Determinants of Contraceptive Discontinuation: A Weibull Regression Analysis

BY

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Declaration

I declare that all the work in this study submitted for my degree is the end result of my own work.

References from studies done by others, is acknowledged and quotations or paraphrases suitably indicated.

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Abstract

This is a study to examine the overall discontinuation rate and factors associated with contraceptive discontinuation among women of reproductive age group between 15 to 49 years in Kenya using data from 2003 KDHS. The Weibull regression model is used to analyze the determinants of discontinuation for all methods combined. According to the findings, the overall all method discontinuation rate is 44.1 percent for the five-year period before the survey and the risk of all method discontinuation increases with time. The results show that age (15-24), Region (Nyanza, Western), Education (No education), Number of Living Children (0) and Marital Status (never married, not living together, divorced, widowed) significantly affect discontinuation in the contraceptive practice of Kenyan women.

The study suggests that during the design and implementation of reproductive health strategies, methods that help delay the onset of childbearing should be emphasized.

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CHAPTER 1

INTRODUCTION

It is generally accepted that contraceptive use plays an important role in reducing fertility. It is useful in evaluating the effect of family planning programs. On the other hand, contraceptive discontinuation is the consequence of contraceptive acceptance, method choice, need and failure. Still, knowledge of the factors that may lead to contraceptive discontinuation remains incomplete and a better understanding is hampered by multiple and complex reasons (Curtis et al., 2011).

1.1 BACKGROUND

Contraceptive discontinuation resulting from an unintended pregnancy is an important determinant of fertility (Moreno, 1993). Fertility is a major determinant of the population growth rate, and a rapid rate of population growth presents major challenges to Kenya's overall development (Kizito, Johnston and Hyslop, 2005). In Sub-Saharan Africa, Kenya is one of the countries having high levels of adult and adolescent childbearing (Ikamari and Towett, 2007). In the last National Housing and Population Census carried out in 2009 Kenya's population stood at 38.6 million. In the new Sessional Paper No. 3 of 2012 on Population Development, the population is expected to reach 77 million by 2030. It is predicted that Kenya's population will double by 2030. The country's population is estimated to grow by 2.9 per cent per annum, which translates to about a million people annually (National Council for Population and Development, 2012). The implication is that the number of people in need of health care, education, housing, water and sanitation, and employment will continue to increase until eventually the available resources cannot adequately meet the needs of the growing population. This is likely to impede the Government efforts towards the realization of the reduction of child mortality, improvement of maternal health, achievement of universal primary education, environmental sustainability and combating HIV/AIDS, malaria and other diseases (Okech et al., 2011).

Statistics show that about half of the most recent births among all women aged 15 to 49 years are unplanned in Kenya, and the situation is worse in Western, Nyanza and Rift valley provinces as well as in rural areas, where more than half of the recent births are unplanned (NCPD, 2012). But the Constitution of Kenya 2010 article 43 (1), states that *"every person has the right to the highest attainable standard of health, which includes the right to health care services, including reproductive health care."* (Kenya Law Reports, 2010). The recognition that lack reproductive health services can impair the woman's quality of life, gives every citizen of Kenya the freedom to take legal action to demand the implementation of various clauses on health rights.

Understanding what motivates women to discontinue contraceptive use is an important step in ensuring that family planning program meets their goals. Hence, the analysis of contraceptive discontinuation can help managers of family planning programmes to understand women's family planning choices. This is necessary because family planning and reproductive health programs must adapt to meet users' changing needs and preferences (Leite et al., 2007).

1.2 STATEMENT OF PROBLEM

According to Phillips and Trussel (1991) the discontinuation pattern of contraceptive use is complex. Steele and Curtis (2003) suggested that simple life-table method-specific discontinuation rates are unlikely to be greatly misleading for basic program monitoring or other descriptive purposes; but if the focus is on understanding the determinants of discontinuation or on impact evaluation, more sophisticated analytic techniques should be used. As pointed by Tripathi (2008), the advantages of analysing the discontinuation patterns are immeasurable to a country such as Kenya because of the implications it has on facilitation and infrastructural development rather than increasing the use of contraceptives. The rate at which women stop using any method of contraception is quantified by the all-method discontinuation rates and it is of greater value than discontinuation of a specific method because it reveals the extent women are unprotected from the risk of unwanted pregnancy. The purpose of the study is to provide an illustration of how the Weibull hazard regression model and the R software function survreg may be used to assess the relationship between independent variables and the hazard of contraceptive discontinuation regardless of duration of use, for all methods using 2003 KDHS data.

1.3 OBJECTIVES

General

This study aims at providing a regression model for analysing the influence of covariates on contraceptive discontinuation for all methods from crude rates

Specific

- Determine overall discontinuation rates
- Examine factors associated with contraceptive discontinuation for all methods using Weibull regression hazard model and the R software function survreg, based on women's contraceptive data from the 2003 Kenya Demographic and Health Survey.

1.4 HYPOTHESIS

Young unmarried women from Nyanza and Western regions who do not have children and lack any formal education are most likely to stop contraceptive use regardless of duration of use. Therefore, by implication have the highest exposure to pregnancy.

1.5 SIGNIFICANCE OF STUDY

Blanc, Curtis, and Croft (1999) define the all-method discontinuation rates as the rate at which women shift from using any method of contraception (excluding sterilization) to using no method. The authors point that a useful measure of contraceptive discontinuation is one that gauges the extent to which women stop using contraception entirely. Hence, the principle objective is modelling and determining the relationship between T (a continuous non-negative random variable representing contraceptive discontinuation time) and $\underline{x}$ (a vector of m covariates). The primary question is: Do any subsets of the m covariates increase or decrease contraceptive-discontinuation risk? If so, by what estimated quantity?

This study adds to literature the determinants of contraceptive discontinuation for all methods combined, from the vantage point of the Weibull regression model.

CHAPTER 2

LITERATURE REVIEW

Zhang, Tsui and Suchindran (1999) assert that contraceptive history data like other event history data, collected with the calendar approach will have full duration, as well as right-censored, episodes. To analyze these kinds of data, life table and other proportional hazard models can be used (Steele and Choe 1997).

Blanc, Curtis, and Croft (1999) state there are two ways to model competing risks in life tables. The first approach, which they refer to as the multiple decrement approach, models the observed dependent rates. The second approach, known as the associated single decrement approach, models the underlying independent rates. The life table rates calculated using the first approach are known as net rates while those calculated using the second approach are known as gross rates. Net rates or crude rates reflect the observed probabilities of discontinuing for a particular reason in the population in the presence of other reasons. They are affected both by the underlying risk of discontinuation for a particular reason and the underlying risk of discontinuing for other reasons. When discontinuation rates are high, multiple-decrement failure rates will be relatively low because most women will have exited the life table for other reasons. Gross rates can be interpreted as the probabilities of discontinuing for a particular reason in the absence of other reasons. They are theoretical rates and represent the underlying risk of discontinuation in the population. Gross discontinuation rates for a particular reason are not affected by the level of discontinuation for other reasons.

Gore, Pocock and Kerr (1984) note that life tables may be used to suggest possible prognostic factors (covariates) but because life tables present cumulative information they do not show clearly how for example the rate of mortality changes year by year (it is difficult to compare cumulative discontinuation rates). The proportional hazards model (Cox, 1972) is one where by an underlying hazard function the covariates act multiplicatively. The authors suggest that the proportional hazards model will not be appropriate if time to peak hazard -is earlier in some prognostic groups than in others, or if covariates have less relevance in later follow-up. They emphasize that little information is lost about covariate effects when arbitrary $h_0(t)$ is allowed in specific examples (say Weibull) for which the proportional hazards model is appropriate. In their discussion they further note that the hazard relates most easily to distinct follow-up intervals.

Williams (1978) notes that the shape of the Weibull distribution does not affect the efficiency of any regression-analysis estimator except the mean logarithmic rate. The writer mentions that the least-squares analysis cannot be recommended because it is seriously inefficient.

Crowder (1989) states that for right-censored observations, the simple form of the Weibull survivor function is an attractive property. The hazard rate function is monotone increasing, constant or decreasing according to the value of one parameter, and this behaviour is appropriate in many situations, though not all (Bennett, 1983).

