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Survival Analysis of Cholera Disease. (A Case Study of Offa Local Government Area of Kwara State)

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ABSTRACT
The outbreak and spread of diseases have been studied for many years, many researchers have been contributing to the knowledge on how various diseases are spread. Therefore this research, Survival Analysis of Cholera disease in Offa Local Government Area of Kwara state was carried out to study the causes of Cholera outbreak, determine if the symptoms of cholera is affected by political wards where people are residing, as well as determine whether the number of people that contact cholera is increasing or reducing and to determine if cholera is influence by gender or not. Results of the analysis from the descriptive statistics revealed that eating of contaminated food and lack of good social amenities are the major causes of the cholera outbreak in the community under study. Also, results of logistic regression shows that those admitted to the hospital when they have cholera related symptoms is influenced by the political ward of the respondent. Also the same analysis showed that number of patients that will be at risk in the nearest future will be reducing while the chi – square analysis revealed that the rate at which people contact cholera is not dependent on gender.
Key Word: Survival, cholera, symptoms and Patients

I. INTRODUCTION

Survival analysis is a very specific type of statistical analyses. Survival analysis is aimed to analyze not the event itself but the time lapsed to the event. This time of interest is also referred to as the failure time or survival time. The time used in survival analysis might be measured in different intervals: days, months, weeks, years, etc. The lengthy studies as a matter of course are preferred for being analyzed since they provide stronger evidence and more reliable results. However, it is practically unfeasible for some of the events to be observed over a long period of time. For example, in a study of the pancreatic cancer, one of the most lethal and rapidly growing type of cancer, researchers might get a very low median for survival time, which may indicate that half of the understudy population died within just a few months period. The events in the survival analysis are usually deleterious in nature. The death is the prototypical event for the analysis, termed usually as a failure. Other events, such as an occurrence of a disease, relapse, smoking and drinking resumption, complication of the disease, might be of the research interest as well. The survival analysis methods can be used in other than medicine fields as well: in economics, political science, sociology, engineering.

Survival data requires a very particular treatment with caution due to the heterogeneity. The heterogeneity of the data is explained by the fact that subjects of the study might not just experience or do not experience the event but be censored otherwise. The censored subjects remain one of the major challenges for researchers when there is a choice of which statistical methods to apply and how to interpret the results. This research was therefore carried out to analyze the survival rate of Cholera outbreak in offa local government of kwara state.

II. RESEARCH METHODOLOGY

2.1 DATA COLLECTION

Use of Questionnaire was adopted as follows

- Pilot survey
- Proper Survey
- Post enumeration survey

The stage of the research project covers:

- Designing of questionnaire

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- Administration of the questionnaire to people
- Data were collected, summarized and presented for analysis.
- Demographic data were classified based on age, sex, religion, educational qualification, Local Government Area and State of origin.

2.2 METHOD OF DATA COLLECTION

The method of data collection refers to the method used in obtaining the information required. Before acquiring the data used for this research work, the population of Offa local government was sampled out with the aid of stratified sampling technique in which the population was grouped homogeneously by grouping them based on each political wards in offa local government area of kwara state. These political wards include Balogun ward, Essa ward A, Essa ward B, Essa ward C, Igboidun, Ojomu centre A, Ojomu centre B, Ojomu north, Shawo centre , Shawo south A, Shawo south B and questionnaires were administered within this political wards and collected, in which proper analysis were carried out on the questionnaires.

There are other methods in which data can be collected which include:

1. Direct observational method: this method entails sending observers to record an event that happened and where it happened. Other methods include telephone method, personal interview, transaction from records etc. All these methods can either yield primary data or secondary data that will be collected.
2. Personal interview method: this is the most accurate way of data collection but is very expensive and it is a common method used in the developed countries because it involves the investigator to travel to selected area, select the sample from the list and then collect information directly from the respondents.

