



# A Neutrosophic Cognitive Map Based Approach to Explore the Health Deterioration Factors

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**Abstract:** Neutrosophy has gained an exponential fame in recent years among researchers and academicians especially when there is a need to deal with different and difficult situations. Out of several neutrosophy-sets related concepts, the researchers have used neutrosophic cognitive maps for identifying the hidden and indeterminate factors that can influence a particular situation or can significantly affect any problems which involve making decisions. In our study, we have used neutrosophic cognitive maps to explore the factors which can lead to health deterioration. The present method not only illustrates the way neutrosophic cognitive maps can be used but also suggests ways which can help the masses in finding out the health affecting factors and to control it. It is believed that the proposed method can be helpful for analyzing many such a situation and can set a benchmark in using soft computing for healthcare.

**Keywords:** neutrosophy sets, neutrosophic logic, neutrosophic cognitive maps, healthcare

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## 1. Introduction

Neutrosophic logic was devised by Florentine Smarandache [1]. Neutrosophic set is more general and complex concept, can be considered as an extended fuzzy logic wherein indeterminacy factor is also included. This particular feature makes neutrosophy more robust and applicable in various domains of real life. The idea of neutrosophic logic presents a necessary part in solving everyday problems. It is a logic in which each proposition is considered to have the percentage of truth, indeterminacy and falsity in subsets T, I, F respectively where T, I, F are neutrosophic components. In this logic instead of only numbers, we use subsets of T, I and F which are estimated by non-standard subsets. A neutrosophic directed graph representing the causal relationship between concepts like policies, events etc. as nodes and causalities indeterminate as edges are called neutrosophic cognitive maps [2].

In this paper, we used these neutrosophic cognitive maps on the factors which affect health overall. The current generation has seen a rapid increase in health deterioration cases [3]. Due to this, health in general, has been affected drastically. The health of people is influenced by various factors. The climate also plays a major role in determining whether a person is healthy or not. The factors that have a vital effect on health include our locality, heredity, our resources and literacy, and our relations with friends and family. There are few other factors like accessibility and use of healthcare co-operations which have a relatively lesser effect on health.

Some other factors that are supposed to be indeterminate are physical exercises, inadequate drainage systems [4]. Neutrosophic cognitive maps are used to depict this condition mathematically

as to how these indeterminate factors have an effect on health. A health improvement approach is represented using neutrosophic cognitive maps in this article.

A neutrosophic set has the capacity of being a general framework for interpreting uncertainty in data sets. It contributes to overcoming the limitations of uncertainty and inconsistency that circles environment and affect the judgment of the decision maker [5]. Hence, neutrosophic logic not only handles the misinterpretations of decision-makers but also the environmental factors of uncertainty circumstances [6].

We can also consolidate multiple decision makers' aspects to accomplish the ideal prospects by managing the confliction and biasness between them [7]. Mohamed Abdel-Basset in his research used neutrosophic theory effectively to solve transition complexities of enterprises based on IOT [8].

Section 2 and Section 3 illustrates the background concepts of neutrosophic cognitive maps (NCM) and factors that can influence health of individuals, whereas in Section 4 NCM based approach to identify the various indeterminate factors which can influence human health is discussed which is followed by discussion and conclusion sections respectively.

## 2. Background

Healthcare is defined as efforts made to maintain or cure physical, mental, or emotional well-being especially by trained and authorized specialists. According to WHO, health is not merely the absence of disease, but it is a state of complete fitness. Lately, we have witnessed a massive increase in health deterioration overall [9]. This has led to the worsening of mental and physical health progressively over time. There are many factors which merge to affect the health of people and societies. The conditions and environment determine whether people are healthy or not. In general, factors like our locality, the climate' nature, genetics, revenue, literacy level, and connections with family and friends have significant impacts on one's health, on the other hand the more generally viewed factors like access and health care services usage oftentimes have less of an impact. Factors such as physical exercises, inadequate drainage systems are neglected by researchers as they are assumed to be indeterminate. To explain how this indeterminate affect health, we represent this situation mathematically using Neutrosophic Cognitive Maps (NCM). It illustrates the extent of dependencies of factors affecting health. In our study, we propose a health improvement approach using neutrosophic cognitive maps. In [4] Florentin Smarandache explains a logic in which each proposition is estimated to have the percentage of truth in a subset T, the percentage of indeterminacy in a subset I, and the percentage of falsity in a subset F is called Neutrosophic Logic. This logic is also considered as the generalized form of Intuitionistic fuzzy logic [10]. According to Charles Ashbacher [11] incomplete information on a variable, proposition or event one has  $T + I + F < 1$  in intuitionistic logic. We use NCM's as in [12] describes the efficiency of NCM technique vs Fuzzy Cognitive Maps (FCM) in situation analysis to deal with the unpredictability and indeterminacy.