Pinder III, Wiener and Smith (1978) refer to the Weibull frequency distribution as having two important applications in survivorship studies. The shape and scale parameters to start with, summarize all the survivorship information in a life table. Thus, where fecundity data are not to be included in the life tables it may be possible to report estimates of shape and scale parameters and to omit the calculation of a life table. Secondly, estimates of the shape parameter computed from different populations can be compared to determine whether the populations have similarly shaped survivorship curves. Populations with similar curves but different mean longevities have different life tables. Comparing estimates of the shape parameter is simpler and has the advantage that standard statistical procedures of hypothesis testing may be employed. These potential uses can only be implemented if methods exist to estimate shape and scale parameters, if confidence intervals can be calculated about these estimates, and if the frequency distributions of approximate Weibull distributions. The authors mention that numerous methods exist for estimating shape and scale parameters and calculating confidence intervals about the estimates.

Tripathi (2008) asserts there are gaps in statistical understanding of assessing early discontinuation of contraceptives. That apart from method failure and loss to follow-up, which remains a statistical problem in clinical trial data, social determinants such as religion, age, distance from the nearest health centre, education, social taboos and traditional beliefs need close attention. The author points to the fact that discontinuation of methods is often high in early months of use, declines with time, and stabilizes as users who continue through the early period of use are comprised of women who are progressively tolerant of method as time progresses. The underlying relationship of discontinuation with time may co-vary with stated determinants. Traditional life table techniques have been replaced with multiple regression techniques that utilize the maximum information available through data. Any model that does not utilize all the information is not able to provide a powerful assessment of the relationship between risk factors and the event of interest (Katz, 1999), or studies with staggered entry times and with a maximum of cases not experiencing the event of nterest. The author explains that since survival analysis makes use of the contribution of censored ases, it is therefore, more useful for analysing discontinuation in contraceptive data. Logistic gression coefficients can be computed to describe the relationship between the independent riables and log odds of discontinuation. But the author adds that for contraceptives more people e likely to discontinue within a short period of time post-enrollment. Therefore, biases inherent in the logistic model should be avoided given the fact that over time, the process of discontinuation stabilizes and different variables behave variably over time. It is noted that the covariates identified in the final model can be validated by checking for over-fitting or under-fitting of the model. An improper application of modeling techniques can result in models that poorly fit the dataset at hand, or, even more likely, inaccurately predict outcomes on new subjects. Finally the author concludes that the advantages of analysing the discontinuation patterns are immense with reference to developing countries since the implication is better facilitation and infrastructural development rather than the trend of increasing the use of contraceptives to build a society more aware of its reproductive choices.

Steele and Curtis (2003) observe that there is little empirical evidence to support the theoretical link between the quality of services and contraceptive discontinuation, but interest remains in contraceptive discontinuation as an outcome associated with the quality of services. They note that as contraceptive use rises throughout the world, contraceptive continuation becomes an increasingly important determinant of contraceptive prevalence and unwanted fertility. From their results they conclude that simple life-table method-specific discontinuation rates are unlikely to be seriously misleading for basic program monitoring or other descriptive purposes; but trends, should be interpreted with caution if there have been large shifts in the method mix or in the profiles of users selecting particular methods, and small method differences should not be over interpreted. If the focus is on understanding the determinants of discontinuation or on impact evaluation, more sophisticated analytic techniques should be used. First- and second-year discontinuation rates are normally used for evaluating family planning programmes (Steele, 2003).

Blanc, Curtis, and Croft (1999) define the all-method discontinuation rates as the rate at which women shift from using any method of contraception (excluding sterilization) to using no method.

The authors point that a useful measure of contraceptive discontinuation is one that gauges the extent to which women stop using contraception entirely. On the same point Magadi, Zulu, Ezeh and Curtis (2001) assert that the all-method rate is valuable in understanding the extent to which women are fully protected from unintended pregnancies.

Most authors who have analyzed calendar data in order to determine contraceptive discontinuation rates have restricted their analysis to 12 or 24 months of observation (Creanga et al, 2007). Creanga, Acharya, Ahmed and Tsui report that these studies have limitations associated with using retrospective data concerning contraceptive practice and pregnancy history. The authors note that contraceptive-discontinuation risk is not constant over time, and most contraceptive discontinuation occurs immediately after adoption. They suggest the use of the Weibull parametric hazard model which, as an accelerated failure time model (the covariates serve to accelerate or decelerate the effect of time), also estimates hazard ratios. The distribution was proposed by Weibull (1939) and its relevance to various failure situations discussed by Weibull (1951). This parametric Weibull model does not require failure rates to remain constant but allows them to increase or decrease over time. The Weibull distribution allows more flexibility in the shape of the hazard function and has been employed previously in contraceptive-continuation studies where hazards are not constant over time (Ali et al. 2001). Contraceptive discontinuation has been shown to be dependent on the specific method used. Individual socioeconomic and demographic characteristics of women have been linked with the probability of contraceptive discontinuation. An association has been found between the place of residence and the failure of specific methods and showed that this relationship varies by country. Younger users have been shown to have higher discontinuation rates tied to method failure, whereas the number of living children, which is closely related to age in most countries, has been shown to be positively associated with longer durations of use of specific methods. At the same time, women who already have a child have a lower likelihood of experiencing method failure, compared with women who have not given birth. Higher educational levels of women and higher socioeconomic status are found to predict low discontinuation. (Ferguson 1992; Ali and Cleland 1995; Tu 1995; Curtis and Blanc 1997; Moreno 1993; Steele et al. 1996; Riley et al. 1994; Steele et al. 1996; Moreno 1993; Bhat and Halli 1998).

Creanga, Acharya, Ahmed and Tsui (2007) explain that when hazard ratios are not proportional, the power of corresponding tests decreases and hazard ratios that increase over time are overestimated and, conversely, converging hazards are underestimated. The authors suggest the using Weibull, which, as an accelerated failure time model, also estimates hazard ratios. They mention that contraceptive-discontinuation risk is not constant over time, and most contraceptive discontinuation occurs immediately after adoption implying the risk of contraceptive failure drops off with longer durations of use. They recommend the parametric Weibull model because it does not require failure rates to remain constant but allows them to increase or decrease over time and allows more flexibility in the shape of the hazard function.

CHAPTER 3

METHODOLOGY

This chapter discusses the regression model used in assessing the relationships between a set of covariates and the hazard of contraceptive discontinuation regardless of duration of use, for all methods combined.

3.1 INTRODUCTION

In analysing discontinuation and failure in contraceptive data, survival analysis is more useful in that it makes use of the contribution of censored cases. Censoring implies that information is incomplete about the outcome in some respect, but not completely missing. The hazard ratio and the survival curve are the primary information desired for a survival analysis and are obtained using a minimum of assumptions (Tripathi, 2008). Parametric survival models are regression models. They assume a continuous parametric distribution for the probability of discontinuation over time. Examples of such distributions are the exponential, Weibull, Gompertz, lognormal, log-logistic, and generalized gamma. The distribution of time-to-discontinuation takes as its starting point the hazard function, which is the ratio of the probability density function to one minus the cumulative density function. The hazard function is referred to as the instantaneous failure rate. It provides a useful method to adjust for regression variables, either by assuming that the covariates serve to multiplicatively shift the hazard function (proportional hazards) or by assuming that the covariates serve to accelerate or decelerate the effect of time (accelerated failure time) (Gutierrez, 2002).

3.2 GENERAL FRAMEWORK OF PARAMETRIC REGRESSION MODELS

In parametric analysis of failure time data the Weibull distribution is considered useful. The Weibull hazard function has a monotone hazard rate. This means that it increases, decreases or is constant according to the value of one parameter. Contraceptive-discontinuation risk is not constant over time. The parametric Weibull model does not require discontinuation risk to remain constant but allows it to increase or decrease over time. The Weibull distribution is very flexible in the shape of the hazard function and has been previously used in contraceptive-discontinuation studies (Creanga et al. 2007).

The Weibull distribution is characterized by two parameters, γ and α. The parameter γ is a scale parameter where the effect of different values of γ is to change the scale on the time axis. Increasing the value of the scale parameter has the effect of stretching out the probability density function and survival curve, when the shape parameter is held constant. The value of α is the shape parameter. Therefore, when $\alpha = 1$ the shape of the Weibull distribution corresponds to an exponential model (the Weibull "nests" the exponential model) and the hazard rate remains constant as time increases. When $\alpha > 1$ the contraceptive discontinuation risk is increasing with time and when $\alpha < 1$ the hazard function is decreasing monotonically over time. Thus, the Weibull may be used to model the survival distribution of a population with increasing, decreasing, or constant risk (Lee et al. 2003).