2.3 METHOD OF DATA ANALYSIS

The statistical technique used for analyzing the data collected for this research work was CHI SQUARE (χ^2). Chi square is a non parametric statistics which is usually applied in a test involving nominal measurement. It is use to test the independent of two traits or correlation. It is also use to test for goodness fit of statistics frequency, measures etc. This area of the research work will mainly deal with the gender contact of cholera within the political wards in Offa local government. The necessary computation formula is

$$X^2 = \sum \frac{(O_{ij} - E_{ij})^2}{E_{ij}}$$

Where O_{ij} – the observed value

E_{ij} – the expected value

To calculate expected frequencies, it is estimated by multiplying the sum of each row by the sum of each column and the product is divided by the grand total

$$E_{ij} = \frac{row\ total \times column\ total}{grand\ total}$$

State the Hypothesis to be use

H_0: Gender is independent of contact and treatment of cholera

H_1: Gender is dependent of contact and treatment of cholera

Level of significance

$\alpha = 0.05$

Test statistic: $X^2 = \sum \frac{(O_{ij} - E_{ij})^2}{E_{ij}}$

2.4 LOGISTIC REGRESSION

Logistic regression analysis is part of a category of statistical model that is used to analyze a dataset in which there is one or more independent variable that determine an outcome. The outcome is measured with a dichotomous variable (in which there are only two possible outcomes).

In logistics regression, the dependent variable is binary or dichotomous, i.e. it only contains data coded as 1(TRUE, success, pregnant etc.) The goal of logistics regression is to find the best fitting model to describe the relationship between the dichotomous characteristics of interest (dependent variable = response or outcome variable) and a set of independent (predictor or explanatory) variables.

Let X denotes the vector of predictors (X_1, X_2, X_3, ..., X_N) and let the conditional probability that the outcome is present be denoted by the equation as: P(Y = $\frac{1}{X} = \pi(X)$). The logistic regression model has a linear form for the logit of this probability.

Logit $\{\pi(X)\}$ = log $\left\{\frac{\pi(X)}{1-\pi(X)}\right\}$ = $\beta_o + \beta_1 x_1 + \beta_2 x_2 + \ldots\ldots + \beta_n x_n$

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2.5 DATA ANALYSIS

Table 1: shows the distribution of the political wards of the respondents

What is your political ward?					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Balogun	1762	35.3	35.3	35.3
	Essa A	486	9.7	9.7	45.1
	Essa B	612	12.3	12.3	57.4
	Essa C	452	9.1	9.1	66.4
	Igboidun	356	7.1	7.1	73.6
	Ojomu Centre A	522	10.5	10.5	84.1
	Ojomu Centre B	183	3.7	3.7	87.7
	Ojomu North	101	2.0	2.0	89.7
	Ojomu South	275	5.5	5.5	95.3
	Shawo Centre	135	2.7	2.7	98.0
	Shawo South A	82	1.6	1.6	99.6
	Shawo South B	19	.4	.4	100.0
	Total	4985	100.0	100.0	

Source: survey by Raji S. T., Okeniyi O. M., Ojo O. D. and Adewoye K. B.

A sum of 5000 questionnaires were administered and 4985 questionnaires were returned from the respondents in the study area. Balogun have the highest respondents with frequency of 1762 (35.3%), followed by Essa B with a frequency of 612 (12.3%), followed by Ojomu centre A, Essa A, Essa C, with frequencies of 522(10.5), 486 (9.7%), 452(9.1%) respectively while the lowest frequency was Shawo South B with 19(0.4%) as frequency.

Table 2: shows the distribution of respondent according to their gender

Gender of the respondents					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	2706	54.3	54.3	54.3
	Female	2017	40.5	40.5	94.7
	Bisexual	262	5.3	5.3	100.0
	Total	4985	100.0	100.0	

Source: survey by Raji S. T., Okeniyi O. M., Ojo O. D. and Adewoye K. B.

From table 2 above, male has the highest frequency of 2706 (54.3%), followed by female with frequency of 2017(40.5%) and the bisexuals has a frequency of 262(5.3%)

Table 3: shows the marital status of the respondents

Marital Status of the respondents					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Single	1619	32.5	32.5	32.5
	Married	1359	27.3	27.3	59.7
	Separated	1435	28.8	28.8	88.5
	Divorced	360	7.2	7.2	95.7
	Widow(er)	212	4.3	4.3	100.0
	Total	4985	100.0	100.0	

Source: survey by Raji S. T., Okeniyi O. M., Ojo O. D. and Adewoye K. B.

