**THE IMPLEMENTATION OF STOCHASTIC MODEL TO THE STUDY OF BREAST CANCER IN RIVERS STATE OF NIGERIA.**

**ABSTRACT**

The Paper applied Stochastic model to the study of breast cancer data in Rivers State by considering Cancer data from the University of Port Harcourt Teaching Hospital, Cancer Registry Unit.

The sample data was transformed to a 3 $×3 $transition count matrix denoted as M while its corresponding transition probability matrix was denoted by **P**. The stochastic principle was used to determine the ages of women that were susceptible to breast cancer and the number of women who transited from one state of cancer to another and also the number of women who left the system as a result of death. The plot of the raw data against the time showed that as the year went by, the number of breast cancer patient increased.

However, this study investigated the discrepancies that existed in regions among women with breast cancers and also estimated the age bracket of women that would be mostly affected with breast cancer in the nearest future.

This study proffered solution to factors that could reduce the risk of breast cancer in Rivers State and across the globe.

***Keywords: Stochastic Principle, Breast Cancer, Rivers State and Transition Matrix***

**1.0 INTRODUCTION**

Breast cancer is the abnormal proliferation of cells usually uncontrollably beyond their usual boundaries which can go on to invade adjoining body **organs1.**

Breast cancer is the abnormal, uncontrolled increase of cells originating from the breast tissue. It is more common for breast cancers to emanate from the lining of the milk ducts or the lobules supplying the **ducts2**. It is the most common cause of cancer in women and also the leading cause of cancer death among women especially in less developed countries.

However, in more developed countries like the United States, lung cancer is the leading cause of death among women followed by breast **cancer3**. It is estimated that over 1 million new cases of breast are diagnosed every year constituting serious health threat to women all over the world4.

Prevalence of breast cancer varies with different regions; hence the Western countries are said to have higher number of cases compared with their African and Asian **counterparts4.**

In contrast to the United States with an incidence rate of 101/100,000, globally, American Indian and Alaska Native women have the lowest incidence rate of developing breast cancer at **21/100,0005**. Even in Africa, this regional variation still exists, with studies showing that 27% of breast cancers were localized in women from the Northern part of Africa like Egypt while 15% was reported in Sub Sahara region of **Africa6**. In central Africa, incidence rate is 27/100,000 and 39/100,000 in the Southern part of Africa and that of China is **25.9/100,0007.**

**2.0 RELATED LITERATURE**

Breast cancer cases are gradually increasing in African countries, probably as a result of gradual adoption of more westernized **lifestyle.4** It is believed that breast cancer cases in Africa (Nigeria inclusive) will continue to increase as a result of ageing, increase growth of the population, people adopting unhealthy lifestyles and absence of health-related intervention against breast **cancers4,8**.

 Late presentation, poor screening and diagnostic modalities, unavailability of quality health care infrastructures, poor health practices and funding among other factors are some of the factors that could lead to poor prognosis, increase morbidity and a low survival outcome in Nigerian **women9,10**. It is important to note that not all tumors are cancers, hence there are benign and malignant tumors; cancers are malignant tumors.

As a result of the resemblance that exists between cancer cells and normal cells from which they originate, they are not often detected by the immune system especially if it is **weakened11**. Cancer cells are usually formed as a result of mutations of DNA or RNA. These mutations may occur spontaneously or may follow chronic exposures to nuclear radiation, electromagnetic radiation (X-rays, Gamma rays), viruses, bacteria, parasites, etc. It is thought that invasive cancers arise from series of molecular alterations at the cellular level. It is this alteration that result in breast epithelial cells that assume immortality and uncontrolled growth. There are other risk factors which could make a person more susceptible to developing breast cancer. Increasing age and female sex are known risk factors for the development of breast cancer. Consequently, breast cancer is 100 times more common in women than in men; however, men tend to have poorer prognosis mainly as a result of delay in **diagnosis4.** A positive family history is another known risk factor including mutation carriers of BRCA 1 and 2. Reproductive and hormonal factor such as late age at first pregnancy, early menarche, late age at cessation of menses, nulliparity have all been shown to be risk factors for the emergence of breast **cancer12,13.** This is not unrelated to the effects of increased and unopposed estrogen in these women14.

Also, a previous history of breast cancer in one breast is associated with a 3-4-fold increase in occurrence of cancer in the other **breast15,16.** Protective life styles against breast cancer can include consumption of diet rich in grains, fruits and vegetables, reduced saturated fats and low in alcohol17.

Early breast cancers are usually asymptomatic, and pain is usually not present at first. Breast cancers may present as a lump with breast asymmetry, skin dimpling / changes around the skin of the breast, nipple deviation or related changes, nipple discharge which could be bloody, axillary lump.

Diagnosis and screening for breast cancer could involve any of the following or a combination; -physical examination of both breasts, mammography, ultrasonography, magnetic resonance imaging, biopsy.

