



Neutrosophic Cognitive Maps for the Analysis of the Factors in the proper Diagnosis of Conversion Disorder

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Abstract. Somatoform disorders encompass a variety of entities and symptoms, including Conversion Disorder. This type of disorder is characterized by a variety of symptoms, which often confuse specialists when establishing a diagnosis, due to its similarity to functional neurological disorders. The variety of manifestations is often interpreted as epileptic seizures. To promote adequate management of these patients, the present investigation carried out a bibliographic review on the subject, in reference sites such as PubMed, Scielo, Elsevier, and Research Gate. In addition, neutrosophic methods that favor decision-making were used, such as the Neutrosophic Cognitive Maps, to determine the factors that will facilitate decision-making to establish an accurate diagnosis. What will contribute to an economy in medical resources such as tests and others. From the results obtained, the need for the integration of a multidisciplinary team in the care of these patients is highlighted, involving the figure of the psychologist and psychiatrist from the beginning of the evaluation.

Keywords: conversion disorder, somatoform disorders, epileptic seizures, neutrosophic cognitive map.

1 Introduction

Functional neurological disorders are a common clinical problem in neurology and psychiatry services. In the new diagnostic categories, emphasis is placed on the positive characteristics necessary for the diagnosis of this disorder [1]. The Diagnostic and Statistical Manual (DSM-5) has included a new classification called "somatic symptom disorders and related disorders" that replaces the old somatoform disorders that included somatization disorder, pain disorder, hypochondriasis, and conversion disorder. People with this type of disorder seek help in primary care and other medical settings and, less frequently, in the field of mental health, generating a high consumption of resources for the public system.

The origin of these disorders is not well defined, although both biological and psychological causes have been found, taking into account the patient's biographical experience and personality traits [2]. In the diagnosis, it is necessary to rule out the presence of an underlying medical pathology through a thorough examination and the performance of complementary tests [3]. The treatment combines strategies for patient management with specific therapeutic interventions (pharmacological and psychotherapeutic measures) [4].

Specialists are prone to confuse this diagnosis with that of organic epileptic disorders. Thus, it can be stated that there is indeterminacy involved; therefore, it is necessary to apply neutrosophic methods that provide better support for decision-making. Based on this, the objective of this research is to analyze the factors that will facilitate the proper diagnosis of Conversion Disorder.

2 Methodology

2.2 Neutrosophic Cognitive Maps

Starting from the previous elements, in this particular work, the use of Neutrosophic Cognitive Maps (NCMs) is proposed considering the advantages that this technique offers compared to other soft-computing techniques, in terms of interpretability, scalability, aggregation of knowledge, dynamism, and its ability to represent feedback and indeterminacy relationships [5]. NCMs are an integration of the Fuzzy Cognitive Maps (FCMs) introduced by Kosko in 1986 and the Neutrosophic Sets (NSs) introduced by Smarandache in 1995.

This technique overcomes the inability of traditional FCMs to represent indeterminacy. The inclusion of indeterminacy establishes that neutrality and ignorance are also forms of uncertainty. NCMs constitute a technique that has received increasing attention due to their possibilities for representing causality. The following is a set of definitions necessary for working with NCMs [6].

Definition 1. Let $N = \{(T, I, F): T, I, F \in [0,1]\}$ be a neutrosophic set of evaluation v : is a mapping of a group of propositional formulas into N , i.e., each sentence p is associated with a value in N , meaning that P is $T\%$ true,

I% indeterminate, and F% false, $v(p) = (T, I, F)$. Hence, neutrosophic logic is a generalization of fuzzy logic, based on the concept of neutrosophy according to [7].

Definition 2. (See [8]) Let K be the ring of real numbers. The ring generated by $K \cup I$ is called a neutrosophic ring if it involves the indeterminacy factor in it, where I satisfies $I^2 = I, I + I = 2I$ and in general, $I + I + \dots + I = nI$, if $k \in$, then $k \cdot I = kI, 0I = 0$. The neutrosophic ring is denoted by $K(I)$, which is generated by $K \cup I$, i. e., $K(I) = \langle K \cup I \rangle$, where $\langle K \cup I \rangle$ denotes the ring generated by K and I .

Definition 3. A neutrosophic matrix is a matrix $A = [c]_{ij} = 1, 2, \dots, m$ and $j = 1, 2, \dots, n; m, n \geq 1$, such that each $a_{ij} \in K(I)$, where $K(I)$ is a neutrosophic ring.

