JOURNAL OF BASIC SCIENCE AND ENGINEERING

A NEW APPROACH TO COMPARING THE RELIABILITY DISTRIBUTIONS IN A FUZZY ENVIRONMENT

Senthil kumar P[a], Vijayabalan D[b], Sukumaran D[c], Venkatachalapathy M[d], Balamurugan K[e], Selvakumari R[f]

Vel Tech High Tech Dr. Rangarajan Dr. Sakunthala Engineering College, Chennai[a,b,c,d]
Assistant Professor[a], Associate professor[b,c], professor[d],
Associate professor[e], Assistant Professor[a]
K. Ramakrishnan College of Engineering, Trichy[d]
K. Ramakrishnan College of Technology, Trichy[e]
Vel Tech Rangarajan Dr. Sakunthala R&D Institute of Science and Technology [f]

DOI: https://doie.org/10.0618/Jbse.2024251594

Abstract

The purpose of this article is to get depth knowledge of distribution under fuzzy environment. Understanding of distribution is one of the most important tools in reliability. In this paper we approach to the fuzzy reliability estimation which includes a distribution function that includes fuzzy parameter. For investigation of this paper we handling fuzzy Weibul, fuzzy log logistic and fuzzy exponential distributions are used to create a cut set of fuzzy reliability functions using the concept of reliability and this method. The findings demonstrate that patients' Corticosterone responses increased after As a result, Corticosteone's reliability is acknowledged. Additionally, we covered the appropriate fuzzy distribution to use when testing hypotheses in a fuzzy environment in order to determine Reliability.

Keywords: Fuzzy Reliability, Weibull, Log-Logistic, Exponential distributions, Corticosterone.

1. INTRODUCTION

It is assumed that the lifetimes are random variables. Crisp parameters define the probability distribution of the variable at random (lifetime density function). Due to data uncertainty and imprecision, it might be challenging to establish the parameters in many circumstances. Therefore, it makes sense to suppose that the parameters are fuzzy quantities. In this study, it is assumed that component lives and repair times follow a distribution known as Weibull with fuzzy parameters. Fisher and Tippett proposed the distribution known as the Weibull function in 1928. This probability distribution was first used in 1939 by the Swedish scientist Wallodi Weibull to describe the lifespan of components with varied failure rates. The distribution known as Weibull has been shown to be adaptable and versatile for expressing monotonic failure rate data among the different distributions that have already been explored.

The assumed probability models or distribution has a significant impact on the significance of the techniques utilized in a statistical research. Making decisions about a population based on information obtained from a sample of that population is the goal of statistical interpretation. A technique to demonstrate the ease with which one can generalize experiential outcomes in a study sample for the higher population that from which the sample was taken, hypothesis testing is a method used for evaluating the strength of testimony from the sample and provides a basis for decisions related to the population. Numerous studies concentrated on applying the theory of fuzzy sets for the investigation of the dependability of fuzzy systems. Reliability or the survival function is the two functions that are most frequently utilized in lifetime data analysis. This function calculates the likelihood that a device will perform properly for a specific period of time. Many techniques and models used in traditional reliability theory make the assumption that the lifespan density function's various parameters are accurate. However, in real life, randomness and fuzziness coexist throughout the system's existence.

Zadeh [10] proposed fuzzy set theory in 1965. Later, fuzzy set theory and mathematics were developed and used in a variety of academic domains [8]. Several writers [1], [2], [4], and [5] suggested and developed the concept of fuzzy dependability. Cai et al. [4] [5] adjusted the system's assumptions so that the success or failure of the fuzzy state assumption is clearly defined. The system may at any point be in either the fuzzy success state possibility assumption or the fuzzy failure stage possibility assumption. The behavior of the system can be fully described by the possibility measure. An introduction to system failure and the application of fuzzy techniques was provided by Cai [5]. A technique of fuzzy reliability analysis utilizing fuzzy numbers was introduced in [4] and [5]. A technique for fuzzy reliability in system research for alpha cuts operations for fuzzy numbers was presented by Chen S.M. [2]. Fuzzy reliability model functions that depend on the Weibull distribution were described by Zdenek Karpisek et al. in their article [11]. Utkin et al. proposed a set of functional equations in [9] for the examination of fuzzy reliability in diverse systems. The point of intersection has a fuzzification value of 0.5. Every fuzzy value above 0.5 shows that there may be values in the collection that correspond to the original phenomenon. It's probable that the original phenomenon's quantity is a member of the set when the fuzzification values decrease below 0.5. Values might not belong to the set.

For the influence of corticosterone release in rats over a 24-hour light/dark period, we present a fuzzy reliability model in this study based upon the Weibull distribution, Log-Logistic distribution, and Exponential distribution. A Weibull distribution with two parameters, a log-logistic distribution, and an exponential distribution were used to compute the cutoffs for a fuzzy reliability function.

