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Application of Fuzzy Matrix Theory In COVID-19 Pandemic.

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Abstract: *This article explores knowledge discovering in COVID-19 pandemic. It discusses about the people who affected severely in COVID-19 . It identifies of which age group of people's associated with the COVID-19 impactions. We use fuzzy matrix theory to determine the risk factor. In introduction we give the major signs and symptoms of corona virus disease 2019. This affects different people in different ways.*
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I. Introduction

People of all ages can be affected by the new corona virus (COVID-19). Older people and people with pre-existing medical conditions (such as Asthma, Diabetes, Heart disease, Cancer) appear to be more severely ill with the virus. Most common symptoms are (1) fever (2)dry cough (3)tiredness. Less common symptoms are (a) aches and pains (b)sore throat (c)diarrhea (d) conjunctivitis (e) headache (f) loss of taste or smell (g)a rash on skin or coloration of fingers or toes. Lastly serious symptoms are (i)difficulty breathing or shortness of breath (ii)loss of speech or movement. People seek immediate medical attention if they have serious symptoms. It identifies of which age groups of people's associated with the COVID-19 impactions. We use fuzzy matrix theory[2] to get the solution of the problem. For getting practical knowledge we refer the papers [3,4]. The continued spread of corona virus disease 2019(COVID-19)has prompted widespread concern around the world. Let I= [0.1] denotes the unit interval**.** We also have [-1,1] to be also a fuzzy interval, x€[-1,1] if -1 ≤ x ≤ 1**.** Here [0,1] is a infinite set as [0,1] is an uncountable set. Let X be any universal set. The characteristic function maps elements of X to elements of the set to elements of the set [0,1], which is expressed by $\mu_A : X \to [0,1]$. Set A is defined by its characteristics function μ_A.. The notion of fuzzy set was first introduced by .Zadeh [1] in 1965.

II. Preliminaries

In this protion we recall some basic notions relevant to the paper.

Definition 2.1:[1] Let X be an ordinary set. A fuzzy subset λ in X is the collection of ordered pairs $(x, \mu_\lambda(x))$. Here $x \in X$ and a membership function $\mu_\lambda : X \to [0,1]$. The value $\mu_\lambda(x)$ of x denotes the degree to which an element x may be a member of λ . Thus a fuzzy subset λ of X is

denoted by $\lambda = \{(x, \mu_\lambda(x)) : x \in X\}$. $\mu_\lambda(x) = 1$, indicates strictly the containment of the element x in λ (full membership). $\mu_\lambda(x) = 0$ denotes that x does not belong to λ(non-membership).

Definition 2.2: [2] A fuzzy matrix may be a matrix with elements having values in the fuzzy interval. In this article, the unit interval[0,1] and the interval [-1,1] are called fuzzy intervals. A **fuzzy matrix** (FM) A of order m × n is **defined** as A = [< aij,aijμ >]m×n where aijμ is the membership value of the element aij in A.

Definition 2.3: Mean of N terms $x_1, x_2, \ldots, x_N$ is given by ($x_1 + x_2 + \ldots, +x_N$) /N and Standard Deviation of $x_1, x_2, \ldots, x_N$ is given by

$$s = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(x_i - \overline{x})^2}$$

where $\bar{x}$ is the mean.

First the raw data is transformed into a Average Time Dependent Matrix [ATD Matrix].
In the next stage we calculate the Average and Standard Deviation..
Next we convert the ATD matrix into a fuzzy matrix using the Average Technique. Here eij €{-1,0,1}is the entries of the fuzzy matrix.. This fuzzy matrix is Refined Time Data Matrix (RTD Matrix). We calculate the Row sum matrix for RTD matrices.
Then we find the Combined Effect Dependent Data Matrix (CETD-Matrix),. It is the cumulative effect of the all these entries. of RTD matrices.
Finally we obtain the Row Sum of the CETD matrix along the Y-axis and time scale along the X-axis..

III. Main Result

COVID-19 disease in Tripura which is affected many people. . The following are the common symptoms found in the state.

