, are key factors that influence first birth and overall fertility. However, most of these studies looked at time to first birth with respect to the age of the woman.

In this study, we focused on time to first birth from marriage. The waiting time of a woman to first birth after marriage, can determine the happiness and or survival of her marriage. While delayed births could lead to contention, suspicions and even breakups of marriages, very early births, especially the unexpected and unwanted ones, could do same or even worse. In most Ghanaian settings, a marriage is considered incomplete without children. Women are expected to show signs of pregnancy within the first year of marriage as a sign of fruitfulness. Because of this, several couples encounter problems from family and society if they have no children. This usually brings about misunderstanding in marriages and sometimes causes divorce.

The questions however remains, how long should a woman expect to wait to have her first child? And what are the associated risk factors for delayed first births? This study on the waiting time from marriage to first birth is made to answer these questions and could help reduce the anxiety and frustrations women encounter when they do not have children as early as they or society, expects. The use of survival analysis techniques in estimating the average time to first birth of wives in Ghana and to determine some factors that are associated with this

 

phenomenon is not only appropriate, but will provide more information and reliable estimates with measurable precision.

## 2. Data and Methods

### 2.1 Data Source

This research used data from the 2008 Ghana Demographic and Health Survey (GDHS) and considered only women of childbearing age (15-49 years). The study considered only women who went into marriage without a child or a pregnancy: Thus, less than nine months waiting times was excluded. In all, a total of 2,313 women age 15-49, from all the administrative regions of Ghana and stratified by rural and urban communities, formed the data for this study with 231 women being right censored.

### 2.2 Data Analysis Methods

This research employed Non parametric survival analysis technique in its data analysis. Three main survival analysis functions are used to describe the distribution of time to first birth; these are the survival function, the hazard function and the cumulative distribution function $F(t)$.

**Survival Function ($S(t)$)**

The survival function denoted $S(t)$ at a given time $t$ is given as:

$$S(t) = P(\text{a wife waits longer than t years to have her firts child})$$
$$= 1 - P(\text{a wife has her first child before time } t)$$

$$S(t) = P\{T > t\} = 1 - F(t) \qquad (1)$$

where $F(t) = P[T < t] = \int_0^1 f(t) = P[\textit{that a woman has her first child before time } t]$

is the cumulative density function of $T$.

**Probability Density Function (or Density Function)**

The probability density function of the survival time T, denoted $f(t)$, is defined as the probability that a wife has her first child in the short interval per unit time. It can be expressed as:

$$f(t) = \lim_{\Delta t \to 0} \frac{P[t \leq T < t + \Delta t]}{\Delta t} \qquad (2)$$

**Hazard Function ($h(t)$):** The hazard function denoted by $h(t)$ can be estimated using:

$$h(t) = \lim_{\Delta t \to 0} \frac{P(\textit{a woman has her first child in the time interval } (t,\ t+\Delta t) \textit{ given that she had not given birth before by time } t)}{\Delta t}$$

$$h(t) = \lim_{\Delta t \to 0} \frac{P[(t \leq T < t + \Delta t)/T \geq t]}{\Delta t}$$

$$h(t) = \frac{f(t)}{(1 - F(t))} = \frac{f(t)}{S(t)} \qquad (3)$$

**Estimation of Survival Functions**

 

In this study, the life table method was used to estimate the functions of survival analysis: Gehan's method **[19] for estimating the survival, hazard and the probability functions was used. Thus**

$$\hat{S}(t_i) = \prod_{j=1}^{i-1} (1 - \hat{q}_j)$$

$$\hat{f}(t_{mi}) = \frac{\hat{S}(t_i) - \hat{S}(t_{i-1})}{b_i} = \frac{\hat{S}(t_i)\hat{q}_i}{b_i}$$

$$\hat{h}(t_{mi}) = \frac{d_i}{b_i(n_i - \frac{1}{2}d_i)} = \frac{2\hat{q}_i}{b_i(1 - \hat{p}_i)}$$

where

$t_{mi}$ is the mid-point of the $i^{th}$ interval,

$d_i$ is the number of women dying in the $i^{th}$ interval,

$n_i$ is the number of women exposed in the $i^{th}$ interval,

$q_i = \frac{d_i}{n_i}$ is the conditional probability of dying in the $i^{th}$ interval,