The elements of the matrix can have the form $a + bI$, where “a” and “b” are real numbers, whereas I is the indeterminacy factor. The usual operations of neutrosophic matrices can be extended from the classical matrix operations.

$$\text{For example, } \begin{pmatrix} -1 & I & 5I \\ I & 4 & 7 \end{pmatrix} \begin{pmatrix} I & 9I & 6 \\ 0 & I & 0 \\ -4 & 7 & 5 \end{pmatrix} = \begin{pmatrix} -21I & 27I & -6 + 25I \\ -28 + I & 49 + 13I & 35 + 6I \end{pmatrix}$$

Additionally, a neutrosophic graph is a graph that has at least one indeterminate edge or one indeterminate node. The neutrosophic adjacency matrix is an extension of the adjacency matrix in classical graph theory. $a_{ij} = 0$ means nodes i and j are not connected, $a_{ij} = 1$ means that these nodes are connected and $a_{ij} = I$, which means the connection is indeterminate (unknown whether it is or not) [8]. Fuzzy set theory does not use such notions. On the other hand, if the indetermination is introduced in a cognitive map, as it is referred to, then this cognitive map is called a neutrosophic cognitive map, which is especially useful in the representation of causal knowledge. It is formally described in Definition 4.

Definition 4. A Neutrosophic Cognitive Map (NCM) is a neutrosophic directed graph with concepts like policies, and events, among others, as nodes and causalities or indeterminates as edges. It represents the causal relationship between concepts. The measures described below are used in the proposed model, they are based on the absolute values of the adjacency matrix [9]:

Outdegree (v_i) is the sum of the row elements in the neutrosophic adjacency matrix. It reflects the strength of outgoing relationships (c_{ij}) of the variable:

$$od(v_i) = \sum_{j=1}^n c_{ij} \quad (1)$$

Indegree (v_i) is the sum of the column elements. It reflects the strength of relations relationships (c_{ij}) outgoing from the variable.

$$id(v_i) = \sum_{j=1}^n c_{ji} \quad (2)$$

Total centrality (total degree (v_i)), is the sum of the indegree and the outdegree of the variable.

$$td(v_i) = od(v_i) + id(v_i) \quad (3)$$

The variables are classified according to the following criteria:

- Transmitting variables are those with $od(v_j) > 0$ e $id(v_i) = 0$
- The receiving variables are those with $od(v_j) = 0$ e $id(v_i) > 0$
- Ordinary variables satisfy both $od(v_j) \neq 0$ e $id(v_i) \neq 0$

The static analysis is applied using the adjacency matrix, taking into consideration the absolute value of the weights. Static analysis in Neutrosophic Cognitive Maps (NCMs), initially contains the neutrosophic number of the form $(a + bI)$, where $I =$ indetermination.

It requires a process of deneutrosophication as proposed in [8], where $I \in [0, 1]$ and it is replaced by their values maximum and minimum. Finally, we work with the average of the extreme values, which is useful to obtain a single value. This value contributes to the identification of the characteristics to be attended, according to the factors obtained, for our case study [10-12-35].

$$\lambda([a_1, a_2]) = \frac{a_1 + a_2}{2} \quad (4)$$

Then,

$$A > B \Leftrightarrow \frac{a_1 + a_2}{2} > \frac{b_1 + b_2}{2} \quad (5)$$

3 Results

3.1 Results of the bibliographic review

A bibliographic search was made on sites such as PubMed, Scielo, Elsevier, and Research Gate, where it was found that there is a little approach to Conversion Disorders, due to their difficult diagnosis. It was possible to verify the little presence of published papers, regarding this topic set in Ecuador. Considering this, the search spectrum was expanded, resulting in the following: [1-3, 13-31] from which could be known that:

- ✓ Somatoform disorders (SD) and conversion disorders (CD) involve a set of entities, phenomena, and symptoms that nosology has classified and conceptualized multiple times throughout history. These are ubiquitous disorders in medicine since their forms of presentation involve practically all systems, but they contain a common denominator, that is, the relevance of somatic symptoms linked to psychic discomfort, apparent or not. [32], [35], [36], [38]
- ✓ The Diagnostic and Statistical Manual of Mental Disorders in its current edition (DSM-5) places them in the category of somatic symptom disorders and related disorders, grouping them into the following entities, each with clinical specifiers: somatic symptom disorder, anxiety disorder due to disease, conversion disorder or functional neurological symptom disorder, factitious disorder (Münchhausen syndrome, applied to oneself or a third party).
- ✓ This type of disorder (previously known as hysteria) is defined as the real loss or alteration of motor or sensory functioning that leads to suspicion of the existence of an underlying somatic disorder or disease. Generally, there is usually a temporal relationship between the stressful event and the onset of conversion symptoms; therefore, a thorough medical examination is essential to reach the diagnosis. [33], [34], [37]
- ✓ The somatoform is closely related to the conversion; in both the phenomenon is unconscious, however, CDs are alterations associated with a more specific dysfunction of the nervous system.
- ✓ CDs are often difficult to diagnose and treat, even by mental health professionals. They are prevalent conditions that are often misdiagnosed as somatic diseases and that require a multidisciplinary approach in all its phases.
- ✓ They constitute entities that must be known by all medical specialties because as was pointed out, the presentation is polymorphous.
- ✓ It is often not easy to diagnose conversion disorder, even more so when the presence of a neurological disorder does not exclude its diagnosis.
- ✓ There may be cases in which a somatic disease is previously present; in this situation, the symptoms and signs do not correlate, and the severity, duration, and dysfunction produced by the signs and symptoms is proportional to that previous disease.
- ✓ Basically, 4 groups of conversion disorders are distinguished:
 - a) **With motor symptoms or deficits.** In this case, among the main clinical manifestations are alterations in psychomotor coordination and balance, paralysis or localized muscle weakness, difficulty swallowing, the sensation of a "lump in the throat", aphonia, and urinary retention. They do not follow the neurological patterns resulting from injury to the peripheral nervous system.
 - b) **With crises or convulsions.** It is clinically characterized by the presence of crises or convulsions, with a voluntary or sensory motor component. Generally, no expected injuries appear (such as tongue biting, paroxysmal activity in the encephalogram, or lack of sphincter control). The crises can last minutes, with an apparent lack of response to stimuli; after the crisis, the patient can remember what has happened.
 - c) **With symptoms or sensory deficits.** In this case, the appearance of the pathology is distant from what is expected by the existing dermatomes and there may be a uniform loss of all sensory modalities. Pain, specific and idiosyncratic pictures related to personal experiences, and pseudohallucinations are frequent. [39]
 - d) **Mixed presentation.** Symptoms from more than one category are identified. Although they are not specific to the disease, there are a series of characteristics and mental disorders that can be associated in some way with the existence of conversion disorders. Among the associated characteristics, histrionic personality traits stand out, the existence of primary benefits (somatic conflict resolution) and/or secondary benefits (sick role), the existence of family patterns, sexual alterations, stress before the onset of symptom and symbolism (the affected organ is not random)
- ✓ The onset of conversion disorder is usually sudden. The clinical course is also characterized by the short duration of most symptoms. Its onset usually occurs in late adolescence and early adulthood (although it can appear at any stage of life); when it begins in mid to late adult life, an underlying neurological or organic disorder is more likely.
- ✓ Within the clinical semiology of conversion disorders, other clinical signs are also indicative: tremors that change in frequency or disappear with distraction maneuvers; fixed and painful dystonia after minimal

trauma; a sensory disorder that reaches exactly to the midline; hypoesthesia of an arm that disappears at the shoulder; to the order to say "yes" when perceiving with eyes closed the touch of cotton, the patient says "no" in the hemi-body with functional hemi-anesthesia; the patient only perceives the vibratory sensitivity in the middle forehead in functional hemi-anesthetics; a totally normal examination in decubitus and astasia-abasia in standing position; a strange gait (dragging a leg, posture with very flexed knees, very notable variations of the disorder throughout the day). [40, 41, 42, 43]

