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Fuzzy database and Fuzzy logic Using Triangular and Trapezoidal Fuzzy Number for coronavirus disease - 2019 diagnosis

Ambadas Deshmukh

Vidyalankar Institute of Technology Mumbai

Email: ambadas.deshmukh@vit.edu.in

Ashok S. Mhaske

Dada Patil Mahavidhyalaya, Karjat-Ahmednagar

Email: mhaske.math@gmail.com

K. L. Bondar

N. E. S Science College Nanded

Email: klbondar_75@rediffmail.com

Dr. Arun Jadhav

D S M College Parbhani

Email: arunbjadhao@gmail.com

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Abstract:
The objective of this article is to introduce correct information for coronavirus disease when there is uncertainty in a medical fuzzy database. Global health crisis had a deep impact due to outbreak of the coronavirus disease 2019. COVID-19 is a reminder that well-prepared decision-making is essential for effective health management. Fuzzy database and fuzzy logic methods are best ways to reduce this ambiguity in medical science. Thirteen scientific databases are selected that affect the patient most in coronavirus. The inputs are fuzzy trapezoidal numbers according to the range that they fall in and output is fuzzy triangular number. The main risk issues of coronavirus disease according to the medical Science are Age, Blood Pressure, blood Sugar, Heart Rate, WBC, CRP, Hemoglobin, Platelet-to-lymphocyte ratio, lymphocyte, neutrophil, monocytes, Hepatitis-B and Liver function therefor there are thirteen input variables. The output is the coronavirus disease condition shown in linguistic terms such as very healthy, healthy critical and very critical.
Keyword: Fuzzy, COVID-19, Mat-lab, Python, Triangular, Trapezoidal, linguistic, Inference, Madani

Introduction:

Although the modern world sees significant changes in science and technology, part of the uncertainty cannot be avoided by any branch of science, engineering, medicine, and administration. It is well known that an important factor in the development of the modern concept of uncertainty was the publication of a seminar paper by Loft A. Zadeh in year 1965. The degree of membership lies between the interval [0,1]. The crisp set defined in such a way

that we can classify it into two groups such as members and non-members. (Khehra, 2021) introduced Fuzzy Logic And Hybrid Based Approaches For The Risk Of Heart Disease Detection. (Prakash, 2018) invented new method using Study Of Fuzzy Logic In Medical Data Analytics. (Dr. K. L. Bodar, 2016)Fuzzy Database And Fuzzy Logic For Fetal Growth Condition.

Some Basic Definition:

1. **Fuzzy Set:**

If X is a universe of discourse and x be any particular element of X, then a fuzzy set $\widetilde{A}$ defined on X may be written as a collection of ordered pairs $\widetilde{A} = \{(x,\mu_{\widetilde{A}}(x)) : x \in X\}$. Where each pair $(x,\mu_{\widetilde{A}}(x))$ is called a singleton and $\mu_{\widetilde{A}}(x)$ is membership function which maps X to [0,1]

2. **Fuzzy Number:**

A Fuzzy set $\widetilde{A}$ is a Fuzzy set on the real line R must be satisfy the following conditions

a. There exist at least one $x_0 \in R$ such that $\mu_{\widetilde{A}}(x_0)=1$.

b. $\mu_{\widetilde{A}}(x)$ is piecewise continuous.

c. $\widetilde{A}$ must be normal and convex.

3. **Triangular Fuzzy Number:** A triangular fuzzy number $\widetilde{A}$ or simply triangular number represented with three points as follows $\widetilde{A} = (a_1, a_2, a_3)$ hold the following conditions.

a. a_1 to a_2 membership function is increasing function

b. a_2 to a_3 membership function is decreasing function.

c. $a_1 \leq a_2 \leq a_3$

Its membership function is defined as follows

$$\mu_{\widetilde{A}}(x)=\begin{cases}\frac{x-a_1}{a_2-a_1} & a_1 \leq x < a_2 \\ 1 & x = a_2 \\ \frac{(a_3-x)}{a_3-a_2} & a_2 < x \leq a_3\end{cases}$$

4. **Trapezoidal Fuzzy Number:** A Trapezoidal fuzzy number $\widetilde{A}$ or simply trapezoidal number represented with four points as follows $\widetilde{A} = (a_1, a_2, a_3, a_4)$ hold the following conditions.

