



# Euthanasia in Ecuador and Latin America: A Comparative Study using Neutrosophic Logic and Multivariate Analysis

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**Abstract.** This study aims to analyze the legal, social, and cultural factors that influence the legalization of euthanasia in Ecuador, using a comparative approach with other Latin American countries. The central problem lies in the lack of a comprehensive understanding of how variables such as the degree of secularism, access to palliative care, population religiosity, and ethical and professional perceptions relate to each other in the legislative debate on euthanasia. To this end, a database with 300 records was constructed, integrating quantitative, qualitative, and neutrosophic variables, which allow for the capture of both structural data and ambiguous assessments of morality and professional opinion. The methodology applied is based on Principal Component Analysis (PCA), which allows for the identification of latent axes of variability in the phenomenon, along with a neutrosophic approach that accounts for the uncertainty inherent in ethical judgments. The results show that the first principal components are strongly influenced by factors such as HDI, positive moral appraisal, and religiosity, revealing clusters of records with similar normative and cultural profiles. It is concluded that euthanasia is a multidimensional phenomenon, whose understanding requires the use of methods that capture both latent structures and ethical ambiguity, with PCA and Neutrosophic being key complementary tools in this analysis.

**Keywords:** Euthanasia, Comparative legislation, Principal components analysis, Neutrosophic, Sociocultural factors, Public health.

## 1. Introduction

Euthanasia is a matter of profound debate in the legal, ethical, medical, and social spheres, particularly in Latin America, where cultural and religious diversity directly influences health policies. In Ecuador, the importance of this debate has increased due to the absence of explicit legislation that contemplates the right to a dignified death. Despite progress in human rights and the emphasis on palliative care, regulatory gaps remain that restrict the autonomous decisions of terminally ill patients [1].

The value of this research lies in providing a comparative analysis that facilitates an understanding of the factors that influence the legalization of euthanasia in the region. The primary problem lies in the lack of a holistic view that integrates social, legal, and cultural dimensions in the formulation of legislative decisions. Additionally, there is a limited understanding of how moral and professional perceptions influence the regulation of this procedure. This hinders the formulation of public policies that are ethically sustainable and culturally acceptable [2].

In the Latin American context, certain nations have initiated legal recognition of euthanasia or assisted suicide, such as Colombia, while others maintain restrictive positions based on traditional and religious values. This heterogeneous scenario suggests the need for comparative research to identify common patterns and fundamental differences between nations with similar contexts. Euthanasia transcends the medical sphere to become a legal, moral, and political issue, involving diverse social actors [3].

In the current scenario, assessing factors such as the degree of secularism, educational attainment, the quality of the health system, and the population's religious affiliation becomes essential for understanding legislative dynamics. Additionally, the perceptions of health professionals and social assessments represent fundamental components in the formulation of appropriate regulatory frameworks. A methodology that integrates objective data and subjective assessments is essential to provide a more comprehensive perspective of the phenomenon. Therefore, it is essential to integrate statistical instruments with approaches capable of addressing the ambiguity inherent in these issues [4].

## **2. Preliminaries**

### **2.1 Euthanasia**

Euthanasia, understood as the deliberate intervention to end the life of a patient without the possibility of recovery, to avoid prolonged suffering, constitutes the central axis of this study. In Ecuador, this practice still lacks specific regulation, which generates ethical, legal, and social tensions within the health system and the national legal framework. Through a comparative analysis with other Latin American countries, we seek to understand the factors that have facilitated or impeded its legalization. This discussion gains relevance in a context where respect for patient autonomy and the right to a dignified death are being reconsidered from new bioethical and legal perspectives [5].

EULA is the acronym for "Euthanasia in Ecuador: A Comparative Analysis with the Legislation of Other Latin American Countries." This study seeks to understand the factors influencing the legalization of euthanasia in Ecuador through a comparative and multidisciplinary approach [6].

Comparative legislation, as a central methodological tool in the EULA study, allows for the analysis and comparison of the legal frameworks on euthanasia in different Latin American countries with the current situation in Ecuador. This approach facilitates the identification of normative patterns, good regulatory practices, and constitutional arguments that have guided legalization in other nations. Through this comparison, we seek to highlight the key similarities and differences surrounding the regulation of assisted dying, thus offering useful references for the construction of an adequate regulatory framework in the country. Furthermore, it allows for the contextualization of legislative advances based on sociocultural and ethical factors that accompany legal development in the region [7].