## 3. Factors affecting health

### 3.1 Air Pollution

Air Pollution is regarded as being instrumental in bringing complications in the health of the individual. It has been clearly observed that there has been a massive increase in mortality rate and hospital admissions that are associated with respiratory diseases which is further related to exposure of human body to harmful air borne particulate matter and ozone [1]. This leads to deteriorating effects on human health which can be both short-term and long-term. It has wide range of effects

which may include minor respiratory irritations, heart disease, lung cancer and other lung diseases etc. [2]. And bad health also causes air pollution in some instances like usage of the ambulance for patient convenience so, both health and air pollution are bi-directional [13].

### 3.2 Family Genetics

The knowledge of our genetic structure and other associated characteristics can help us in many ways. There are numerous diseases which are passed on from one generation to another, so members of the family have a potential risk to develop some diseases which have been in their ancestors as well which is mainly due to the fact that highly penetrant genetic mutations are transmitted through generations. These diseases include cardiovascular diseases, diabetes and several cancers as well [14].

### 3.3 Unhygienic Livelihood

Poor hygiene is the reason for transmission and spread of disease as it becomes home of several bacteria and viruses. It reduces human wellbeing, social and economic development. On the contrary, maintaining good hygiene and sanitation results in good impact on health and help in reducing diseases like diarrhea [15].

In slum areas, generally large population lives with less facilities available like no proper sanitation facilities and limited supply of water and the hygiene is not maintained in those areas which results in severe health problems [16]. The hygienic and sanitary condition of many fish retail markets are very poor that may have an adverse effect on fish retailer's health [17].

### 3.4 Impure Water

Contamination of water can occur anywhere in lakes, rivers, wells to modern water tanks that supplies water to the citizens homes. More than 500,000 deaths recorded every year due to contaminated drinking water.

According to World Health Organization more than one third wealth of Sub Saharan African poor people is spent on waterborne diseases like Diarrhea, Malaria and worm infections. In countries which are not yet developed fully are having problem with contaminated supply of drinking water with bacteria, which results in several diseases [10]. Water quality should be checked on a regular basis so that it will not impact the health of people.

### 3.5 Junk Food

Food without nutrition can be called as junk, most of them are good at taste but bad for the health of an individual as some of them contains beverages like salt, oils and large amount of sugar. It can be fried, burgers soft drinks and some packaged food. They contain high calories due to that the body cannot intake nutritious food with vitamins and minerals.

According to food institutes analytical data, millennials solely spend 15 percent of their budgets on dining out. In contrast to some 40 years back people now spend half of their food budget on eating in restaurants. A couple of years back only 38 percent of food budget were spending on eating outside home.

The increased prevalence of cardiovascular risk and other diseases like obesity and diabetes is a result of changing food habits i.e., consuming junk food [18]. Similarly, due to bad health i.e., contagious disease food will also get affected so the process is vice versa [19].

### *3.6 Smoking and Alcohol Consumption*

Dr Stanley Chia said cigarettes contain four thousand plus syntheses and 400 toxic substances that involve carbon monoxide, tar, DDT, arsenic and formaldehyde. On the other hand, heavy alcohol consumption also leads to numerous critical health diseases. Over drinking can begin instant difficulties like nausea and vomiting, alcohol poisoning, blurred eyesight, impaired judgment and acute intoxication.

Furthermore, the combined consumption of cigarettes and alcohol is hazardous for the brain. Scientists showed neural harm in particular brain areas due to mutual use of tobacco and alcohol. For a man who inhaled more than 25 cigarettes every day had a higher danger of diabetes of 1.94 collated to non-smokers. And the man who absorbed 30.0-49.9 g of alcohol diurnal had a relevant risk for diabetes of 0.61 [20].

