Comparative study of reliability of some antiseptic soaps; a 3-parameter Weibull distribution

[1]Olubiyi O.A [2]Ogunsakin R.E [3*]Babalola B.T
[1,2]Department of Mathematical Sciences, Ekiti State University, Ado Ekiti.
[*3]Department of Mathematical and Physical Sciences, Afe Babalola University,Ado Ekiti.
teniolababa@gmail.com

ABSTRACT:

This study was carried out to estimate the dissolution time of some antiseptic soaps . The lifetime behavior of the antiseptic soaps was also modeled in order to estimate some basic measures and compare their lifetimes. In the analysis of data, the weibull distribution of 3-parameter case was used. The method of maximum likelihood estimator was used in estimating the parameters. The mean and variance time to failure, reliability, Weibull conditional reliability and Weibull reliable life of the products were obtained.

Keywords: Weibull distribution, antiseptic, reliability,

1. INTRODUCTION:

Soap is an essential consumable item and there is a huge demand for it in the market particularly the antiseptic soap. Antiseptic soap sometimes called antibacterial soap or anti-fungal soap is regular soap in liquid or solid form that contains some kind of ingredients that reduce the chance of infection when applied to the skin. These products also have antimicrobial properties meaning they kill or inhibit growth of microbes like bacteria, virus or fungi. It cleanses and protects skin for a hygienic clean and healthy refreshing feeling every day. It contains skin moisturing agent. The active ingredients in antiseptic soap are isopropyl alcohol, pine oil, chloroxylenol. These ingredients make antiseptic disinfectant that kill bacteria. Antiseptic is any chemical applied to the skin in order to destroy bacteria and other micro-organism thereby preventing infection while a disinfectant is a substance that kills micro-organism and thus prevent infection, it is usually applied to strong chemicals that are used to decontaminate inanimate objects such as items of medical equipment.

In probability theory and statistics, the Weibull distribution is a continuous distribution. It is named after Professor Wallodi Weibull, who described it in detail in 1951. Weibull models are used to describe various types of observed failures of component and phenomena. They are widely used in reliability and survival analysis.

2. LITERATURE REVIEW

Here, we seek to give a brief exploration of some of the works done on the concept of Weibull distribution. Some of them as summarized below;

Marshall and Olkin (1967) proposes a more flexible bivariate model namely Marshall-Olkin bivariate Weibull (MOBW) model. Therefore, if it is observed empirically that the marginal are decreasing or mimodal and monotone hazard function, and then MOBW model can be used quite successfully. Further MOBW can also be given a stock model interpretation.

Recently Kundu and Dey (2009) proposed also an efficient estimation procedure to compute the maximum likelihood estimates [MLE] using expectation maximization [EM] algorithm, which extends the expectation maximization algorithm proposed by Karles (2003), to find the maximum likelihood estimates of the MOBE model.

Failure time analysis is a method of data analysis when aim to discover the cause for the failure of a component or a device. Failure time analysis is commonly used in the field of industrial life testing. Actually, the failure time problem is a part of reliability problem. Gilbert and Sun (2005) has introduced one kind of failure time analysis that can apply to HIV Vaccine effect on antiretroviral therapy. They considered method of using a surrogate end that can be assessed by standard survival analysis techniques. In terms of Univarate models, Weilbull is the most widely used in failure model. Dodson (2006) aimed at introducing two parameters Weibull model into fatique and reliability analysis. He focused on prediction of failure times of product by using Weibull distribution and pointed out that it is powerful in terms of widely application. Chi (1997) said that unless he has strong evidence that the lifetime data studied that focus on combining Weibull and other distribution together. Eckhard, Werner and Markus (2001) gave a clear explanation about the application of lognormal distribution. It is useful when we analyze the reliability of the devices. Gamma distribution has been applied on the cluster of life time data. Jonna and Thomas (1994) stated that gamma frailty model is a good way for model clustered failure time data. Acceptance Sampling Plan was developed in 1954 by Epstem based on truncated life testing, assuming that the lifetime of an item follows the exponential distribution. He considered two situations to develop the acceptance plan for this distribution. The first is the replacement case, in which if an item failure before the experiment time, the failed item is replaced by a new item, in non – replacement case, a failed item is not replaced by a new one.

3. METHODOLOGY

The Weibull distribution has been widely used on the study of life data since it can represent the time of failure for the product, a piece of equipment or the time for completing a task. The Weibull distribution (Weibull 1939) has three parameters. The shape parameter (β), the shape parameter (Θ) and the location parameter (y).The shape parameter (β) can be represented as the failure rate when the failure rate β < 1, the failure rate decreases over time for β=1, the Weibull distribution has a constant failure rate and reduces the exponential distribution. In case where β >1, the failure rate increases with time, when β=3.4, the Weibull distribution behaves similarly to the normal distribution. The range of flexibility is one of the reasons why the Weibull distribution is widely applied. It is able to mimic the behaviour of other distribution

3.1 Definition

The probability of a weibull distribution with a random variable x is

$$f(x) = \left(\frac{\beta}{\theta}\right)\left(\frac{x-y}{\theta}\right)^{\beta-1} e^{-\left(\frac{x-y}{\theta}\right)^{\beta}}$$

Where f(x) >0 ;x ≥ 0, β, Θ, y > 0

β is the shape parameter

θ is the scale parameter

y is the location parameter

The probability density function is referred to as 3-parameter weibull distribution.

