**Original Research Article**

**STOCHASTIC APPROACH USING STATISTICAL DISTRIBUTION TO EXPECTED LIFETIME OF HYPERTENSION PATIENTS**

**Abstract**

Hypertensive heart disease, marked by morphological and functional dysfunction, is mostly caused by persistent uncontrolled hypertension that affects the left ventricle, left atrium, and coronary arteries. Hypertensive heart disease is underreported, and its linkages and repercussions are not well understood. This work considers an afflicted individual with a single source Power Burr X Distribution with distinct thresholds. The shock model and cumulative damage process determine the estimated time to cross the threshold. Specific distributions are used in order to demonstrate the analytical results quantitatively.

**Key Words:** Power Burr X Distribution, Expected Time, Hypertension Patients, Threshold and Parameters.

**Introduction**

Blood flows through blood vessels and presses up against their walls while the heart beats. The pressure that arises from this is known as blood pressure. For the blood to flow throughout its tissues, the body needs this pressure. To guarantee that every component of the body gets the oxygen it needs. Healthy arteries can enlarge to allow more blood to flow through them because they are elastic. The vascular walls' elasticity is determined by the amount of blood pressure applied to them. Blood pressure needs to be within a healthy level for one to remain healthy. The device used to measure blood pressure is known as a sphygmomanometer. The record of blood pressure has two members. The systolic blood pressure (Upper) indicates the pressure that blood exerts on arterial walls during heart pumping. The force that blood applies to artery walls in the interval between heartbeats is indicated by reduced diastolic blood pressure. Blood pressure is measured in millimetres of mercury (mm Hg).

Hypertension, often known as high or rising blood pressure, is the term used to describe a persistently raised pressure in the blood vessels. Every part of the body receives blood from the heart via the arteries. With every beat, the heart pumps blood into the vessels. Blood pressure is produced by the heart's pumping action on the walls of blood vessels, also known as arteries. The higher the pressure, the harder the heart must pump. Hypertension is a hazardous medical disease that increases the risk of developing kidney, brain, heart, and other conditions. Over a billion individuals worldwide 1 in 4 men and 1 in 5 women-haves the ailment, making it a primary cause of premature death. The burden of hypertension is disproportionately felt in low- and middle-income countries, where two-thirds of cases of the condition are found. This is partially because risk factors for these groups have increased in the last several years.

The Threshold Values of Blood Pressure category for Systolic (mm Hg) and Diastolic (mm Hg) for Normal (< 120 & < 80); Prehypertension (120-139 & 80-89); Hypertension stage-1 (140-159 & 90-99); Hypertension stage-2 (160 & 100) and Hypertensive Crisis (180 & 110).

**Background of the Study**

The WHO has published its first global report on hypertension. This report's backdrop is the growing prevalence of hypertension worldwide, which is linked to cardiovascular disease and overall death from all causes. The paper highlights the pressing necessity of addressing hypertension and its related problems, which impact more than one billion individuals globally. It continues to be a major public health concern since it increases the risk of cardiovascular disease, stroke, and early mortality. Only 54% of persons with hypertension are diagnosed, 42% receive therapy, and only 21% have their hypertension under control, according to the report Braun-Menendez E. et.al. (1940). These figures highlight the need for better understanding and treatment of hypertension.

When the situation was broken down by region, the percentage of adults with hypertension in 2019 fell in the WHO European region when compared to 1990, but it increased in the Asian regions, especially in the WHO Western Pacific Region (which includes countries like Australia, New Zealand, China, Republic of Korea, Philippines, Malaysia, Vietnam, and Japan) and WHO Southeast Asia Region (which includes countries like India, Nepal, Indonesia, and Thailand) (from 29% to 32%). From 144 million in 1990 to 346 million in 2019, the number of hypertensive adults in the WHO Western Pacific area more than doubled Braun-Menendez E. et.al. (1940). Moreover, over the previous thirty years (1999-2019), the number of adult hypertension patients in the WHO European area and the WHO region of the Americas has increased by 41%, as shown in the Graphic Abstract. On the other hand, there was a noteworthy 144% growth in the WHO Western Pacific and South-East Asia regions. Stressing the importance of controlling hypertension is essential to reducing the worldwide start of cardiovascular illnesses, especially in the WHO Western Pacific and South-East Asia regions.

**Model assumptions**

The only cause of hypertension infection is diabetes considered in this study. Every person's threshold is a random variable which is identically independently distributed (i.i.d). When a person's overall damage (hypertension) exceeds a threshold level, Y (Power Burr X distribution), which is also a random variable, they are diagnosed with diabetes and are considered to have hypertension. The inter-arriving times between consecutive connections are i.i.d random variables.