a. a_1 to a_2 membership function is increasing function

b. a_2 to a_3 membership function is 1.

c. a_3 to a_4 membership function is decreasing function.

d. $a_1 \leq a_2 \leq a_3 \leq a_4$

Its membership function is defined as follows

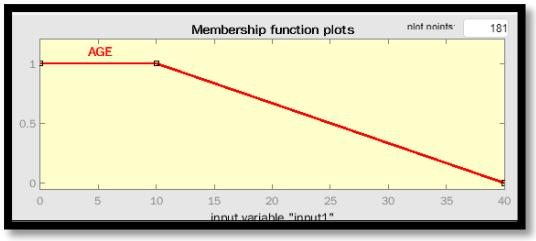
$$\mu_{\widetilde{A}}(x)=\begin{cases}\frac{x-a_1}{a_2-a_1} & ; \text{if } a_1 \leq x < a_2 \\ 1 & ; \text{if } a_2 \leq x \leq a_3 \\ \frac{(a_4-x)}{a_4-a_3} & ; \text{if } a_3 < x \leq a_4\end{cases}$$

Input Variables:

Age:

We estimate that infection in individuals 10 years of age is approximately very low as compare to of adults aged over 10 years and risk factor increases rapidly to 90% of aged over 40 years.

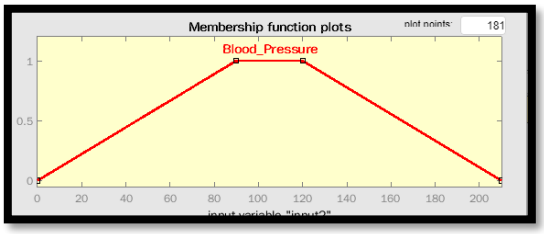
$$\mu(x) = \begin{cases} 1 & x \leq 10 \text{ and} \\ \frac{40-x}{30} & 10 < x < 40 \\ 0 & x \geq 40 \end{cases}$$



Blood Pressure:

There is a possibility that having high or low blood pressure might put patient at greater risk for severe illness and death with COVID-19.

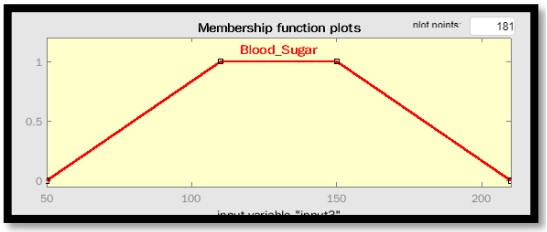
$$\mu(x) = \begin{cases} \frac{x-0}{90} & 0 \leq x \leq 90 \\ 1 & 90 < x \leq 120 \\ \frac{210-x}{90} & 120 < x \leq 210 \end{cases}$$



Diabetes (blood Sugar):

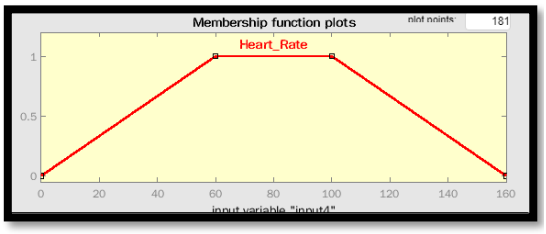
High and low blood sugar level and low weakens the immune system and makes it less able to fight with the virus.

$$\mu(x) = \begin{cases} \frac{x-50}{60} & 50 \leq x \leq 110 \\ 1 & 110 < x \leq 150 \\ \frac{210-x}{60} & 150 < x \leq 210 \end{cases}$$



Heart Rate (bpm): High or low heart rate to response to fever or inflammation.

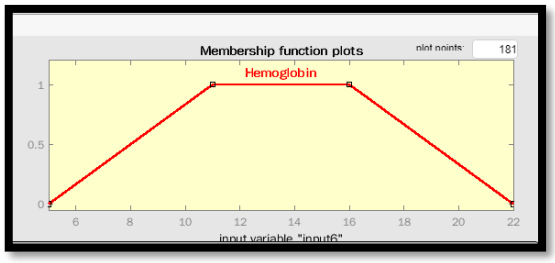
$$\mu(x) = \begin{cases} \frac{x-60}{60} & 0 \leq x \leq 60 \\ 1 & \text{if } 60 < x \leq 100 \\ \frac{160-x}{60} & 100 < x \leq 160 \end{cases}$$



Hemoglobin:

Patients with anemia will have low or high hemoglobin levels and anemia seems to be associated with an enhanced risk of severe COVID-19 infection.