Let $\underline{x} = (x_1, \ldots, x_m)'$ represent a vector of *m* covariates, $\underline{\beta} = (\beta_1, \ldots, \beta_m)'$ a vector of *m* regression parameters and *T* discontinuation time. The principle objective is modelling and determining the relationship between *T* and $\underline{x}$. The primary question is: Do any subsets of the *m* covariates increase or decrease contraceptive-discontinuation risk? If so, by what estimated quantity?

The probability density function and the corresponding likelihood function for Weibull distribution are as follows:

$$f(t) = \alpha\gamma(\gamma t)^{\alpha-1}e^{-(\gamma t)^{\alpha}} \qquad t \geq 0, \qquad \alpha, \gamma > 0 \qquad (3.1)$$

and

$$L(\gamma, \alpha, t) = \prod_{i=1}^{n} \alpha\gamma(\gamma t_i)^{\alpha-1} e^{-(\gamma t_i)^{\alpha}} .$$

The cumulative distribution is

$$F(t) = 1 - e^{-(\gamma t)^{\alpha}}. \qquad (3.2)$$

Therefore, the survival function is

$$S(t) = e^{-(\gamma t)^{\alpha}} \qquad (3.3)$$

and the hazard function given by the ratio of (3.1) to (3.3) is

$$h(t) = \alpha\gamma(\gamma t)^{\alpha-1} \qquad (3.4)$$

The logarithm of $S(t)$ is

$$logS(t) = -(\gamma t)^{\alpha} \qquad (3.5)$$

When $\alpha < 1$, $logS(t)$ decreases very slowly from 0 and then approaches a constant value. When $\alpha > 1$, $logS(t)$ decreases sharply from 0 as t increases. When $\alpha = 1$, the survival plot is a straight line with negative slope.

Taking logarithm both sides of equation (3.5) gives the following expression:

$$\log[-\log S(t)] = \alpha \log_e \gamma + \alpha \log_e t \quad (3.6)$$

3.2.1 Covariates

Suppose the parameter γ is related to $\underline{x}$ in the Weibull distribution as follows:

$$\gamma = e^{-(\beta_0 + \sum_{i=1}^{m} \beta_i x_i)} = \exp[-(\beta_0 + \underline{\beta}'\underline{x})]$$

Then the covariate vector $\underline{x}$ can now be included in the hazard function as follows:

$$h(t|\underline{x}) = \alpha\gamma^{\alpha} t^{\alpha-1} = \alpha t^{\alpha-1} e^{-(\beta_0 + \sum_{i=1}^{m} \beta_i x_i)\alpha} = \alpha t^{\alpha-1} \exp\left[-\left(\beta_0 + \underline{\beta}'\underline{x}\right)\alpha\right] \quad (3.7)$$

The survival function in (3.3) changes into

$$S(t|\underline{x}) = e^{(-t^{\alpha})\exp\left[-\left(\beta_0 + \underline{\beta}'\underline{x}\right)\alpha\right]} \quad (3.8)$$

or

$$\log[-\log S(t)] = -\alpha\left(\beta_0 + \underline{\beta}'\underline{x}\right) + \alpha \log_e t \quad (3.9)$$

which implies that $\log[-\log S(t)]$, $\log_e t$ and the covariates are linearly related. This supports a graphical assessment of the assumption of a Weibull model by plotting the $\log[-\log S(t)]$ against $\log_e t$.

The effects of the covariates act multiplicatively on the hazard function (3.7)

$$h(t|\underline{x}) = h_0(t)[\exp(\beta_1 x_1) \times \exp(\beta_2 x_2) \times \ldots \times \exp(\beta_m x_m)]$$

where $h_0(t)$ is the baseline hazard.

3.2.2 Accelerated failure time model (AFT)

The Weibull regression model, which includes the exponential, is a special case of both the Cox proportional hazards model and the accelerated failure time model (Tableman, 2008). The AFT model assumes that the relationship of logarithm of survival time T and the covariates is linear and can be written as

$$logT = \beta_0 + \sum_{j=1}^{m} \beta_j x_j + \sigma\varepsilon \quad (3.10)$$

where σ is an unknown scale parameter($\sigma > 0$) and ϵ, is the error term which takes on a particular distribution. In this model, the covariate x will either "accelerate" or "decelerate" the survival time or the failure process (Lee et al. 2003).

The estimation of the regression parameters (β_0, β coefficients for the m covariates $and\ \sigma$) is done using the maximum-likelihood method under the assumption that the observations are independent. These calculations can be carried out using the R software function survreg in the survival package. This survival package works with objects of class Surv, which is a data structure that combines times and censoring information (Dalgaard, 2002). The R function survreg estimates $\beta_0, \underline{\beta} and\ \sigma$.

3.3 WEIBULL REGRESSION MODEL

The effects of the covariates can be modeled using (3.10). The log-discontinuation-time of an observation *i* is

$$logT_i = \beta_0 + \sum_{j=1}^{m} \beta_j x_{ji} + \sigma\varepsilon_i \ = \ \mu_i + \sigma\varepsilon_i \qquad (3.11)$$

where $\mu_i = \beta_0 + \sum_{j=1}^{m} \beta_j x_{ji}$ and

$\varepsilon \sim standard\ extreme\ value\ distribution(Gumbel\ distribution)$. This is the Weibull regression model. *T* has the Weibull distribution with

$$\gamma_i = exp\left(-\frac{\mu_i}{\sigma}\right) \quad and \quad \alpha = \frac{1}{\sigma}\ . \qquad (3.12)$$

The hazard, density and survival functions that are related with covariates through γ_i in (3.12) are given respectively as follows (Lee et al. 2003):

$$h(t|\gamma_i, \alpha) = \alpha\gamma_i t^{\alpha-1} \qquad (3.13)$$

$$f(t|\gamma_i, \alpha) = \alpha\gamma_i t^{\alpha-1} \exp(-\gamma_i t^{\alpha}) \qquad (3.14)$$

$$S(t|\gamma_i, \alpha) = \exp(-\gamma_i t^{\alpha}) \qquad (3.15)$$

Based on (3.13) and (3.12), the hazard ratio of any two observations $i\ and\ j$ is

$$\frac{h_i}{h_j} = \exp\left(-\frac{\mu_i - \mu_j}{\sigma}\right) = \exp\left(-\frac{1}{\sigma}\sum_{k=1}^{m} \beta_j (x_{ki} - x_{kj})\right).$$

The measure of effect is called hazard ratio. This ratio is independent of time, which is referred to as the *proportional hazards property*. The ratio reflects the relative proportional change in $h(t)$ associated with a unit change in x_i. The effects of the explanatory variables in the model alter the scale parameter of the distribution, while the shape parameter remains constant.

Kleinbaum and Klein (2005, pg 273) note that "the Weibull model has the property that if the AFT assumption holds then the PH assumption also holds. The PH assumption allows for the estimation of a hazard ratio enabling a comparison of rates among different populations. The AFT assumption allows for the estimation of an acceleration factor; which can describe the direct effect of the covariates on the survival time and the error variance (σ)".

In the Weibull model output, R uses AFT by default and the estimated parameters are

$$scale = \sigma \qquad \hat{\gamma} = exp\left(\frac{-intercept}{\sigma}\right) \qquad \hat{\alpha} = \frac{1}{\sigma} \qquad and\ \hat{\beta} = \frac{-(coefficient\ of\ x)}{\sigma}$$

3.4 HYPOTHESIS TESTING ON THE PARAMETERS

The test of hypothesis can be accomplished by the likelihood ratio and Wald tests. These tests are based on asymptotic approximations in statistical inference.

To test whether the regression parameters β have equal effect on the survival time, the null hypothesis is put in the form $H_0: \beta_1 = 0$ against the alternative that $H_1: \beta_1 \neq 0$ with β partitioned as $\beta' = (\beta_1, \beta_2)'$ where $\beta_1\ is\ k \times 1\ and\ k < m$.

The test statistic is defined by

$$\chi_\omega = \hat{\beta}'_1 \sum\nolimits_{11}^{-1} \hat{\beta}_1$$

where $\sum_{11}$ is $k \times k$ sub-matrix of the covariance matrix $C\hat{o}v(\hat{\beta})$ corresponding to $\hat{\beta}_1$. Under H_0,X_w

χ_ω has an asymptotic chi-square distribution with k degrees of freedom. When the Wald's statistic is used, H_0 is rejected at the α level of significance if $\chi_\omega > \chi^2{}_{\kappa,1-\frac{\alpha}{2}}$ (two-sided test) or $\chi_\omega > \chi^2{}_{\kappa,\alpha}$ (one-sided).