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From table 3 above, the marital status of the respondents shows that, the highest frequency of 1619(32.5%) falls in the Singles category, while separated, Divorced & widower have 1435(28.8%), 360 (7.2%) and 212(4.3%) frequencies respectively.

Table 4: Shows the number of respondent who had contacted cholera before

Number of respondents who had contacted cholera before					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	3055	61.3	61.3	61.3
	Yes	1930	38.7	38.7	100.0
	Total	4985	100.0	100.0	

Source: survey by Raji S. T., Okeniyi O. M., Ojo O. D. and Adewoye K. B.

From table 4 above out of the 4985 respondents, 1930(61.3%) of the respondents indicated that they have contacted cholera before while the remaining 3055 said they have not contacted the disease before, which implies that only 38.7% of the respondents have contacted cholera before.

Table 5: Show the number of respondents who had ever taken vaccine against cholera before.

Respondent who have ever take vaccine against cholera before.					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	2859	57.4	57.4	57.4
	No	2126	42.6	42.6	100.0
	Total	4985	100.0	100.0	

Source: survey by Raji S. T., Okeniyi O. M., Ojo O. D. and Adewoye K. B.

From table 5 above, 2859 respondent which represent 57.4% claimed that they had taken vaccine against cholera before, while only 42.6% claimed they had not.

Table 6: Shows the number of respondents with cholera symptoms

What was your symptoms					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Cough	462	9.3	9.3	9.3
	Nausea, vomiting, diarrhea	2630	52.8	52.8	62.0
	Fever	1893	38.0	38.0	100.0
	Total	4985	100.0	100.0	

Source: survey by Raji S. T., Okeniyi O. M., Ojo O. D. and Adewoye K. B.

From table 6 above, majority of the respondents who are about 52.8% indicated that they have Nausea, vomiting and diarrhea as cholera symptoms followed by fever with frequency of 1893 (38.0%) while cough only contributed to 9.3% as symptoms of cholera in the study area.

Table 7: shows the number of respondents idea on the causes of cholera

What do you think is the courses of cholera					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Water	2682	53.8	53.8	53.8
	Contaminated Food	1824	36.6	36.6	90.4
	Mosquito Bite	479	9.6	9.6	100.0
	Total	4985	100.0	100.0	

Source: survey by Raji S. T., Okeniyi O. M., Ojo O. D. and Adewoye K. B.

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From table 7 above, the likely causes of cholera according to the respondents shows that, 2682 representing 53.8% of the respondents agreed that water is the major causes of cholera, while causes by contaminated food has a frequency of 1824 (36.6%) of the respondents and about 479 of the respondents representing 9.6% chooses mosquito bite as the cause of cholera.

Table 8: Shows the distribution of respondents according to the type of water used at home

Types of water do you use at home					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Well water	2049	41.1	41.1	41.1
	Borehole water	1392	27.9	27.9	69.0
	Municipal common water	1040	20.9	20.9	89.9
	Untreated water (river, pond, dam)	504	10.1	10.1	100.0
	Total	4985	100.0	100.0	

Source: survey by Raji S. T., Okeniyi O. M., Ojo O. D. and Adewoye K. B.

Table 8 above shows that 2049 of the respondents representing 41.1% uses well water in their various homes, followed by Borehole water with frequency of 1392(27.9%), while uses of Municipal common water and untreated water (river, pond, dam) have frequency of 1040 (20.9%) and 504 (10.1%) respectively.

Table 9: Shows the Symptoms of body discomfort in the last time you contacted cholera

Symptoms of body discomfort in the last time you contacted cholera					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Nausea, vomiting, diarrhea	1392	27.9	27.9	27.9
	Chills	536	10.8	10.8	38.7
	Headaches	715	14.3	14.3	53.0
	Malaria	527	10.6	10.6	63.6
	Cough	436	8.7	8.7	72.3
	Difficulty Breathing	586	11.8	11.8	84.1
	Dizziness	272	5.5	5.5	89.5
	Sore throat	171	3.4	3.4	93.0
	Persistent fever	350	7.0	7.0	100.0
	Total	4985	100.0	100.0	

Source: survey by Raji S. T., Okeniyi O. M., Ojo O. D. and Adewoye K. B.