### *3.7 Inadequate Drainage System*

According to WHO, significant environmental health step to reduce disease is decreased monsoon water and household wastewater. The unmanaged drainage system of rainwater gives putrid pools that provide replication places for viruses. Environmental hygiene standards are not perfect in developing countries and it is also a global concern which helps in the extent of disease. Outcomes propose that drainage and sewerage might be a vital effect on diarrhea, nutritional status, and for intestinal nematode, health impact was most effective [21].

Risky hygiene methods have big impacts on people's health. 297000 children are dying annually from diarrheal because of bad sanitation, unsafe drinking water, and poor hygiene [22].

### *3.8 Physical Exercise*

Exercise gives strength to our heart and enhances our blood transmission. The extended bloodstream and boosts the levels of oxygen in the human body. It also benefits heart hazards like coronary artery disease, heart attack, and high cholesterol.

Average physical exercise improves the cardiovascular system and also helps in an overcome from a physical disorder such as osteoporosis, renal disease, and diabetes. Now research showed us physical exercise has benefits for psychological health as well. And the most significant effect of exercise is on cognition. It also deals with neurodegenerative diseases like AD etc. and also reduces the risk of depression [23].

Better quality of life is joined with physical activity and exercise [24]. With the help of physical activity, exercise capacity and body fitness are improved which may give many health profits [25-27].

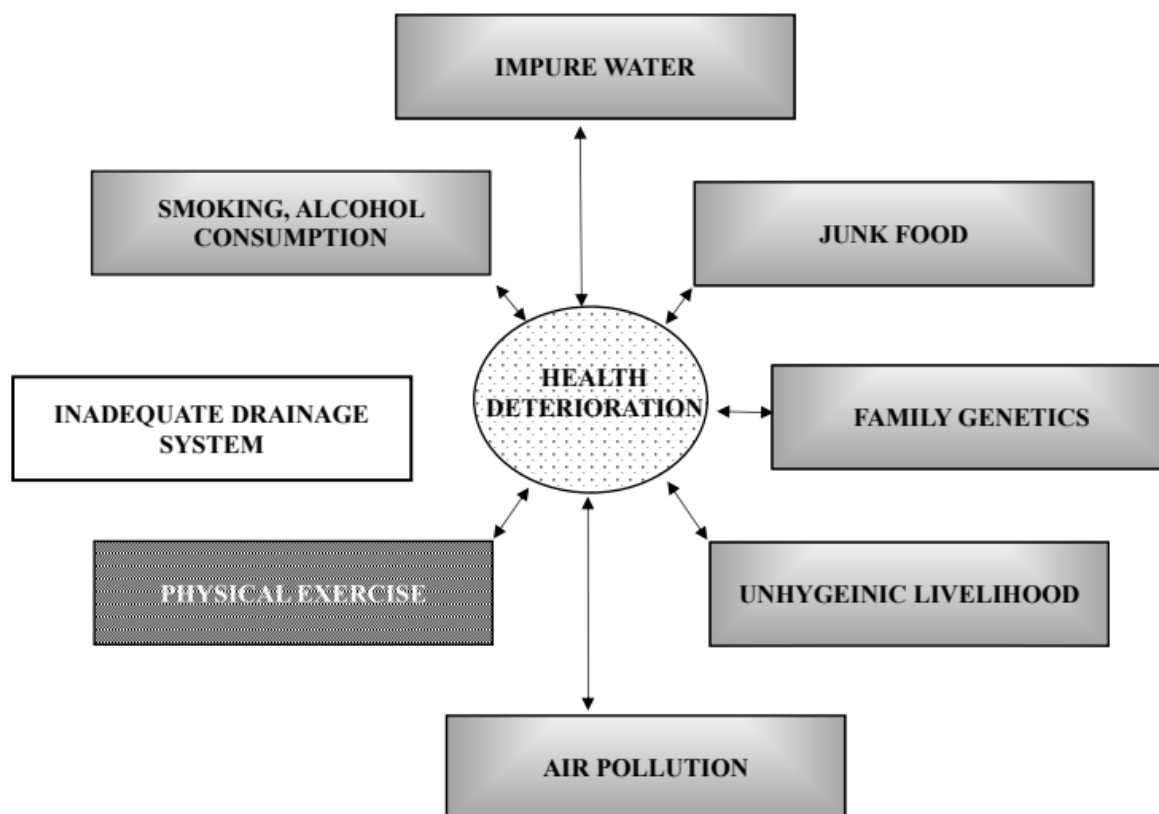


Figure 1: Factors affecting health

#### 4. Neutrosophic Cognitive Map Based Approach to Identify Causes for Health Deterioration

A Neutrosophic Cognitive Map is a graph in which direct edges represents relationship or indeterminates, dotted edges represent indeterminacy and concepts represented by nodes [28, 29]. Assume,  $(C_i)$  &  $(C_j)$  indicate nodes of the neutrosophic graph. The edge directed from  $(C_i)$  to  $(C_j)$  is the connection of both the nodes that indicate the causality of  $(C_i)$  on  $(C_j)$ .