The logarithm of the hazard ratio is $log(h_1/h_{ref}) = -\beta_1/\sigma = \hat{\beta}_1$ .The ratio is independent of time. Failure to reject H_0: $\beta_1 = 0$ or $h_1/h_{ref} = 1$, implies that there are no significant differences between the hazards for the covariates in question. Hence, none of the covariates is related to the survival time. A positive estimate for $\hat{\beta}_1$ indicates that the hazard h_1 is $exp(\beta_1/\sigma)$ times higher than h_{ref} . Hence, positive values of the hazard ratio mean that higher values of the variable correspond to higher hazards and shorter expected durations of the event of interest. A negative estimate for $\hat{\beta}_1$ indicates that the hazard h_1 is $exp(\beta_1/\sigma)$ times lower than h_{ref} . This implies that lower values of the variable correspond to lower hazards and higher expected duration of the event of interest.

The results of the Weibull regression analysis on the contraceptive discontinuation rates are presented in chapter 4.

CHAPTER 4

DATA ANALYSIS AND RESULTS

4.1 DATA AND METHODS

The analysis draws upon data from the 2003 Demographic and Health Surveys (DHS) for Kenya, relating to women's contraceptive discontinuations occurring in the five years preceding the survey, regardless of duration of use. The data focuses on sampled women from each of the eight provinces in Kenya of reproductive ages between 15 and 49 years. The survey used a two-stage sampling design - household clusters, and household individuals.

The Women's Questionnaire obtained information related to background characteristics (e.g., education, residential history, media exposure), pregnancies and births history, family planning knowledge, contraceptive use history, reasons for use of a specific method and discontinuations, and fecundity and fertility preferences. The sample of women for discontinuation analysis was 4074 women who have ever used any method of contraception.

Contraceptive discontinuation refers to stopping any contraceptive use. Contraceptive failure is defined as the ending of continuous use as a result of getting pregnant while using the method. All methods combined represents all contraceptive methods used in Kenya considered together. The rate at which women stop using any method of contraception is quantified by the all-method discontinuation rates and it is of greater value than discontinuation of a specific method because it reveals the extent women are unprotected from the risk of unwanted pregnancy.

The covariates used for the analysis are classified into two categories. Age, parity and marital status are in the time-varying category while province, residence, education, and wealth are considered fixed. The five-year age groups from 15 to 49 are the age categories; education categories are no education, primary, secondary and higher; categories for the number of living children are set from zero to six-plus (6+); marital status categories are never married, married, living together, widowed, divorced and not living together; and wealth quintile is categorized as poorest, poorer, middle, richer and richest. There are eight provinces, namely, Nairobi, Central, Coast, Eastern, Nyanza, Rift valley, Western and North Eastern; and residence categories are urban and rural areas. The overall objective is to examine the determinants of contraceptive discontinuation for all methods combined among women in Kenya using the Weibull regression hazard model. This is to enable the understanding of the effectiveness of public health and family planning programs. The Weibull regression hazard model is fitted to assess the relationships between covariates and the hazard of contraceptive discontinuation regardless of duration of use, for all methods combined. All analyses are performed with and the models fitted by R software.

4.2 FINDINGS

4.2.1 Contraceptive Discontinuation Rates

The gap between the percentage of women in the childbearing age group who have ever used and those currently using contraception is a crude measure of extent of discontinuation in a given population (Curtis and Nietzel 1996). Hence, Table 4.1 shows the socio-demographic differentials in the discontinuation rates for all methods used in Kenya.

Table 4.1 Contraceptive discontinuation rates for all methods used in Kenya

Characteristics	Ever Use	Current	Discontinuation Rate
Age			
15-19	262	118	**55.0**
20-24	768	358	**53.4**
25-29	880	495	**43.8**
30-34	769	456	**40.7**
35-39	586	377	**35.7**
40-44	506	316	**37.5**
45-49	303	156	**48.5**
Region			
Nairobi	669	390	**41.7**
Central	882	554	**37.2**

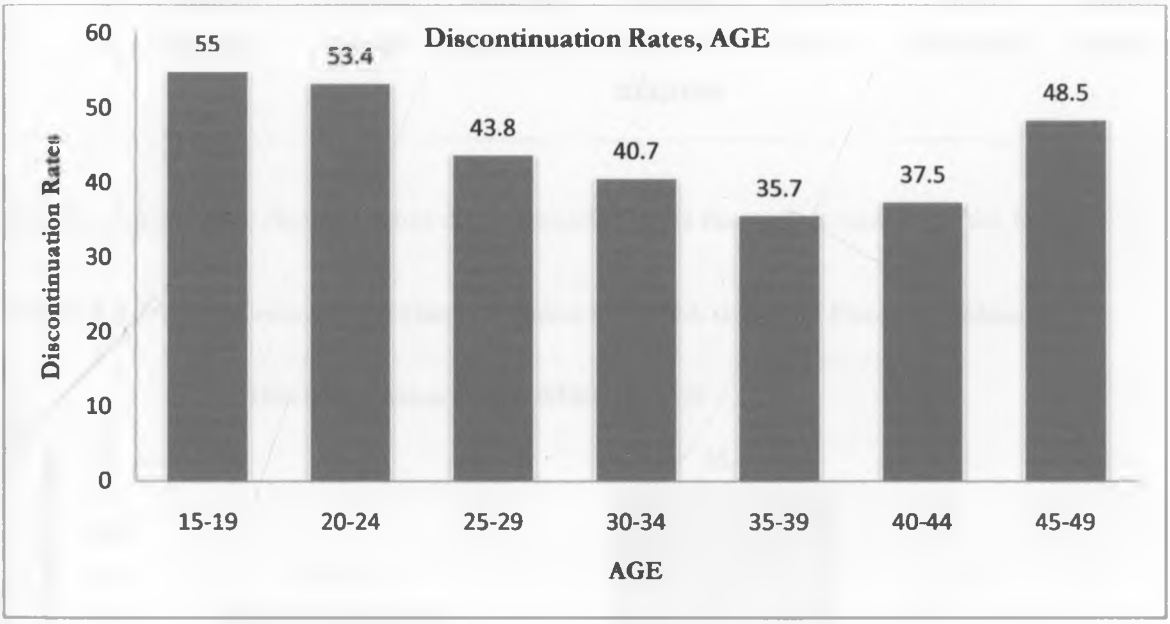
Coast & NE	379	198	**47.8**
Eastern	580	352	**39.3**
Nyanza	458	219	**52.2**
Rift Valley	584	321	**45.0**
Western	522	242	**53.6**
Place of Residence			
Urban	1513	871	**42.4**
Rural	2561	1405	**45.1**
Education Level			
No education	256	111	**56.6**
Primary	2212	1180	**46.7**
Secondary	1199	705	**41.2**
Higher	407	280	**31.2**
Number of living children			
0	377	129	**65.8**
1	783	399	**49.0**
2	795	466	**41.4**

3	675	437	**35.3**
4	553	327	**40.9**
5	346	213	**38.4**
6+	545	305	**44.0**
Marital Status			
Never married	521	214	**58.9**
Married	2754	1720	**37.5**
Living together	278	151	**45.7**
Widowed	178	54	**69.7**
Divorced	76	29	**61.8**
Notliving together	267	108	**59.6**
Wealth Status			
Poorest	332	152	**54.2**
Poorer	601	304	**49.4**
Middle	734	410	**44.1**
Richer	902	528	**41.5**
Richest	1505	882	**41.4**

