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Internal Medicine

Maternal Death in Delta State, Nigeria; Techniques of Survival Research

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Abstract	Original Research Article

This research has proposed the use of survival analysis techniques in achieving appropriate estimates of maternal mortality and its usefulness. The results of its request for data from Delta State, Nigeria, showed that although about 90% of pregnant women survived childbirth, only 86% survived until the end of the postpartum period. There were significant differences by location, and Maternal Age: The Weibull distribution well reflected maternal survival.
Keywords: Maternal Mortality, hazard, Survival Analysis, Maternal Survival, Maternal Cox Regression.

INTRODUCTION

Death of a woman during pregnancy or within 42 days of termination of pregnancy, regardless of the duration and place of pregnancy, due to any cause associated with or caused by pregnancy or its management, but not due to unintended or incidental causes [1]. Since 1990, the world mortality rate has fallen 45%, but still 800 people die every day due to pregnancy or childbirth. This is equivalent to "the death of a woman during pregnancy or within 42 days of termination of pregnancy, irrespective of the duration and location of pregnancy, from any cause associated with or exacerbated by pregnancy or its management, but not from accidental or incidental causes," according to the United Nations Population Fund (UNFPA) [1]. Since 1990, the world mortality rate has decreased by 45 percent per year, but still 800 women die every day from pregnancy and child health related causes. Most of these deaths are injuries are entirely preventable [2]." UNFPA reported that 289,000 women died in 2013 from causes linked to pregnancy or childbirth [3]. These cause rage, many of which have highly successful innovations, from serious bleeding to obstructed labor. The global maternal mortality ratio has fallen from 380 maternal deaths per 100,000 live births in 1990 to 210 deaths per 100,000 live births in 2013, as women have gained access to family planning and qualified birth attendance with backup emergency obstetric treatment. This has resulted in many countries having maternal death rates [4]. While worldwide mortality rates have decreased, much more needs to be done. There are still high rates, particularly in impoverished communities with more than 85% living in Africa [5]. The impact of the death of a mother occurs in poor families and their children are more likely to die before reaching their second birthday if they survive [6]. Direct or indirect causes may be factors that increase maternal death. Generally speaking, there is a difference between a direct maternal death that is the result of a pregnancy, childbirth, or management complication of the two, and an indirect maternal death [7] that is a pregnancy-related death in a woman with a pre-existing or newly established unrelated health condition. Accidental, incidental, or non-obstetrical maternal deaths are considered accidents during but unrelated to a pregnancy. Postpartum bleeding, the most popular cause, (15%), complications from unsafe abortion (15%), hypertensive disorders of pregnancy (10%), postpartum infections (8%), and obstructed labour (6%) [8]. Other causes of maternal mortality include blood clotting (3%) and pre-existing conditions (28%) [9]. Malaria, anemia [10], HIV/AIDS, and cardiovascular disease are indirect causes, all of which can exacerbate or worsen pregnancy. Important markers of maternal outcomes are socio-demographic variables, such as age, access to services and income levels. Young mothers face a greater risk of complications and death during pregnancy than older mothers [11], especially adolescents 15 years of age or younger [12]. Adolescents have a higher risk of postpartum hemorrhage, puerperal endometritis, virginal surgical delivery, episiotomy, low birth weight, preterm delivery, and small gestational age. Infants, all of which

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can lead to maternal death [12]. Maternal results are affected by surgical support and family support. In addition, maternal health is adversely affected by socioeconomic poverty and social exclusion, which can contribute to increased maternal death [13]. In addition, lack of access to qualified medical care during childbirth, travel distance to the nearest clinic to obtain adequate care, number of previous births, obstacles to obtaining prenatal medical care and inadequate facilities all increase maternal deaths. Another big cause of maternal death is unsafe abortion. A woman dies every eight minutes from complications resulting from unsafe abortions, according to the World Health Organisation. Hemorrhage, infection, sepsis and genital trauma are complications [14]. Globally, preventable deaths from improperly performed procedures account for 13% of maternal mortality, and 25% or more in some countries where maternal mortality from other causes is relatively low, making unsafe abortion the world's leading single cause of maternal mortality [15]. Consequently, this study is as mentioned in Luguterah & Nokoe, the challenge arising from getting some censored data occurs in a maximum of one case.