$p_i = (1 - q_i)$ is the conditional probability of dying in the $i^{th}$ interval,

$b_i$ is the width of the $i^{th}$ interval

**The Log Rank Test**

The Log-rank test by Peto, R and Peto, J. [20], the most widely used technique when data is censored, was used to test the difference of survival functions. For a $k$ factor group, this test the hypothesis that;

$$H_o: S_1(t) = S_2(t) = \cdots = S_k(t) \quad \text{for all } t$$

Against the alternative;

$$H_1: \quad not\ all\ S_j(t)\ are\ equal.$$
$$j = 1, 2, .. k.$$

Where $S_j(t)$ is the survival function for the $j^{th}$ group

This is tested as a chi-square test which compares the observed numbers of first births to the expected number of first births under the hypothesis.

Thus, given that $O_j$ and $E_j$ is the observed and expected number of first births respectively for the $j^{th}$ group, the test statistic is given by;

$$\chi^2 = \sum_{j=1}^{k} \frac{(O_j - E_j)^2}{E_j}$$

where $E_j = \sum_{all\ t} e_{jt}$

$$e_{jt} = \frac{n_{jt}}{\sum_{all\ j} n_{jt}} \times d_t$$

and

$n_{jt}$ is the number of wives still not given birth at time up to $t$ for the $j^{th}$ group

$d_t$ is the total number of first births for all groups at time $t$. thus

 

$$d_t = \sum_{all\ j} d_{jt}$$

has approximately the chi-square distribution with $k-1$ degrees of freedom. The larger the value of the chi-square, the greater the difference between the survival curves and this could lead to a rejection of the null hypothesis in favor of the alternative that the $k$ groups do not have the same survival distribution.

**Cox Proportional Hazard Modeling**

The Cox proportional model is used to explore the relationship between the time to first birth after marriage of a wife and some explanatory variables. Cox model allows us to estimate the hazard (instantaneous chance of giving birth) for an individual given the prognostic variables. The Cox model is simply given by:

$$H_i(t;x) = H_0 e^{\beta_i x_i} \qquad (4)$$

where $H_i(t;x)$ is the hazard function at time $t$ for a subject with covariate $x_1, x_2, \ldots, x_k$ , $H_0(t)$ is the baseline hazard function and is defined as the hazard function when all the covariates are zero, the $\beta_i$'s are regression coefficients. Equation 4 can be expressed as

$$\ln(H(t;x)/H_0(t)) = (\beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_k X_k) \qquad (5)$$

where $H(t;x)/H_0(t)$ represents the hazard ratio and is the relative chance of giving birth.

## 3. RESULTS AND DISCUSSIONS

### Survival analysis


**Figure 1: Survival curve for time from marriage to first birth**

 

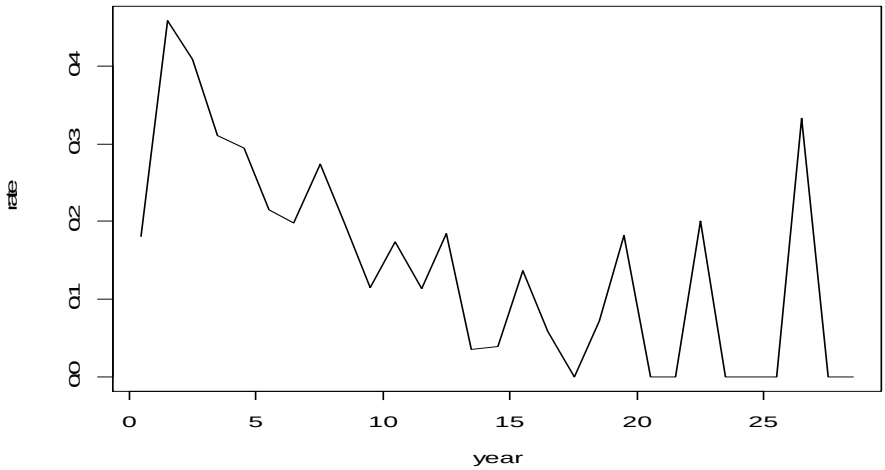


**Figure 2: Hazard plot of time from marriage to first birth**

 