A. Fever - is measured in degree centigrade.
B. Dry cough, C. Tiredness, D. Headache, E, Loss of taste or smell, F. difficulty breathing or shortness of breath .
we choose a scale for measuring the symptoms B to F. 1-10,11-20 , 21-30, 31-40, 41-50,51-60,61-70 are the scales -Very low, Low, Moderate Above moderate, Highly moderate, High, Very high respectively(according to the interview taken from the patients).
A total of 120 patients with COVID-19 were enrolled in this study from hospitals.

Supplemental Information

Supplementary Table 1

Number (%)
All (N=120) ICU (N=20)(16.67%)
Non-ICU
(N=100)(83.33%)

Age group (36- 45), (46-55), (56--65), (66-75).
Gender
Female 44 (44.12%)
Male 76 (63.33%)

The symptoms are classified according to the people age.

Table 2 (Raw data Matrix)

Age	A	B	C	D	E	F
36-45	96.5	13	10	21	12	10
46-55	97	15	20	20	25	15
56-65	100	25	30	35	31	20
66-75	102	25	30	36	30	23

The above table contains of four different Age groups of COVID-19 patients

Table 3

Age	A	B	C	D	E	F
36-45	9.65	1.3	1.0	2.1	1.2	1.0
46-55	9.70	1.5	2.0	2.0	2.5	1.5
56-65	10.00	2.5	3.0	3.5	3.1	2.0
66-75	10.20	2.5	3.0	3.6	3.0	2.3

We divide every row of the raw data matrix by 10 which is the length of the class interval. It is Known as ehe average time dependent data matrix,. In short we write ATD matrix.

Now we calculate the average and standard deviation of the above ATD matrix of each column .
Average of the first column is(9.65+9.7+10+10.2)/4 = 9.89
Standard deviation of the first column is 0.260
Similarly the average and standard deviation of the 2nd,3rd,4th,5th and 6th columns are calculated.

Table -4 (Average)

9.89 1.95 2.25 2.8 2.45 1.7

Table-5 (Standard deviation)

0.26 o.64 o.76 0.87 0.87 0.57

We calculate the average μ_j and the standard deviation σ_j of each column in the ATD Matrix. Then we determine the average of μ_j of each jth column and σ_j the S.D of each jth column. A parameter α from the interval [0,1] is chosen . The Refined Dependent Data Matrix (RTD Matrix)or Fuzzy Matrix e_{ij} is formed using the formula.

If $a_{ij} \leq (\mu_j - \alpha \times \sigma_j)$ then $e_{ij} = -1$.
If $a_{ij} \in (\mu_j - \alpha \times \sigma_j , \mu_j + \alpha \times \sigma_j)$ then $e_{ij} = 0$.
If $a_{ij} \geq (\mu_j + \alpha \times \sigma_j)$ then $e_{ij} = 1$.
Here a_{ij}'s are the entries of the ATD Matrix . The matrix is also termed as the Fuzzy Matrix as the entries are -1,0,1 .

We calculate Fuzzy RTD Matrix for different α- values. It is randomly chosen between interval 0to1.Taking α =0.25 RTD matrix of the COVID-19 impact problem is given below-

RTD Matrix (α =0.25)

-1	-1	- 1	-1	-1	-1
-1	-1	-1	-1	0	-1
1	1	1	0	1	1
1	1	1	0	1	1

Row sum matrix for RTD Matrix (α=0.25)

-6	-5	5	5

RTD (α =0.40) or Fuzzy matrix of the COVID-19 impact problem is given below-

-1	-1	- 1	-1	-1	-1
-1	-1	-1	-1	1	-1
1	1	1	1	1	1
1	1	1	1	1	1

Row sum matrix for RTD Matrix (α=0.40)

-6	-4	6	6

RTD (α =0.75) or Fuzzy matrix of the COVID-19 impact problem is given below-

-1	-1	- 1	-1	1	-1
-1	0	-1	-1	0	0
0	1	1	1	0	0
1	1	1	1	0	1

Row sum matrix for RTD Matrix (α=0.75)

