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Neutrosophic Analysis of Risk Factors in the Etiology of Cerebral Palsy

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Abstract. Cerebral Palsy is the most common form of motor disorder in childhood. The risk factors associated with this disorder are difficult to establish since its etiology is frequently multifactorial. A descriptive study was carried out, with a sample of 152 patients diagnosed with Cerebral Palsy, treated in the period from March 2020 to January 2022. To carry out the investigation, the bibliography taken from sites such as Pubmed, Dialnet, and Scielo, among others, was consulted. The medical records of these patients were also reviewed, in order to establish the risk factors associated with the etiology of this condition. They were subjected to expert consultation, which was processed through the application of Compensatory Fuzzy Logic in its neutrosophic extension. This strategic analysis allowed us to know that the highest percentage of cases is located in the Perinatal Period.

Keywords: Cerebral Palsy, Risk Facts, Etiology, Compensatory Fuzzy Logic in neutrosophic extension.

1 Introduction

Cerebral Palsy (CP) is a general term for a group of permanent developmental disorders of movement and posture. Causing activity limitation that is attributed to nonprogressive disorders that occur in fetal or infant brain development. Along with motor disabilities, children with cerebral palsy have disturbances in sensation, perception, learning, and behavior. CP places high demands on health, social, and educational services, as well as a heavy financial and emotional burden on families [1].

Cerebral Palsy is the most common cause of physical disability in childhood. The prevalence is reported to be as high as 3/1000 live births in the United States with 764,000 people living with signs of cerebral palsy. Rates increased towards the end of the 20th century and have now plateaued [2]. There are some factors contributing to this trend: a higher survival rate among premature babies, a higher incidence of cerebral palsy in full-term newborns, and greater longevity among people with cerebral palsy [3].

The vulnerability of motor pathways during brain development is a determinant factor for motor manifestation in CP. The etiology of CP varies. The most frequent causes of CP include complications of prematurity, perinatal or postnatal hypoxic-ischemia, bilirubin exposure, infection, or trauma [4]. However, in many patients with CP, an etiology cannot be determined, particularly for those born at term and/or without a clear brain lesion identifiable by neuroimaging. It is suspected that much of this unknown pathophysiology may be due to genetic or epigenetic factors. Indeed, current estimates indicate that as many as 30% of patients diagnosed with CP may be genetically determined [5].

Patients with CP are often classified clinically into spastic, hypotonic, dystonic (also called "dyskinetic"), ataxic, and mixed subgroups and by the limbs involved (diplegia, hemiplegia, or quadriplegia, and occasionally other patterns). Each of these clinical subgroups and patterns of involvement is also etiologically and genetically heterogeneous, and while certain major genetic forms of CP characteristically produce only one particular kind of involvement, the clinical presentation of other genetic forms of CP is variable [6], [7], [26].

CP presents great clinical variability due to its diverse etiology and risk factors, which can be classified as prenatal, perinatal, and postnatal [8]. Diagnosis is mainly clinical. Signs of suspicion of CP are behavioral alterations, tone (spasticity), and motor signs, as well as the exaltation or delay in the disappearance of primitive reflexes. Motor disorders are accompanied by sensory, perceptual, postural control or balance, gastrointestinal, pulmonary, urinary, and cognitive alterations related to intellectual disability and communicative alterations [9], [25].

The objective of this study is to determine the most common risk factors in the etiology of Cerebral Palsy and to propose preventive actions for this type of motor condition.

2 Method

2.1 Neutrosophy applied to Compensatory Fuzzy Logic

The theory of Neutrosophy, in this case, the inclusion of this theory enriches the possibilities of analysis by complementing the values shown in table 1 ([10,11]). This is mainly due to two reasons, firstly, the addition of the notion of indeterminacy and, secondly, the possibility of calculating using linguistic terms. That is why it was decided to opt for a fusion of both techniques and carry out the study through the use of neutrosophic Compensatory Fuzzy Logic (CFL). Firstly, let us formally expose the original definition of Neutrosophic Logic as shown in [12-18].

Definition 1. Let X be a universe of discourse. A Neutrosophic Set (NS) is characterized by three membership functions $u_A(x), r_A(x), v_A(x): X \rightarrow]$, -0.1+[, which satisfies the condition $-0 \leq inf u_A(x) + inf r_A(x) + inf v_A(x) sup u_A(x) + sup r_A(x) + \sup v_A(x) \leq 3^+$ for all $x \in X$. $u_A(x), r_A(x)$ and $v_A(x)$ denote the true, indeterminate, and false membership functions of x in A, respectively, and their images are standard or nonstandard subsets of -0,1+[[17], [30].