**Table 1: Survival Distribution Table of Marriage to First Birth Interval**

| Time | $F(t)$ | $S(t)$ | SE for $F(t)$ & $S(t)$ | Time | $h(t)$ | SE for $h(t)$ |
|---|---|---|---|---|---|---|
| 1 | 0.181261 | 0.818739 | 0.008061 | 0.50 | 0.181261 | 0.008061 |
| 2 | 0.556854 | 0.443146 | 0.010516 | 1.50 | 0.458746 | 0.116870 |
| 3 | 0.738152 | 0.261848 | 0.009430 | 2.50 | 0.409115 | 0.016007 |
| 4 | 0.819638 | 0.180362 | 0.008371 | 3.50 | 0.311195 | 0.020168 |
| 5 | 0.872731 | 0.127269 | 0.007375 | 4.50 | 0.294372 | 0.024484 |
| 6 | 0.900176 | 0.099824 | 0.007612 | 5.50 | 0.215645 | 0.026743 |
| 7 | 0.919971 | 0.080029 | 0.006159 | 6.50 | 0.198300 | 0.030012 |
| 8 | 0.941905 | 0.058095 | 0.005425 | 7.50 | 0.274074 | 0.038390 |
| 9 | 0.953271 | 0.046729 | 0.004981 | 8.50 | 0.195652 | 0.041359 |
| 10 | 0.958650 | 0.04135 | 0.004757 | 9.50 | 0.115108 | 0.038283 |
| 11 | 0.965842 | 0.034158 | 0.004440 | 10.5 | 0.173913 | 0.049986 |
| 12 | 0.969723 | 0.030277 | 0.004261 | 11.5 | 0.113636 | 0.047845 |
| 13 | 0.975301 | 0.024699 | 0.003964 | 12.5 | 0.184211 | 0.062886 |
| 14 | 0.976152 | 0.023848 | 0.003917 | 13.5 | 0.034483 | 0.033883 |
| 15 | 0.977087 | 0.022913 | 0.003874 | 14.5 | 0.039216 | 0.038439 |
| 16 | 0.980212 | 0.019788 | 0.003742 | 15.5 | 0.136364 | 0.073165 |
| 17 | 0.981376 | 0.018624 | 0.003699 | 16.5 | 0.058824 | 0.057067 |
| 18 | 0.981376 | 0.018624 | 0.006990 | 17.5 | 0.000000 | 0.000000 |
| 19 | 0.982706 | 0.017294 | 0.003666 | 18.5 | 0.071429 | 0.068830 |
| 20 | 0.985850 | 0.01415 | 0.003611 | 19.5 | 0.181818 | 0.116291 |
| 21 | 0.985850 | 0.01415 | 0.003611 | 20.5 | 0.000000 | 0.000000 |
| 22 | 0.985850 | 0.01415 | 0.003611 | 21.5 | 0.000000 | 0.000000 |
| 23 | 0.988680 | 0.01132 | 0.003841 | 22.5 | 0.200000 | 0.178885 |
| 24 | 0.988680 | 0.01132 | 0.003841 | 23.5 | 0.000000 | 0.000000 |
| 25 | 0.988680 | 0.01132 | 0.003841 | 24.5 | 0.000000 | 0.000000 |
| 26 | 0.988680 | 0.01132 | 0.003841 | 25.5 | 0.000000 | 0.000000 |
| 27 | 0.992454 | 0.007546 | 0.004006 | 26.5 | 0.333333 | 0.272166 |
| 28 | 0.992454 | 0.007546 | 0.004006 | 27.5 | 0.000000 | 0.000000 |
| 29 | 0.992454 | 0.007546 | 0.004006 | 28.5 | 0.000000 | 0.000000 |

The results show that about 18% (probability of 0.181261) of married women give birth within the first year of marriage: This represents the proportion of wives who get pregnant within the first few months (about three months) of marriage. By the end of the second year of marriage, more than half of the married women had given birth (probability of 0.556854).