Management of breast cancers could include any of or a combination of the following – surgery, radiation therapy, hormone therapy, chemotherapy.

However, this study investigated the discrepancies that existed in regions among women with breast cancers and also estimated the age bracket of women that would be mostly affected with breast cancer in the nearest future and also obtained the state transition probabilities.

The study is limited to the application of Stochastic model on the stages of breast cancer in Rivers State and it is relevant because the model is designed to predict the transition of the stages of breast cancer in Rivers State.

**3.0 METHODOLOGY**

**3.1 AN EXPANATION OF THE STOCHASTIC MODEL**

Stochastic model like Markov process is widely used in different fields to model systems that can be in one or more states with certain probabilities though these probabilities are subject to changes over time. Cancer operates in stages and a model of this nature should be employed in its study.

The study employed the stochastic modeling of breast cancer by describing a sequence of possible events in which the probability of each event depends only on the state attained in the previous event. Thus, if the current state of a process is known, its past states need not be required to predict its future state. This invariably means that a process’s past and future states are independent of its present state. One usefulness of this property of Markov model is that some parameters are likely to be redundant. Transition matrix and state transition probabilities were developed in the case of this study. The transition matrix is usually given the symbol $P=\left(P\_{ij}\right).$

 In the transition **matrix P:**

The ROWS represent **NOW or FROM** which is given by$\left(X\_{t}\right)$

The columns represent **NEXT or TO** which is referred to **(** $X\_{t+1}$**)**

The entry $\left(i,j\right) $is the conditional probability that NEXT = $j$, given that NOW $=i$; the probability of going FROM state $i $ **TO** state $j$ is;

$P\_{ij}=P\left[X\_{t+1}=j| X\_{t}=i\right]$

The transition matrix P must list all possible states in the state space S. P is a square matrix $\left(N×N\right)$

Because both $X\_{t+1 }$and $X\_{t}$ take values in the state space S (of size N)

The rows of P should sum to one (1).

 $\sum\_{j=1}^{N}P\_{ij}=\sum\_{j=1}^{N}P\left(X\_{t+1}=j|X\_{t}=i\right)$

 $\sum\_{j=1}^{N}Ρ\left\{X\_{t}=i\right\} \left(X\_{t+1}=j\right)=1$

This simply states that $X\_{t+1}$ must take one of the listed values.

**The columns of** $Ρ$ **do not in general sum up to one (1)**

**3.1 THE WORKING OF THE MARKOV MODEL**

For the purpose of this study, the raw data was transformed into $3×3$ transition probability matrix. Thus, three states were considered. A random walk is said to exhibit the Markov property if the position of the movement at time (n+1) depends only upon the position of the movement at n.

Let $X\_{n}$ denote the position of the random movement at time n, then the equation becomes $Ρ\left(X\_{n+1}=j|X\_{n}=i\right)=Ρ\_{ij}$…………………………………………………………..3.1

Where $Ρ\_{ij}$ is independent of $X\_{n-1},X\_{n-2},X\_{n-3}……,X\_{0}$ so that the state $X$ at time $\left(n+1\right)$ depends only upon the state of $X$ at time n.

This implies that each $Ρ\_{ij}$for $j=1,2,3…..N$ is a probability row vector describing every possible transition from state I to any other existing N possible states in the process.

 Thus, for every I, $\sum\_{}^{}NP\left(ij=1\right)$…………3.2

 Generally, a random movement exists in N possible states in the system hence $Ρ\left(X\_{n+1}=j\right) $ will depend on the whole sequence of random variables starting with the initial **value10** $X\_{0}$ yields

 $Ρ\left(X\_{n+1}=j|X\_{n}=i,X\_{n-1}=i\_{n-1},X\_{0 =}i\_{0}\right)=Ρ\left(X\_{n+1}=j|X\_{n}=i\right)$………………………………3.3

**MODEL FORMATION**

In this research, the ages of breast cancer patients were grouped into stages (states). Thus, we considered 0- 44(state 1) 45-58(state 2) and 58 & above (state 3).

The model is presented below;

3

2

1

The horizontal arrow signifies transition from one state to the other while the vertical arrow signifies exiting or leaving the system(death).

**4.0 RESULT ANALYSIS**

The data used for this work were collected from University of Port Harcourt Teaching Hospital Cancer Registry Unit. A total observation of 568 was recorded within the period under consideration.

The collected data were transformed to a 3 x 3 matrix called the state transition matrix and probability transition matrix represented by M and P respectively.