Other forms of probability density function are the 2-parameter and 1-parameter weibull distribution which are derived from the reduction of the 3-parameter. The location parameter "y" is set to zero to obtain the 2-parameter

$$f(x) = \left(\frac{\beta}{\theta}\right)\left(\frac{x}{\theta}\right)^{\beta-1} e^{-}\left[\frac{x}{\theta}\right]^{\beta}$$

If $\beta = C$, then

$$f(x) = \left(\frac{C}{\theta}\right)\left(\frac{x}{\theta}\right)^{c-1} e^{-}\left[\frac{x}{\theta}\right]^{c}$$

The Weibull distribution is related to a number of other probability distribution, in particular it interpolate between the exponential distribution (β = 1) and Rayleigh distribution (β = 2). If the quality X is a "time to failure" the weibull distribution gives a distribution for which the failure rate is proportional to a power of time.

3.2 Estimation Using Maximum Likelihood

Maximum likelihood estimation (MLE) is generally the most versatile and popular method. Although MLE in the weibull case requires numerical method and is considered the most accurate of the parameter estimation methods, but does not provide a visual goodness of fit using probability plotting or hazard plotting. If the fit is acceptable, use maximum likelihood estimation to determine the parameter.

Maximum likelihood estimation supports the 2- parameter and 3- parameter weibull distribution and provides confidence limit for all parameter as well as for reliability and percentiles.

The maximum likelihood equations for the weibull distribution are:

$$\frac{1}{r}\sum_{i1}^{r} In(x_1) = \left[\sum_{i=1}^{n} x_1^{\beta} In\left(x_1\right)\right]\left[\sum_{i=1}^{n} x_1^{\beta}\right]^{-1} - \frac{1}{\beta}$$

$$\theta' = \left[\frac{1}{r}\sum_{i=1}^{n} x_1^{\beta}\right]^{\frac{1}{\beta}}$$

Where r is the number of failures and n is the total number of data points, both censored and uncensored.

4. PRESENTATION OF DATA:

The data used was generated by dissolution of five brands of antiseptic soap and the method of maximum likelihood estimator was used in estimating the parameters. The data used was assumed to be an uncensored data, as no suspension is present (i.e. all units were dissolved).

The table below shows the dissolution (per hours) of each of the five brands of antiseptic soap are slated below

Dettol soap	Premier cool	Tubor action soap	Septol soap	Delta soap
678.00	598.00	571.32	596.00	674.10
684.36	625.10	576.00	624.00	686.00
690.00	642.00	618.16	640.21	691.00

729.00	731.00	627.00	730.00	715.30
732.48	748.20	735.00	734.28	722.50
753.00	764.00	742.20	755.00	738.00

Data in each of the column was generated by cutting each brands of the antiseptic soap into six cubes of size 2cm x2cm then dissolving each cube in 25cl volume of water to get it dissolution time.

4.1 Estimation of basic measures of Dettol soap

The estimates for the shape, scale and location parameter are 27.8507, 724.8991 and 578.17 respectively. Having found the parameter estimate, we obtain the mean time to failure (MTTF), variance(σ^2) and Weibull reliability.

5. Summary:

The statistica software package was used to estimate the parameter and the maximum likelihood estimates were obtained. The package was used to estimate data of the weibull distribution with 3-parameters. Rank regressions on Y (RRY) are used in estimating data, which shows the existence of location parameter. Due to the level of precision, there are some little differences between the values of various measures when compared together. Statistica software therefore been used to compute the mean time to failure(MTTF), Weibull reliability R(X),variance and standard deviation of the products.

For the first product which is Dettol soap, the basic measures are obtained as; the mean time to failure is 712.26hours, its variance is 28.252hour, while the standard deviation is 5.315.The reliability for Dettol soap to last 760hours is 0.8809. For the second product which is premier cool soap, the basic measure are; the mean time to failure is 687.26hours its variance is 64.975hours while the standard deviation is 8.061, the reliability for premier cool soap to last 760hours is 0.7924.For the third product which is tubor action soap, the basic measure are obtained as; the mean time to failure is 647.409hours, and its variance is 69.260hours, while the standard deviation is 0.968, the reliability for tubor action soap to last 760hours is 0.7413. For the fourth product which is septol soap, the basic measures are obtained as; the mean time to failure is 602.331hours, and it variance is 61.707hours while the standard deviation is 7.855, the reliability for septol soap to last 760hours is 0.2448. Finally for the last product which is Delta soap, the basic measures are obtained as; the mean time to failure is 705.360hours and the variance is

32.379hours while the standard deviation is 5.690, the reliability for Delta soap to last 760hours is 0.0528.

Tubor action soap fails at a low level than the other four soap, which implies that antimicrobial properties in it is not capable of inhibiting growth of microbes like bacteria or fungi which is very dangerous to human health. The unit of raw materials for premier cool, septol soap, Delta soap and Dettol soap fail at high level which implies that the level of effectiveness may be measured at the microbiological level or at the population level, as added protection against bacterial contamination or the occurrence of common infectious illnesses.

Generally, the weibull distribution has been found to be the most applicable distribution in life data analysis due to the nature of its probability density function as it can approximate many other distribution for some values.

6. CONCLUSION:

Weibull distribution can be used in place of other distribution and it is good for analyzing life data as well as reliability of product and services.

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