From table 9 above it was discovered that the symptoms of body discomfort of the respondent in the last time they contacted cholera, 1392 representing 27.9% agreed Nausea, vomiting, diarrhea as the symptoms while Chills, Headaches have the following frequencies 536(10.8%), 715(14.3%) respectively. About 350 of the respondents choose persistent fever while 171(3.4%) indicated that sore throat is the symptom.

Table 10: Shows how the respondent contacted cholera

Table 35: How do you get cholera?					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	By drinking contaminated water	1596	32.0	32.0	32.0
	By eating contaminated food	508	10.2	10.2	42.2
	Burial preparation	646	13.0	13.0	55.2
	By not washing hands	472	9.5	9.5	64.6

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	Caring for people that are ill with cholera	381	7.6	7.6	72.3
	From the air	569	11.4	11.4	83.7
	Flies and insects	210	4.2	4.2	87.9
	Shaking hands	126	2.5	2.5	90.4
	From a dirty environment	327	6.6	6.6	97.0
	Other	150	3.0	3.0	100.0
	Total	4985	100.0	100.0	

Source: survey by Raji S. T., Okeniyi O. M., Ojo O. D. and Adewoye K. B.

From table 10 above it was discovered that, 1596 out of 4985 respondents representing 32% indicated that they got cholera by drinking contaminated water, frequency of 646 (13%) got it from burial preparation while contacts from flies and insects has the least frequency of 210(4.2%).

Table 11: Shows the perceptions of the respondent on how to prevent cholera

ways to prevent cholera					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Wash your hands	474	9.5	9.5	9.5
	Drink treated water	2526	50.7	50.7	60.2
	Eat properly heated food	1333	26.7	26.7	86.9
	Disinfect house with chlorine	481	9.6	9.6	96.6
	Take an antibiotic pill	171	3.4	3.4	100.0
	Total	4985	100.0	100.0	

Source: survey by Raji S. T., Okeniyi O. M., Ojo O. D. and Adewoye K. B.

Table 11 above shows the ways respondents believed cholera can be prevented and from the table, 2526(50.7%) of the respondents indicated that cholera can be prevented by drinking treated water, 1333(26.7%) signify that eating properly heated food prevents cholera while a minimal number of 171 representing 3.4% of respondents agreed that taking an antibiotic pill can prevent cholera.

Logistic Regression

Table 12: Shows the number of respondent that have contacted cholera before?

Variables in the Equation					
			Score	df	Sig.
Step 0	Variables	Which Political ward do you reside?	37.077	1	.000
		How old are you as at your last birthday?	3177.39	1	.000
		Gender	72.286	1	.000
		Marital Status	24.899	1	.000
		Number of Children	28.422	1	.000
		What is your Level of Education?	.069	1	.794
		What do you do for a living?	15.207	1	.000
		What is your religious belief?	203.894	1	.000
	Overall Statistics		3296.768	8	.000

Source: survey by Raji S. T., Okeniyi O. M., Ojo O. D. and Adewoye K. B.

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From table 12 above, it was discovered that those that have contacted cholera before is significant and (1-0.632 = 0.368) 37% of the respondent claims they have contacted cholera before and it was also discovered that those that have contacted cholera before is significant to political ward, age, gender, marital status, number of children, religion and the job the respondents do for a living but is not significant to the level of education.

Table 13: Shows the number of respondent ever take any vaccine against cholera before.

Variables in the Equation					
			Score	df	Sig.
Step 0	Variables	Which Political ward do you reside?	19.596	1	.000
		How old are you as at your last birthday?	4.774	1	.029
		Gender	32.887	1	.000
		Marital Status	21.582	1	.000
		Number of Children	154.030	1	.000
		What is your Level of Education?	74.100	1	.000
		What do you do for a living?	13.100	1	.000
		What is your religious belief?	3.157	1	.076
	Overall Statistics		262.692	8	.000

Source: survey by Raji S. T., Okeniyi O. M., Ojo O. D. and Adewoye K. B.

