Section: Community Medicine

Original Research Article

ANALYSIS OF NON-COMMUNICABLE RISK FACTOR OF CHRONIC KIDNEY DISEASE USING PARTICULAR DISTRIBUTION

Manoharan. M[1], Kaveri. P[2], Saranya. S[3], Pradeep MVM[4], Bincy. K[5]

[1]Statistician, Department of Community Medicine, SRM Medical College Hospital and Research Centre
[2]Assistant Professor, Department of Community Medicine, SRM Medical College Hospital and Research Centre
[3]Statistician, Department of Community Medicine, SRM Medical College Hospital and Research Centre
[4]Assistant Professor, Department of Community Medicine, SRM Medical College Hospital and Research Centre
[5]Tutor, Department of Community Medicine, SRM Medical College Hospital and Research Centre.

Received : 05/06/2023
Received in revised form : 23/07/2023
Accepted : 02/08/2023

Keywords:
Non-Communicable Diseases, Chronic Kidney Disease, Risk Factors, Expected Time and Threshold.

Corresponding Author:
Dr. Pradeep MVM,
Email: doctormvmpradeep@gmail.com

DOI: 10.47009/jamp.2023.5.4.308

Source of Support: Nil,
Conflict of Interest: None declared

Int J Acad Med Pharm
2023; 5 (4); 1548-1551

Abstract

Background: Current trends indicate that global Non-Communicable Diseases (NCD) accounts for about 60% of deaths and will increase by 17% over the next 10 years with poor and disadvantaged populations disproportionately affected, widening health disparities between and within countries. It is against these challenges this "Statistical Analysis of Non-Communicable diseases" was undertaken. From simulations with the stochastic model expressed for threshold of Chronic Kidney Disease is shown. However, most of the behavior in this stochastic model for the expected time strongly depends on initial Conditions.

INTRODUCTION

According to a recent study1 between 8 and 10% of people worldwide are suffering from a kind of damage in their kidney and due to the complications of chronic kidney disease, death among affected people increases progressively every year. Chronic kidney disease (CKD), also known as chronic kidney failure; is a syndrome characterized by a continuous loss of kidney function (2017).[10] The two kidneys organs in the renal system perform several essential functions namely removing wastes products from the blood, keeping the balance of fluid levels and generating hormones to produce red blood cells. The causes of chronic kidney disease can be related to multiple health problems such as diabetes, high blood pressure, high cholesterol, kidney infections, and blockages in the flow of urine and so on (2012).[7] In general there are no symptoms of kidney disease in the early stages. However, when it reaches a more advanced stage symptoms can appear as nausea, loss of appetite, tiredness and weakness, hypertension, sleep problems, edema, blood in urine and decreased mental alertness (2017).[10] Because there is no cure for chronic kidney disease, it is necessary to have regular checks in order to get treatment which can help relieve the symptoms and stop it getting worse.

Chronic kidney disease (CKD) is a major burden on the healthcare system because of its increasing prevalence, high risk of progression to end-stage renal disease, and poor morbidity and mortality prognosis. It is rapidly becoming a global health crisis. Unhealthy dietary habits and insufficient water consumption are significant contributors to this disease. Without kidneys, a person can only live for 18 days on average, requiring kidney transplantation and dialysis. Gazi Mohammed Ifraz. et.al., (2021).[5]

Exponential distribution plays an important role in statistical theory of reliability and lifetime analysis. Several extensions to the exponential distribution have been developed by many authors during the last decades. There is an increasing interest in using the weighted exponential distributions in modeling of the skewed positive data especially for lifetime analysis (2012).[9] (2012).[11] (2014).[4] and (2012).[12] Some important probability distributions in statistics such as gamma belongs to the family of weighted exponential distributions. Many weighted exponential distribution have been developed so far via adding an extra shape parameter to a given symmetric distribution. Gupta and Kundu (2000).[8] and Al-Mutairi et.al., (2011).[2] by using the idea of Azzalini (1985).[3], introduced two new classes of the univariate and bivariate weighted exponential distributions.

Weighted Exponential Distribution

Kundu and Gupta (2009).[6] introduced a new class of weighted exponential distribution using the idea of Azzalini (1985).[3] and it can be defined as follows: A random variable X is said to have a weighted exponential distribution with the shape parameter α and scale parameter λ if it has the following probability density function (PDF).

$$f(x,\lambda,\alpha) = \frac{\alpha+1}{\alpha}\lambda\, e^{(-\lambda x)}\left[1-e^{(-\alpha\lambda x)}\right] \qquad x > 0, \quad \lambda,\alpha > 0 \qquad \ldots(1)$$

A random variable X follows Weighted Exponential (α,λ) if it has the PDF (1). The PDF of WE distribution is unimodal and it has increasing hazard function for all values of α. Since the hazard function is always an increasing function this is suitable for modelling lifetime data when wear-out or ageing is present.

