Estimation of Drug Administered by Fuzzy CETD Matrix to a Patient for a Bacterial Disease

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ABSTRACT
This paper deals with the study of the estimation of the maximum amount of drug to be given for a patient using fuzzy CETD matrix. It is based on the clinical survey of 30 patient's culture report of the real data which was collected from a microbiological laboratory.

Keywords
Fuzzy matrix, ATD Matrix, RTD Matrix, CETD Matrix, Antibiotic Drug.

1. INTRODUCTION
Many patients suffer from different bacterial diseases hence they undergo some microbiological laboratory test hence the doctor suggests them to take the antibiotic drug which suits them, since it is required for the doctors to estimate the maximum amount of the drug to be given to kill the bacteria for each patient who suffer from bacterial fever. The Doctors prescription will be based on the age, sex, different bacterial conjectives, Body weight etc. This work is based on the survey of the 30 patient's culture report and the consultancy with the doctor. First and foremost the data was gathered from those patients report using linguistic questionnaire and this linguistic questionnaire was transformed into a fuzzy data. It is important to note while doing fuzzy mathematical models the fuzzy matrix may take the entries from the interval [-1, 1] then also they are known as fuzzy matrices. In this paper we will make use of the Fuzzy CETD matrix to solve this problem [11, 12].

2. PRELIMINARIES [2-4, 15, 16]
2.1 Definition
A fuzzy number A is a convex normalized fuzzy set on the real line R such that:

1) There exists at least one $x_0 \in R$ with $\mu_A(x_0) = 1$.
2) $\mu_A(x)$ is piecewise continuous.

2.2 Definition
The classical set $\tilde{A}_\alpha$ called alpha cut set is the set of elements in which a fuzzy set A defined on and any number $\alpha \in [0,1]$ is given by

$$A_\alpha = \{x \in X / \mu_A(x) \geq \alpha\}$$

2.3 Definition
Average Time Dependent Data matrix (ATD matrix) (a_{ij}) is obtained by dividing each entry of the raw data matrix by the number of years or the time period. This matrix represents a data, which is totally uniform.

2.4 Definition
The time dependent matrix has been converted to matrix with entriese_{ij}, where $e_{ij} \in \{-1,0,1\}$ using simple average techniques and such a matrix is called Refined Time dependent matrix (RTD matrix.)

2.5 Definition
Combined Effective Time Dependent Data Matrix (CETD) is obtained by finding the row sum matrix of the RTD matrix and also by combining these matrices by varying$\alpha \in [0,1]$, and such a matrix is called CETD matrix.

3. ALGORITHMIC APPROACH OF THE FUZZY CETD MATRIX
Following are the five stages to solve the above problem using CETD matrix:

Step:-1: In the first stage, give a matrix representation of the raw data. The initial M x N matrix is not uniform. i.e., take the data as it is and transform into a raw time dependent data matrix by taking along the rows the zone mm of the antibiotic drug and along the columns the different categories like age group, body weight etc.

Step:-2:So in the second stage, in order to obtain an unbiased uniform effect on each and every data so collected, transform this initial matrix into an Average Time Dependent Data matrix (ATD matrix). This is done by dividing each entry of the raw data matrix by the number of dosage of zone mm. i.e., the difference of the class interval of each row. This matrix represents a data, which is totally uniform.

Step:-3: To make the calculations easier and simpler, in the third stage, use the simple average techniques, to convert the above time dependent data matrix into a matrix with entries e_{ij} where, $e_{ij} \in \{-1, 0, 1\}$. i.e., find the average and standard deviation (SD) of every column in the ATD matrix. Using the average μ_j of each jth column and σ_j the S.D of each jth column thus choose a parameter α from the interval $[0,1]$ and name this matrix as the Refined Time Dependent Data matrix (RTD matrix). Thus determine the value of the entry e_{ij} in the refined time dependent data matrix

For each of the attributes j (j=1,2,………N) ,A rule has been framed:

If $a_{ij} \leq (\mu_j - \alpha * \sigma_j)$ then $e_{ij} = -1$;

else,

If $a_{ij} \in (\mu_j - \alpha * \sigma_j, \mu_j + \alpha * \sigma_j)$ then $e_{ij} = 0$;

else

$a_{ij} \geq (\mu_j + \alpha * \sigma_j)$ then $e_{ij} = 1$;

Here '*' denotes the usual multiplication.

Thus, for different values of α, obtain some of the different refined time dependent fuzzy matrices. The main purpose of introducing the refined time dependent fuzzy matrix is to minimize the time involved in performing the simple arithmetic calculations and operation on the matrix. For this matrix the entries are -1, 0 or 1.