Notation

χ	–	Weibull distribution's scale parameter
δ	–	Shape of the Weibull distribution parameter
γ	–	Explicit exponential distribution scale parameter

η	–	Shape of Exponential distribution parameter
ρ	–	Log-logistic distribution scale parameter
σ	–	Shape of the Log-Logistic distribution parameter
$\bar{\chi}[x_\beta^L]$	–	Beta cut of the Weibull distribution's scale value
$\bar{\delta}[x_\beta^L]$	–	Beta cut of the Weibull distribution's shape value
$\bar{\tau}[x_\beta^L]$	–	Scale value of the exponential distribution's Beta cut
$\bar{\upsilon}[x_\beta^L]$	–	Beta cut of the exponential distribution's shape value
$\bar{\rho}[x_\beta^L]$	–	Scale value of the log-logistic distribution's Beta cut
$\bar{\sigma}[x_\beta^L]$	–	Beta cut of the Log-logistic distribution's shape value
$\Re_\omega(t)$	–	Weibull distribution's reliability function
$\Re_\varepsilon(t)$	–	Exponential distribution's reliability function
$\Re_{LL}(t)$	–	Distribution with a log-logistic reliability function
t	–	Test completion period

2. Preliminaries

2.1 Fuzzy Number:

Let $\boldsymbol{\chi}$ be the Universal Set and $S_X = \{x \epsilon \chi : f(x;\theta > 0\}$ be the support of X. A fuzzy subset $\tilde{x}$ of S_X is defined by its membership function $\mu_{\tilde{x}}: S_X \to [0,1]$.We denote the Beta-cuts of $\tilde{x}$ by $\tilde{x}_\beta = \{x: \mu_{\tilde{x}}(x) \geq \beta\}$and $\tilde{x}_\beta$ are the closure of the set $\{x : \mu_{\tilde{x}}(x) > 0\}$.

The fuzzy set $\tilde{x}$ is called the normal fuzzy and called convex fuzzy sets if $\mu_{\tilde{x}}(\lambda x + (1-\lambda)y) \geq \min\{\mu_{\tilde{x}}(x), \mu_{\tilde{x}}(y)\}$ for every $x, y \in \$_x$, $\lambda \in [0,1]$.The fuzzy set $\tilde{x}$ is called the fuzzy number if it is a normal and convex fuzzy set and its alpha cuts are bounded for all $\alpha \in [0,1]$

.In addition, if $\tilde{x}$ is a fuzzy number and the support of its membership functions $\mu_{\tilde{x}}$ is compact, then we called $\tilde{x}$ as a bounded fuzzy number.

If $\tilde{x}$ is a closed and bounded fuzzy number with $x_\alpha^L = \inf\{x : x \in \tilde{x}_\alpha\}$ and $x_\alpha^U = \sup\{x : x \in \tilde{x}_\alpha\}$ and its membership function be strictly increasing on the interval $[x_\alpha^L, x_1^L]$ and strictly decreasing in the interval $[x_1^U, x_\alpha^U]$ then $\tilde{x}$ is called canonical fuzzy number.

2.2 Fuzzy Random Variable

The fuzzy number $\tilde{x}$ with membership function $\mu_{\tilde{x}}(r)$ can be introduced by any real number $\alpha \in \$_x$ such that $\mu_{\tilde{x}}(x) = 1$, $\mu_{\tilde{x}}(r) < 1$, for $r \neq x$ .we denote the set of all fuzzy real numbers introduced by real number $x \epsilon S_X$ by $F(S_X)$.

The relation $\sim$ on $F(S_X)$ define as $\tilde{x}_1 \sim \tilde{x}_2$,If and only if $\tilde{x}_1$ and $\tilde{x}_2$ are introduced by the same real number X. then $\sim$ is an equivalence relation, which induce the equivalence classes $[\tilde{x}] = \{\tilde{a} : \tilde{a} \sim \tilde{x}\}$.

The set $(F(S_X)/\sim)$ called a fuzzy real number system. In practice, we take only a one element $\tilde{x}$ from each equivalence class $[\tilde{x}]$ to form the fuzzy real number system $(F(S_X)/\sim)$. If the fuzzy real number system $(F(S_X)/\sim)$ consist of all call $(F(S_X)/\sim)$ as the canonical fuzzy real number system.

Let X be a random variable with support S_X and $F(S_X)$ is the set of all canonical fuzzy numbers induce the real numbers in S_X. A fuzzy random variable is a function $\tilde{x}: \omega \rightarrow F(S_X)$, where for all $\beta \in [0,1]$.

Definition: 2.3

Let ψ be a global set. The relationship function provides the fuzzy set's enumeration $\phi_{\bar{\psi}} : \psi \rightarrow [0,1]$, the degrees of ψ , can have values that range from 0 to 1 as well as belong to the fuzzy set. The functions that define each level of membership are $0 \leq \psi \leq 1$.

Definition: 2.4

Vol. 21, No. 1, (2024)
ISSN: 1005-0930

A fuzzy set with a relationship function as well as a fundamental set containing underlying variables makes up a fuzzy random variable. A fuzzy random variable X is a map $\rho : \mathrm{X} \to \mathrm{P}(R)$ fulfills the aforementioned requirements:

(1) For each $\alpha \in [0,1]$ both $\mathrm{X}_{\delta L}$ and $\mathrm{X}_{\delta U}$ specified as $\mathrm{X}_{\delta L}(\phi)(\overline{\psi}) = low\{\psi \in R : \mathrm{X}(\phi)(\overline{\psi}) \geq \alpha\}$ and $\mathrm{X}_{\delta U}(\phi)(\overline{\psi}) = high\{\psi \in R : \mathrm{X}(\phi)(\overline{\psi}) \geq \beta\}$ are defined on such $(\rho, A.F)$ in which the mathematical expectation $\mathrm{X}_{\delta L}$ and $\mathrm{X}_{\delta U}$ exist as bounded real valued random variables.