The corresponding distribution function of X is

$$F(x,\lambda,\alpha) = 1 + \frac{1}{\alpha}e^{\{-\lambda(\alpha+1)x\}} - \frac{\alpha+1}{\alpha}e^{(-\lambda x)} \qquad \ldots(2)$$

he WE distribution of Gupta and Kundu (2009)6 has several desirable properties. Although exponential distribution is not a member of this family of distributions, exponential distribution can be obtained as limiting distribution from the WE class. Recently, this model has received some attention in the statistical literature because of its flexibility and simplicity, see for example Shakhatreh (2012)12, Roy and Adnan (2012)11, Al-Mutairi et.al., (2011)2, Farahani and Khorram (2014)4 and the references cited therein.

This new WE model has the probability density function (PDF) whose shape is very close to the shape of the PDFS of Weibull, gamma or generalized exponential distributions. Therefore, this model can be used as an alternative to any of these distributions. It is observed that this model can also be obtained as a hidden truncation model. Different properties of this new model have been discussed and compared with the corresponding properties of well-known distributions. Gupta and Kundu (2009)6.

MODEL DESCRIPTION AND SOLUTION

$$\bar{H}(x) = \frac{\alpha+1}{\alpha}e^{(-\lambda x)} - \frac{1}{\alpha}e^{\{-\lambda(\alpha+1)x\}} \qquad \ldots(3)$$

There may be no practical way to inspect an individual item to determine its threshold y. In this case the threshold must be a random variable. The shock survival probability is given by

$$P(X_i < Y) = \int_0^\infty g_k(x)\bar{H}(x)\,dx$$

$$= \int_0^\infty g_k(x)\left(\frac{\alpha+1}{\alpha}e^{(-\lambda x)} - \frac{1}{\alpha}e^{\{-\lambda(\alpha+1)x\}}\,dx\right)$$

$$\int_0^\infty g_k(x)\frac{\alpha+1}{\alpha}e^{(-\lambda x)}\,dx - \int_0^\infty g_k(x)\frac{1}{\alpha}e^{\{-\lambda(\alpha+1)x\}}\,dx$$

$$= \frac{\alpha+1}{\alpha}g_k^*(\lambda) - \frac{1}{\alpha}g_k^*\lambda(\alpha+1) \qquad \ldots(4)$$

Probability of Continuous random variable to cross the threshold level T is greater than t is exactly i decisions in (0,t] and the threshold level is not reached.

$$P(T > t) = \sum_{k=0}^\infty V_k(t)P(X_i < Y)$$

The number of decisions made in $(0,t]$ from a renewal process $V_i(t)[F_k(t) - F_{k+1}(t)]$

$$= \sum_{k=0}^\infty [F_k(t) - F_{k+1}(t)]\left[\frac{\alpha+1}{\alpha}g_k^*(\lambda) - \frac{1}{\alpha}g_k^*\lambda(\alpha+1)\right]$$

$$= \frac{\alpha+1}{\alpha}\sum_{k=0}^\infty [F_k(t) - F_{k+1}(t)]\,g_k^*(\lambda) - \frac{1}{\alpha}\sum_{k=0}^\infty [F_k(t) - F_{k+1}(t)]\,g_k^*[\lambda(\alpha+1)]$$

$$= \frac{\alpha+1}{\alpha}\sum_{k=0}^\infty [F_k(t) - F_{k+1}(t)]\,[g^*(\lambda)]^k - \frac{1}{\alpha}\sum_{k=0}^\infty [F_k(t) - F_{k+1}(t)]\,\{g^*[\lambda(\alpha+1)]\}^k \qquad \ldots(5)$$

Taking Laplace transformation L(t) we get,
On simplification we get

ISSN (O): 2687-5365; ISSN (P): 2753-6556

$$L(t) = 1 - \frac{\alpha+1}{\alpha} + \frac{\alpha+1}{\alpha}[1 - g^*(\lambda)]\ f^*(s) \sum_{k=0}^{\infty} \{g^*(\lambda) f^*(s)\}^{k-1} + \frac{1}{\alpha} - \frac{1}{\alpha}[1 - g^*(\lambda)(\alpha+1)]\ f^*(s) \sum_{k=0}^{\infty} \{g^*(\lambda)(\alpha+1)\, f^*(s)\}^{k-1}$$

$$= \frac{\alpha+1}{\alpha}[1 - g^*(\lambda)]\ f^*(s) \sum_{k=0}^{\infty} \{g^*(\lambda) f^*(s)\}^{k-1} - \frac{1}{\alpha}[1 - g^*(\lambda)(\alpha+1)]\ f^*(s) \sum_{k=0}^{\infty} \{g^*(\lambda)(\alpha+1)\, f^*(s)\}^{k-1} \quad \ldots (6)$$

