CHAPTER ONE
INTRODUCTION

1.1 INTRODUCTION

Survival data has been used in a broad sense for data involving time to the occurrence of a certain event. This event may be death, the appearance of a tumor, the development of some disease, recurrence of a disease, conception, cessation of smoking, and so forth. In the past decades, applications of the statistical methods for survival data analysis have been extended beyond biomedical and reliability research to other fields, for example, lifetime of electronic devices, components or systems (reliability engineering), felons' time to parole (criminology), duration of first marriage (sociology), length of newspaper or magazine subscription (marketing), workmen's compensation claims (insurance), health insurance practice, business and economics.

The study of survival data has previously focused on predicting the probability of response, survival, or mean lifetime, and comparing the survival distributions of experimental animals or of human patients. In recent years, the identification of risk and/or prognostic factors related to response, survival, and the development of a disease has become important.

The analysis of survival data is complicated by issues of censoring and truncation. Censored data arises when an individual's life length only is known to occur in a certain period of time. Possible types of censoring are right censoring, where all that is known is that the individual is still alive at a given time, left censoring is when all that is known is that the individual experienced the event of interest prior to the start of the study, or interval censoring, where the only information is that the event occurs within some interval of time.

One type of right censoring that is very common is Type I censoring, where the event is observed only if it occurs prior to some pre-specified time, e.g. at the closing of a study.

A second type of right censoring is Type II censoring in which the study continues until the failure of the first *r* individuals, where *r* is some predetermined integer.

Experiments involving Type II censoring are often used in testing of equipment life. Most methods used in survival analysis are proper for right censored data.

Truncation is a condition which screens certain subjects so that the investigator will not be aware of their existence, only individuals who meet some condition are observed.

1.2 The Aim of the Work

1.3 REVIEW OF PREVIOUS STUDIES

MRL function has been used in studies concerning aging of non–repairable and repairable technical systems (Reinertsen (1996), Siddiqui (1994)), burn-in time of a component or a system (Block and Savits (1998), Park (1985), Watson (1964)), warranty servicing strategies involving minimal and imperfect repairs (Yun et al. (2008)) and to test tensile strength of engineered materials (Guess et al. (2005)).

The concepts of the reversed hazard rate (RHR), reversed mean residual (RMR), reversed variance residual (RVR) have focused by many authors in the field of reliability. These measures have many applications in various situations such as, in the analysis of the left-censored data (Andersen et al., 1993) and in the forensic science where exact time of failure of a unit is of importance, like death in case of human beings.
The RMR and the RVR are useful tools to model and analyze the wear-out and maintenance policies.

Haines and Singpurwalla (1974), introduced general concept of the α-percentile residual life function was originally.

Hall and Wellner (1981), characterized a family of the mean residual life functions that are linear in age t.

Bhattacharjee (1982), introduced the mean residual life function, deriving necessary and sufficient conditions for an arbitrary function to be a mean residual life function.

Hall and Wellner (1984), introduced a class of survival distributions characterized by linear mean residual lifetimes.

Gupta and Langford (1984), under mild assumptions determined a general form of distribution when its median residual life function is known.

Guess and Proschan (1985), reviewed both theory and application aspects of the mean residual life function.

Ghosh and Mustafi (1986), Csörgö and Csörgö (1987) and Alam and Kulasekera (1993), investigated large sample estimation of the MERL function and stochastic properties of such estimators.

Berger, Boos, and Guess (1988), proposed a nonparametric test statistic to compare the mean residual life functions based on two independent samples.

Oakes and Dasu (1990), defined the mean residual life function and discuss the asymptotic properties of one-sample nonparametric estimator and proposed the proportional mean residual life model $m(t \mid X) = m(t)\exp\left(X^T \beta\right)$, Where $m(t \mid X) = E(T - t \mid T > t, X)$ and $m(t)$ is the unknown and unspecified baseline mean residual lifetime.