The overall all method discontinuation rate is 44.1%

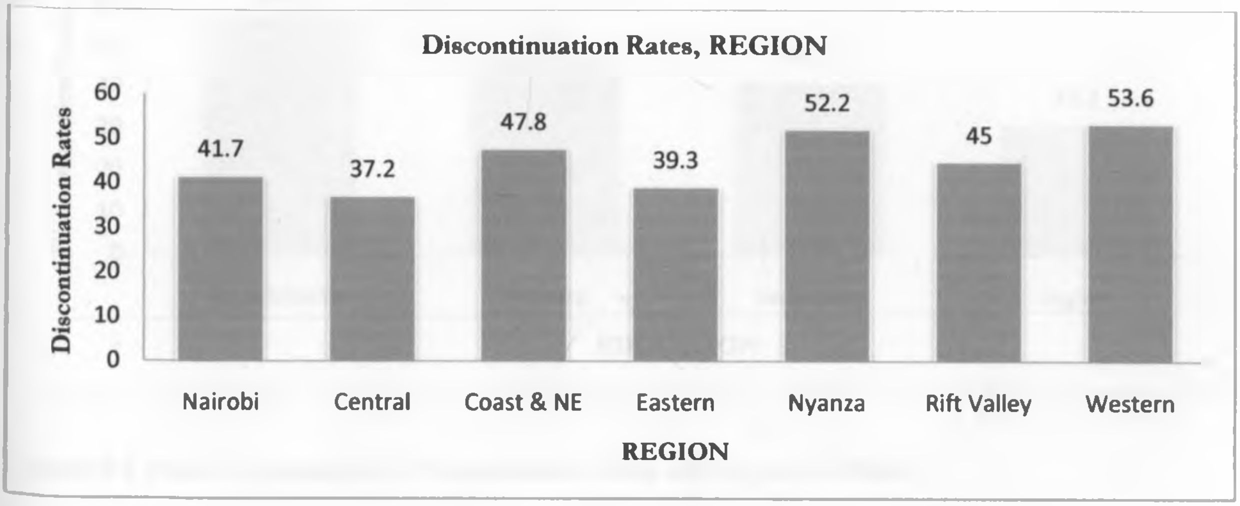
The 2003 KDHS data reveals that the overall all method discontinuation rate is 44.1% for the five-year period before the survey. The results as illustrated in figure 4-1 show that in the age category, women aged 15-19 have the highest discontinuation rates for all methods whereas women aged 35-39 have the lowest discontinuation rates. Contraception discontinuation rates generally decline with increase in age. This suggests that younger women struggle with consistent use of contraceptives than older women.

Figure 4-1 Trend in Contraceptive Discontinuation Rates with respect Age



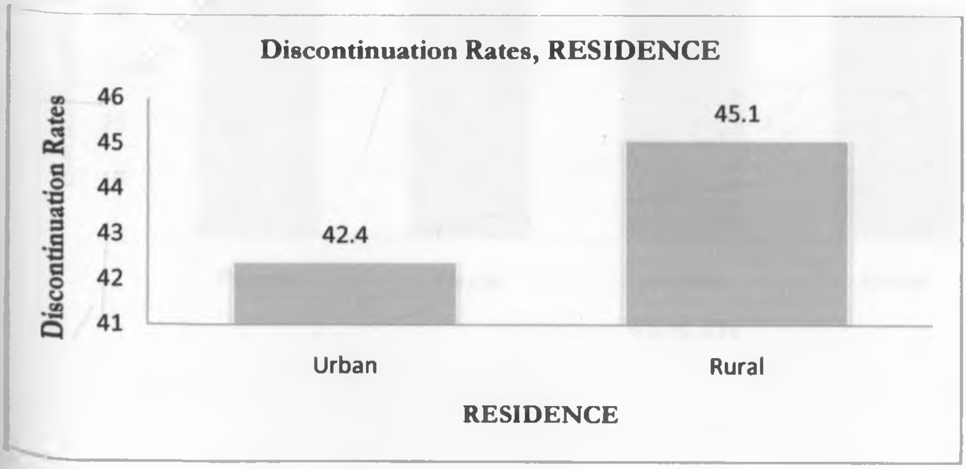
Kenyans living in Western have the highest discontinuation rates compared to those in other regions of the country (see figure 4-2). Women in Central province appear to consistently use contraceptives for longer duration than other regions.

Figure 4-2 Trend in Contraceptive Discontinuation Rates with respect to Region



Rural residents have slightly higher discontinuation rates than urban residents (see figure 4-3).

Figure 4-3 Trend in Contraceptive Discontinuation Rates with respect to Place of Residence



Women with higher levels of education as seen in figure 4-4 and those in the highest economic wealth status have the lowest discontinuation rates for all methods (see figure 4-5). Women's education and wealth status are positively associated with continuity in contraceptive use.

Figure 4-4 Trend in Contraceptive Discontinuation Rates with respect to Education

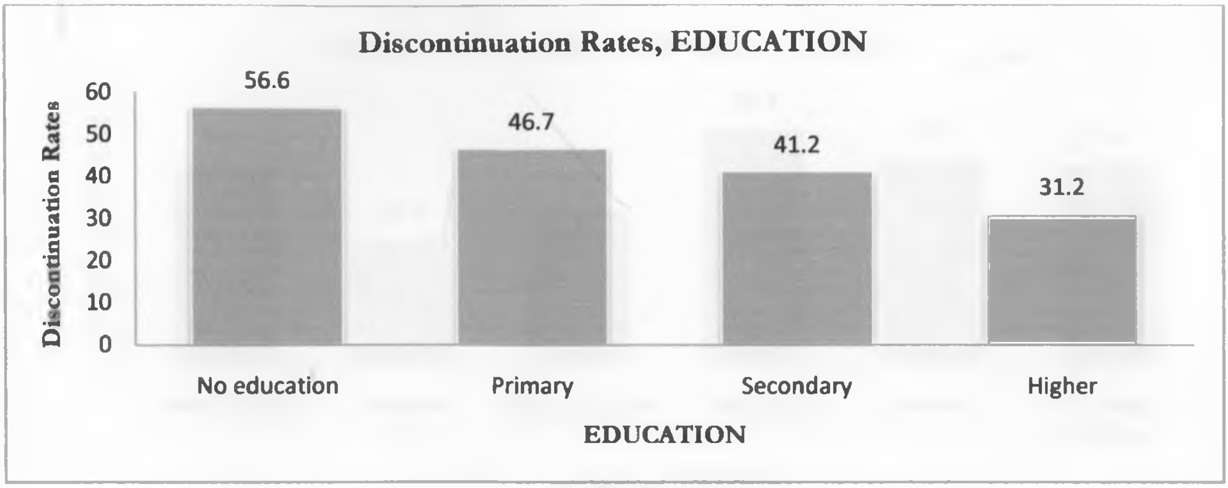
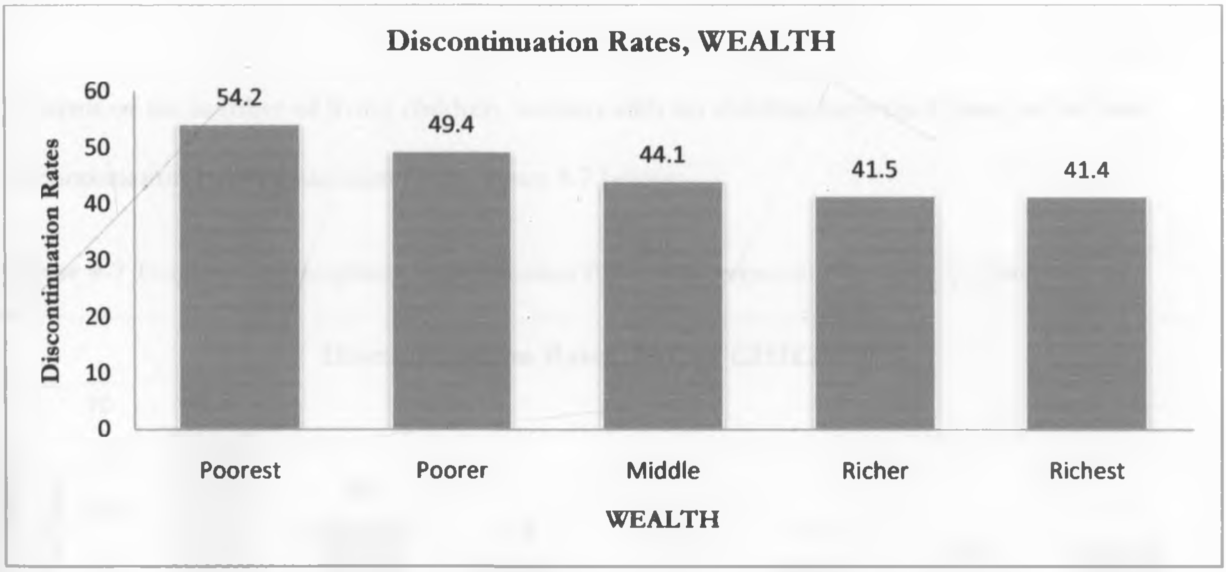
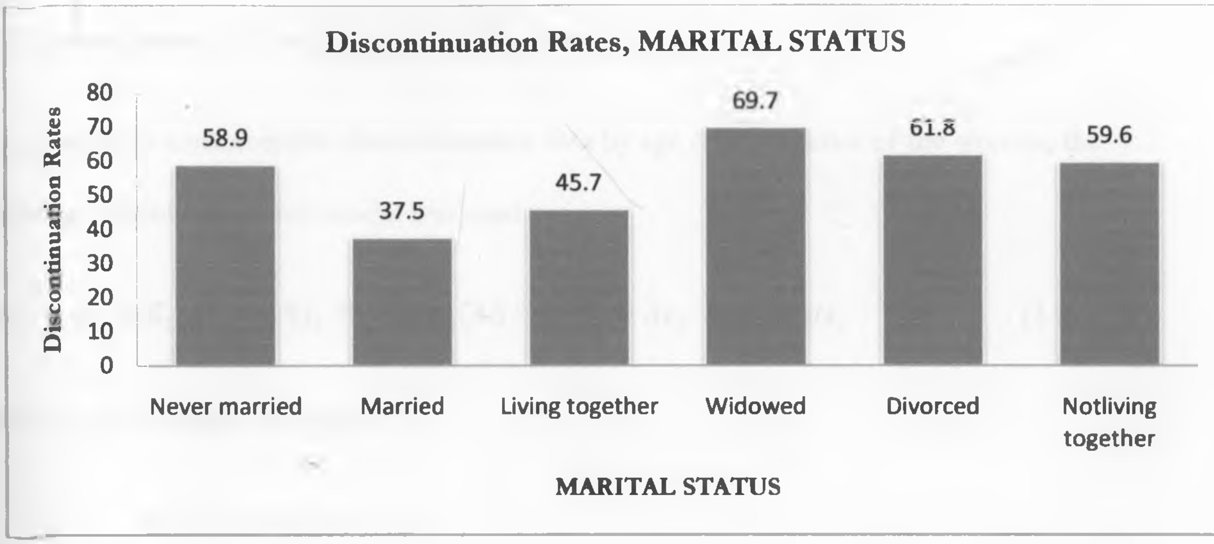