In table 13 above, it was observed that those that have ever taken any vaccine against cholera before is significant and (1-0.774=0.226) 23% of the respondents claimed they have not taken any vaccine against cholera before and it was also discovered that those that have take any vaccine against cholera before is significant to political ward, age, gender, marital status number of children, level of education and the job the respondents do for a living but is not significant to the religious belief of the respondents.

Table 14: Shows the number of respondent that ever confirm of having cholera

Variables in the Equation					
			Score	df	Sig.
Step 0	Variables	Which Political ward do you reside?	210.696	1	.000
		How old are you as at your last birthday?	431.956	1	.000
		Gender	318.104	1	.000
		Marital Status	18.509	1	.000
		Number of Children	1.753	1	.186
		What is your Level of Education?	.655	1	.419
		What do you do for a living?	14.089	1	.000
		What is your religious belief?	180.707	1	.000
	Overall Statistics		1031.872	8	.000

Source: survey by Raji S. T., Okeniyi O. M., Ojo O. D. and Adewoye K. B.

Table 14 above shows that those that ever confirmed having cholera is significant and that (3.62 – 1 = 2.62) 26.2% of the respondents claimed they were ever confirmed of having cholera and it was also discovered that those ever confirmed of cholera is significant to political ward, age, gender, marital status, religious belief, job type of respondent but is not significant to number of children and level of education of the respondents. This implies that those that will be confirm of having cholera in the future will increase.

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TEST OF HYPOTHESIS USING CHI-SQUARE
H_0: How people contacted cholera is independent of gender.
H_1: How people contacted cholera is dependent on gender.

TESTSTATISTIC: $X^2 = \sum \frac{(O_{ij} - E_{ij})^2}{E_{ij}}$

CRITICAL VALUE $\alpha = 0.05$
DECISION RULE: Reject H_0 if P-value < critical value (α), if otherwise do not reject.

Table 15: Chi-Square test on gender of the respondents and how they contact cholera

	Value	Df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.003[a]	1	.957		
Continuity Correction[b]	.000	1	1.000		
Likelihood Ratio	.003	1	.957		
Fisher's Exact Test				1.000	.638
Linear-by-Linear Association	.003	1	.958		
N of Valid Cases	89				

Source: Survey 2022 by Raji S. T., Okeniyi O. M., Ojo O. D. and Adewoye K. B.
CONCLUSION: Since P-value (0.638) > Critical value (0.05), H_0 is not rejected and conclude that how people have been contacting cholera is independent of gender.

III. SUMMARY AND CONCLUSION

This research work was carried out to know the rate at which cholera spread, the courses, the symptoms, the preventions and as well determine if cholera is gender dependent it in Offa local Government of Kwara State. The method that was employed in data collection is questionnaire method. Questionnaires were administered to 5000 respondent and 4985 were received back. The methods of data analysis used were data exploration, Chi-Square test and logistics regression

Result of the analysis from the frequency distribution shows that Balogun have the highest number of respondents with frequency of 1762 (35.3%), followed by Essa B with frequency of 612 (12.3%), followed by Ojomu centre A, Essa A, Essa C, with frequencies of 522(10.5), 486 (9.7%), 452(9.1%) respectively while the lowest frequency was Shawo South B with 19(0.4%). Gender distribution of the survey shows that, male respondents have the highest frequency of 2706 (54.3%), while the female have 2017(40.5%). The marital status of the respondents showed that, about 1619(32.5%) were singles, while separated, Divorced & widower are 1435(28.8%), 360 (7.2%) and 212(4.3%) respectively.

Also, level of education of the respondents in the study area indicates that respondents who had elementary & secondary education have the highest frequency of 3066 (61.5%), respondents who had Post-Secondary education or Tertiary have frequency of 1172 (23.5%) while respondents that had no formal education have the lowest frequency with 127(2.5%). The occupational status of the respondents in the understudy area, shows that majority of the respondents were student with 1634(32.8%) frequency, Government employed have 1327(26.6%) frequency while Retiree are about 882 (17.7%).

