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On Discrete Three Parameter Burr Type XII and Discrete Lomax Distributions and Their Applications to Model Count Data from Medical Science

Abstract

In this paper we propose a discrete analogue of three parameter Burr type XII distribution and discrete Lomax distribution as new discrete models using the general approach of discretization of continuous distribution. The models are plausible in modeling discrete data and exhibit both increasing and decreasing hazard rates. We shall first study some basic distributional and moment properties of these new distributions. Then, certain structural properties of the distributions such as their unimodality, hazard rate behaviors and the second rate of failure functions are discussed. Developing a discrete versions of three parameter Burr type XII and Lomax distributions would be helpful in modeling a discrete data which exhibits heavy tails and can be useful in medical science and other fields. The equivalence of discrete three parameter Burr type XII (DBD-XII) and continuous Burr type XII (BD-XII) distributions has been established and similarly characterization results have also been made to establish a direct link between the discrete Lomax distribution and its continuous counterpart. Various theorems relating a three parameter discrete Burr type XII distribution and discrete Lomax distribution with other statistical distributions have also been proved. Finally, the models are examined with an example data set originated from a study [1,2], data set of counts of cysts of kidneys using steroids and compared with the classical models.

Keywords: Discrete Lomax Distribution; AIC; ML estimate; Failure rate; Medical Sciences; Index of Dispersion

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Para BA* and Jan TR

Department of statistics, University of Kashmir, India

***Corresponding author:** Bilal Ahmad Para, Department of statistics, University of Kashmir, Srinagar, J&K(India)-192301, Srinagar, Jammu and Kashmir, India, Tel: 09797056761; Email: parabilal@gmail.com

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Introduction

Statistical models describe a phenomenon in the form of mathematical equations. Plethora of continuous lifetime models in reliability theory is now available in the subject to portray the survival behavior of a component or a system. Most of the lifetimes are continuous in nature and hence many continuous life distributions have been studied in literature Kapur & Lamberson [3], Lawless [4] and Sinha [5]. However, it is sometimes impossible or inconvenient in life testing experiments to measure the life length of a device on a continuous scale. Equipment or a piece of equipment operates in cycles and experimenter observes the number of cycles successfully completed prior to failure. A frequently referred example is copier whose life length would be the total number of copies it produces. Another example is the lifetime of an on/off switching device is a discrete random variable, or life length of a device receiving a number of shocks it sustain before it fails. Or in case of survival analysis, we may record the number of days of survival for lung cancer patients since therapy, or the times from remission to relapse are also usually recorded in number of days. In the recent past special roles of discrete distribution is getting recognition from the analysts in the field of reliability theory. In this context, the well known distributions namely geometric and negative binomial are known discrete alternatives for the exponential and gamma distributions, respectively. It is also well known that these discrete distributions have monotonic hazard rate functions and thus they are unsuitable for some situations. Fortunately, many continuous distributions can be discretized. As mentioned earlier, the discrete versions of exponential and gamma are geometric and negative binomial. There are three discrete versions of the continuous Weibull distribution [14]. The discrete versions of the normal and rayleigh distributions were also proposed by Roy [6,7]. Discrete analogues of two parameter Burr XII and Pareto distributions were also proposed by Krishna & Punder [8]. Recently discrete inverse Weibull distribution was studied [9], which is a discrete version of the continuous inverse Weibull variable, defined as where denotes the continuous Weibull random variable. Para & Jan [10] proposed a discrete version of two parameter Burr type III distribution as a reliability model to fit a range of discrete life time data. Deniz & Ojeda [11] introduced a discrete version of Lindley distribution by discretizing the continuous failure model of the Lindley distribution. Also, a compound discrete Lindley distribution in closed form is obtained after revising some of its properties. Nekoukhou et al. [12] presented a discrete analog of the generalized exponential distribution, which can be viewed as another generalization of the geometric distribution, and some of its distributional and moment properties were discussed.