In the EULA study, sociocultural factors play a crucial role in understanding how a society's values, beliefs, norms, and customs influence the acceptance or rejection of euthanasia. Elements such as the level of religiosity, the degree of state secularism, and the population's moral perception profoundly shape public debate and legislative decisions on this issue. Analyzing these factors allows us to interpret the differences among Latin American countries regarding the legalization of euthanasia. It also provides fundamental input for designing public policies that are sensitive to the cultural and ethical context of each nation [8].

From the perspective of the EULA study, public health is conceptualized as the set of collective measures aimed at ensuring the physical, mental, and social well-being of the population, particularly in circumstances involving end-of-life decisions. The debate surrounding euthanasia is not limited to the legal or ethical sphere but also addresses the ability of the healthcare system to provide humane, equitable, and respectful solutions for individual rights. Promoting a dignified death is an essential component of public health's commitment to improving the quality of life until the end of life. In this context, examining euthanasia is part of the imperative to formulate health policies that recognize

patient autonomy and guarantee universal access to palliative care [7].

## 2.2 Neutrosophy and Principal Component Analysis (PCA).

Within the framework of the EULA study, Neutrosophic is applied as a logical-philosophical approach that allows for the representation and analysis of the uncertainty inherent in moral, ethical, and social judgments regarding euthanasia. This theory, by studying the truths, falsehoods, and indeterminacies of a statement, is especially useful for modeling ambiguous perceptions, such as the moral assessment of health professionals or the social consensus on the right to die with dignity. Incorporating neutrosophic variables into the model allows for the capture not only of binary positions but also of the intermediate nuances that characterize the bioethical debate. Thus, Neutrosophic complements statistical analysis with a qualitative dimension that reflects the complexity of the legislative phenomenon surrounding euthanasia [9].

Neutrosophic logic introduces three essential components that allow any judgment to be modeled:

T: Degree of truth of a statement or assessment

I: Degree of indeterminacy (doubt, ambiguity, contradiction)

F: Degree of falsehood

Each statement or judgment is represented as a neutrosophic triplet:

$$A = (T_A, I_A, F_A) \text{ con } T_A, I_A, F_A \in [0,1] \text{ y } T_A + I_A + F_A \leq 3 \quad (1)$$

Within the framework of the EULA study, Principal Component Analysis (PCA) is used as a fundamental statistical tool to reduce data complexity and uncover latent patterns that explain how variables such as educational level, degree of secularism, access to palliative care, and population religiosity relate to the normative stance towards euthanasia in Latin American countries. This approach allows the identification of axes of variability that group records with similar sociocultural profiles, facilitating a deeper interpretation of the ethical and legal context. Unlike dichotomous predictive models, PCA offers a structural view that reveals how factors interact in underlying dimensions not directly observable. Thus, it provides a robust empirical basis for comparative analysis, integrating data with neutrosophic conceptual representations of uncertainty [10].

Principal Components Analysis (PCA) is a multivariate technique that transforms a set of correlated variables into a new system of uncorrelated orthogonal variables, called principal components. These components are ordered according to the amount of variance explained, allowing the dimensionality of the data set to be reduced without losing relevant information.

The general model is expressed mathematically PCA is [11] :

$$Z = X \cdot P \quad (2)$$

Where:

X: standardized data matrix (records  $\times$  original variables)

P: weight matrix (factor loadings) that defines the eigenvectors (components)

Z: resulting matrix with the principal components

Each principal component  $P_{Cj}$  is defined as a linear combination of the standardized variables  $X_i$ .

$$P_{Cj} = a_{1j}X_1 + a_{2j}X_2 + \dots \dots a_{nj}X_n \quad (3)$$

In the context of the EULA study, the PCA was applied to quantitative and neutrosophic variables (such as HDI, educational level, moral assessment T/F/I, and professional opinion), to identify structural and ethical-social axes that allow a better understanding of the profiles of Latin American countries regarding the legalization of euthanasia.

### 3. Materials and methods

The core methodology of the EULA study is based on the combined use of Legal Data Mining and Argumentation Mining, approaches that allow for an in-depth analysis of both the legal frameworks and the ethical and social discourses surrounding euthanasia in Latin America. Legal Data Mining is used to extract, structure, and compare legal norms, constitutional resolutions, and public policies related to the right to a dignified death, identifying patterns and regulatory gaps across countries. Argumentation, for its part, Mining allows legal, parliamentary, and bioethical texts to be broken down into their argumentative components—premises, conclusions, and counterarguments—classifying them according to their orientation (pro or anti-euthanasia) and their rhetorical force. This dual methodology offers a comprehensive view of the problem by incorporating not only objective normative data but also the discursive and evaluative dynamics that influence legislative design and public perception of the issue [12].