 $M=\left(\begin{matrix}23&87&45\\22&133&60\\21&124&53\end{matrix}\right)$

 $p^{0}=\left(\begin{matrix}0.1484&0.5613&0.2903\\0.1023&0.6186&0.2791\\0.1061&0.6263&0.2677\end{matrix}\right)$

 $p^{6}=\left(\begin{matrix}0.1084&0.6146&0.2772\\0.1084&0.6146&0.2772\\0.1084&0.6147&0.2772\end{matrix}\right)$

 $P^{24}=\left(\begin{matrix}0.0929&0.5265&0.2315\\0.0917&0.5201&0.2287\\0.0928&0.5261&0.2313\end{matrix}\right)$

Three age brackets were considered as below:

**TABLE 1 State and age wise scenario of breast cancer**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| NUMBER OF STATES | 0 - 44 | 45-58 | 58 & ABOVE | TOTAL |
| 1 | 38 | 86 | 75 | 199 |
| 2 | 37 | 63 | 58 | 158 |
| 3 | 48 | 97 | 66 | 211 |
| TOTAL | 123 | 227 | 189 | 568 |

We generated a simultaneous equation to determine the value of $π$ which represented the state that would be susceptible to breast cancer in the future. Hence linear equations representing the limiting probabilities will be generated. The equations would be of the form $π=πP$

Hence $\left(π\_{1},π\_{2},π\_{3}\right)\left[\begin{matrix}0.0929&0.5265&0.2315\\0.0917&0.5201&0.2287\\0.0928&0.5261&0.2313\end{matrix}\right]$

This gave rise to three distinct linear equations as shown below:

 $π\_{1}=0.0929π\_{1}+0.5265π\_{2}+0.2315π\_{3}………….(1)$

 $π\_{2}=0.0917π\_{1}+0.5201π\_{2}+0.2287π\_{3}…………(2)$

 $π\_{3}=0.928π\_{1}+0.5261π\_{2}+0.2313π\_{3}…………….(3)$

 $π\_{1}+π\_{2}+π\_{3}=1……………………………………..(\*)$

 From eqns. 1, 2 and 3 we have;

 $9071π\_{1}=5265π\_{2}+2315π\_{3}……………(4)$

 $4739π\_{2}+928π\_{1}+2313π\_{3}………………(5)$

 $7687π\_{3}=928π\_{1}+5261π\_{2}……………………..(6)$

Rearranging and subtracting eqn. (6) from eqn. (5)

 $4739π\_{2}=928π\_{1}+2313π\_{3}……………(5)$

 $-5261π\_{2}=928π\_{1}-7687π\_{3}…………..(6)$

 $10000π\_{2}=10000π\_{3}$

 $∴ π\_{2}=π\_{3}…………………………………..(7)$

 From eqn. (4) we have;

 $9071π\_{1}=5265π\_{3}+2315π\_{3}$

 $9071π\_{1}=7580π\_{3}$

 $∴ \frac{7580}{9071}π\_{3}$

Recall that $π\_{1}+π\_{2}+π\_{3}=1……………….(\*)$

By replacement we have;

 $\frac{7580}{9071}π\_{3}+π\_{3}+π\_{3}=1$

Taking L.C.M, we have;

 $25722π\_{3}=9071$

 $π\_{3}=\frac{9071}{25722}$

 $∴ π\_{3}=0.3527$

From eqn. (7) $π\_{2}=π\_{3}$ hence $π\_{2}=0.3527$

 $π\_{1}=1-(0.3527+0.3527)$

 $π\_{1}=0.2946$

From the values of $π\_{1}, π\_{2} and π\_{3}$ we deuced that at the long run, the number of People with breast cancer at state 2 (45-58) will equal the number of People at state 3 (55 & above).

**FIGURE I Number of cancer cases from 2016 to 2024**

NO OF PERIODS

The three graphs in figures I, II and III showed that breast cancer invasion increased yearly throughout the nine years of investigation and rose to an unprecedented level during the Covid periods.

We also considered individual states of cancer against number of periods (years).

The plot agreed that the age 45-58 (state 2) recorded the highest breast Cancer rate or prevalence.

**FIGURE II Number of cancer cases in states**

**FIGURE III** **Breast cancer invasion**



4.0 **SUMMARY OF FINDINGS**

We randomly considered a six-year probability matrix in order to determine the state transition matrices of breast cancer prevalent in Rivers State. In the year 2030, the number of breast cancer patients in state 2 will equal the number in state 3. This also indicated a yearly increase.

**CONCLUSION**

Breast cancer is the most common cancer in women and also the leading cause of death among women. Breast cancer invasion increased yearly throughout the nine years.

Women between the ages of 45-58 suffered most from breast cancer.

**RECOMMENDATIONS**

We recommend protective life styles against breast cancer such as consumption of diet rich in grains, fruits and vegetables, reduced saturated fats and low in alcohol. Also, women should be guided on the choice of contraceptives, clamping down on contraceptives that pose higher risks for occurrence of breast cancer like the oral contraceptive pills.

Also, early detection and screening is highly recommended through less expensive modalities like physical examination, mammography and ultrasonography.

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