Rao, Damaraju, and Alhumoud (1993), Gelfand and Kottas (2003), Jeong, Jung and Bandos(2007), develop and describe a regression model for the residual life function.

Maguluri and Zhang (1994), proposed the Cox-type estimating equation based on the proportional hazards structure (Cox, 1972), and introduced the forward recurrence times in the renewal process.

Sengupta et al. (1998), Chandra and Roy (2001) and Finkelstein (2002), have discussed some of the well-known and new properties of the reversed hazard rate.

Chandra and Roy (2001), Di Crescenzo and Longobardi (2002), Li and Lu (2003), Nanda *et al.* (2003), Ahmad *et al.* (2005) and Mahdy (2009), introduced the reversed residual lifetime random variable.

Gelfand and Kottas (2003), proposed a Bayesian semi-parametric approach to the median residual life model.

Kayid, Ahmad (2004) and Ahmad et al. (2005), introduced the reversed mean residual life orderings.

Chen and Cheng (2006), proposed a inference based on the median residual life model which be more robust to model misspecification by modeling a broad range of quantiles of the residual lifetime, and offer a more complete evaluation of the distribution of the residual lifetime.

Jeong, Jung and Costantino (2007), proposed Two-sample comparison of the MERL functions.

Al-Zahrani and Stoyanov (2008), introduced some properties of life distributions with increasing elasticity and log-concavity due to RMR and RVR in continuous lifetime are obtained.

Jeong, Jung and Costantino (2008), introduced a nonparametric median residual life function that can be constructed through the Kaplan–Meier survival estimator in the case of the two-sample comparison.

Jung, Jeong and Bandos (2009), proposed a general regression model based on the median residual lifetime, which is built upon the work by Ying, Jung and Wei (1995). These methods typically begin by modeling a survival function and then make inference on the median residual life function.

Joo, Jie Mi (2010), introduce a comparison of the hazard rate functions of two parallel systems, each of which consists of two independent components with exponential distribution functions, also gives various conditions under which there exists a hazard rate ordering between the two parallel systems.

N. Unnikrishnan Nair, B. Vineshkumar (2011), introduced the properties of the reversed percentile residual life function and its relationship with the reversed hazard function, also introduce some models with simple functional forms for both reversed hazard rate and reversed percentile residual life function are proposed.

M. Kayid, S. Izadkhah, and H. Alhalees (2014), introduced a new stochastic order called proportional mean residual life order and several characterizations and preservation properties of the new order under some reliability operations.

1.4 The Outline of Research

This thesis consists of four chapters:

- In chapter 2:

Some definitions and notations are introduced which will be used in this study, this chapter consist of five sections,

In section (2.2) hazard rate function

In section (2.3) reversed hazard rate function

In section (2.4) mean residual life function

In section (2.5) reversed mean residual life function

In section (2.6) variance residual life function

In section (2.7) reversed variance residual life function

In section (2.8) quantile function

In section (2.9) survival analysis

- In chapter 3:

This chapter consists of nine sections that is

In section (3.2) median residual life function

In section (3.3) median inactivity lifetime distribution and its properties

In section (3.4) percentile residual life function

In section (3.5) reversed percentile residual life function

In section (3.6) regression model for median life function

In section (3.7) the sample estimator of median residual lifetime

In section (3.8) regression quantiles of residual lifetime

In section (3.9) censored regression residual quantile estimator

- In chapter 4:

This chapter consist of four sections that is

In section (4.2) proportional median residual life model

In section (4.3) proportional quantile reversed residual life model and this section contain of (model description and estimating equations, estimating procedure, estimation interval and variance of parameter estimation).

In section (4.4) parametric distribution and it contain of

*accelerated median residual life model with three distribution which (webuall distribution – exponential power distribution – pareto distribution)

*accelerated quantile reversed residual life model with three distribution which (webuall distribution – exponential power distribution – pareto distribution)

- In chapter 5: Application