(2) For each $\phi \in \sigma$ and $(\alpha, \beta) \in [0,1]$, $\mathrm{X}_{\delta L}(\phi)(\overline{\psi}) \geq \alpha$ and $\mathrm{X}_{\delta U}(\phi)(\overline{\psi}) \geq \beta$

Definition: 2.5

In that it refers to an interconnected set of potential values rather than a single one, a number that is fuzzy is an extrapolation of a regular number. Where each conceivable value has a weight that ranges from o to 1 the function for membership is the name of this weight. A convex and typical fuzzy set is what makes up a fuzzy number. If $\overline{\underline{\psi}}$ is a fuzzy number then $\overline{\underline{\psi}}$ is a fuzzy convex set, if $\phi_{\overline{\psi}}(x_0) = 1$ then $\phi_{\overline{\psi}}(x)$ is non-decreasing for $x \leq x_0$ and non-increasing for $x \geq x_0$

Definition: 2.6

The triplet designates a triangular fuzzy number $\psi = (\psi_1, \psi_2, \psi_3)$, the membership function

$$\phi_{\overline{\psi}}(t) = \begin{cases} 0 & t \leq \psi_1 \\ \dfrac{t - \psi_1}{\psi_2 - \psi_1} & \psi_1 \leq t \leq \psi_2 \\ \dfrac{\psi_2 - t}{\psi_3 - \psi_2} & \psi_2 \leq t \leq \psi_3 \\ 1 & \psi_3 \geq t \end{cases}$$

The non-fuzzy set that defines the alpha-cut for a fuzzy number is $M\psi[\alpha] = \{\omega \in R : \phi_{\overline{\psi}}(t) \geq \alpha\}$ Hence we have $M\psi[\alpha] = [M\psi[\alpha 1], M\psi[\alpha 2]]$. When using alpha cuts, the range of confidence can be expressed as $M\psi[\alpha] = [(\psi_2 - \psi_1)\alpha + \psi_1, (\psi_2 - \psi_3)\alpha + \psi_3]$

2.7 The Weibull distribution's probability density function

A continuous random parameter T_ω having a Weibull distribution with two parameters $\omega(\chi, \delta)$ has a probability density function, where $\delta > 0$ is the shape parameter and $\chi > 0$ is the scale parameter

Vol. 21, No. 1, (2024)
ISSN: 1005-0930

$$f_{\varpi}(t)=\left\{\delta\chi^{-\delta}(t)^{\delta-1}e^{-\left(\frac{t}{\chi}\right)^{\delta}},t\geq 0,\chi\geq 0,\delta\geq 0\right\}$$

The following formulas provide the Weibull distribution's cumulative distribution function (CDF)

$$F_{\varpi}(t)=1-e^{-\left(\frac{t}{\chi}\right)^{\delta}}$$

The Weibull distribution's reliability function is $\Re_{\varpi}(t)=e^{-\left(\frac{t}{\chi}\right)^{\delta}}$

2.8 The probability density function for the exponential distribution

A continuous random variable T_{ε} with Exponential distribution $\varepsilon(\gamma,\eta)$ where, $\eta>0$ is shape parameter and $\gamma>0$ is scale parameter has the probability density function is given by

$$f_{\varepsilon}(t)=\gamma^{-1}e^{-\gamma(t-\eta)},t>0,\gamma\geq 0,\eta\geq 0$$

The following gives the formula for the two-parameter exponential cumulative density function

$$F_{\varpi}(t)=Q_{\varepsilon}(t)=1-e^{-\gamma(t-\eta)}$$

The reliability function of the Exponential distribution is

$$\Re_{\varepsilon}(t)=1-Q_{\varepsilon}(t)$$

$$\Re_{\varepsilon}(t)=1-\int_{0}^{t-\eta}f(\tau)d\tau$$

$$\Re_{\varepsilon}(t)=\int_{0}^{t-\eta}\gamma e^{-\gamma\tau}d\tau$$

$$\Re_{\varepsilon}(t)=e^{-\gamma(t-\eta)}$$

2.9 The Log-Logistic distribution probability density function

A continuous random variable T_{LL} with Exponential distribution $LL(\rho,\sigma)$ where, $\sigma>0$ is shape parameter and $\rho>0$ is scale parameter has the probability density function is given by

$$f_{LL}(x,\rho,\sigma)=\frac{\left(\frac{\sigma}{\rho}\right)\left(\frac{x}{\rho}\right)^{\sigma-1}}{\left(1+\left(\frac{x}{\rho}\right)^{\sigma}\right)^{2}},\rho>0,\sigma>0$$

The Reliability function of Log-Logistic distribution is

$$\Re_{LL}(t)=\left[1+\left(\frac{t}{\rho}\right)^{\sigma}\right]^{-1}$$

3. NEW FINDING

3.1 Fuzzy Reliability Model of Weibull Distribution

We consider the Weibull distribution with fuzzy parameters by replacing the scale parameter χ into the fuzzy number $\overline{\chi}$ and shape parameter δ into $\overline{\delta}$

The Fuzzy Probability density function of Weibull Distribution is

$$\overline{f_t}\left(\overline{\chi},\overline{\delta}\right)=\left\{\overline{\delta}\,\overline{\chi}^{\overline{\delta}}(t)^{\overline{\delta}-1}e^{-\left(\frac{t}{\overline{\chi}}\right)^{\overline{\delta}}}\right\}$$

The Fuzzy Reliability function of Weibull Distribution is

$$\overline{F}_{\omega}(t)=1-e^{-\left(\frac{t}{\overline{\chi}}\right)^{\overline{\delta}}}$$

For ∈ [0,1], the Beta cuts of fuzzy Weibull reliability function corresponding to two parameters is

$$\overline{\Re}_{\omega}[x_{\beta}^{L}]=\{\overline{\Re}_{\omega 1}[[x_{\beta}^{L}]],\overline{\Re}_{\omega 2}[[x_{\beta}^{L}]]\}$$

Where

$$\overline{\Re}_{\omega 1}[x_{\beta}^{L}]=Low_{\omega}\{e^{-\left(\frac{t}{\overline{\chi}}\right)^{\overline{\delta}}},\overline{\chi}\in\overline{\chi}[x_{\beta}^{L}],\overline{\delta}\in\overline{\delta}[x_{\beta}^{L}]\}$$

$$\overline{\Re}_{\omega 2}[x_{\beta}^{L}]=Up_{\omega}\{e^{-\left(\frac{t}{\overline{\chi}}\right)^{\overline{\delta}}},\overline{\chi}\in\overline{\chi}[x_{\beta}^{L}],\overline{\delta}\in\overline{\delta}[x_{\beta}^{L}]\}$$

3.2 Fuzzy Reliability Model of Exponential Distribution

We consider the Exponential distribution with fuzzy parameters by replacing the scale parameter γ into the fuzzy number $\overline{\gamma}$ and shape parameter η into $\overline{\eta}$.