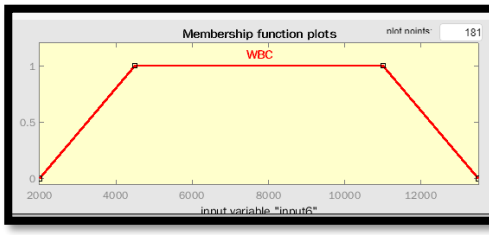
$$\mu(x) = \begin{cases} \frac{x-5}{6} & 5 \leq x \leq 11 \\ 1 & 11 < x \leq 16 \\ \frac{21-x}{6} & 16 < x \leq 22 \end{cases}$$



WBC (White Blood Cell):

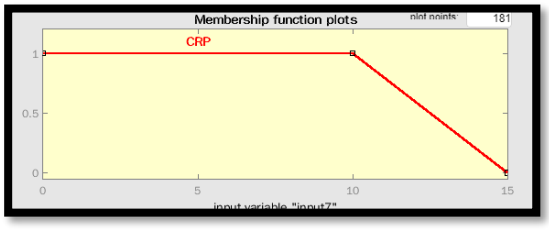
More severe illness and death in people with COVID-19 who had a high WBC count. A number of other studies have found that lower WBC counts6 or elevated WBC counts with decreased levels of lymphocytes

$$\mu(x) = \begin{cases} \frac{x-2000}{2500} & 2000 \leq x \leq 4500 \\ 1 & 4500 < x \leq 11000 \\ \frac{11000-x}{2500} & 11000 < x \leq 13500 \end{cases}$$



CRP(C-reactive protein): CRP level is used for early diagnosis of pneumonia.

$$\mu(x) = \begin{cases} 1 & x \leq 10 \text{ and} \\ \frac{15-x}{5} & 10 < x < 15 \\ 0 & x \geq 15 \end{cases}$$

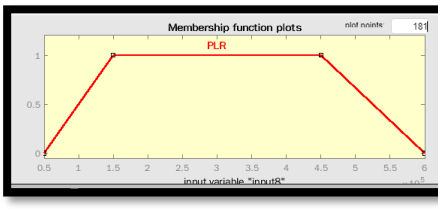


PLR PLR, LYM, NEU, MON:

PLR PLR, LYM, NEU, MON of severe patients were significantly higher than those of non-severe patients in coronavirus disease

$$\mu(x) = \begin{cases} \frac{x-50000}{150000} & 50000 \leq x \leq 150000 \\ 1 & 150000 < x \leq 450000 \\ \frac{600000-x}{150000} & 450000 < x \leq 600000 \end{cases}$$

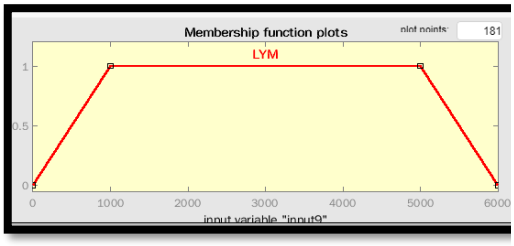
=



LYM (lymphocyte):

$$\mu(x) = \begin{cases} \frac{x-0}{1000} & 0 \leq x \leq 1000 \\ 1 & 1000 < x \leq 5000 \\ \frac{6000-x}{1000} & 5000 < x \leq 6000 \end{cases}$$

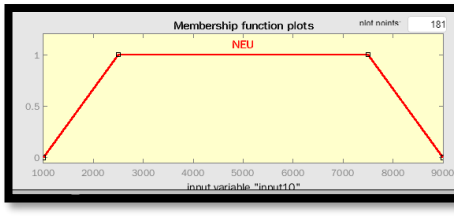
=



NEU (neutrophil):

$$\mu(x) = \begin{cases} \frac{x-1000}{1500} & 1000 \leq x \leq 2500 \\ 1 & 2500 < x \leq 7500 \\ \frac{9000-x}{1500} & 7500 < x \leq 9000 \end{cases}$$