Definition 2. Let X be a universe of discourse. A Single Value Neutrosophic Set (SVNS) A over X is an object of the form:

$$A = \{\langle x, u_A(x), r_A(x), v_A(x)\rangle : x \in X\} \quad (1)$$

Where $u_A, r_A, v_A: X \rightarrow [0,1]$, satisfy the condition $0 \leq u_A(x), r_A(x), v_A(x) \leq 3$ for all $x \in X$. $u_A(x), r_A(x)\ y\ v_A(x)$ denote the true, indeterminate, and false membership functions of x in A, respectively. For convenience, a Single Value Neutrosophic Number (SVNN) will be expressed as A = (a, b, c), where a, b, c [0,1] and satisfies 0 ≤ a + b + c ≤ 3.

The SVNSs arose with the idea of applying the neutrosophic sets for practical purposes. Some operations between SVNN are expressed below:

1. Given A1 = (a1, b1, c1) and A2 = (a2, b2, c2), two SVNNs, the sum between A1 and A2 is defined as:
$$A_1 A_2 = (a_1 + a_2 - a_1 a_2, b_1 b_2, c_1 c_2) \quad (2)$$
2. Given A1 = (a1, b1, c1) and A2 = (a2, b2, c2), two SVNNs, the multiplication between A1 and A2 is defined as:
$$A_1 A_2 = (a_1 a_2, b_1 + b_2 - b_1 b_2, c_1 + c_2 - c_1 c_2) \quad (3)$$
3. The product by a positive scalar with a SVNN, A = (a, b, c) is defined by:
$$A = (1 - (1 - a), b, c) \quad (4)$$
4. Let $\{A_1, A_2, \ldots, A_n\}$ be a set of n SVNNs, where Aj = (aj, bj, cj) (j = 1, 2, …, n), then the Single Value Neutrosophic Weighted Mean Operator (SVNWMO) over the set is calculated by the following Equation:
$$\sum_{j=1}^{n} \lambda_j A_j = \left(1 - \prod_{j=1}^{n} (1 - a_j)^{\lambda_j}, \prod_{j=1}^{n} {b_j}^{\lambda_j}, \prod_{j=1}^{n} {c_j}^{\lambda_j}, \right) \quad (5)$$

Where λ_j is the weight of Aj, $\lambda_j \in [0, 1]$ and $\sum_{j=1}^{n} = 1$.

In this paper, linguistic terms will be associated with SVNN, so that experts can carry out their evaluations in linguistic terms, which is more natural. Therefore, the scales shown in Table 2 will be taken into account.

Truth value	Category	SVNN
0	Fake	(0,1,1)
0.1	Almost fake	(0.10,0.90,0.90)
0.2	Pretty fake	(0.20,0.85,0.80)
0.3	Somewhat fake	(0.30,0.75,0.70)
0.4	More false than true	(0.40,0.65,0.60)
0.5	As true as false	(0.50,0.50,0.50)
0.6	More true than false	(0.60,0.35,0.40)
0.7	Somewhat true	(0.70,0.25,0.30)
0.8	True enough	(0.8,0,15,0.20)
0.9	Almost true	(0.9, 0.1, 0.1)
1	Real	(1,0,0)

Table 1. Evolution of the scale from fuzzy to neutrosophic linguistic variables

To convert neutrosophic numbers to neat numbers the following equation will be used:

$$s(V) = 2 + T - F - I \tag{6}$$

Compensatory Fuzzy Logic uses mathematical operators that guarantee the effective combination of intangible elements evaluated by experts, considering categorical scales of veracity, with quantitative information, which provides truth values through conveniently defined predicates based on such information:

Operators	Predicate logic
Conjunction	(and), C,∧
Disjunction	(or), d, ∨
Fuzzy strict order	(either)
Denial	(not)

Table 2. Presentation of the mathematical operators in the logic of predicates of the CFL.