The Fuzzy Probability density function of Exponential Distribution is

$$\overline{f_t}(\overline{\gamma},\overline{\eta})=\overline{\gamma}^{-1}e^{-\overline{\gamma}(t-\overline{\eta})},t>0,\overline{\gamma}>0,\overline{\eta}>0$$

The Fuzzy Reliability function of Exponential Distribution is

$$\overline{\Re}_{\varepsilon}\left(t\right)=e^{-\overline{\gamma}(t-\overline{\eta})}$$

For $\in [0,1]$the Beta cuts of fuzzy Exponential reliability function corresponding to two parameters is

$$\overline{\Re}_{\varepsilon}[x_{\beta}^{L}] = \{\overline{\Re}_{\varepsilon 1}[x_{\beta}^{L}], \overline{\Re}_{\varepsilon 2}[x_{\beta}^{L}]\}$$

where

$$\overline{\Re}_{\varepsilon 1}[x_{\beta}^{L}] = Low_{\varepsilon}\left(e^{-\overline{\gamma}(t-\overline{\eta})}, \overline{\gamma} \in \overline{\gamma}[x_{\beta}^{L}], \overline{\eta} \in \overline{\eta}[x_{\beta}^{L}]\right)$$

$$\overline{\Re}_{\varepsilon 1}[x_{\beta}^{L}] = Up_{\varepsilon}\left(e^{-\overline{\gamma}(t-\overline{\eta})}, \overline{\gamma} \in \overline{\gamma}[x_{\beta}^{L}], \overline{\eta} \in \overline{\eta}[x_{\beta}^{L}]\right)$$

3.3 Fuzzy Reliability Model of Log-Logistic distribution

We consider the Exponential distribution with fuzzy parameters by replacing the scale parameter ρ into the fuzzy number $\overline{\rho}$ and shape parameter σ into

The fuzzy probability density function of Log-Logistic distribution is

$$\overline{f}_{LL}(t, \overline{\rho}, \overline{\sigma}) = \frac{\left(\frac{\overline{\sigma}}{\overline{\rho}}\right)\left(\frac{t}{\overline{\rho}}\right)^{\overline{\sigma}-1}}{\left(1 + \left(\frac{t}{\overline{\rho}}\right)^{\overline{\sigma}}\right)^{2}}, \overline{\rho} > 0, \overline{\sigma} > 0$$

The Fuzzy Reliability function of Log-Logistic distribution is

$$\overline{\Re}_{LL}(t) = \left[1 + \left(\frac{t}{\overline{\rho}}\right)^{\overline{\sigma}}\right]^{-1}$$

For $\beta \epsilon [0,1]$ the Beta-cuts of fuzzy Log-Logistic reliability function corresponding to two parameters is

$$\overline{\Re}_{LL}[x_{\beta}^{L}] = \{\overline{\Re}_{L1}[x_{\beta}^{L}], \overline{\Re}_{LL}[x_{\beta}^{L}]\}$$

Where

$$\Re_{LL1}[x_{\beta}^{L}] = Low_{LL}\left[1 + \left(\frac{t}{\overline{\rho}}\right)^{\overline{\sigma}}\right]^{-1}, \overline{\rho} \in \overline{\rho}\left[x_{\beta}^{L}\right], \overline{\sigma} \in \overline{\sigma}\left[x_{\beta}^{L}\right]$$

$$\Re_{LL2}[x_{\beta}^{L}] = Up_{LL}\left[1 + \left(\frac{t}{\overline{\rho}}\right)^{\overline{\sigma}}\right]^{-1}, \overline{\rho} \in \overline{\rho}\left[x_{\beta}^{L}\right], \overline{\sigma} \in \overline{\sigma}\left[x_{\beta}^{L}\right]$$

JOURNAL OF BASIC SCIENCE AND ENGINEERING

4. APPLICATION

Consider the following scenario: As an a minimum of a week prior to surgery, the levels of corticosterone were measured in blood samples of rats that had free access to both food and water while being kept at a constant temperature with a fixed 12-hour light/12-hour dark photoperiod (lights regarding compared to 7.30am to 19.30 hours). By everyday handling, the rats were acclimated to the experimenter's presence during this period. The tests were conducted in the early spring. Rats were used to test the consequences of corticosterone release. [6].

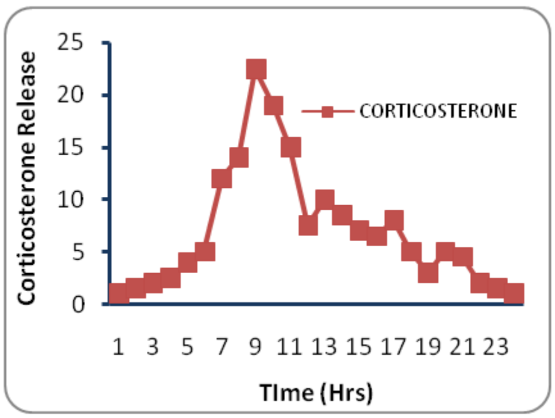

Fig. 4.1 Corticosterone releases of rats over a 24- hour light/dark period.