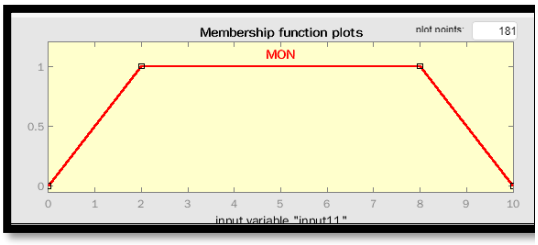
=



MON (monocyte):

$$\mu(x) = \begin{cases} \frac{x-0}{2} & 0 \leq x \leq 2 \\ 1 & 2 < x \leq 8 \\ \frac{10-x}{2} & 8 < x \leq 10 \end{cases}$$

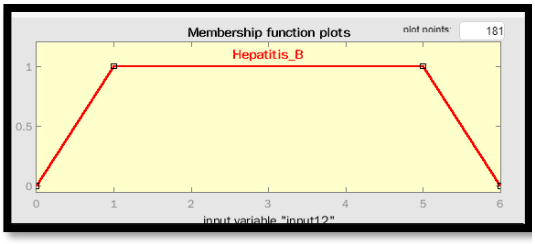
=



Hepatitis B: people having Hepatitis B are increased risk of severe illness if they get COVID-19 infection

$$\mu(x) = \begin{cases} \frac{x-0}{1} & 0 \leq x \leq 1 \\ 1 & 1 < x \leq 5 \\ \frac{6-x}{1} & 5 < x \leq 6 \end{cases}$$

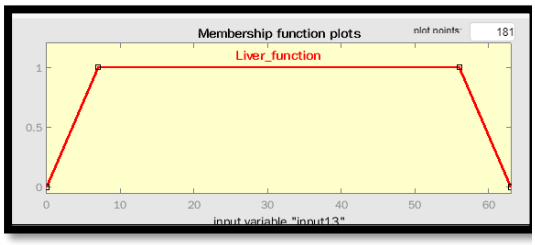
=



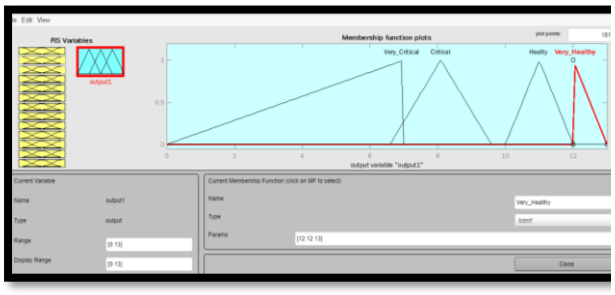
Liver function: people with liver disease, might be at higher risk for severe illness from COVID-19

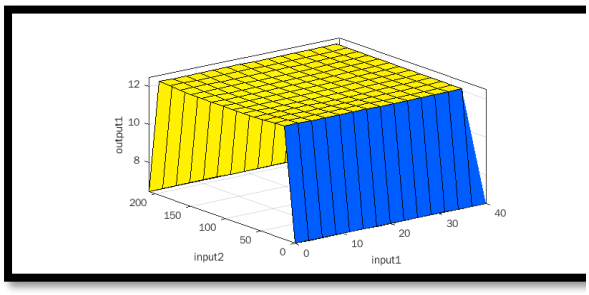
$$\mu(x) = \begin{cases} \frac{x-0}{7} & 0 \leq x \leq 7 \\ 1 & 7 < x \leq 56 \\ \frac{63-x}{7} & 56 < x \leq 63 \end{cases}$$