MATERIALS AND METHOD
Survival Data Analysis
We assume that the time of maternal deaths is a function of the random process when applying survival analysis methods to Maternal Mortality, and thus the time of death is a random variable with a distribution of probability and therefore other associated distributions.

Basic Concepts in Survival
Let T, denote the survival time of a woman from her time of conception. The distribution of T can be characterized by three equivalent functions [16].

Survival Function, S(t)
$S(t) = P($ a woman who has conceived surviving longer than time t from conception$) = P(T > t)$
$S(t) = 1 - P($ a woman who has conceived dying before time t from conception$) = 1 - F(t)$

$$S(t) = \left\{ \begin{array}{ll} 1 & for\ t = 0 \\ 0 & for\ t = \infty \end{array} \right.$$

S(t) is a non-increasing function of time with properties

Probability density function, f(t)

The probability density function of the survival time is defined as the limit of the probability that a woman dies in the short interval, t to $t + \Delta t$, per unit width, Δt, or simply the probability of dying in a small interval per unit time. It can be expressed as

$$h(t) = \frac{lim_{\Delta t \to 0} P[a\ woman\ who\ has\ conceived\ dying\ in\ the\ interval\ (t, t + \delta t)\ ]\ given\ that\ the\ woman\ has\ survived\ to\ t}{\Delta t}$$

$$= \frac{lim_{\Delta t \to 0} P[x_t \in (t, t + \Delta t)]}{\Delta t}$$

where x_t denotes a woman who has conceived, dying after she has survived to time t

These functions are related by;

$$h(t) = \frac{f(t)}{S(t)}$$

Estimating the Survival Functions
A variety of options can be used to estimate survival functions: the Kaplan-Meier and the Life Table Process. A non-parametric method of estimating the survival functions was used in this analysis, the Life table method. This approach, which uses time intervals, estimates the survival functions up to the upper limit of each interval, and at the midpoint of each interval, estimates the hazard and density functions [17]. Let ti be the end time for the ith interval and qi be the conditional probability of dying. Then;

$$\hat{S}(t) = \prod_{j=1}^{i=1} \left(1 - \hat{q}_j\right)$$
$$\hat{f}(t_{mi}) = \frac{\hat{S}(t) - \hat{S}(t_{i-1})}{b_i} = \frac{\hat{S}(t_i)\hat{q}_j}{b_i}$$
$$\hat{h}(t_{mi}) = \frac{d_i}{b_i(n_i - \frac{1}{2} d_i)} = \frac{2\hat{q}_j}{b_i(1 - \hat{p}_i)}$$

Where,
t_{mi} is the mid-point of the ith interval,
d_i is the number of women dying in the ith interval after their conception,

$$q_i = \frac{d_i}{n_i}$$

n_i is the number of women exposed in the ith interval after conception, is the conditional probability of a woman dying in the ith interval after conception

$p_i = (1 - q_i)$ is the conditional probability of a woman dying in the ith interval after conception
b_i is the width of the ith interval.

The standard error of the survival function [18] is estimated by:

$$s.e.\left(\hat{S}(t_i)\right) \approx \hat{S}(t_i)\sqrt{\sum_{j=1}^{i=1}\frac{\hat{q}_j}{\hat{n}_j(1-\hat{q}_j)}}$$

while that of the hazard function [19] is estimated by;

$$s.e.\left(\hat{h}(t_{mi})\right) \approx \hat{h}(t_{mi})\sqrt{\frac{\left[1-\left[\frac{1}{2}\hat{h}(t_{mi})b_i\right]^2\right]}{n_i\hat{q}_i}}$$

The probability density function [19] is estimated by;

$$s.e.\left(\hat{f}(t_{mi})\right) \approx \hat{S}(t_i)\hat{q}_j\sqrt{\frac{\sum_{j=1}^{i=1}\frac{\hat{q}_j}{\hat{n}_j(1-\hat{q}_j)}+\frac{1-\hat{q}_j}{\hat{n}_j(1-\hat{q}_j)}}{b_i}}$$