Step:-4: At the fourth stage, using the refined time dependent fuzzy matrices, combine these matrices by varying $\alpha \in [0,1]$ and get the Combined Effective Time Dependent Data matrix (CETD) which gives the cumulative effect of all these entries.

Step:-5: In the final stage, obtain the row sum of the combined effect time dependent data matrix and the conclusions are derived based on the row sums. All these are represented by graphs and graphs play a vital role in exhibiting the data by the simplest means that can be even understood by a layman.

4. CASE STUDY

Overall Patients Culture Report:

Table 4.1 Urine Aerobic Specimen Type

S. No	No Of Patients	Significance Of The Bacteria	Isolation Of Bacteria	No Of Bacteria Present
1	12	Significant Bacteria	Heavy growth of E-Coli	>1,00,000 colonics /ml
2	7	Probably Significant Bacteria	Moderate growth of E-Coli	50,000 Colonics /ml
3	11	Probably Significant Bacteria	Scanty Growth of E-Coli	30,000 Colonics/ml

Table4.2 Dosage of the drug consumed by 30 patients

Dosage in Zone mm / Drugs Name	6mm	15mm	16mm	20mm	21mm	23mm	25mm	26mm
1.Oflaxacin	12			18				
2.Ciprofloxacin	12					18		
3.Ceftriaxone	19					11		
4.Cephotaxime	19					11		
5.Levofloxacin					30			
6.Nettlin		18	12					
7.Gentamycin			30					
8.Amoxyclav	30							
9.Cotrimaxazole				18				12
10.Cefuraxime	30							
11.Norfloxacin	12			18				
12.Imipenum					30			
13.Piperacillin							30	
14.Cepeparazon							30	
15.Amikacin					30			
16.Tobramycin		30						
17.Nalidixic acid	30							
18.Nitrofurantoin				30				
19.Cefixime	30							
20.Ceftazidime				30				

4.1 Estimation of Maximum Amount of the Drug to Kill the Bacteria with their Attributes

Using the linguistic questionnaire, the following seven attributes (X_1, X_2, .X_7) are taken for this study.

X_1 –All age group above 12 years

X_2 – Significant Bacteria

X_3 – Isolation of the bacteria

X_4 – Patients Body weight

X_5 – Temperature

X_6 – Bacterial Conjectives

X_7 - No of Bacteria Present

The above attributes are taken as the columns of the initial raw data matrix. The amount of dosage i.e., zone mm of the antibiotic drug to be given for the patients varies as 14-16, 17-18, 19-20, 21-22, 23-25, 26-27 and are taken as the rows of the matrix. Based on the attributes the Initial Raw data matrix has been obtained. It has been clearly stated from 30 patient's culture reports and doctor's suggestion. The initial Raw Data Matrix of the amount of Antibiotic drug given to kill the bacteria of order 6 X 7 is given below:

Case-(i):

Table 4.1.1 Initial Raw Data matrix

Attributes / Zone in mm	X1	X2	X3	X4	X5	X6	X7
14-16	14	3	2	0	4	0	1
17-18	5	8	7	0	5	0	3
19-20	0	9	8	11	10	0	5
21-22	0	21	17	23	19	22	24
23-25	0	2	5	8	10	16	11
26-27	0	0	0	2	4	6	4

Table 4.1.2 ATD Matrix

Attributes / Zone	X1	X2	X3	X4	X5	X6	X7
14-16	4.67	1	0.67	0	1.33	0	0.333
17-18	2.5	4	3.5	0	2.5	0	1.5
19-20	0	4.5	4	5.5	5	0	2.5
21-22	0	10.5	8.5	11.5	9.5	11	12
23-25	0	0.67	1.67	2.67	3.33	5.33	3.67
26-27	0	0	0	1	2	3	2

Table 4.1.3 ATD Matrix

Mean	1.19	3.44	3.06	3.44	3.94	3.22	3.67
S.D	1.80	3.58	2.82	4.07	2.74	4.00	3.86

Case (ii):

The RTD matrix for α = 0.1 The row sum matrix

$$\begin{bmatrix} 1 & -1 & -1 & -1 & -1 & -1 & -1 \\ 1 & 0 & 1 & -1 & -1 & -1 & -1 \\ -1 & 1 & 1 & 1 & 1 & -1 & -1 \\ -1 & 1 & 1 & 1 & 1 & 1 & 1 \\ -1 & -1 & -1 & 0 & 0 & 1 & 0 \\ -1 & -1 & -1 & -1 & -1 & 0 & -1 \end{bmatrix} \qquad \begin{bmatrix} -5 \\ -2 \\ 1 \\ 5 \\ -2 \\ -6 \end{bmatrix}$$