Maps from $[0,1]^n$ to [0,1], or go from $[0,1]^2$ to [0,1] and n from [0,1][12]. Which satisfies the following axioms ([19]):

1. min{ x1, x2, ⋯, xn } ≤ d(x1, x2, ⋯, xn) ≤ max{ x1, x2, ⋯, xn } (Compensation Property).
2. d(x1, x2, ⋯, xn) = d(x1, x2, ⋯, xn) (Property of Commutativity or Symmetry).
3. If x1 = y1, x2 = y2, ⋯, xi−1 = yi−1, xi+1 = yi+1, ⋯, xn = yn, such that neither is zero, and xi >yi, then d (x1, x2, ⋯, xn) > d(y1, y2 ,⋯,yn) (Strict Growth Property)
4. If xi = 1 for some i, then d (x1, x2, ⋯, xn) = 1 (Veto Property)
5. c(x1, x2, ⋯, xn) = d(x1, x2, ⋯, xn) = x (Idempotency Property)

The coefficient of variation (Cv) of the predicates will be calculated using equation 5 applying statistical decision criteria according to the following parameters:

- If Cv ≥0.20, take the modal value (rating given by the experts that is repeated the most in the analyzed range)
- If Cv<0.20, take the value of the arithmetic mean (average rating of the experts)

$$Cv = \frac{S}{X_{med}} \tag{7}$$

Where S is the standard deviation of the data and X_{med} is the mean of the data.

3. Results

A review of the medical records of patients with a confirmed diagnosis of Cerebral Palsy was carried out, during the period from March 2020 to January 2022, with a sample of 152 cases. Of which the following were taken as data of interest for the study:

- ✓ Prenatal Period: 36
- ✓ Perinatal Period: 55
- ✓ Postnatal Period: 8
- ✓ Mixed: 51
- ✓ Not specified: 2

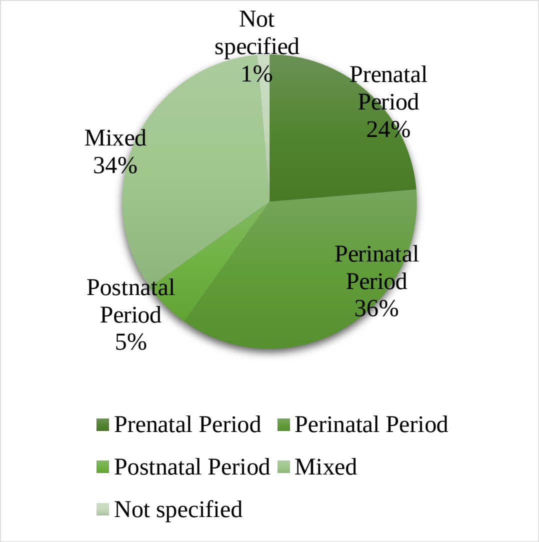

Figure 1. Period of occurrence of risk factors in LESNC. Source: review of medical records. Note: own elaboration

Figure 1 summarizes the moment in which the injury occurred in each of the patients that were considered for this study. According to the results of the analysis and the data obtained from the medical records, the period with the highest incidence was the Perinatal Period and mixed causes. It is necessary to take these values into account to establish a proposal for solutions.

Next, the dispensarization of the factors that intervene in the etiology are shown in tables, for each patient and divided by periods, for a better understanding.

Risk Factors	No.	%
Maternal Vaginal Infections	6	16.6
History of preterm labor threats	6	16.6
c/Toxaemia	5	13.8
Fetal suffering	10	27.7
Maternal Anemia	1	2.7
Maternal age under 18 years	1	2.7
Maternal age over 40 years	1	2.7
Twin pregnancy	1	2.7
Genetic Background	1	2.7
IUGR (Intrauterine Growth Retardation)	1	2.7
Obstetric History of Preterm Labor	1	2.7
Fever during labor	2	5.5

Table 3. Distribution of patients with CP according to risk factors manifested in the Prenatal Period. Source: medical records. Note: own elaboration

Risk Factors	No.	%
Severe hypoxia at birth	13	23.6
Neonatal convulsions	9	16.36
Low Birth Weight	5	9
Cesarean section	4	7.2
Mechanic ventilation	1	1.8
Instrumented delivery	6	11
Sepsis of the Newborn	8	14.54
Preterm labor	5	9

Risk Factors	No.	%
Metabolic disorders	1	1.8
Post-term delivery	1	1.8
Obstetric trauma	1	1.8
CNS infections	1	1.8

Table 4. Distribution of patients with CP according to risk factors present in the Perinatal Period. Source: medical records. Note: own elaboration