All the edges in the map are assigned with a weight in the set  $\{-1, 0, 1, I\}$ . Maps with the weight of the edge  $\{-1, 0, 1, I\}$  are described as simple Neutrosophic Cognitive Maps [3, 30].

Assume  $C_1, C_2, C_3, \dots, C_n$  are nodes of the graph, so the matrix  $N(E)$  is defined as  $N(E) = (e_{ij})$ , where  $(e_{ij})$  is weight of  $(C_i C_j)$  directed edge, where  $e_{ij} \in \{-1, 0, 1, I\}$  in this neutrosophic cognitive map,  $N(E)$  is the neutrosophic adjacency matrix.

Now here we present a situation through a graphical model as shown in figure (2). We take various factors in India which have a vital role in health deterioration. Indeterminacy plays a critical role in practical living as affirmed by W.B. Vasantha Kandasamy [4, 31]. Hence, in this condition, when data under analysis include indeterminate concepts, we are unable to form mathematical expression by any other method except NCMs because NCM shows the importance of indeterminacy in the situation. An inadequate drainage system leads to unhygienic livelihood as well as affects the purity of water. Here inadequate drainage system is an indeterminate factor. To show the dependency of this indeterminate factor on health deterioration we use Neutrosophic Cognitive Maps. Indeterminacy is represented in figure (1) [32].

Dotted lines depict the indeterminate connection among the nodes.