The RTD matrix for α = 0.15 The row sum matrix

$$\begin{bmatrix} 1 & -1 & -1 & -1 & -1 & -1 & -1 \\ 1 & 1 & 1 & -1 & -1 & -1 & -1 \\ -1 & 1 & 1 & 1 & 1 & -1 & -1 \\ -1 & 1 & 1 & 1 & 1 & 1 & 1 \\ -1 & -1 & -1 & -1 & 0 & 1 & 0 \\ -1 & -1 & -1 & -1 & -1 & 0 & -1 \end{bmatrix} \qquad \begin{bmatrix} -5 \\ -1 \\ 1 \\ 5 \\ -3 \\ -6 \end{bmatrix}$$

The RTD matrix for α = 0.2 The row sum matrix

$$\begin{bmatrix} 1 & -1 & -1 & -1 & -1 & -1 & -1 \\ 1 & 1 & 0 & -1 & -1 & -1 & -1 \\ -1 & 1 & 0 & 1 & 1 & -1 & -1 \\ -1 & 1 & 1 & 1 & 1 & 1 & 1 \\ -1 & -1 & -1 & 0 & 0 & 1 & 0 \\ -1 & -1 & -1 & -1 & -1 & 0 & -1 \end{bmatrix} \qquad \begin{bmatrix} -5 \\ -2 \\ 0 \\ 5 \\ -2 \\ -6 \end{bmatrix}$$

The RTD matrix for α = 0.3 The row sum matrix

$$\begin{bmatrix} 1 & -1 & -1 & -1 & -1 & -1 & -1 \\ 1 & 0 & 0 & -1 & -1 & -1 & -1 \\ -1 & 1 & 1 & 1 & 1 & -1 & -1 \\ -1 & 1 & 1 & 1 & 1 & 1 & 1 \\ -1 & -1 & -1 & 0 & 1 & 1 & 0 \\ -1 & -1 & -1 & -1 & -1 & 0 & -1 \end{bmatrix} \qquad \begin{bmatrix} -5 \\ -3 \\ 1 \\ 5 \\ -1 \\ -6 \end{bmatrix}$$