Risk Factors	No.	%
Head trauma	2	25
CNS infections	2	25
Convulsive status	3	37.5
Intoxications	1	12.5

Table 5. Distribution of patients with CP according to risk factors present in the Postnatal Period. Source: medical records. Note: own elaboration

- ✓ In the Prenatal period, the factors with the highest incidence were: Maternal Vaginal Infections, History of Preterm Labor Threats, AHT, and Fetal Suffering, representing among them 74.4% of the total 36 cases located in this period.
- ✓ In the Perinatal period, which was the most frequent, with 55% of the total sample, the factors that appear higher were: severe hypoxia at birth, neonatal convulsions, low birth weight, instrumented delivery, sepsis of the NB and preterm labor, the sum of them represents 83.5% of the total.
- ✓ From the postnatal period, 3 factors were selected: cranioencephalic trauma, CNS infections, and convulsive status, which accounted for 87.5% of the total.

Of the factors that were mentioned in tables 3, 4, and 5, those with the highest incidence were selected according to what was found in this study. These factors were analyzed using Compensatory Fuzzy Logic in its neutrosophic extension to determine, through the experience of the experts consulted, which of these provide the most significant values in medical practice to make it possible to guide preventive work. [31, 32, 33]

3.1 Application of Compensatory Fuzzy Logic in its neutrosophic extension

For the analysis of the risk factors involved in the etiology of Cerebral Palsy (CP), the following procedures were performed:

1. Review of the medical records of these patients, taking as a reference the data provided regarding the etiology of the diagnosis, from which the factors with the highest incidence were selected, according to Tables 3, 4, and 5.
2. Interviews and consultations with the selected experts, consisting of specialists in the care of children with Cerebral Palsy, such as Pediatricians, Neurologists, Specialists in Physical Medicine and Rehabilitation, Nurses, and Obstetricians.
3. Analysis of the previously selected risk factors, applying compensatory fuzzy logic in its neutrosophic extension according to the following methodology:

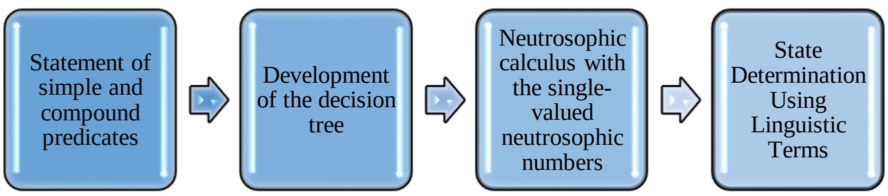

Figure 2. Working algorithm. Note: own elaboration

The results are shown below:

Simple and compound predicates and their calculation expressions:

- ✓ Risk factors $RF(X)$
- ✓ Prenatal Period $PreNP(X)$

✓ Perinatal Period	$PeriNP(X)$
✓ Postnatal Period	$PostNP(X)$
✓ Maternal Vaginal Infections	$MVI(X)$
✓ Preterm Labor Threats	$PLT(X)$
✓ Arterial hypertension	$AH(X)$
✓ Fetal Suffering	$FS(X)$
✓ Severe Hypoxia at Birth	$SHB(X)$
✓ Neonatal Convulsions	$NC(X)$
✓ Low Birth Weight	$LBW(X)$
✓ Instrumented Delivery	$ID(X)$
✓ Sepsis of the Newborn	$SNB(X)$
✓ Preterm Delivery	$PD(X)$
✓ Cranioencephalic Trauma	$CET(X)$
✓ Central Nervous System infections	$SNSI(X)$
✓ Convulsive Status	$CS(X)$

Calculation Expressions:

$$RF(X) = PreNP(X) \wedge PeriNP(X) \wedge PostNP(X)$$
$$PreNP(x) = MVI(X) \wedge PLT(X) \wedge AH(X) \wedge FS$$
$$PeriNP(X) = SHB(X) \wedge NS(X) \wedge LBW(X) \wedge ID(X) \wedge SNB(X) \wedge PTD(X)$$
$$PostNP(X) = CET(X) \wedge CNSI(X) \wedge SC(X)$$