Figure 4-5 Trend in Contraceptive Discontinuation Rates with respect to Wealth



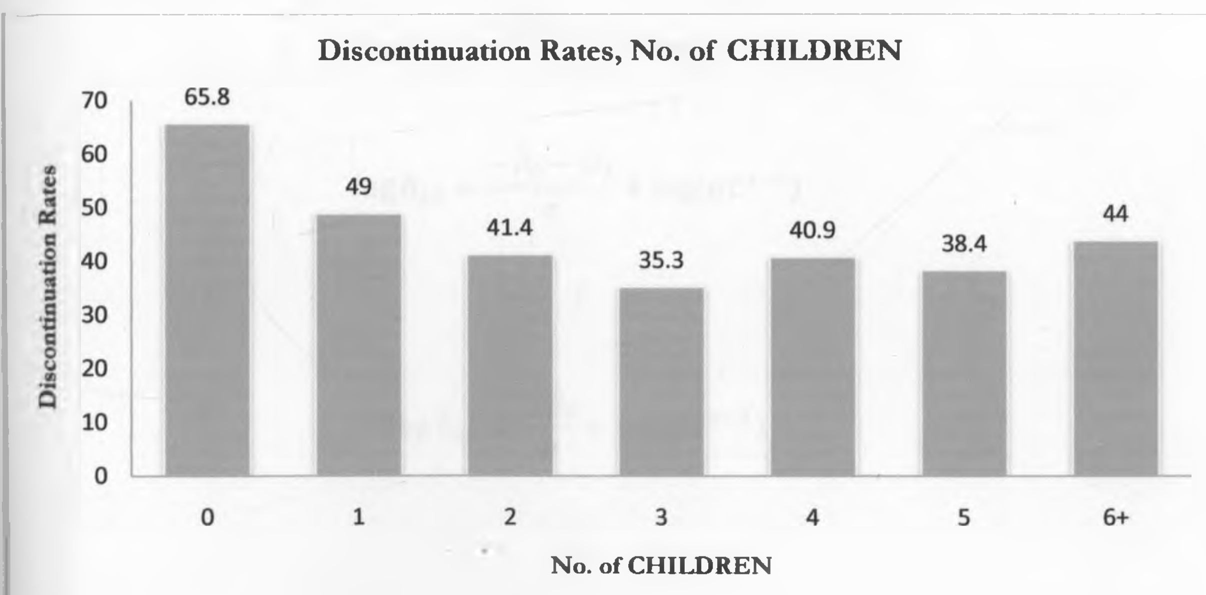
In the marital status category (see figure 4-6), the widowed have the highest all method discontinuation rates. However, the rate is lowest for married users.

Figure 4-6 Trend in Contraceptive Discontinuation Rates with respect to Marital Status



In terms of the number of living children, women with no children have the highest all method discontinuation rates as can seen in the figure 4.7 below.

Figure 4-7 Trend in Contraceptive Discontinuation Rates with respect to No. of living Children



ıe results indicate that Kenyan women with no children face impediments with the consistent use contraceptives than those with children.

:.2 Determinants of Contraceptive Discontinuation

ınsidering the contraceptive discontinuation data by age characteristics of the women, the lowing Weibull regression model was used:

$$;T_i = \beta_0 + \beta_1(15-19)_i + \cdots + \beta_6(45-49)_i + \sigma\varepsilon_i \;= \mu_i + \sigma\varepsilon_i \qquad (4.1)$$

$$;h(t,\gamma_i,\alpha) = \log\gamma_i + \log(\alpha t^{\alpha-1})$$

$$= \frac{-\mu_i}{\sigma} + \log(\alpha t^{\alpha-1})$$

$$= \frac{-\beta_0-\beta_1(15-19)_i-\cdots-\beta_6(45-49)_i}{\sigma} + \log(\alpha t^{\alpha-1}) \qquad (4.2)$$

the hazard function of the age categories be denoted as $h_{15}, h_{20}, h_{25}, h_{30}, h_{35}, h_{40}$and h_{45} ›ectively. From (4.2)

$$\log h_{15} = \frac{-\beta_0-\beta_1}{\sigma} + \log(\alpha t^{\alpha-1})$$

$$\log h_{20} = \frac{-\beta_0-\beta_2}{\sigma} + \log(\alpha t^{\alpha-1})$$

$$\vdots$$

$$\log h_{35} = \frac{-\beta_0}{\sigma} + \log(\alpha t^{\alpha-1})$$

$$\vdots$$

$$\log h_{45} = \frac{-\beta_0 - \beta_6}{\sigma} + \log(\alpha t^{\alpha-1})$$

[herefore, the logarithm of the hazard ratio of contraceptive discontinuation rates in age-category 5-19 and age- (ref) category 35-39 is

$$\log\left(\frac{h_{15}}{h_{35}}\right) = \frac{-\beta_0 - \beta_1}{\sigma} + \log(\alpha t^{\alpha-1}) - \left[\frac{-\beta_0}{\sigma} + \log(\alpha t^{\alpha-1})\right]$$

$$= -\frac{\beta_1}{\sigma}$$

imilarly, the rest of the hazard ratios are as follows:

$$\log\left(\frac{h_{20}}{h_{35}}\right) = {}^{-\beta_2}/_{\sigma}, \quad \log\left(\frac{h_{25}}{h_{35}}\right) = {}^{-\beta_3}/_{\sigma} \ldots \log\left(\frac{h_{45}}{h_{35}}\right) = {}^{-\beta_6}/_{\sigma}$$

hese ratios are constants and their effects are independent of time. To test the null hypothesis that ge categories of the women have an equal effect on the discontinuation in contraceptive use is lentical to testing the following hypotheses:

$$H_0 : \frac{h_{15}}{h_{35}} = 1 \; or \; \beta_1 = 0, \qquad H_0 : \frac{h_{20}}{h_{35}} = 1 \; or \; \beta_2 = 0, \cdots \; H_0 : \frac{h_{45}}{h_{35}} = 1 \; or \; \beta_6 = 0$$

ble 4.2 provides the results for contraceptive discontinuation by age characteristics for all ethods combined, using the Weibull hazard regression model. The hazard ratio is estimated as $p(-\hat{\beta}_i/\hat{\sigma})$. Overall, contraceptive discontinuation rate changes significantly with age-categories women aged 15-19 and 20-24 for all methods combined. After controlling for all covariates, men aged 15-19 and 20-24 are 95.5% and 94.5% less likely to continue use of contraceptive for methods compared to women aged 35-39 respectively. The result suggests that the proportion of women aged 15-24 face more obstacles to consistent use and are likely to discontinue a method than older women. Consequently, this puts the women aged 15-24 at risk of having an unwanted pregnancy.