From the hazard distribution, Table 1, the chances of a woman having her first birth is very high within the second and third years of marriage but fluctuatingly declines as her years in marriage increases until about 20 years in marriage, where her chance fluctuatingly increases with time. The married woman's best chance of given birth is in the second year where the chances of a wife, who has never given birth before, giving birth for the first time is almost 46% (probability of 0.458746). This is closely followed by the third year in marriage where this chance is almost 41% (probability of 0.409115). Thereafter, their chances generally keep dwindling until about 20 years in marriage. About 74% of married women had their first baby within the first three years of marriage (probability of 0.738152). This probably is due to the pressure of family and society members, and or explains the reason for the pressure mounted on women to "prove" their fertility early in the marriage. Surprisingly, after 26 years of marriage without a child, a woman's chances of having her first child shoots up to a 1 in 3 chance (probability of 0.333333).

 

**Table 2: Log-rank test (comparing of survival distributions of age at first birth)**

| Variable | Log-rank test | | |
|---|---|---|---|
| | Chi-square | Df | P-value |
| Regions with maternal health intervention: yes/no | 14.6074 | 1 | 0.102 |
| Type of place of residence: urban/rural | 11.9852 | 1 | 0.001* |
| Highest educational level: no education, primary, secondary, post-secondary | 10.6549 | 3 | 0.031* |
| Ever terminated a pregnancy: yes/no | 14.7123 | 1 | 0.001* |
| Partners educational level: no education, primary, secondary, post-secondary | 27.2426 | 3 | 0.000* |
| Age at first marriage: grouped | 3.184 | 3 | 0.364 |
| Wealth index: poorest, poorer, middle, richer, richest | 16.866 | 4 | 0.002* |
| Age at first intercourse: grouped | 5.517 | 2 | 0.063** |

*: means significant at the 5% significance level
**: means significant at the 10% significance level

The association of the individual factors on time to first birth was tested using the Log-rank test. The results (Table 2) show that, the time to first birth significantly differed by type of place of residence, highest educational level of a wife, whether a woman has ever terminated a pregnancy, Partner's educational level and the wealth index of families $(p - value \leq 0.05)$. Other factors tested did not significantly differ in survival functions $(p - value \geq 0.05)$.

**Cox's Regression Analysis**

The joint effect of the factors studied on time to first birth was studied using Cox regression since there were censored data. The results, shown in Table 3, show that the region of Residence as well as whether a wife had ever terminated a pregnancy were significant determinants of time to first birth at the 10% significance level. While middle income or poorer families significantly differed from richest families in their waiting times, wives who had secondary education had significantly different waiting times as compared with wives with post-secondary education. However, type and place of residence, age at first marriage and age at first intercourse were not significant. The Parameter estimates show that wives from the regions with maternal health intervention and those who have ever terminated a pregnancy had significantly longer delayed time than their counter parts that have never terminated a pregnancy. Wives with secondary education and those of low and middle income families are also shown to have shorter waiting times when compared with wives with post-secondary education and of very high income families respectively.

**Table 3: Cox proportional Hazard regression of waiting time to first birth**

| **Explanatory variables** | **Level** | **β** | **SE** | **Wald Statistic** | **p-value** | **exp(β)** |
|---|---|---|---|---|---|---|
| Region with maternal health intervention | Yes | -0.156 | 0.053 | 8.751 | 0.003* | 0.855 |
| Type and place of residents | Rural | 0.093 | 0.060 | 2.362 | 0.124 | 1.097 |
| Educational level (compared with Post-Secondary Education) | | | | 3.590 | 0.309 | |
| | no education | -0.029 | 0.135 | 0.046 | 0.831 | 0.972 |
| | Primary | 0.085 | 0.063 | 1.835 | 0.175 | 0.972 |
| | Secondary | 0.108 | 0.062 | 3.029 | 0.082** | 1.115 |
| Wealth index (Compared with | | | | 5.863 | 0.201 | |