Modeling and other Tests based on Survival Techniques

Once the survival function has been identified, it is possible to perform multiple tests and modeling of maternal mortality, as well as to determine the appropriate distributions that best characterize maternal mortality, using both parametric and non-parametric methods [20]. These include the identification by regression analysis of prognostic factors and the determination of an appropriate distance

The Log-rank test

The Log-rank test [21], a non-parametric test of difference for survival functions, is the most commonly used technique when data is censored. For the various classes, it calculates the difference in survival at each of the times given. This checks the hypothesis for a k factor group that:

$H_o : S_1(t) = S_2(t) = \ldots = S_k(t)$ for all t
H_1 : not all $S_j(t)$ are equal. $j = 1, 2, \ldots k$
where Sj (t) is the survival function for the jth group

This is tested as a chi-square test which compares the observed numbers of failures to the expected number of failures under the hypothesis. Thus, given that O_j and E_j is the observed and expected number of deaths respectively for the jth group, the test statistic is given by;

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

has approximately a chi-square distribution with k - 1 degrees of freedom. A large chi-square value will lead to a rejection of the null hypothesis in favor of the alternative that the k groups do not have the same survival distribution.

Proportional Hazard Regression

The Cox proportional regression [22] was used on the basis of the presumption of proportionality to determine the effect of some socioeconomic and demographic variables on maternal survival. In this model, through the equation, the hazard for a person is believed to be connected to the covariates;

$h_i(t) = \lambda_0(t) \exp \{ \beta_1 x_{i1} + \ldots + \beta_k x_{ik} \}$

Taking the logarithm of both sides, the model can also be written as
$\log h_i(t) = \alpha(t) + \beta_1 x_{i1} + \ldots + \beta_k x_{ik}$
where $\alpha(t) = \log \lambda_0(t)$.

The ratio of the hazard for the two individuals i and j (say rural women and urban women) is then given by;
$h_i(t) = \lambda_0(t) \exp \{ \beta_1 x_{i1} + \ldots + \beta_k x_{ik} \}$
$h_j(t) = \lambda_0(t) \exp \{ \beta_1 x_{j1} + \ldots + \beta_k x_{jk} \}$

$= \exp \{ \beta_1(x_{i1} - x_{j1}) + \ldots + \beta_k(x_{ik} - x_{jk})$
where $\beta_1, \ldots, \beta_k$ measures the relative risk for the ith woman over the jth, with respect to the change in the x_l^{th} covariate, $l = 1, \ldots, k$ respectively.

Determination of an appropriate distribution

For the determination of an acceptable distribution of survival data, there is a graphical and analytical process. The hazard plotting technique [23], a graphical plotting technique designed to manage censored details, was used in this analysis. The shape of the hazard plot gives a clear indicator of the distribution that could better match it: for example, an exponential distribution would imply a constant hazard; while a rising and then decreasing hazard would suggest a normal or log-logistic log model, a monotonic distribution could suggest a log-logistic model; the distribution of Weibull could have an increasing, decreasing distribution. The monotonously rising form of the hazard plot for maternal mortality, suggests that the assumption that maternal survival had a Weibull distribution. The parameters of the assumed Weibull distribution were then estimated using the hazard plotting technique. The adequacy of the fit was also assessed using R-squared value of the linear plot of log (t) against H (t): H (t) is the cumulative hazard at time t.