=

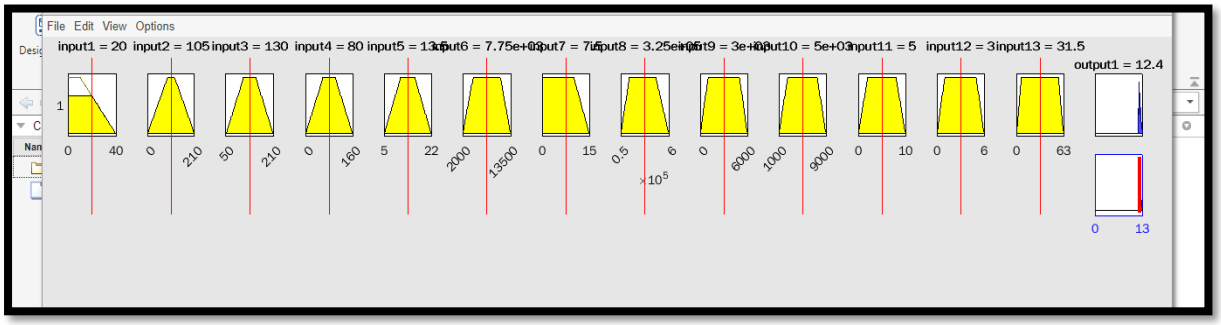


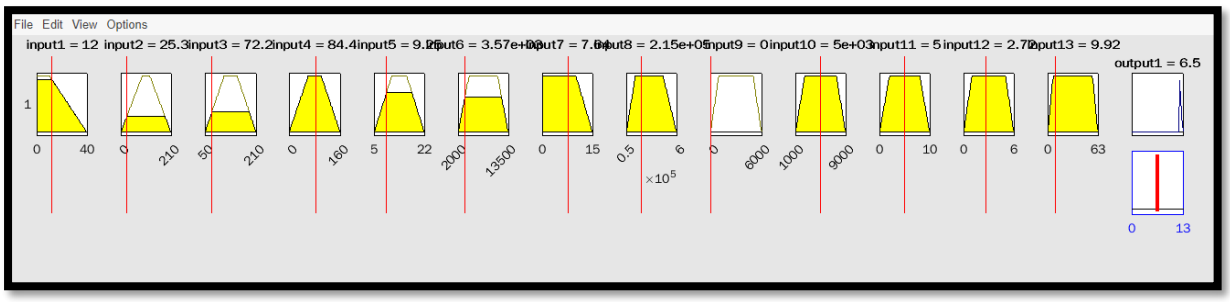
Output: The output is the coronavirus disease condition shown in linguistic terms such as very healthy, healthy critical and very critical.





Output Obtained by Fuzzy Inference System Madani:





Python Program:

```
age=int(input("Enter Your Age value="))
```

```
if(age<=10):
    out1=1
elif(10< age and age<=40):
    out1=(40-age)/30
elif(age>40):
    out1=0
print(out1)
bp=int(input("Enter Your Blood Pressure value="))
if(0<=bp and bp<=90):
    out2=(bp-0)/90
elif(90< bp and bp<=120):
    out2=1
elif(120<bp and bp<=210):
    out2=(210-bp)/90
print(out2)
bs=int(input("Enter Your Blood Sugar value="))
if(50<=bs and bs<=110):
    out3=(bs-50)/60
elif(110< bs and bs<=150):
    out3=1
elif(150<bs and bs<=210):
    out3=(210-bs)/60
print(out3)
hr=int(input("Enter Your Heart Rate (bpm) value="))
if(0<=hr and hr<=60):
    out4=(hr-0)/60
elif(60< hr and hr<=100):
    out4=1
```