**Power Burr X Distribution**

Let the random variable follows the Power Burr X distribution with parameters and , the power transformation generates the PBX distribution. The random variable t follows the PBX distribution with parameters and. The cumulative distribution function of PBX distribution is

Where are an additional shape parameter, the survival rate function and the hazard rate function of PBX distribution are given respectively

**Model Description**

The survivor function is given by

Consider the shocks happen at random, according to a PBX distribution. Using a value of = 1 for the shape parameter

From renewal process

The life time is given by

The distribution function of life time (T), By taking Laplace-Stieltjes transform, it can be shown that

Random variable following the inter-arrival time through exponential distribution with shape parameters. substituting in the below equation we get

**Expected Time of Hypertension Patients**

The probability of a hypertension disease expected time to leave the patients is calculated. The mean time for the exit of hypertension patients is found in equation (9).

**Numerical Illustration**

The illustrations below depict the behaviour of the same when various factors are changed, based on the expressions given for the estimated time.



Figure – 1: Increases of parameter at different level



Figure – 2: Increases of parameter at different level



Figure – 3: Increases of parameter at different level

**Discussion**

As the parameter and fixed, when increases constantly and with vary at different stage, i.e., The observed expected time decreases in a hypertension patients lifetime at the initial stage very quickly when there is no death identified. Then as the inter-arrival time risk of hypertension increases the expected time decreases gradually in the later stage.

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**Conclusion**

Even now, hypertension remains one of the major causes of death worldwide. It can be avoided with medication and lifestyle modifications. Significant and reliable markers of hypertension include blood pressure (BP) readings obtained in the workplace, on the go via ambulatory blood pressure monitoring, and self-measured at home. Primary hypertension is defined as elevated blood pressure without an apparent reason that is linked to alterations in lifestyle and environmental factors that raise the risk of cardiovascular disease. In addition, there is secondary hypertension, which can result from various toxicities, iatrogenic diseases, and genetic problems.

Complications of hypertension are the clinical outcomes of persistently elevated blood pressure that result in heart disease (CVD), atherosclerosis, kidney disease, diabetes mellitus, metabolic syndrome, preeclampsia, erectile dysfunction, and eye diseases. Pharmaceutical therapies and lifestyle modifications, such as eating a diet high in fruits and vegetables, low-fat meat or fish with a reduced content of saturated and total fat, salt restriction, appropriate body weight, regular exercise, moderate alcohol consumption, and quitting smoking, are the two main treatments for hypertension, though the latter vary slightly depending on various published hypertension treatment guidelines.

**Disclaimer (Artificial intelligence)**

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Details of the AI usage are given below:

1.

2.

3.

**References**

1. Aditya Dixit and Prashant Kumar Dhakad. (2017). Hypertension: An Overview. *Eur. Chem. Bull.* *Journal.* Vol. 6 (9), pp.393-399.
2. Braun-Menendez E, Fasciolo JC, Leloir LF, Muñoz JM. (1940). The substance causing renal hypertension. *J Physiol*. Vol.98, pp.283-298.
3. Campese VM, Kogosov E. (1995).Renal afferent denervation prevents hypertension in rats with chronic renal failure. *Hypertension*. Vol.25, pp.878-882.
4. David G.Harrison et.al. (2021). Pathophysiology of hypertension: The Mosaic theory and Beyond. *Circulation research*. Vol.128 (7), pp. 847-863.
5. Esary JD, Marshall AW, Proschan F. (1973). Shock models and their processes. *Ann. Probability*, pp.627-649.
6. Guyton AC. (1987). Renal function curve-a key to understanding the pathogenesis of hypertension. *Hypertension*. Vol.10, pp.1-6.
7. Lip.S, Padmanabhan S. (2020). Genomics of blood pressure and hypertension: extending the mosaic theory toward stratification. *Can J Cardiol*. Vol.36, pp.694-705.
8. P.Pandiyan, V.S.Bhuvana, K.Kannadasan and R.Vinoth. (2014). Tracing the Threshold Level of the HIV Infected Patients through Stochastic Model, *International journal of Modern Research and Review*. Vol.2 (2), pp.107-111.
9. Schnackenberg CG, Welch WJ, Wilcox CS. (1998). Normalization of blood pressure and renal vascular resistance in SHR with a membrane-permeable superoxide dismutase mimetic: role of nitric oxide. *Hypertension*. Vol.32, pp.59-64.
10. World Health Organization. Global report on hypertension: the race against a silent killer. Geneva, Switzerland. (2023). *World Health Organization*, pp. 1-276.
11. Xiao L, Itani HA, do Carmo LS, Carver LS, Breyer RM, Harrison DG. (2019). Central EP3 receptors mediate salt-sensitive hypertension and immune activation. *Hypertension*. Vol.74, pp.1507-1515.