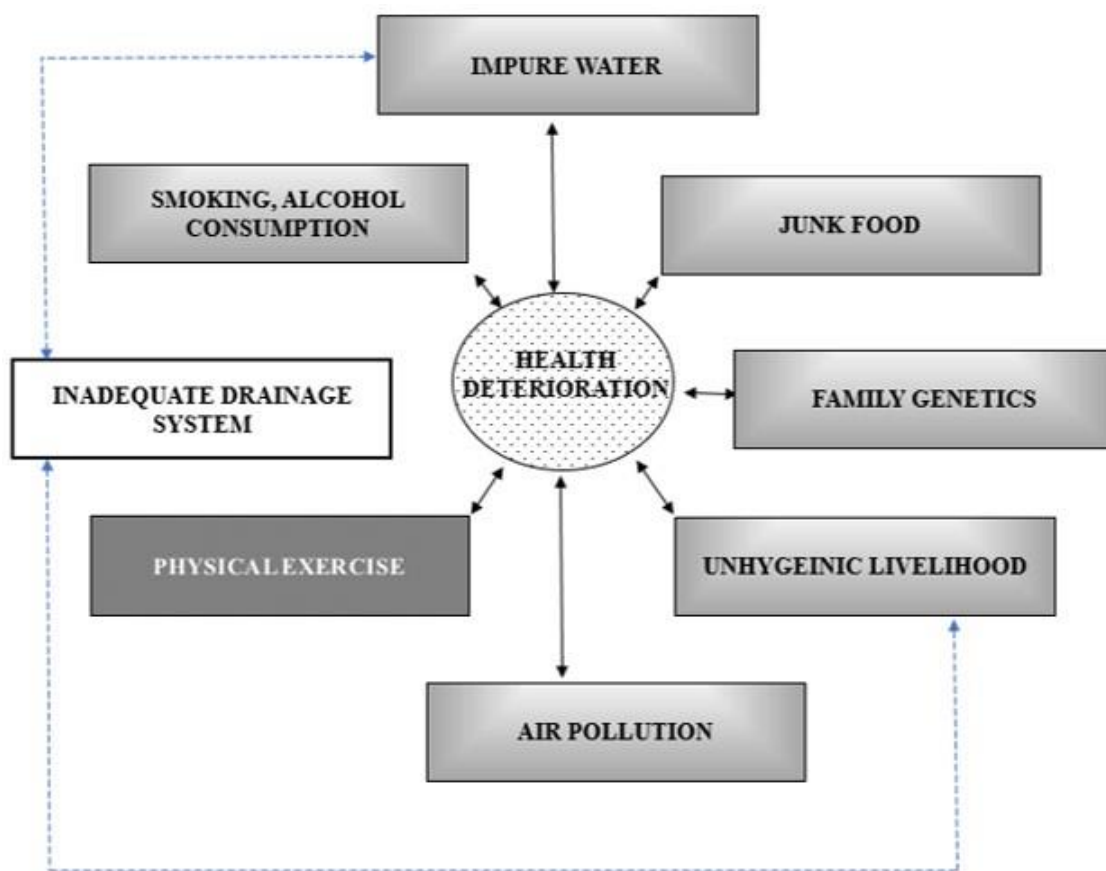


Figure 2: Indeterminate factor affecting health

Let us consider the following nodes:

F1 → Air pollution

F2 → Family Genetics

F3 → Unhygienic Livelihood

F4 → Impure Water

F5 → Junk Food

F6 → Smoking & Alcohol Consumption

F7 → Inadequate Drainage System

F8 → Physical Exercise

F9 → Health Deterioration

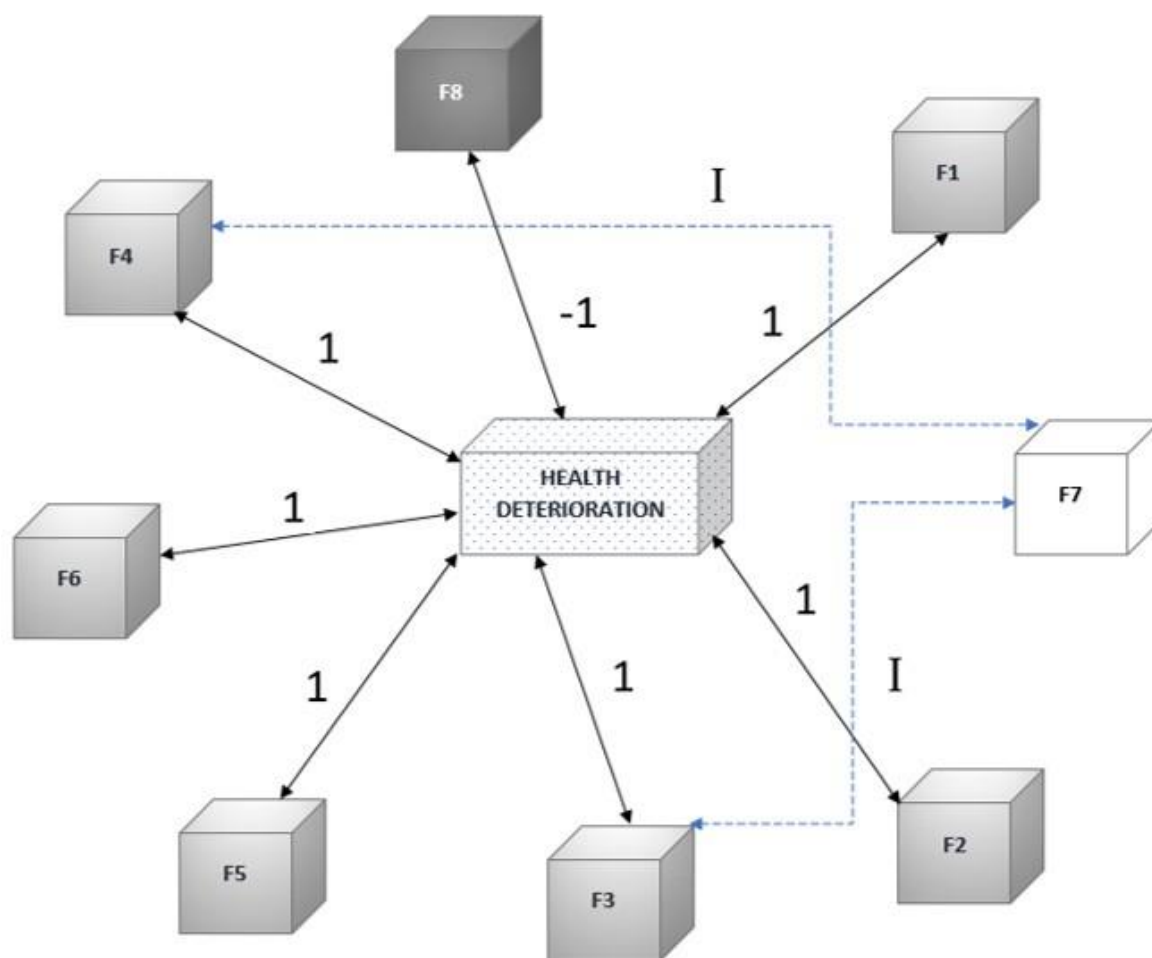


Figure 3: Symbolic representation of NCM model

Neutrosophic Cognitive Maps (NCM) express the presence or absence of relationships among concepts and show indeterminate relations among the concepts as shown above. Further, we describe the Neutrosophic Augmented Matrix  $F(M)$  in Figure 4.

$$\begin{pmatrix}
 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\
 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\
 0 & 0 & 0 & 0 & 0 & 0 & I & 0 & 1 \\
 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\
 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\
 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\
 0 & 0 & I & I & 0 & 0 & 0 & 0 & 0 \\
 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 \\
 1 & 1 & 1 & 1 & 1 & 1 & 1 & -1 & 0
 \end{pmatrix}$$

Figure4: Related connection matrix to the graph in Figure3.

Assume we consider the state vector (The detail of state vector assumption is given in [4]) to be  $Y1$  i.e.:

$$Y1 = (0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 1)$$

Now, we see how it affects  $F(M)$ . After thresholding and updating the following resultant vector is incurred.

$$Y1F(M) = (1\ 1\ 1\ 1\ 1\ 1\ 0\ -1\ 1) \rightarrow (1\ 1\ 1\ 1\ 1\ 1\ 0\ 0\ 1) = Y2$$

$$Y2F(M) = (1\ 1\ 1\ 1\ 1\ 1\ I\ -1\ 6) \rightarrow (1\ 1\ 1\ 1\ 1\ 1\ I\ 0\ 1) = Y3$$

$$Y3F(M) = (1\ 1\ 1+I\ 1+I\ 1\ 1\ I\ -1\ 6) \rightarrow (1\ 1\ 1\ 1\ 1\ 1\ I\ 0\ 1) = Y3$$

The symbol  $\rightarrow$  signifies the thresholder and updated resultant vector. This depicts that health gets affected by air pollution, family genetics, unhygienic livelihood, impure water, junk food, smoking & alcohol consumption and the factor inadequate drainage system is indeterminate to health deterioration.

## 5. Discussion

In this paper, we have stated factors which affect health like air pollution, impure water, etc. To analyze the dependency of each factor including indeterminate factors like inadequate drainage system we have formulated a mathematical expression.

$$(1\ 1\ 1\ 1\ 1\ 1\ I\ 0\ 1) = Y3$$

If we examined these dependencies without mathematical expression, then we would have to set up huge labs and perform extensive researches. To overcome this, we use a soft computing approach which makes this interpretation very simple.

In our problem, we can employ two approaches of soft computing: Fuzzy Cognitive Maps (FCM) and Neutrosophic Cognitive Maps (NCM). We haven't used FCM here as in [12] because it has not been successful to associate the indeterminate relations among concepts. NCM is used as it not only represents presence or absence of relationships within concepts but also represents indeterminate relations among the concepts [33, 34]. The research in the literature has stated mostly 5-7 factors, whereas we have identified one more factor, in other words approximately 14% coverage has been increased.

## 6. Conclusion

In this paper, we have tried to come up with a soft computing-based technique to better investigate the factors which could influence the health of a person significantly but has not been addressed adequately in the literature. Some of the factors which affect health are indeterminate but they are essential for measuring health deterioration. We have used a powerful tool, neutrosophic logic that applies over those indeterminate factors which are important but are not affecting health deterioration directly. We have got an increased 14% coverage of the indeterminate factors which can help in making people aware of these so that the masses can get benefits.



In the future, neutrosophy can be applied in various fields namely, expert systems, soft computing techniques in e-commerce and e-learning, reliability theory, image segmentation, robotics etc. which will enhance them eventually. It can also be used widely in situational analysis. Neutrosophy paved its way into research because the universe is filled with indeterminacy. This logic can ease researchers and developers in building algorithms involved in decision making wherein indeterminate factors can be taken into consideration [35, 36].

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