Here Weibull Distribution, $\lambda = 14.077$ and $\phi = 1.3181$

Let the corresponding triangular fuzzy numbers are $\bar{\lambda} = [14, 14.077, 15]$, $\bar{\phi} = [1, 1.3181, 2]$ and the corresponding α cuts are $\bar{\lambda}[\alpha] = [14 + 0.077\alpha, 15 - 0.923\alpha]$ and $\bar{\phi}[\alpha] = [1 + 0.3181\alpha, 2 - 0.6819\alpha]$

Here Log-Lagistic Distribution, $\lambda = 9.4288$ and $\phi = 1.7714$, Let the corresponding triangular fuzzy numbers are $\bar{\lambda} = [9, 9.4288, 10]$, $\bar{\phi} = [1, 1.7714, 2]$

and the corresponding α cuts are

$\bar{\lambda}[\alpha] = [9 + 0.4288\alpha, 10 - 0.5712\alpha]$ and $\bar{\phi}[\alpha] = [1 + 0.7714\alpha, 2 - 0.2286\alpha]$

Here Exponential Distribution, $\lambda = 1$ and $\phi = 0.8696$, Let the corresponding triangular fuzzy numbers are $\bar{\lambda} = [0, 1, 2]$, $\bar{\phi} = [0, 0.8696, 1]$

Vol. 21, No. 1, (2024)
ISSN: 1005-0930

and the corresponding α cuts are

$\bar{\lambda}[\alpha] = [0+\alpha, 2-\alpha]$ and $\bar{\phi}[\alpha] = [0+0.8696\alpha, 1-0.1304\alpha]$

Table: 4.1 Fuzzy Reliability function based on weibull distribution

α	λ1	λ2	Φ1	Φ2	R1(x)	R2(x)
0	1	2	14	15	0.367879	0.999969
0.1	1.031	1.931	14.008	14.908	0.52098	0.999945
0.2	1.062	1.862	14.015	14.815	0.65026	0.9999
0.3	1.093	1.793	14.023	14.723	0.750242	0.999815
0.4	1.124	1.724	14.031	14.631	0.823692	0.999654
0.5	1.155	1.655	14.039	14.539	0.876109	0.999341
0.6	1.186	1.586	14.046	14.446	0.912951	0.998723
0.7	1.217	1.517	14.054	14.354	0.938671	0.997479
0.8	1.248	1.448	14.062	14.262	0.956602	0.994918
0.9	1.279	1.379	14.069	14.169	0.969125	0.989524
1	1.31	1.31	14.077	14.077	0.977903	0.977903

Table: 4.2 Fuzzy Reliability function based on Log-Logistic distribution

α	λ1	λ2	Φ1	Φ2	R1(x)	R2(x)
0	1	2	9	10	0.5	0.999024
0.1	1.0771	1.9771	9.0429	9.9429	0.661869	0.998862
0.2	1.1543	1.9543	9.0858	9.8858	0.786467	0.998673
0.3	1.2314	1.9314	9.1286	9.8286	0.869907	0.998453
0.4	1.3086	1.9086	9.1715	9.7715	0.921778	0.998196
0.5	1.3857	1.8857	9.2144	9.7144	0.952835	0.997896
0.6	1.4628	1.8628	9.2573	9.6573	0.97128	0.997546
0.7	1.54	1.84	9.3002	9.6002	0.982288	0.997139
0.8	1.6171	1.8171	9.343	9.543	0.98891	0.996663
0.9	1.6943	1.7943	9.3859	9.4859	0.992959	0.996111
1	1.7714	1.7714	9.4288	9.4288	0.995464	0.995464

Table: 4.3 Fuzzy Reliability function based on Exponential distribution

α	λ1	λ2	Φ1	Φ2	R1(x)	R2(x)
0	0	1	0	2	1	2.718282
0.1	0.0087	0.9087	0.1	1.9	0.992201	2.265578
0.2	0.0174	0.8174	0.2	1.8	0.986176	1.923064
0.3	0.0261	0.7261	0.3	1.7	0.981896	1.662413
0.4	0.0348	0.6348	0.4	1.6	0.979336	1.463572
0.5	0.0435	0.5435	0.5	1.5	0.978485	1.312259

Vol. 21, No. 1, (2024)
ISSN: 1005-0930

0.6	0.0522	0.4522	0.6	1.4	0.979336	1.198271
0.7	0.0609	0.3609	0.7	1.3	0.981896	1.114349
0.8	0.0696	0.2696	0.8	1.2	0.986176	1.0554
0.9	0.0783	0.1783	0.9	1.1	0.992201	1.01799
1	0.087	0.087	1	1	1	1

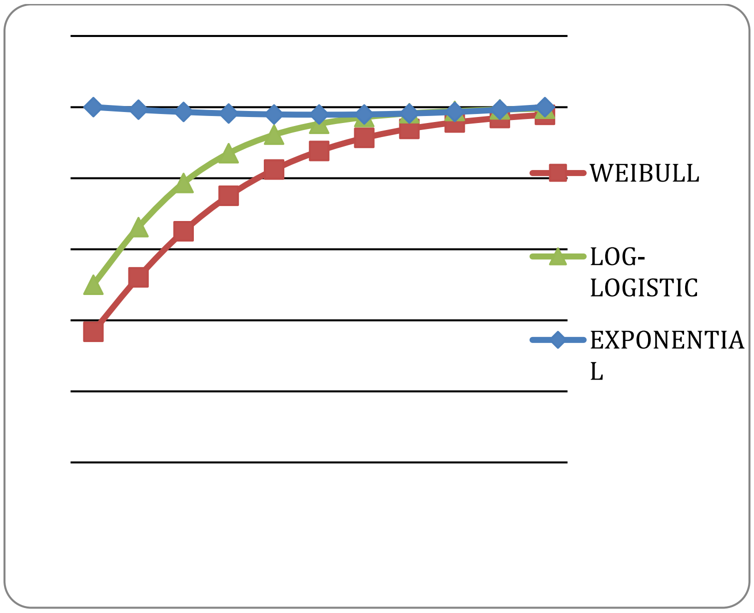

Fig. 4.2 Lower-Beta cut for the reliability function.