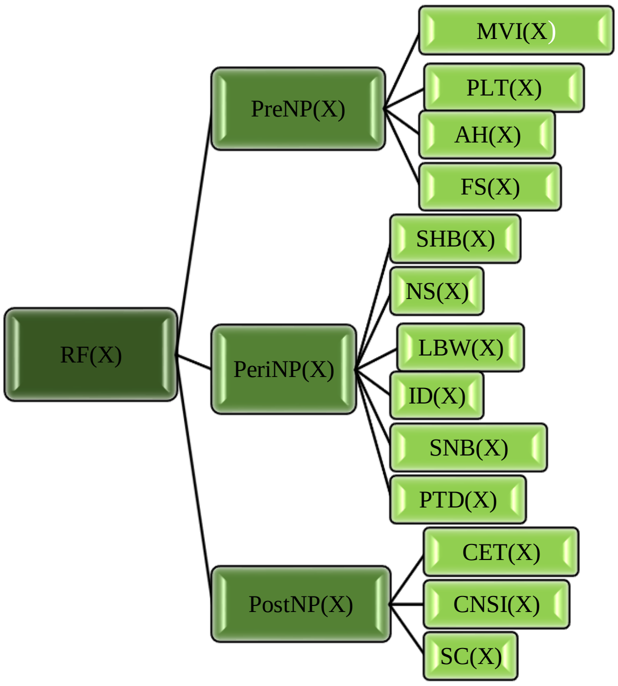

Figure 3: Predicate tree. Own elaboration

The following tables show the calculation of the predicates by groups of experts using the neutrosophic scales in Table 1 and the mathematical operators in Table 2:

Simple Predicates	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5
$MVI(X)$	(1;0;0)	(0.7;0.25;0.3)	(0.5;0.5;0.5)	(0.5;0.5;0.5)	(0.9;0.1;0.1)
$PLT(X)$	(0.5;0.5;0.5)	(1;0;0)	(0.8;0.15;0.2)	(0.9;0.1;0.1)	(1;0;0)
$AH(X)$	(1;0;0)	(0.9;0.1;0.1)	(0.9;0.1;0.1)	(1;0;0)	(0.8;0.15;0.2)
$FS(X)$	(0.9;0.1;0.1)	(0.8;0.15;0.2)	(1;0;0)	(0.9;0.1;0.1)	(1;0;0)

Simple Predicates	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5
$SHB(X)$	(0.8;0.15;0.2)	(1;0;0)	(1;0;0)	(1;0;0)	(1;0;0)
$NC(X)$	(1;0;0)	(1;0;0)	(1;0;0)	(0.9;0.1;0.1)	(1;0;0)
$LBW(X)$	(0.5;0.5;0.5)	(1;0;0)	(0.8;0.15;0.2)	(0.7;0.25;0.3)	(0.5;0.5;0.5)
$ID(X)$	(0.8;0.15;0.2)	(0.7;0.25;0.3)	(0.5;0.5;0.5)	(0.7;0.25;0.3)	(0.4;0.65;0.6)
$SNB(X)$	(1;0;0)	(0.7;0.25;0.3)	(1;0;0)	(0.4;0.65;0.6)	(1;0;0)
$PD(X)$	(0.5;0.5;0.5)	(1;0;0)	(0.6;0.35;0.4)	(1;0;0)	(0.6;0.35;0.4)
$CET(X)$	(0.8;0.15;0.2)	(0.6;0.35;0.4)	(0.6;0.35;0.4)	(0.6;0.35;0.4)	(0.7;0.25;0.3)
$SNSI(X)$	(0.9;0.1;0.1)	(1;0;0)	(0.8;0.15;0.2)	(1;0;0)	(1;0;0)
$CS(X)$	(0.5;0.5;0.5)	(0.5;0.5;0.5)	(0.5;0.5;0.5)	(0.2;0.85;0.8)	(0.5;0.5;0.5)

Table 3. Calculation of the truth value of the simple predicates of experts 1 to 5. Source: evaluation of experts. Own elaboration