 

| | | | | | | |
|---|---|---|---|---|---|---|
| Richest families) | Rich families | 0.126 | 0.101 | 1.554 | 0.213 | 1.134 |
| | middle income families | 0.179 | 0.094 | 3.648 | 0.056** | 1.196 |
| | Poor families | 0.180 | 0.086 | 4.352 | 0.037* | 1.197 |
| | Poorest families | 0.148 | 0.078 | 3.625 | 0.057** | 1.160 |
| Ever terminated a pregnancy | No | 0.183 | 0.058 | 10.078 | 0.002* | 1.201 |
| Age at first marriage | | 0.012 | 0.008 | 2.3090 | 0.129 | 1.012 |
| Age at first intercourse | | -0.009 | 0.010 | 0.808 | 0.369 | 0.991 |

*: means significant at the 5% significance level
**: means significant at the 10% significance level

**Discussion and Conclusions**

This Study has used survival analysis techniques to study the waiting time to first birth after marriage of women, using the 2008 Ghana demographic and health survey data which contained both censored and uncensored responses. Non-parametric survival analysis techniques such as the life table, log-rank test and semi-parametric Cox proportional hazard regression analysis were used to estimate, investigate differences and determinants of waiting time to first birth after marriage. The Study revealed that, the median time to first birth for couples is 2 years after marriage and that a large portion of women gave birth within two years of marriage. This is in conformity with the expectations of most Ghanaian societies and the wider family members. Although most women gave birth within the first three years of marriage (about 74%), about 3% (0.033804) of married women gave birth for the first time after 10 years of marriage: This should provide hope for couples who have not yet given birth, especially those who are within the range of dates considered in this study.

The log-rank test also showed that the different levels of type of place of residence, educational levels of the wife, as well as that of the husband, whether the wife had ever terminated a pregnancy, as well as the wealth index of the family, were all risk factors of waiting time to first birth ($p-value \leq 0.05$). This is consistent with several studies [21, 22, 23, 17]. In her study, Laurie [22] suggested that the place of residence is a useful indication of change from traditional or rural behavior to modern behavior and that the first birth distribution for urban communities were more dispersed than those for rural distributions: These differences, she stated, are associated with differences in marriage and fertility timing between rural and urban communities and are partly an impact of educational differentials between rural and urban areas on age at first marriage. This study however showed that, independent of the timing of marriage, there were location, educational, wealth index and pregnancy history differentials.

On the other hand, the effect of the maternal morbidity and mortality intervention in some regions, the effect of lower incomes and the effect of induced abortions on early births were seen in the results of the Cox regression. The longer waiting times for wives who reside in the regions that benefitted from the maternal intervention, is more of an indication of planned parenthood as the intervention, which sought to make the use of contraceptives and maternal health care more available and easily assessable, could have the net effect of given mothers full control over when to have their baby. The effect of lower incomes, especially poverty, on time to first birth was also highlighted in this study, it is realized that wives from poor and middle income families have their first birth earlier as compared to those from high income families. This is consistent with studies made by Chen and Morgan [21] who stated that women who are less educated and living in poverty have their first births earlier than those of a higher educational and income background. The adverse relationship of ever having terminated a pregnancy on early births was also shown in this study and is as expected due to known risks associated with the termination of Pregnancies.

Results of the Cox regression also showed that the age at first marriage of a woman, her age at first intercourse, type and place of residence and the educational level of women, were shown not to significantly determine her chances of giving birth for the first time. Studies by [12, 13, 14, 15, 16, 17] which showed that higher education attainment strongly reduces the likelihood of having a first child early hence causing an increase in the age at first birth, may not be contrary to results obtained from this study as it is conceivable that while higher educational attainment could delay marriage, once a person got married, be it at an early age or later age, the waiting time to first birth might not be affected. The results on the effect of age at first sex on time to first birth after marriage are consistent with that of Arnold and Blanc [24]. Similarly studies by Ngalinda [2] may not be contradictory to this study as it is also conceivable that, once a woman got married, her chances of getting

 

pregnant were the same, independent of her age at first sex or her type and place of residence.

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