By taking Laplace-Stieltjes transform, it can be shown that

$$l^*(s) = \frac{\alpha+1}{\alpha}\frac{[1-g^*(\lambda)]\ f^*(s)}{[1-g^*(\lambda)]\ f^*(s)} - \frac{1}{\alpha}\frac{[1-g^*(\lambda)(\alpha+1)]\ f^*(s)}{[1-g^*(\lambda)(\alpha+1)]\ f^*(s)}$$

Let the random variable U denoting inter arrival time which follows exponential with parameter.

Now $f^*(s) = \left(\frac{c}{c+s}\right)$ substituting in the below equation we get

$$= \frac{\alpha+1}{\alpha}\frac{[1-g^*(\lambda)]\ \frac{c}{c+s}}{\left[1-g^*(\lambda)\frac{c}{c+s}\right]} - \frac{1}{\alpha}\frac{[1-g^*(\lambda)(\alpha+1)]\ \frac{c}{c+s}}{\left[1-g^*(\lambda)(\alpha+1)\frac{c}{c+s}\right]}$$

$$= \frac{\alpha+1}{\alpha}\frac{[1-g^*(\lambda)]\ c}{[c+s-g^*(\lambda)c]} - \frac{1}{\alpha}\frac{[1-g^*(\lambda)(\alpha+1)]\ c}{[c+s-g^*(\lambda)(\alpha+1)c]}$$

$$g^*(\lambda) = \frac{\mu}{\mu+\lambda}, \qquad g^*(\lambda)(\alpha+1) = \frac{\mu}{\mu+\lambda(\alpha+1)}$$

$$= \frac{\alpha+1}{\alpha c\left[1-\frac{\mu}{\mu+\lambda}\right]} - \frac{1}{\alpha c\left[1-\frac{\mu}{\mu+\lambda(\alpha+1)}\right]}$$

On simplification we get the expected time of chronic kidney patients is

$$E(T) = \frac{(\alpha+1)(\mu+\lambda)}{\alpha c\lambda} - \frac{(\mu+\lambda)(\alpha+1)}{\alpha c\lambda\,(\alpha+1)}$$

NUMERICAL ILLUSTRATION

Simulation models are particularly useful in studying in chronic kidney patients where random fluctuations are likely to be more serious. The theory developed was tested using stimulated data in MathCAD software. To illustrate the method described in this paper, we give some limited simulation results in the figures given.

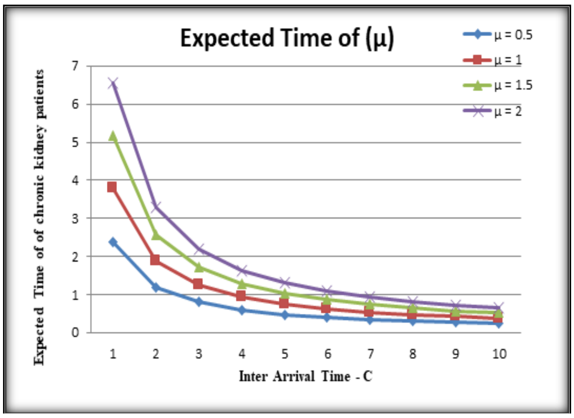

Figure: 1 The value of Expected time of chronic kidney patients for different values of μ

ISSN (O): 2687-5365; ISSN (P): 2753-6556

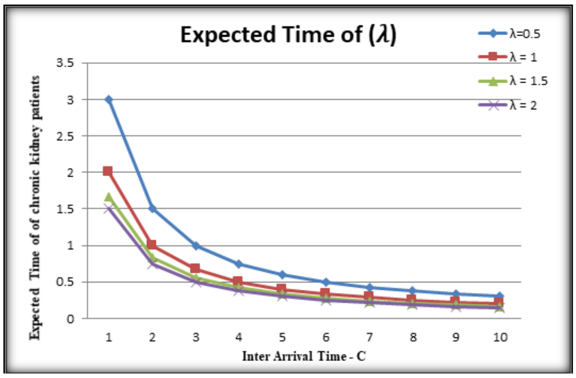

Figure: 2 The value of Expected time of chronic kidney patients for different values of λ