Table 4.2 Analysis Results for contraceptive discontinuation for all methods combined by age characteristic using a Weibull Regression Model

Characteristic	Regression Coefficient	Standard Error	p	$exp(-\hat{\beta}_i/\hat{\sigma})$
Age				
15-19	**0.4322**	**0.197**	**0.0281**	**0.045***
20-24	**0.4027**	**0.197**	**0.0407**	**0.055***
25-29	0.2045	0.197	0.299	0.230
30-34	0.1311	0.197	0.505	0.390
35-39 (ref)	0.0000	-	-	1.000
40-44	0.0492	0.197	0.803	0.702
45-49	0.3064	0.197	0.119	0.111
Log(scale)	-1.9723	0.000	0.000	-
Shape parameter	7.1942			

*Significant at $p \leq 0.05$

(ref) = Reference Category

To choose between a set of competing parametric models, Akaike's information criterion was used to determine the model that provides the best fit with the data. The results of fitting parametric models in R are reported in Table 4.2.1. The AIC for the Weibull model is the smallest, indicating that this model provides the best fit for the contraceptive discontinuation data.

Ali, Marshall and Babiker (2001) noted that the Weibull distribution appeared to be more robust to model misspecifications than the log-logistic distribution. Hence, in the analysis of determinants of discontinuation for all methods the use of crude rates provides a realistic description of data when Weibull hazard regression model is fitted.

Table 4.2.1 The AIC results for competing parametric regression models

Model	AIC
Exponential	81.104
Weibull	55.492
log-logistic	55.841
log-normal	56.008

Table 4.3 presents the parameter estimates for the Weibull hazard regression analysis for other demographic and socioeconomic variables. Contraceptive discontinuation rate changes significantly in the Nyanza and Western regions. Women living in Nyanza and Western regions are 94.8% and 95.9% less likely to continue use of contraceptive for all methods combined compared to women living in Central respectively. There is no significant difference between contraceptive discontinuation among women who live in urban and rural areas. The result is consistent with findings from other countries (Creanga et al. 2007). The effect of women with no formal education is statistically significant. The results show that women with no formal education are 96.1% less likely to continue use of contraceptive for all methods compared to women with higher education. This indicates the importance of influencing women behavior related contraceptive discontinuation through education. Discontinuation rate is statistically significant for those women who do not have a child. Kenyan women with no children are 94.4% less likely to continue use of contraceptive for all methods combined compared to women with three children. It would appear that unwanted or

unplanned pregnancy poses a serious risk for women with no children. Marital status has a strong effect on combined methods contraceptive discontinuation rate. Therefore the never married, not living together, divorced and widowed respondents are 94.6%, 95.0%, 96.0% and 98.2% less likely to continue use of contraceptive for all methods compared to married women in Kenya. There are no marked variations in the discontinuation rates among women in the five levels of wealth status. The effect of wealth index is not generally statistically significant.

Table 4.3 Results of contraceptive discontinuation for all methods combined by selected characteristics using Weibull hazard regression model

Characteristics	Regression coefficient	Standard Error	p	$exp(-\hat{\beta}_i/\hat{\sigma})$
Region				
Central (ref)	0.0000	-	-	1.000
Coast & NE	0.2507	0.162	0.1210	0.111
Eastern	0.0549	0.162	0.7340	0.618
Nairobi	0.1142	0.162	0.4800	0.368
Nyanza	**0.3388**	**0.162**	**0.0360**	**0.052***
Rift Valley	0.1904	0.162	0.2390	0.189
Western	**0.3652**	**0.162**	**0.0238**	**0.041***
Log(scale)	-2.1696	0.000	0.0000	-
Shape parameter	3.7879			
Residence				
Urban (ref)	0.0000	-	-	1.000
Rural	0.0617	0.0364	0.0898	0.091
Log(scale)	-3.6601	0.0000	0.0000	-
Shape parameter	38.9105			

Education				
No education	**0.596**	**0.259**	**0.0213**	**0.039***
Primary	0.403	0.259	0.119	0.110
Secondary	0.278	0.259	0.283	0.219
Higher (ref)	0	-	-	1.000
Log(scale)	-1.699	0.000	0.000	-
Shape parameter	5.4645			
Number of living children				
0	**0.6227**	**0.306**	**0.0421**	**0.056***
1	0.3279	0.306	0.284	0.220
2	0.1594	0.306	0.603	0.479
3 (ref)	0.0000	-	-	1.000
4	0.1472	0.306	0.631	0.507
5	0.0842	0.306	0.784	0.678
6+	0.2203	0.306	0.472	0.362
Log(scale)	-1.5295	0.000	0.000	-
Shape parameter	4.6083			
Marital Status				
Living together	0.198	0.219	0.3670	0.279
Divorced	**0.500**	**0.219**	**0.0227**	**0.040***
Married (ref)	0.000	-	-	1.000
Never married	**0.452**	**0.219**	**0.03950**	**0.054***
Not living together	**0.463**	**0.219**	**0.03460**	**0.050***
Widowed	**0.620**	**0.219**	**0.00471**	**0.018***

Log(scale)	-1.864	0.000	0.00000	-
Shape parameter	6.4516			
Wealth Index				
Middle	0.06318	0.147	0.6680	0.545
Poorer	0.17667	0.147	0.2300	0.183
Poorest	0.26940	0.147	0.0671	0.075
Richer	0.00241	0.147	0.9870	0.977
Richest (ref)	0.00000	-	-	1.000
Log(scale)	-2.26312	0.000	0.000	-
Shape parameter	9.6154			

*Significant at $p \leq 0.05$

(ref) = Reference Category

The shape parameters $[= (1/Scale)]$ are greater than one implying that the risk of all method contraceptive discontinuation increases with time.

CHAPTER 5

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 DISCUSSION AND CONCLUSION

This study set out to examine the overall discontinuation rate and factors associated with contraceptive discontinuation for all methods combined among women in Kenya using data from the 2003 KDHS.

According to the findings obtained from the Weibull regression hazard model, higher levels of contraceptive discontinuation for all methods are concentrated among young women aged 15-24 than among older women. Further insights into the inconsistent use of contraceptive by women aged 15-24 can be gained through a detailed study of their adoption habits and reasons for discontinuing. The existing family planning programs and providers need to adopt models that can respond effectively to the contraceptive dynamics of these women. Their high discontinuation rates suggest that the existing service models are inadequate (Blanc et al. 2009). In the design and implementation of reproductive health strategies, methods that help delay the onset of childbearing of this group of women should be emphasized.

Women in Nyanza and Western regions of Kenya are significantly more likely to discontinue contraceptive use of all methods compared to those in central region. It is true that one or two communities chiefly occupy each of the eight regions of Kenya. These communities have their own socio-cultural ideologies about sexuality and reproduction which may affect the reproductive performance and uptake of family planning programmes of a given region (Ikamari and Towett, 2007). Hence, in the design and implementation of reproductive health programmes, an attempt should be made to address the socio-cultural practices that govern reproductive health in each community.

There is no significant difference between contraceptive discontinuation among women in urban and rural areas. This could imply that access to family planning services is inadequate both in rural and urban areas. However, the results show that women in urban areas are less likely to discontinue contraceptive use than those in rural areas.

The effect of women with no formal education on contraceptive discontinuation of all methods is statistically significant. Women with higher education are more likely to be better informed about the importance of family planning and social-economic benefits of a small family size than illiterate women. This stresses the value of influencing women behavior related contraceptive discontinuation through education.

Discontinuation rate for all methods is statistically significant for those women who do not have a child. Contraceptive discontinuation rate tends to be higher for low parity (0-1) women than for higher parity women. The contraceptive practice of this group of women is characterized by much experimentation and inconsistent use (Blanc et al. 2009). Therefore, women without children will require a comprehensive contraceptive package and information to assist them make an informed choice should they decide to have a child or plan their families.

Marital status has a strong effect on combined methods contraceptive discontinuation rate. The results show that contraceptive discontinuation in Kenya is dominated by women who are not in permanent relationships. However, women in more permanent relationships appear to have an incentive to look for family planning methods and stick to them. It is culturally and socially acceptable for a married woman to be using family planning methods. The strong effects of marital status point to the need for further research on contraceptive discontinuation dynamics among unmarried women.

There are no marked variations in the discontinuation rates among women in the five levels of wealth status. This is similar to findings in previous studies (Ali and Cleland, 1995; Moreno, 1993). A possible reason as to why wealth is generally not statistically significant is that it is mitigated by social determinants such as education and culture.