RESULTS AND DISCUSSION

Table-1: Maternal Survival Estimates

Time from conception (month)	Probability of failure	S.E	Survival probability	S.E	Hazard	S.E	Density	S.E
0 to 1	0.00000	0.00000	1.00000	0.00000	0.00000	*	0.00000	*
1 to 2	0.00000	0.00000	1.00000	0.00000	0.00000	*	0.00000	*
2 to 3	0.00125	0.00125	0.98879	0.00125	0.00125	0.00125	0.00125	0.00125
3 to 4	0.01807	0.00501	0.99674	0.00528	0.01941	0.00528	0.01804	0.00528
4 to 5	0.00507	0.00299	0.96547	0.00608	0.00512	0.00298	0.00502	0.00272
5 to 6	0.00527	0.00405	0.96436	0.00782	0.00828	0.00406	0.00802	0.00441
6 to 7	0.01011	0.00512	0.95626	0.00808	0.01024	0.00518	0.01004	0.00521
7 to 8	0.02069	0.00825	0.93438	0.01189	0.02203	0.00841	0.01999	0.00819
8 to 9	0.01227	0.00887	0.90272	0.01418	0.01675	0.00924	0.02164	0.00811
9 to 10	0.09669	0.02799	0.86121	0.02678	0.11281	0.03187	0.09013	0.03575

Table 1 summarizes the predictions of survival with their accuracy tests. It shows that approximately 90% of pregnant women in Delta State Nigeria make it through to childbirth, while 86% make it through to the end of the postpartum period: this means 14% maternal mortality. In the first month after birth, about 10 percent of women who conceived lost their lives, comprising over 50 percent of the overall maternal deaths. For a pregnant woman, this makes the first month after childbirth the most dangerous time. Thus, once pregnant, a Deltan woman has around a 1 in 10 risk of dying before delivery and a 2 in 10 chance of dying at the end of the 10 months after conception (up to one month after delivery). Consequently, if a pregnant Deltan woman gave birth safely, she still had around a 1 in 10 risk of dying within a month of delivery. Therefore, an emphasis on the health of a mother immediately after birth and up to one month afterwards could decrease maternal mortality by up to half.

Table-2: Log-Rank Test of Differences in Maternal Survival

	Variable	χ^2	d. f	p-value
1	Ever Given Birth	4.71126	1	0.038
2	Mother Ever Schooled	0.11025	1	0.752
3	Marital Status	6.11881	3	0.042
4	Type of Town	19.16420	3	0.000
5	Age of Mother at birth	6.26881	4	0.160
6	Mother's total number of births	110.14811	8	0.000
7	Region	6.17817	9	0.611

The results of the log-rank tests shown in Table 2 show that maternal mortality is all correlated with the form of area, ever-present birth, marital status and mother's age at birth.

Table-3: Maternal Cox Regression

Variable	β	s.e.	Wald	d. f	p-value	Exp(β)
Town (compared to						
Rural	0.347	0.335	1.07293	1	0.001	1.41482
Urban	-0.890	0.262	11.53925	1	0.204	0.41066
Mother Ever Schooled (compared to never)	0.221	0.242	0.83398	1	0.420	1.24732
Ever given birth (Compared to never)	-0.833	0. 249	11.19158	1	0.000	0.43474
Age of mother at Pregnancy	-0.051	0.021	5.89796	1	0.004	0.95028

The Cox regression findings suggest that a mother who has ever given birth has a 67 percent lower chance of dying due to complications related to pregnancy than a woman who has never given birth. The probability of dying usually decreases by 4.5 percent with every additional year of age as a woman grows older: these findings are statistically important. With rural people having a 67 percent lower risk than urban people, area differences were also important: hence, the more urban the region, the greater the risk of maternal deaths. This could represent initiatives to make motherhood safer in rural communities, or inadequacies or unreliability of data.

Table-4: Summary of fitted distribution for Maternal Survival

Variable	Assumed Distribution	Parameter Estimates	R^2 Estimates
Maternal Survival	Weibull	$\gamma = 1.84902$ $\lambda = 0.02861$	0.9806

The approximate parameters of the fitted Weibull distribution, and its appropriateness, are shown on Table 4, the results shows that the Weibull distribution explains Maternal Survival very well.

CONCLUSION

This research has shown that the study of Maternal Survival can be extended to Survival Strategies, which are complex interventions. The Weibull model accurately explains maternal survival and, thus, mortality. The Weibull distribution describing maternal survival had parameters of shape and scale γ, λ, > 0, suggesting an increasing risk of mortality over time and therefore an increasing risk: The prognostic factors influencing the danger and therefore survival are the determinants of the Weibull distribution describing maternal survival for these results.

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