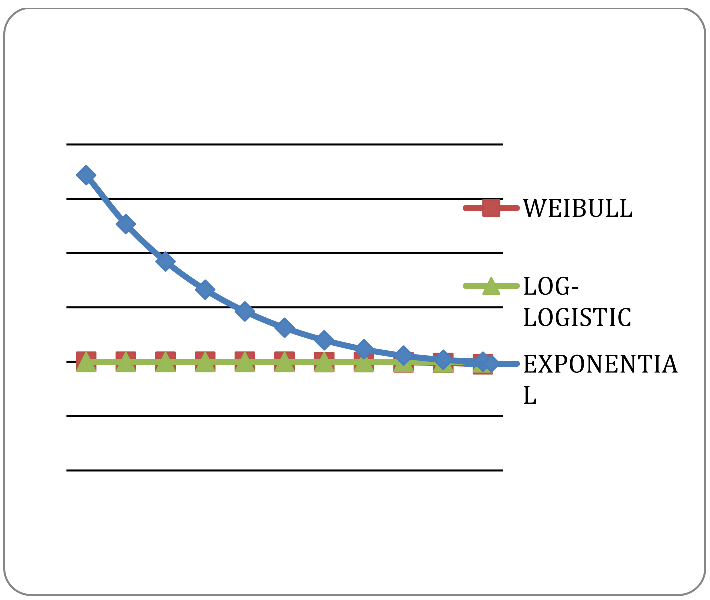

Fig. 3.3 Upper Beta-cut for the reliability function.

5. Testing of Hypothesis:

Testing of hypotheses is a procedure used to determine the degree of trial validity and provides a strategy for population-related decision-making, i.e., it conveys a method for acknowledging the consistency with which one can extrapolate experimental results from the sample under examine to the larger population that from which the population being studied was drawn. We start by defining a hypothesis, which is a specific statement of the population's parameters.

An example of such a hypothesis is H_0. Here, we define H_0 in the following manner:

$H_0 : \bar{\mu}_{Low1} - \bar{\mu}_{Low2} > 0$ There is significant difference in $\bar{\mu}_{\inf 1}$ than $\bar{\mu}_{\inf 2}$

$H_1 : \bar{\mu}_{Low1} - \bar{\mu}_{Low2} \leq 0$

Test statistics for Lower alpha values is defined by

$$\tau_{Low} = \left[\frac{\bar{\mu}_{Low1} - \bar{\mu}_{Low2}}{\sqrt{\frac{\delta^2_{Low1}}{n_{Low1} - 1} + \frac{\delta^2_{Low2}}{n_{Low2} - 1}}} \right]$$

$\delta^2_{Low1} = \left[\frac{\sum \left(\mu_{Low} - \bar{\mu}_{Low1} \right)}{n_{Low1} - 1} \right]$ and $\delta^2_{Low2} = \left[\frac{\sum \left(\mu_{Low} - \bar{\mu}_{Low2} \right)}{n_{Low2} - 1} \right]$

Test statistics for Upper alpha values is defined by

$$\tau_{Up} = \left[\frac{\bar{\mu}_{Up1} - \bar{\mu}_{Up2}}{\sqrt{\frac{\delta^2_{Up1}}{n_{Up1} - 1} + \frac{\delta^2_{Up2}}{n_{Up2} - 1}}} \right]$$

$\delta^2_{Up1} = \left[\frac{\sum \left(\mu_{Up} - \bar{\mu}_{Up1} \right)}{n_{Up1} - 1} \right]$ and $\delta^2_{Up2} = \left[\frac{\sum \left(\mu_{Up} - \bar{\mu}_{Up2} \right)}{n_{Up2} - 1} \right]$

5.1 Lower Fuzzy Reliability

Null hypothesis $H_{\omega LL0}$: The LFR in WD and LLD do not differ much from one another.

Alternative hypothesis $H_{\omega LL1} : \mathrm{H}_1 \neq \mathrm{H}_2$

Null hypothesis $H_{\omega \varepsilon 0}$: The LFR among WD and ED does not significantly differ.

Alternative hypothesis $H_{\omega \varepsilon 1} : \mathrm{H}_1 \neq \mathrm{H}_3$

Null hypothesis $H_{LL\varepsilon 0}$: The LFR from LLD and ED is not significantly different from each other.