Simple Predicates	Expert 6	Expert 7	Expert 8	Expert 9	Expert 10
$MVI(X)$	(0.7;0.25;0.3)	(0.5;0.5;0.5)	(0.7;0.25;0.3)	(0.6;0.35;0.4)	(0.4;0.65;0.6)
$PLT(X)$	(0.8;0.15;0.2)	(1;0;0)	(1;0;0)	(0.8;0.15;0.2)	(0.9;0.1;0.1)
$AH(X)$	(0.4;0.65;0.6)	(0.9;0.1;0.1)	(0.8;0.15;0.2)	(0.9;0.1;0.1)	(0.7;0.25;0.3)
$FS(X)$	(1;0;0)	(1;0;0)	(0.9;0.1;0.1)	(1;0;0)	(0.8;0.15;0.2)
$SHB(X)$	(0.9;0.1;0.1)	(1;0;0)	(0.9;0.1;0.1)	(0.9;0.1;0.1)	(0.9;0.1;0.1)
$NC(X)$	(0.7;0.25;0.3)	(0.5;0.5;0.5)	(0.9;0.1;0.1)	(0.9;0.1;0.1)	(0.9;0.1;0.1)
$LBW(X)$	(0.7;0.25;0.3)	(0.8;0.15;0.2)	(0.8;0.15;0.2)	(0.7;0.25;0.3)	(0.9;0.1;0.1)
$ID(X)$	(0.9;0.1;0.1)	(0.9;0.1;0.1)	(1;0;0)	(0.9;0.1;0.1)	(0.9;0.1;0.1)
$SNB(X)$	(1;0;0)	(1;0;0)	(0.7;0.25;0.3)	(0.7;0.25;0.3)	(1;0;0)
$PD(X)$	(0.6;0.35;0.4)	(0.5;0.5;0.5)	(0.9;0.1;0.1)	(0.6;0.35;0.4)	(0.5;0.5;0.5)
$CET(X)$	(1;0;0)	(1;0;0)	(0.9;0.1;0.1)	(0.7;0.25;0.3)	(1;0;0)
$SNSI(X)$	(1;0;0)	(0.8;0.15;0.2)	(0.8;0.15;0.2)	(0.8;0.15;0.2)	(1;0;0)
$CS(X)$	(0.8;0.15;0.2)	(0.8;0.15;0.2)	(0.8;0.15;0.2)	(0.5;0.5;0.5)	(0.4;0.65;0.6)

Table 4: Calculation of the truth value of the simple predicates of the experts 6 to 10. Source: evaluation of experts. Own elaboration

Simple Predica-tes	Mode	Mean	Truth Value	Category
$MVI(X)$	(1;0;0)	(1;0;0)	(1;0;0)	True
$PLT(X)$	(0.8;0.15;0.2)	(1;0;0)	(0.8;0.15;0.2)	True enough
$AH(X)$	(0.9;0.1;0.1)	(1;0;0)	(0.9;0.1;0.1)	Almost true
$FS(X)$	(1;0;0)	(1;0;0)	(1;0;0)	True
$SHB(X)$	(1;0;0)	(1;0;0)	(1;0;0)	True
$NC(X)$	(0.9;0.1;0.1)	(1;0;0)	(0.9;0.1;0.1)	Almost true
$LBW(X)$	(0.8;0.15;0.2)	(1;0;0)	(0.8;0.15;0.2)	True enough
$ID(X)$	(0.9;0.1;0.1)	(1,0.001,0.002)	(0.9;0.1;0.1)	Almost true
$SNB(X)$	(1;0;0)	(1;0;0)	(1;0;0)	True
$PD(X)$	(1;0;0)	(1;0;0)	(1;0;0)	True
$CET(X)$	(0.7;0.25;0.3)	(1,0,0.001)	(0.7;0.25;0.3)	Somewhat true
$SNSI(X)$	(1;0;0)	(1;0;0)	(1;0;0)	True
$CS(X)$	(0.5;0.5;0.5)	(1,0.044,0.042)	(0.5;0.5;0.5)	As true as false

Table 5: Calculation of the Truth Values of simple predicates. Source: expert evaluation. Own elaboration

The calculation of the truth values of the simple predicates showed that there is a high incidence of the factors related to the Perinatal Period, followed by those related to the Prenatal Period. This indicates that the Static Injury of the Central Nervous System (SICNS) derives fundamentally from the combination of these factors, according to the experts mentioned above. Fundamentally, those related to Maternal Vaginal Infections, Fetal Suffering, Severe Hypoxia at Birth, Sepsis of the Newborn, Preterm Delivery, and Central Nervous System Infections. These aspects must be taken into account to guide possible solutions.