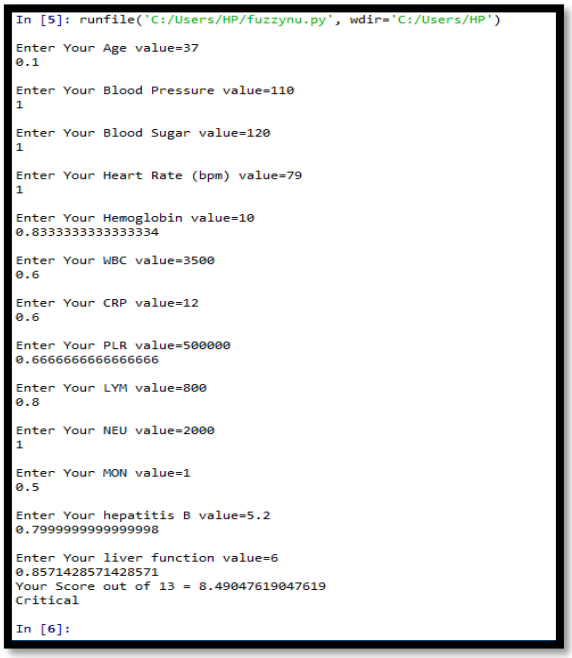
```
elif(100<hr and hr<=160):
    out4=(160-hr)/60
print(out4)
hb=int(input("Enter Your Hemoglobin value="))
if(5<=hb and hb<=11):
    out5=(hb-5)/6
elif(11< hb and hb<=16):
    out5=1
elif(16<hb and hb<=22):
    out5=(22-hb)/6
print(out5)
WBC=int(input("Enter Your WBC value="))
if(2000<=WBC and WBC<=4500):
    out6=(WBC-2000)/2500
elif(4500< WBC and WBC<=11000):
    out6=1
elif(11000<WBC and WBC<=13500):
    out6=(13500-WBC)/2500
print(out6)
CRP=int(input("Enter Your CRP value="))
if( CRP<=10):
    out7=1
elif(10< CRP and CRP<=15):
    out7=(15-CRP)/5
elif(15<CRP):
    out7=0
print(out7)
```

```
PLR=int(input("Enter Your PLR value="))
if(50000<=PLR and PLR<=150000):
   out8=(PLR-50000)/150000
elif(150000< PLR and PLR<=450000):
   out8=1
elif(450000<PLR and PLR<=600000):
   out8=(600000-PLR)/150000
print(out8)
LYM=int(input("Enter Your LYM value="))
if(0<=LYM and LYM<=1000):
   out9=(LYM-0)/1000
elif(1000< LYM and LYM<=5000):
   out9=1
elif(5000<LYM and LYM<=6000):
   out9=(6000-LYM)/1000
print(out9)
NEU=int(input("Enter Your NEU value="))
if(0<=NEU and NEU<=1000):
   out10=(NEU-0)/1000
elif(1000< NEU and NEU<=5000):
   out10=1
elif(5000<NEU and NEU<=6000):
   out10=(6000-NEU)/1000
print(out10)
MON=int(input("Enter Your MON value="))
if(0<=MON and MON<=2):
   out11=(MON-0)/2
elif(2< MON and MON<=8):
```

```
    out11=1
elif(8<MON and MON<=10):
    out11=(10-MON)/2
print(out11)
HEPB=int(input("Enter Your hepatitis B value="))
if(0<=HEPB and HEPB<=1):
    out12=(HEPB-0)/1
elif(1< HEPB and HEPB<=5):
    out12=1
elif(5<HEPB and HEPB<=6):
    out12=(6-HEPB)/1
print(out12)
LF=int(input("Enter Your liver function value="))
if(0<=LF and LF<=7):
    out13=(LF-0)/7
elif(7< LF and LF<=56):
    out13=1
elif(56<LF and LF<=63):
    out13=(63-LF)/1
print(out13)
sum=out1+out2+out3+out4+out5+out7+out9+out10+out11+out12+out13
print("Your Score out of 13 =",sum)
if (12<=sum and sum<=13):
    print("Very Healty")
elif(10<=sum and sum<12):
    print("Healthy")
elif(7<=sum and sum<10):
    print("Critical")
```

```
elif( sum<7):
   print("Very Critical")
```

Output Obtained (Python Program):



```
In [5]: runfile('C:/Users/HP/fuzzynu.py', wdir='C:/Users/HP')

Enter Your Age value=37
0.1

Enter Your Blood Pressure value=110
1

Enter Your Blood Sugar value=120
1

Enter Your Heart Rate (bpm) value=79
1

Enter Your Hemoglobin value=10
0.8333333333333334

Enter Your WBC value=3500
0.6

Enter Your CRP value=12
0.6

Enter Your PLR value=500000
0.6666666666666666

Enter Your LYM value=800
0.8

Enter Your NEU value=2000
1

Enter Your MON value=1
0.5

Enter Your hepatitis B value=5.2
0.7999999999999998

Enter Your liver function value=6
0.8571428571428571
Your Score out of 13 = 8.49047619047619
Critical

In [6]:
```

Conclusion:

In this chapter we discussed a new method based on the fuzzy theory has been developed to solve the problem of fetal coronavirus disease under the fuzzy environment. In our proposed fuzzy database system we use the fuzzy inference rules using mat-lab and python programming to build fuzzy rules. The advantage of our developed system is that we can use the available data existing in the current database systems for decision making. In future, we want to extend our work doing more research by using fuzzy database for other diseases like cancer, diabetes and Brain diseases etc.

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