Alternative hypothesis $H_{LL\varepsilon 1} : \mathrm{H}_2 \neq \mathrm{H}_3$

Table 5.1 Calculation of Sample Means and Standard Deviations of Lower Reliability

α	X1	X2	X3	S1*S1	S2*S2	S3*S3

Vol. 21, No. 1, (2024)
ISSN: 1005-0930

0	0.367879	0.5	1	0.1824323	0.14055001	0.0001664
0.1	0.52098	0.661869	0.992201	0.075087	0.045382207	0.0000260
0.2	0.65026	0.786467	0.986176	0.0209497	0.007820395	0.0000009
0.3	0.750242	0.869907	0.981896	0.0020033	2.493E-05	0.0000271
0.4	0.823692	0.921778	0.979336	0.0008232	0.002197547	0.0000603
0.5	0.876109	0.952835	0.978485	0.0065787	0.006073864	0.0000742
0.6	0.912951	0.97128	0.979336	0.0139124	0.009289104	0.0000603
0.7	0.938671	0.982288	0.981896	0.0206414	0.011532183	0.0000271
0.8	0.956602	0.98891	0.986176	0.0261152	0.01299828	0.0000009
0.9	0.969125	0.992959	0.992201	0.0303195	0.013937927	0.0000260
1	0.977903	0.995464	1	0.0334535	0.014535678	0.0001664

$$\overline{\mathrm{H}_1} = \frac{\sum \mathrm{H}_1}{n_1}, \overline{\mathrm{H}_2} = \frac{\sum \mathrm{H}_2}{n_2}, \overline{\mathrm{H}_3} = \frac{\sum \mathrm{H}_3}{n_3}, \$_1^2 = \frac{\sum (\mathrm{H}_1 - \overline{\mathrm{H}_1})^2 + (\sum \mathrm{H}_2 - \overline{\mathrm{H}_2})^2}{n_1 + n_2}$$

$$\$_2^2 = \frac{\sum (\mathrm{H}_2 - \overline{\mathrm{H}_2})^2 + (\sum \mathrm{H}_3 - \overline{\mathrm{H}_3})^2}{n_2 + n_3}, \$_3^2 = \frac{\sum (\mathrm{H}_1 - \overline{\mathrm{H}_1})^2 + (\sum \mathrm{H}_3 - \overline{\mathrm{H}_3})^2}{n_1 + n_3}$$

$$\overline{\mathrm{H}_1} = 0.794946727, \overline{\mathrm{H}_2} = 0.874887, \overline{\mathrm{H}_3} = 0.98706390$$

$$\$_1^2 = 0.4123162, \$_2^2 = 0.264342126, \$_3^2 = 0.0006355$$

Calculated value of $|t_{\omega LL}| = 1.019242, |t_{LL\varepsilon}| = 2.285573553, |t_{\omega\varepsilon}| = 3.1355442$

At a 5% level of significance, the tabulated value of 11+11-2=20 d.f. is 2.080.

Calculated $t_{\omega LL}$ less than value $t_{\omega LL}$'s tabulated

The null hypothesis $H_{\omega LL0}$ is acceptable.

11+11-2=20 d.f. has a tabulated value of 2.080 at the 5% level of significance.

Calculated value of $t_{LL\varepsilon}$ is bigger than the value of $t_{LL\varepsilon}$ in the table.

The null hypothesis $H_{LL\varepsilon 0}$ is rejected.

At a 5% level of significance, the tabulated value of 11+11-2=20 d.f. is 2.080.

Calculated value of $t_{\omega\varepsilon}$ is higher than the value of $t_{\omega\varepsilon}$ in the table.

We do not accept the null theory $H_{\omega\varepsilon 0}$.

5.2 Upper Fuzzy Reliability

Null hypothesis $H_{\omega LLU0}$: The UFR in WD and LLD are not significantly different from one another.

Alternative hypothesis $H_{\omega LLU1}: \mathrm{I}_1 \neq \mathrm{I}_2$

Null hypothesis $H_{\omega \varepsilon U0}$: This UFR for WD and ED are identical, and this is a significant distinction.

Alternative hypothesis $H_{\omega \varepsilon U1}: \mathrm{I}_1 \neq \mathrm{I}_3$

Null hypothesis $H_{LL\varepsilon U0}$: Its UER in the LLD and ED are identical, and this is a significant distinction.

Alternative hypothesis $H_{LL\varepsilon U1}: \mathrm{I}_2 \neq \mathrm{I}_3$

Table 5.2 Calculation of Sample Means and Standard Deviations of Upper Reliability

α	I1	Y2	Y3	S1*S1	S2*S2	S3*S3
0	0.999969	0.999024	2.718282	0.0091644	0.009677837	1.0924054
0.1	0.999945	0.998862	2.265578	0.009169	0.009709737	0.3510302
0.2	0.9999	0.998673	1.923064	0.0091776	0.009747021	0.062482
0.3	0.999815	0.998453	1.662413	0.0091939	0.009790509	0.0001142
0.4	0.999654	0.998196	1.463572	0.0092248	0.009841434	0.043902
0.5	0.999341	0.997896	1.312259	0.0092851	0.009901046	0.1302062
0.6	0.998723	0.997546	1.198271	0.0094045	0.009970821	0.2254626
0.7	0.997479	0.997139	1.114349	0.0096474	0.010052268	0.3122027
0.8	0.994918	0.996663	1.0554	0.010157	0.010147943	0.3815533
0.9	0.989524	0.996111	1.01799	0.0112733	0.010259462	0.4291691
1	0.977903	0.995464	1	0.0138761	0.010390948	0.4530636

$$\overline{\mathrm{I}}_1 = \frac{\sum \mathrm{I}_1}{n_1}, \overline{\mathrm{I}}_2 = \frac{\sum \mathrm{I}_2}{n_2}, \overline{\mathrm{I}}_3 = \frac{\sum \mathrm{I}_3}{n_3}, \$U_1^2 = \frac{\sum (\mathrm{I}_1 - \overline{\mathrm{I}}_1)^2 + (\sum \mathrm{I}_2 - \overline{\mathrm{I}}_2)^2}{n_1 + n_2}$$