The findings from this study show that contraceptive discontinuation rate is high and the risk of all method discontinuation increases with time. The study also confirms most findings from previous studies relating to the impact of socio-demographic differentials on contraceptive discontinuation in Kenya. Finally, the results from the Weibull regression hazard model revealed that Age (15-24), Region (Nyanza, Western), Education (No education), Number of Living Children (0) and Marital Status (Never married, Not living together, Divorced, Widowed) significantly affect discontinuation in the contraceptive practice of Kenyan women.

In conclusion, the study confirms the hypothesis that young unmarried women from Nyanza and Western regions who do not have children and lack any formal education are most likely to stop contraceptive use regardless of duration of use. Therefore, they have the highest exposure to pregnancy.

5.2 RECOMMENDATIONS

The analysis from the KDHS contraceptive data suggests several areas for future research. A detailed study of the adoption habits and reasons for discontinuing of young women aged 15-24 deserves further investigation. Further research on contraceptive discontinuation dynamics among unmarried women will also be necessary to enhance the quality of information on contraceptive research. Other factors such as religion distance from the nearest health centre, social taboos and traditional beliefs should be included in the analysis of contraceptive discontinuation.

BIBLIOGRAPHY:

1. Phillips, J. F., Mundigo, A., Chamratrithirong, A. (1991). The Correlates of Continuity in Contraceptive use. Journal of Family Welfare of India 35, 3-17.

2. Trussel, J. (1991). Methodological Pitfalls in the Analysis of Contraceptive Failure. Statistics in Mediane 10,201-220. African Journal

3. Steele, F., and Curtis, A., 2003. "Appropriate methods for analyzing the effect of method choice on contraceptive discontinuation." Demography 40(1): 1-22.

4. Tripathi, V. (2008). Statistical Approach for Evaluation of Contraceptive. African Journal of Reproductive Health Vol. 12, No. 1, pp. 17-21

5. Williams, J., S., (1978). Efficient Analysis of Weibull Survival Data from Experiments on Heterogeneous Patient Populations. Biometrics, Vol. 34, No. 2, pp. 209-222

6. Crowder, M., (1989). A Multivariate Distribution with Weibull Connections. Journal of the Royal Statistical Society. Series B, Vol. 51, No. 1, pp. 93-107

7. Zhang, F., Tsui, A., O., and Suchindran, C., M., (1999). The Determinants of Contraceptive Discontinuation in Northern India: A Multilevel Analysis of Calendar Data. MEASURE Evaluation Project

8. Pinder III, J., E., Wiener, J., G., and Smith, M., H., (1978). The Weibull Distribution: A New Method of Summarizing Survivorship Data. Ecology, Vol. 59, No. 1, pp. 175-179

9. Blanc, Ann K., Curtis, Siân, Croft, Trevor (1999). Does Contraceptive Discontinuation Matter? Quality of Care and Fertility Consequences. MEASURE Evaluation Technical Report Series No. 3.

10. Magadi, M., em Zulu, ac Ezeh and Curtis, S., (2001). Contraceptive Use Dynamics In Kenya: Further Analysis Of Demographic And Health Survey (DHS) Data. MEASURE Evaluation project, African Population and Health Research Center

11. Creanga, A., A., Acharya, R., Ahmed, S., and Tsui, A., O., (2007). Contraceptive Discontinuation and Failure and Subsequent Abortion in Romania: 1994-99. Studies in Family Planning, Vol. 38, No. 1, pp. 23-34

12. Moreno, L., (1993). Differences by Residence and Education In Contraceptive Failure Rates in Developing Countries. International Family Planning Perspectives, Vol. 19, No. 2, pp. 54-60+71

13. Kizito, P., Johnston, A., and Hyslop, A., (2005). Background to the Further Analysis of the 2003 Kenya Demographic and Health Survey. Summaries of Selected NCAPD Working Papers

14. Leite, I., C., and Gupta, N. (2007). Assessing regional differences in contraceptive discontinuation, failure and switching in Brazil. Reproductive Health

15. Ikamari, L., D., E., and Towett, R., (2007). Sexual initiation and contraceptive use among female adolescents in Kenya. African Journal of Health Sciences, Vol. 14, No. 1-2, pp. 1-13

16. Okech, T., C., Wawire, N., W., Mburu, T., K., (2011). Contraceptive Use among Women of Reproductive Age in Kenya's City Slums. International Journal of Business and Social Science Vol. 2 No. 1

17. Family Planning Opportunities at County Governments Under the New Kenyan Constitution. NCPD Policy Brief No. 27 – 2012

18. Republic of Kenya, (2010), The Constitution of Kenya, Revised edition, Kenya Law Reports, National Council for Law Reporting, Nairobi, Kenya

19. Curtis, S., Evens, E., and Sambisa, W., (2011). Contraceptive Discontinuation and Unintended Pregnancy: An Imperfect Relationship. International Perspectives on Sexual and Reproductive Health, Vol. 37, No. 2 pp. 58-66

20. Kleinbaum, D., G., and Klein, M., (2005). Survival Analysis: A Self – Learning Text. Statistics for Biology and Health. Second Edition pp 273

21. Tableman, M., (2008). Survival Analysis Using S/R*. pp 77-79

APPENDIX:

R OUTPUT FOR AGE CHARACTERISTIC

```
sd.age=read.table("clipboard",header=T,sep="\t")

sd.age

   AGE dRate Status

1. 15-19   55.0     1

2. 20-24   53.4     1

3. 25-29   43.8     1

4. 30-34   40.7     1

5. 35-39   35.7     1

6. 40-44   37.5     1

7. 45-49   48.5     1

sd.age$AGE=as.factor (sd.age$AGE)

summary(sd.age$AGE)

15-19 20-24 25-29 30-34 35-39 40-44 45-49

    1     1     1     1     1     1     1

sd.age$AGE=relevel (sd.age$AGE,ref="35-39")

attach(sd.age)

library(survival)

Loading required package: splines

weibu.age=survreg(Surv(dRate,Status)~AGE,data=sd.age,dist="weibull")

summary(weibu.age)
```

Call:

survreg(formula = Surv(dRate, Status) ~ AGE, data = sd.age, dist = "weibull")

	Value	Std. Error	z	p
(Intercept)	3.5752	0.139	25.694	1.35e-145
AGE15-19	0.4322	0.197	2.196	2.81e-02
AGE20-24	0.4027	0.197	2.046	4.07e-02
AGE25-29	0.2045	0.197	1.039	2.99e-01
AGE30-34	0.1311	0.197	0.666	5.05e-01
AGE40-44	0.0492	0.197	0.250	8.03e-01
AGE45-49	0.3064	0.197	1.557	1.19e-01
Log(scale)	-1.9723	0.000	-Inf	0.00e+00

Scale= 0.139

Weibull distribution

Loglik(model)= -19.7   Loglik(intercept only)= -23.7

Chisq= 7.86 on 6 degrees of freedom, p= 0.25

Number of Newton-Raphson Iterations: 1

n= 7

```
> Ageweibu=cbind(weibu.age$coef)
> hrr.age=exp(-Ageweibu[2,1])^(1/(weibu.age$scale));hrr.age
 AGE15-19
0.04477639
```

```
> hrr2.age=exp(-Ageweibu[3,1])^(1/(weibu.age$scale));hrr2.age
AGE20-24
 0.05536
> hrr3.age=exp(-Ageweibu[4,1])^(1/(weibu.age$scale));hrr3.age
 AGE25-29
0.2300151
> hrr4.age=exp(-Ageweibu[5,1])^(1/(weibu.age$scale));hrr4.age
 AGE30-34
0.3898291
> hrr5.age=exp(-Ageweibu[6,1])^(1/(weibu.age$scale));hrr5.age
 AGE40-44
0.7022064
> hrr6.age=exp(-Ageweibu[7,1])^(1/(weibu.age$scale));hrr6.age
 AGE45-49
0.1105623

> anova(weibu.age)
    Df   Deviance Resid. Df    -2*LL    Pr(>Chi)
NULL    NA       NA        5 47.34780       NA
AGE      6 7.855411        -1  39.49238  0.2488888
>
> expo.age=survreg(Surv(dRate,Status)~AGE,data=sd.age,dist="exponential")
> logn.age=survreg(Surv(dRate,Status)~AGE,data=sd.age,dist="lognormal")
> logl.age=survreg(Surv(dRate,Status)~AGE,data=sd.age,dist="loglogistic")
```

```
> extractAIC(weibu.age)[2]

[1] 55.49238

> extractAIC(expo.age)[2]

[1] 81.10412

> extractAIC(logl.age)[2]

[1] 55.841

> extractAIC(logn.age)[2]

[1] 56.0077
```

****