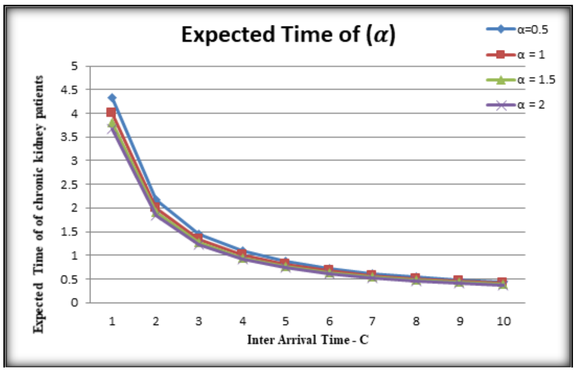

Figure: 3 The value of Expected time of chronic kidney patients for different values of α

CONCLUSION

CKD continues to rise and is a major public health problem in LMICs (Low and Low Middle Income Countries). Due to economic challenges related to the cost of kidney care, unavailability and inaccessibility of various KRT (kidney replacement therapy) modalities due to economic challenges, early disease detection, preventive measures and use of integrative approaches for chronic disease management remains the best options for management of CKD in these settings. There is need for the governments in LMICs to improve primary health care systems and to strengthen their NCD strategies in order for these preventive measures to become effective.

When the inter-arrival time 'c,' which follows an exponential distribution, is held constant (μ), the case of chronic kidney increases. As a result, the value of the expected time to pass the time to chronic kidney is found to be lowering in all cases of parameter value μ = 0.5, 1, 1.5, 2. As the parameter value μ grows, the expected time decreases as well, as shown in Figure 1. When λ is kept constant and the inter-arrival time 'c' grows, the estimated time to cross the time to chronic kidney decreases in all scenarios where the parameter value is λ = 0.5, 1, 1.5, 2. As the parameter value μ grows, the expected time decreases as well, as shown in Figure 2. When α is kept constant and the inter-arrival time 'c' grows, the estimated time to cross the time to chronic kidney decreases in all scenarios where the parameter value is α = 0.5, 1, 1.5, 2. As the parameter value μ grows, the expected time decreases as well, as shown in Figure 3.

REFERENCES

1. "Chronic Kidney Disease", http://www.worldkidneyday.org/faqs/chronic-kidney-disease.
2. Al-Mutairi, D.K., Ghitany, M.E and Kundu, D. (2011), "A new bivariate distribution with weighted exponential marginal and its multivariate generalization", Statistical Papers, Vol. 52, pp.921 - 936.
3. Azzalini, A. (1985) "A class of distributions which includes the normal ones", Scandinavian Journal of Statistics, Vol. 12, pp.171 - 178.
4. Farahani, Z.S.M and Khorram, E. (2014), "Bayesian statistical inference for weighted exponential distribution", Communications in Statistics - Simulation and Computation, Vol. 43, pp.1362 - 1382.
5. Gazi Mohammed Ifraz, Muhammad Hasnath Rashid, Tahia Tazin, Sami Bourouis and Mohammad Monirujjaman Khan. (2021), "Comparative Analysis for Prediction of Kidney Disease Using Intelligent Machine Learning Methods". Computational and Mathematical methods in medicine, pp.1-10.
6. Gupta, R.D. and Kundu, D. (2009), "A new class of weighted exponential distribution", Statistics, Vol. 43, pp.621 - 634.
7. Levey, A.S., Coresh, J. (2012) "Chronic kidney disease". The lancet. Vol.379, pp.165–180.
8. R. D. Gupta, D. Kundu, (2000). "Generalized exponential distributions; different method of estimations". J. Stat. Comput. Sim. Vol.69, pp.315–338.
9. R. Shongkour, M. A. S. Adnan, (2012). "Wrapped weighted exponential distributions", Stat. Prob. Lett.Vol. 82 (1), pp.77–83.
10. Romagnani, P., Remuzzi, G., Glassock, R., Levin, A., Jager, K.J., Tonelli, M., Massy, Z., Wanner, C., Anders, H.-J. (2017). "Chronic kidney disease". Nat. Rev. Dis. Primer. Vol.3, pp.17088
11. Roy, S and Adnan, M.A.S. (2012), "Wrapped weighted exponential distributions", Statistics and Probability Letters, Vol. 82, pp.77 – 83.
12. Shakhatreh, M.K. (2012), "A two-parameter of weighted exponential distribution", Statistics and Probability Letters, Vol. 82, pp.252 - 261.

ISSN (O): 2687-5365; ISSN (P): 2753-6556