Computation of Compound Predicates

Predicates	Truth Value	Category
$RF(X)$	(0.70,0.25,0.30)	Somewhat true
$PreNP(X)$	(0.8,0,15,0.20)	True enough
$PeriNP(X)$	(0.9;0.1;0.1)	Almost true
$PostNP(X)$	(0.70,0.25,0.30)	Somewhat true

Table 6: Calculation of truth values of compound predicates. Source: expert evaluation. Own elaboration

From the previous exercise, it was possible to obtain that the most significant value in the compound predicates was obtained by the one related to the Perinatal Period, giving greater significance to the causes mentioned in the simple predicates related to this period. Followed by the Prenatal Period, which is where the conditions are met for gestation to occur properly. It is important to focus on all the factors, bearing in mind that this type of injury can be caused by one or a combination of several of them. In some patients, the moment in which it could occur is not specified. Therefore, taking measures aimed at preventing Cerebral Palsy can contribute to the good development of minors and their families.

4 Discussion

The prevalence of Cerebral Palsy is 1.5-3 per 1,000 live births, being higher in preterm infants <28 weeks (111.8/1,000 live births) and newborns <1,500 g (59.2 /1,000 live births). Children with CP have complex medical care needs and often require the participation of a multidisciplinary team since, in addition to neurological problems, they are associated with other disorders that will be more frequent with a greater degree of involvement of CP and that will be key in estimating life expectancy [2], [28]. These results show the need to take preventive actions to prevent the injury from occurring.

Cerebral Palsy is the most common motor disability in childhood. Its early identification is an important priority for parents and is critical for access to early intervention resources, which may optimize function [1], [27]. Early diagnosis can lead to better stimulation and treatment of minors who suffer from it.

Recognizing the specific cause of CP in an affected individual is essential to providing optimal clinical management. The structural and/or functional abnormalities of the central nervous system that underlie CP may have their origin at conception, during embryonic or fetal development, during the perinatal period, or in early childhood. Nongenetic factors, such as teratogenic exposures, hypoxia, hemorrhage, or infections, cause PC in some patients.[6]. The study mentioned above showed similar results to those found in the current research. [29]

In a study carried out in full-term infants, a significant correlation was found between admission to the Intensive Care Unit (ICU), and neonatal encephalopathy, in children who developed CP; An association of CP with infections, malformations of the central nervous system, perinatal adverse events and multiple gestations has also been found; as well as with placental infarcts and pre-eclampsia. According to the results of this study, the most frequent risk factors associated with CP in a Mexican community are perinatal ones [20]. This research applied in Mexico coincides with the results of this study applied in Ecuador.

In an investigation entitled: “Pediatric cerebral palsy in Botswana: etiology, outcomes, and comorbidities”, reference is made to how Cerebral Palsy in Botswana has different etiologies and is associated with poorer outcomes and higher prevalence of comorbidities than what has been reported in high-resource settings. Further studies are necessary to determine optimal preventative and treatment strategies in this population [21, [22], [24].

Therefore, the validity of the study carried out is highlighted and it is recommended to establish a series of actions to reduce the incidence of SICNS, such as:

1. Educate pregnant women about the possible risk factors in this important period for the proper gestation of the fetus. In order to raise awareness of the possible consequences that could lead to alterations for the future baby and his family. [23]
2. Execute actions in hospital centers on the importance of maintaining special care at the time of delivery and the prevention of risk factors.
3. Carry out community actions that prepare postpartum women and their families on the importance of caring for the newborn baby, avoiding the risk factors that have been mentioned in the research.

Conclusions

In patients with Static Injury of the Central Nervous System, the risk factors occurred fundamentally in two periods: Perinatal, which was the one with the highest incidence, and Mixed, marked by the combination of two or more periods. According to the expert consultation, processed by the Application of Compensatory Fuzzy Logic in its neutrosophic extension, the factors with the highest incidence in the etiology of Cerebral Palsy are those related to Maternal Vaginal Infections, Fetal Suffering, Severe Hypoxia at Birth, Sepsis of the Newborn, Preterm Delivery and Central Nervous System Infections. These aspects must be taken into account to guide possible solutions. Through the compensatory fuzzy logic method applied with single-value neutrosophic numbers, it was possible to carry out the strategic analysis, with which the criteria of the experts consulted were taken into account to propose solutions to prevent the occurrence of this type of diagnosis (CP).

Extend the proposal of preventive actions, resulting from the investigation, to other Maternal-child care centers. In order to reduce the incidence of Cerebral Palsy, taking into account that it affects the proper development of the infant, its inclusion in society, and family dynamics. In addition to the high costs that this type of condition implies for the health system and the family economy.

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