- ✓ Clinical differences based on sex have been described, with falls due to muscle atony being more frequent in women together with higher rates of major depression, while tonic-clonic movements of the extremities are more frequent in men and higher rates of Deficit Disorder. of attention and hyperactivity.
- ✓ For its evaluation in primary care centers, the diagnosis of Somatoform Disorder is developed along a route with 3 simultaneous parts:
 - a) ruling out a general medical condition as the cause of the symptoms.
 - b) identifying psychosocial dysfunction and recognizing and relieving stressors. A biopsychosocial evaluation is therapeutic and is often followed by improvement, even resolution of symptoms.
- ✓ Findings that are highly suggestive of a somatization disorder include a history of multiple somatic complaints, multiple visits to doctors and different specialists, as well as the presence of a family member of chronic and recurrent symptoms and dysfunction in the main areas of life. (family, peers, and school).
- ✓ In the evaluation process, unnecessary or repetitive complementary tests should be avoided as an attempt to demonstrate to the family the psychosomatic origin of the condition. A cost-effective method of determination in an appropriate manner with the appropriate analytical and imaging tests is the basis of the diagnostic plan and always follows the signs or symptoms that suggest organicity.

3.2 Application of the Neurosophic Cognitive Map

According to the bibliography consulted in section 3.1, several factors or diagnostic guidelines were established for the comprehensive approach of patients with somatization disorder in a conversion form, which was used for the elaboration of the map shown in Figure 1.

- 1) Environmental factors
- 2) Intellectual capacity
- 3) Patient Age
- 4) Underlying psychological symptoms
- 5) Personality elements
- 6) Associated genetic predisposition

A group of experts composed of Neurologists, Pediatricians, Psychiatrists, and Psychologists was selected. As an inclusion criterion, it was taken into account that the experts had a professional experience of at least five years, both teaching and assisting. Associated with the Autonomous University of the Andes.

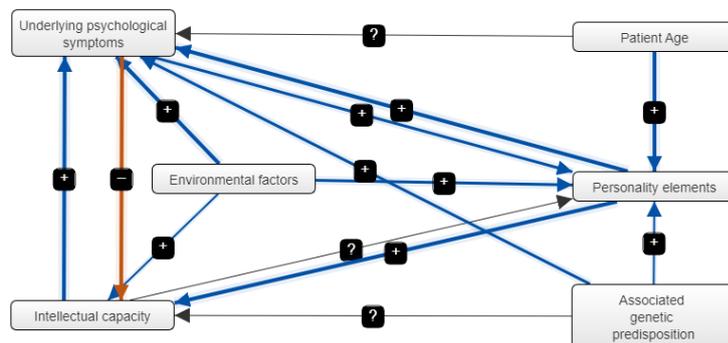


Figure 1: Neurosophic Cognitive Map. Source: own elaboration.

	Environmental Factors	Intellectual Capacity	Patient Age	Underlying psychological symptoms	Personality Elements	Associated Genetic Predisposition
Environmental Factors	0	0.31	0	1	0.73	0
Intellectual Capacity	0	0	0	1	1	0
Patient Age	0	0	0	1	1	0
Underlying Psychological Symptoms	0	-0.12	0	0	0.63	0
Personality	0	0.14	0	1	0	0

Elements						
Associated Genetic Predisposition	0	I	0	0.72	0.36	0

Table 1: Adjacency matrix. Source: own elaboration.

Component	Indegree	Outdegree	Centrality
Associated genetic predisposition	0	1.58	1.58
Personality elements	3.2199999999999998	1.1400000000000001	4.3599999999999999
Underlying psychological symptoms	4.22	0.75	4.97
Patient Age	0	1.5	1.5
Intellectual capacity	1.07	1.5	2.5700000000000003
Environmental factors	0	2.04	2.04

Figure 2: Static Analysis. Source: own elaboration.

4 Discussion

The order of the variables according to their level of centrality is as follows:

1. Underlying psychological symptoms
2. Personality elements
3. Intellectual capacity
4. Environmental factors
5. Associated genetic predisposition
6. Patient Age

Among these six components, 14 connections were established for a map density of 0.46, with approximately 2.3 connections for each component. Of the 14 connections, three of them are indeterminate, three are transmitters and three are ordinary.

- ✓ Of the three transmitter variables: Associated genetic predisposition, Patient Age, and Environmental factors, the latter is the one with the highest level of centrality (2.04). Therefore, it is the variable with the highest level of importance within the neutrosophic cognitive map modeled for this analysis. This variable provides the greatest amount of information that directly affects the patient's behavior. This indicates that, on this variable, specialists should pay special attention to establish a timely diagnosis of the nosological entity. This will make it possible to reduce costs in terms of medical examinations performed unnecessarily. The Personality elements variable takes second place in importance because certain personality patterns predispose to the disease.
- ✓ Of the three connections of indeterminacy, it can be said that the specialists present a contrast of criteria with respect to the nodes Associated genetic predisposition-Intellectual capacity, Intellectual capacity- Personality elements, and Patient Age- Personality elements.