Furthermore, out of the 4985 respondents, about 1930 indicated that they have contacted cholera before while the remaining 3055 said they have not contacted the cholera disease before, which implies that only 38.7% of the respondents have contacted cholera before while 2859 respondent which represent 57.4% claims that they have taken vaccine against cholera before and majority of the respondents indicated that they have Nausea, vomiting and diarrhea as cholera symptoms followed by fever. While 53.8% of the respondents agreed that water, contaminated food are the major course of cholera and the analysis shows that majority of the respondents uses well water in their various homes .

Moreover, the results of the analysis shows that the symptoms of body discomfort of the respondents in the last time they contacted cholera are Nausea, vomiting and diarrhea. Also, majority of the respondents claimed that they got cholera by drinking contaminated water while majority also

claims that drinking treated water and eating properly heated food will prevent people from having cholera.

Result of logistic regression shows that those that have contacted cholera before is significant to political ward, age, gender, marital status, number of children, religion and job type of the respondent but is not significant to the level of education. Also it was discovered that those that have taken vaccine against cholera before is significant to political ward, age, gender, marital status, number of children, level of education and job type of the respondents but is not significant to the religious belief of the respondents. Also the result of the analysis shows that those that ever confirmed having cholera is significant to political ward, age, gender, marital status, religious belief and the type of job the respondents do but is not significant to number of children and level of education of the respondent.

From the analysis it was discovered that those that were admitted to the hospital when they had the symptom(s) is significant and 38% of the respondent claims they were admitted to the hospital when they had the symptom. It was also discovered that those admitted to the hospital when they had the symptom is significant to political ward, age, gender, marital status, religious belief, job the respondent do for a living, number of children and level of education of the respondent. This implies that the number of patients to be admitted with cholera related symptoms in the future will likely reduce. Result of the chi – square on how people contacted cholera is independent of gender, this implies gender does not have influence on how cholera is been contacted.

3.2 Recommendation

1. Health Planners should educate people more on the causes and prevention of cholera disease.
2. Health Planners should made available enough drugs to cholera patient as at when due.
3. Government at federal, states and local government should encourage cholera patient to present themselves for test at a free or barest minimum rate.
4. All agencies involved in educating the masses on disease control should be funded adequately.
5. Government at federal, states, and local level should embark on a massive enlightenments and awareness in the rural areas were about 80% of the population understudy resides.
6. Cholera Immunization should be giving to the child after 3 months of birth and made available to all.

REFERENCES

[1]. Dennis L. Chao, Ira M. Longini Jr and J. Glenn Morris Jr, Modeling Cholera outbreaks, Curr Top MicrobiolImmunol. 2014; 379: 195– 209. doi: 10.1007/82_2013_307

[2]. Kamuhanda Anthony Eustace, Shaibu Osman and Mary Wainaina, " Mathematical Modelling and analysis of the Dynamics of Cholera" , Global Journal of Pure and Applied Mathematics. ISSN 0973-1768 Volume 14, Number 9 (2018), pp. 1259– 1275 © Research India Publications

[3]. KinfeHailemariamHntsa, BerheNereaKahsay, "Analysis of Cholera Epidemic Controlling Using Mathematical Modeling", International Journal of Mathematics and Mathematical Sciences, vol. 2020, Article 7369204, 13 pages, 2020. https://doi.org/10.1155/2020/7369204

[4]. C.M. Kribs-Zaleta, J.X. Velasco-Hernandez, A Simple Vaccination Model With Multiple Epidemic States, Math. Biosc. 164, 2012, 183-201.

[5]. M. De La Sen, S. Alonso-Quesada and A. Ibeas, Observer based Vaccination for a SEIR Epidemic Model with Time Varying Total Population, International Conference on Circuits, Systems and Simulation (IPCSIT), (2011) Vol. 7, pp.11-22. IACSIT Press Singapore.

[6]. United Nation Published Annual Journal (2017).