Vol. 21, No. 1, (2024)
ISSN: 1005-0930

$$\$U_2^2 = \frac{\sum(\mathrm{I}_2 - \overline{\mathrm{I}}_2)^2 + (\sum \mathrm{I}_3 - \overline{\mathrm{I}}_3)^2}{N_2 + N_3}, \$U_3^2 = \frac{\sum(\mathrm{I}_1 - \overline{\mathrm{I}}_1)^2 + (\sum \mathrm{I}_3 - \overline{\mathrm{I}}_3)^2}{n_1 + n_3}$$

$\overline{\mathrm{I}}_1 = 1.0957171, \overline{\mathrm{I}}_2 = 1.0974027, \overline{\mathrm{I}}_3 = 1.6731178$

$\$U_1^2 = 0.1095733, \$U_2^2 = 0.10948906, \$U_3^2 = 3.4815913$

Calculated value of $|t_{\omega LLU}| = 0.037772, |t_{LL\varepsilon U}| = 3.18633479, |t_{\omega \varepsilon U}| = 3.1956264$

For the 11+11-2=20 d.f., the tabulated value of $t_{\omega LLU}$ is 2.080 at the 5% level of significance.

Value of $t_{\omega LLU}$ less than calculated value of $t_{\omega LLU}$ in the table

Accepted is the null hypothesis $H_{\omega LLU0}$.

At a 5% level of significance, the tabulated value of 11+11-2=20 d.f. is 2.080.

Calculated value of $t_{\omega LLU}$ is bigger than the tabulated value of $t_{\omega LLU}$

We reject the null hypothesis $H_{\omega LLU0}$.

11+11-2=20 d.f. has a tabulated value of 2.080 at the 5% level of significance.

Calculated value of $t_{\omega \varepsilon U}$ > Tabulated value of $t_{\omega \varepsilon U}$

We do not accept the null hypothesis $H_{\omega \varepsilon U0}$.

Table 4.6: Paired sample t-test for fuzzy Reliability Model for the effect of Corticosterone based on two parameter distributions

Test	Calculated value		Table Value	Hypothesis		d. f	Result
	Lower Fuzzy Reliability	Upper Fuzzy Reliability		Lower Fuzzy Reliability	Upper Fuzzy Reliability		
$t_{\omega LL}$	1.019242	0.037772	2.086	Accept	Accept	5%	The Fuzzy Reliability in the Weibull distribution and the Log-Logistic distribution do not

							differ significantly from one another.
$t_{LL\varepsilon}$	2.285574	3.186335	2.086	Reject	Reject		The Fuzzy Reliability in the Log-Logistic distribution and the Exponential distribution differ significantly.
$t_{\omega\varepsilon}$	3.135544	3.195626	2.086	Reject	Reject		The Weibull distribution's fuzzy reliability and the exponential distribution differ significantly.
$t_{\omega LL}$	1.019242	0.037772	2.845	Accept	Accept	1%	The Fuzzy Reliability in the Weibull distribution and the Log-Logistic distribution do not significantly differ from one another.
$t_{LL\varepsilon}$	2.285574	3.186335	2.845	Accept	Reject		The Fuzzy Reliability in the Log-Logistic distribution and the Exponential distribution do not differ significantly from one another.
$t_{\omega\varepsilon}$	3.135544	3.195626	2.845	Reject	Reject		The Fuzzy Reliability in the Weibull distribution and the Exponential distribution are very different from one another.

6. CONCLUSION

Here, by estimating the Beta-cut for the reliability of the FWD, FED, and FLLD, we successfully created fuzzy models to quantify the effect of corticosterone. In lower Beta-cuts and greater Beta-cuts, the reliability values' Beta-cut is enhanced. The results of the testing of the hypotheses demonstrate a substantial difference between the pairs of FWD and FLLD that fit the effect of corticosterone more reliably than other pairs.

REFERENCES

[1] Chen, C.H., Mon, L., Fuzzy System reliability analysis by interval of confidence, fuzzy Sets and systems, 56, pp.29-36, 1993,.

[2] Chen. S.M., New method for fuzzy system reliability analysis, Cybernetics and systems",27, PP.385-401.
[3] Dunn.J.L., Scheving and P.Millet,Circadian variations in stress-evoked increase in plasma corticosterone.Am J Physiol 223:pp. 402-406,1972.
[4] K.Y.Cai, C. Y. Wen and M.L. Zhang,Fuzzy reliability modeling of gracefully degradable computing systems,Reliability Engineering and systems safety,vol.33,PP.141-157,1991.
[5] K.Y.Cai, Wen and M.L. Zhang., Fuzzy variables as a basis for a theory of fuzzy reliability in the possibility context,Fuzzy Sets and Systems,Vol 42, pp. 145-172,1991.
[6] Seggie, J.B. E., Shaw,I.Uhler and G.M. Brown, Baseline 24-hour plasma corticosterone rhythm in normal,sham operated and septally lesioned rats .Neuroendocrinology: pp.51-61.
[7] S.F., DE BOER AND J. VAN DER GUGTEN, Daily Variations in Plasma Noradrenaline,Adrenaline and Corticosterone Concentrations in Rats.
[8] Singer, D., A fuzzy set approach to fault tree and reliability analysis, Fuzzy sets and system, 34(2), pp.145-155, 1990.
[9] Utkin. L. V and Gurov. S.V,A general formal approach for the fuzzy reliability ananlysis in the possibility context, Fuzzy sets and systems, 83, pp.203-213, 1996.
[10] Zadeh,L.A.,Fuzzy sets, Information and control,8, pp.338-352, 1965.
[11] Zdenek Karpisek,PertStepanek, PetrJunrak,Weibull fuzzy probability distribution for the reliability of concrete structures,Engineering Mechanics,Vol.17,pp.363-372,2010.

Vol. 21, No. 1, (2024)
ISSN: 1005-0930