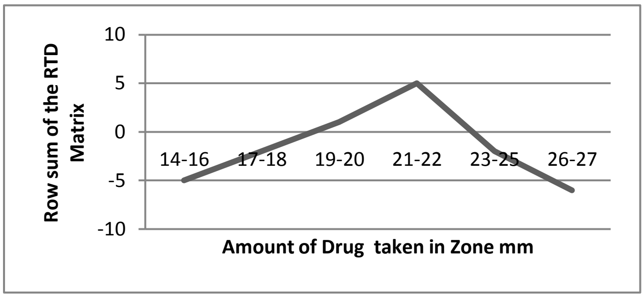

Fig 4.1.1.Graph Depicting the maximum amount of drug for α = 0.1

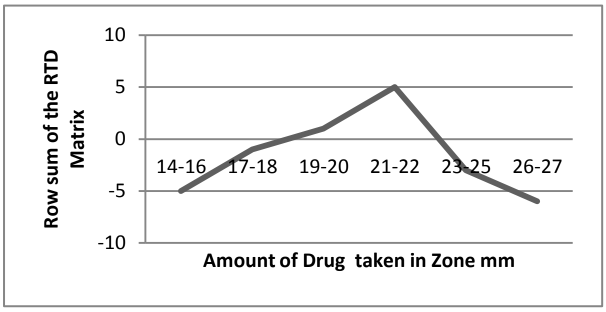

Fig 4.1.2 Graph Depicting the maximum amount of drug for α = 0.15

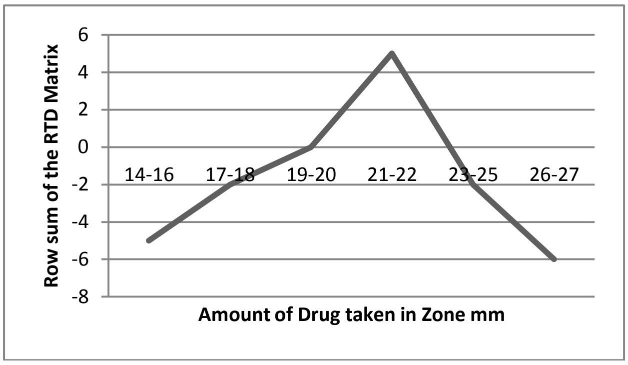

Fig 4.1.3 Graph depicting the maximum amount of drug for α =0.2

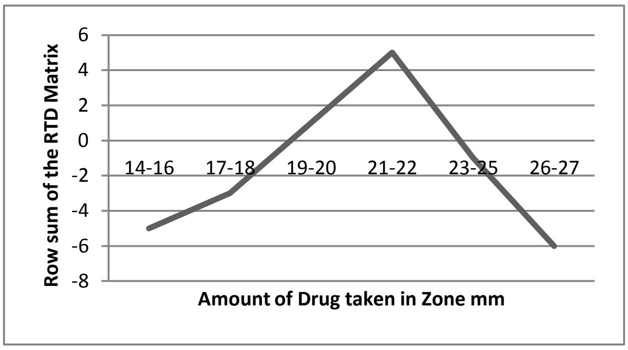

Fig 4.1.4 Graph depicting the maximum amount of drug for α =0.3

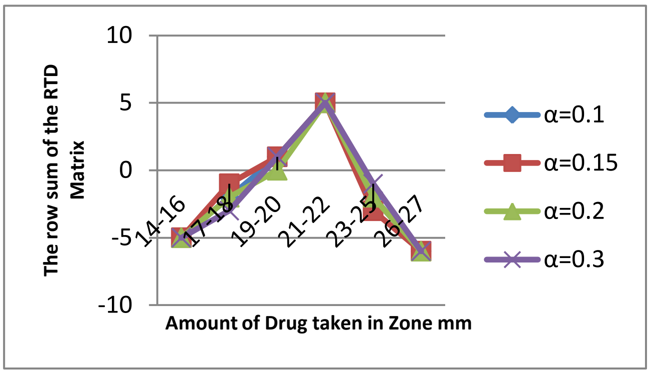

Fig 4.1.5 The Graphical Comparison of the maximum amount of Antibiotic Drug taken by the patient

The CETD matrix for all $\alpha \in [0,1]$ **Row sum matrix**

$$\begin{bmatrix} 4 & -4 & -4 & -4 & -4 & -4 & -4 \\ 4 & 2 & 2 & -4 & -4 & -4 & -4 \\ -4 & 4 & 3 & 4 & 4 & -4 & -4 \\ -4 & 4 & 4 & 4 & 4 & 4 & 4 \\ -4 & -4 & -4 & -1 & 1 & 4 & 0 \\ -4 & -4 & -4 & -4 & -4 & 0 & -4 \end{bmatrix} \qquad \begin{bmatrix} -20 \\ -8 \\ 3 \\ 20 \\ -8 \\ -24 \end{bmatrix}$$

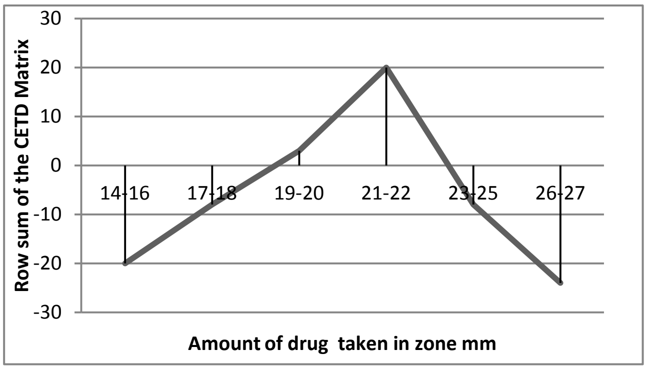

Figure 4.1.6 Graph depicting the maximum amount of drug for CETD matrix

5. CONCLUSION:

In this section, the conclusions are based on the analysis of the above results. From the graph above, it is observed that the maximum amount of the drug consumed by the patient to kill the bacteria as obtained from the combined time dependent data matrix, given by the cumulative effect of all the values of $\alpha \in [0, 1]$ gives the maximum amount of drug that a patient should consume to kill the bacteria. These results coincide well with the doctor's prescription. Thus the maximum amount of the Amikacin drug has been estimated about 21-22 mm for the patient to kill the bacteria. The importance of the dosage takes place a vital role in the field of medicine. Unless otherwise proper guidelines are adhered the proper and correct result will not take place. The purpose of administering the medicine approximately as per the guidelines prescribed by the pharmacologist experts the net result will not be reached. Thus Fuzzy CETD Matrix has been applied to estimate the maximum amount of Antibiotic drug was about to 21-22mm of a given for the patient to kill the bacteria.

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