-4	-3	3	5

RTD (α =0.90) or Fuzzy matrix of the COVID-19 impact problem is given below-

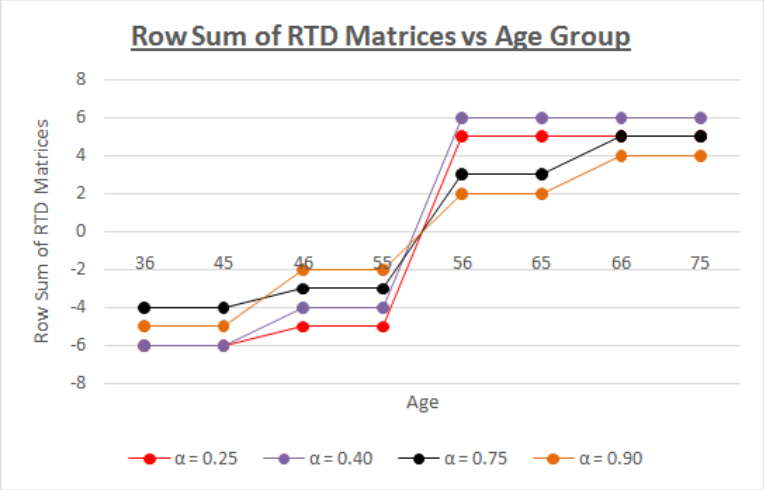
-1	-1	- 1	0	-1	-1
0	-1	0	-1	0	0
0	0	1	1	0	0
1	0	1	1	0	1

Row sum matrix for RTD Matrix (α=0.90)

-5	-2	2	4

We draw the chart using the above matrix values. Then plot the l charts using age group and the fuzzy row matrices of different α-values . It gives the result of which the age groups of people are affected by COVID-19 disease.

Age	α = 0.25	α = 0.40	α = 0.75	α = 0.90
36	-6	-6	-4	-5
45	-6	-6	-4	-5
46	-5	-4	-3	-2
55	-5	-4	-3	-2
56	5	6	3	2
65	5	6	3	2
66	5	6	5	4
75	5	6	5	4

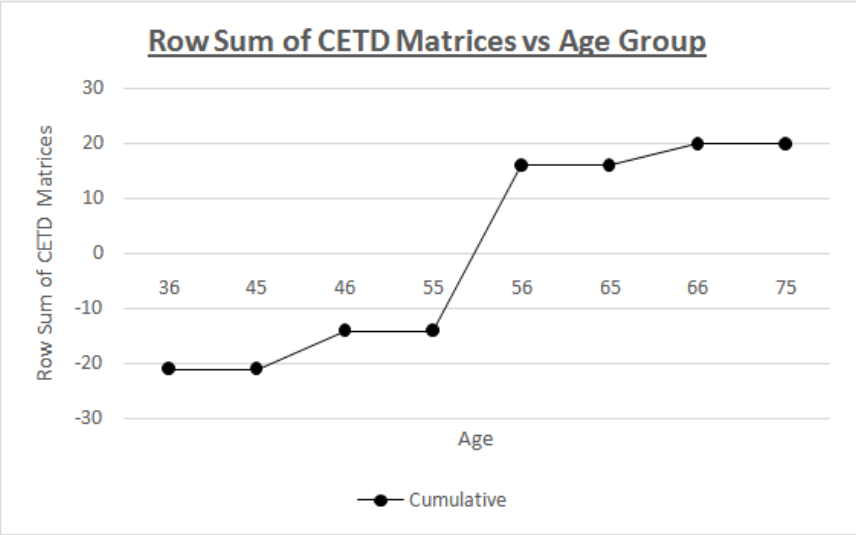


Now the combined effect Time Dependent(CETD)is given below-

-21 -14 16 20

Now we draw the graph using the above matrix values-

Age	Cumulative
36	-21
45	-21
46	-14
55	-14
56	16
65	16
66	20
75	20



The above graphical chart shows the comparison analysis of all fuzzy row Sum matrices with age group. Thus we have the conclusion that the age groups 56-65 and above groups of people impacted by COVID-19 disease of Tripura state, India.

IV. Conclusions

We collect the raw data from the people of Tripura ,India who are testing COVID-19 . It is possible to identify the maximum age group in which they suffer in COVID-19 disease. Our next target to study fuzzy similarity measure of COVID-19 patients.

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