Taking into consideration the previous interrelationships, future prediction scenarios were established for variables of interest for the study.

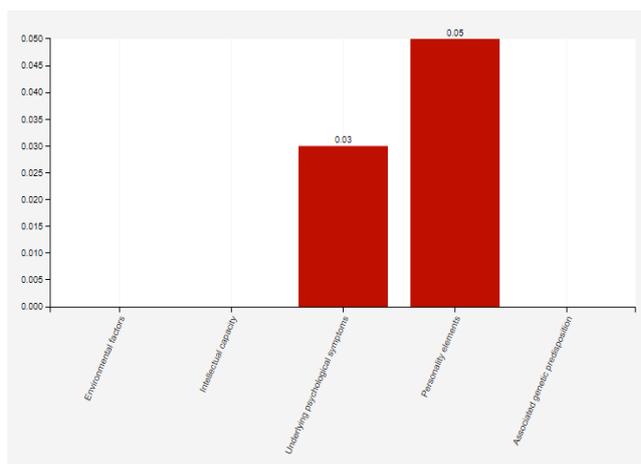


Figure 3: Scenario 1. Source: own elaboration.

If age is increased, then personality elements and underlying psychological symptoms increase in turn. Because the assessment of the situation depends in this case on the level of perception acquired by the patient as he increases in age. In this case, the patient, as he grows, acquires the possibility of establishing judgments and comparisons about reality.

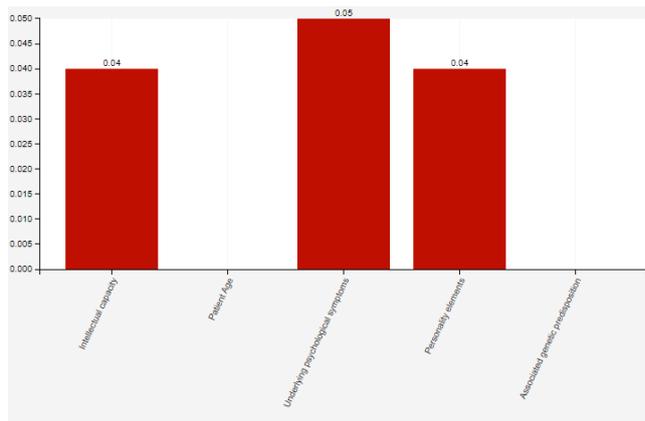


Figure 4: Scenario 2. Source: own elaboration

If environmental factors are modified, either by deterioration or improvement, then the intellectual capacity, the symptoms, and the elements of the personality are exacerbated or mitigated, due to the magnitude of the inter-relationship between these variables. Therefore, an exhaustive exploration of the environment and society where the subject develops must be carried out, in order to enrich the diagnosis.

5 Recommendations

Considering the high costs for the health system implied by the use of diagnostic means for somatoform disorders, including conversion disorders, it is recommended for their comprehensive care, to highlight the importance of a multidisciplinary assessment, since said entity is suspected. Involving the figure of the psychologist and psychiatrist from the beginning in the approach to the patient. In this way, the evaluation will be facilitated more deeply, rapport will be established and proper therapeutic adherence will be facilitated.

Providing specialists with knowledge for adequate evaluation and clinical management will be essential, avoiding, in addition to unnecessary medical evaluations, the iatrogenesis produced by them, which can contribute to a better prognosis for patients.

Conclusion

The factors that will provide an adequate diagnosis of Conversion Disorder were analyzed, it is important to highlight that, in the case of this type of disorder, it is necessary to focus on the predisposing environmental and personality factors, as well as the underlying psychological symptoms.

Multidisciplinary evaluation of this type of patient is necessary, where a team made up of neurologists, pediatricians, psychologists and psychiatrists intervene and evaluate together.

Somatoform disorders make up a heterogeneous group of disorders with a broad symptom spectrum that ranges from transient functional somatic symptoms to serious somatoform disorders themselves.

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Received: August 31, 2022. **Accepted:** October 24, 2022