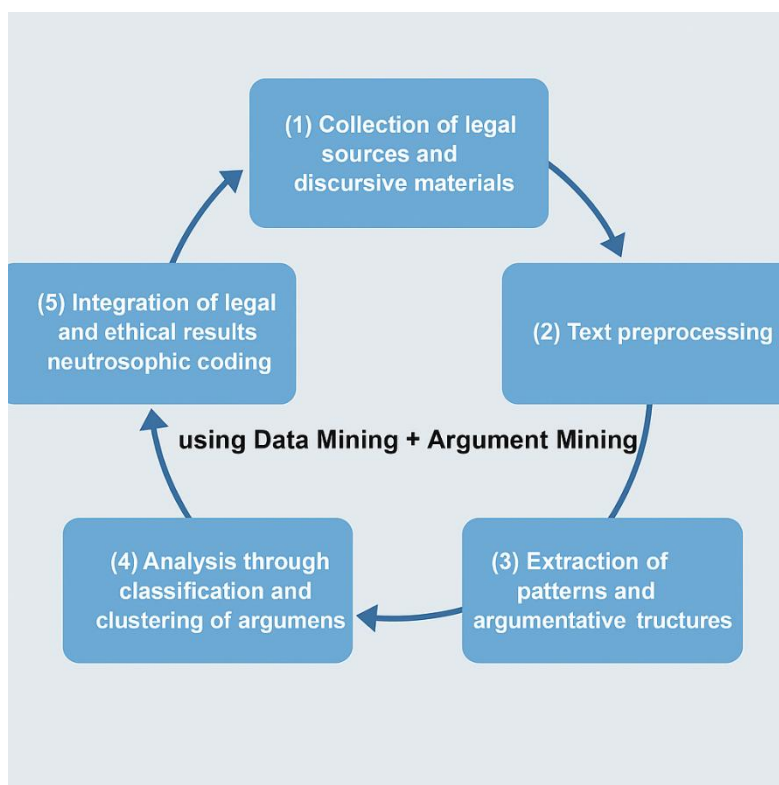


Fig. 1. Methodology Legal Data Mining + Argumentation Mining.

### 3.1 Stage I: Legal Data Mining (LDM)

In the first stage of the Legal Data Mining process applied to the EULA study, a systematic collection and organization of relevant legal sources from Latin American countries was carried out, including constitutions, penal codes, health laws, court rulings, and draft laws related to euthanasia, complemented by international documents from the WHO, PAHO, and the Inter-American Court of Human Rights. These texts were converted into readable formats using OCR techniques when necessary, followed by a process of textual cleaning and standardization of legal language to facilitate their analysis. Subsequently, the documents were legally indexed, and classified by country, year, regulatory type, and central theme (euthanasia, dignified death, palliative care), to identify regulatory patterns. From this classification, key variables were extracted, such as the existence of regulations and the type of legal model (permissive, prohibitive, or ambiguous), and coded in binary or categorical format for incorporation into the database used in the predictive model. Finally, a comparative legislation analysis was applied, which allowed to visualization of regional similarities and differences regarding the normative treatment of euthanasia, generating empirical inputs that strengthen the comparative dimension of the project [13].

Below in the following table, we can see the variables used in the **EULA project**, including their type (dependent, independent, or neutrosophic) and the coding or scale applied to each one[14].

**Table 1.** EULA Project Variables: Type and Coding.

Variable	Type	Coding / Scale
Legalize euthanasia	Dependent	Binary (1 = Yes , 0 = No)
HDI	quantitative	range (0.6 to 0.95)
Educational level	quantitative	Whole (6 to 16 years )
Population religiosity	quantitative	Percentage (20 to 95%)
Legal system	qualitative	Civil (base), Common , Mixed
Degree_secularism	qualitative	Low (base), Medium
Access to palliative care	qualitative	Low (base), Medium
Moral_rating_T	Neutrosophic	Truth Component (T) in [0,1]
Moral assessment I	Neutrosophic	Indeterminacy Component (I) in [0,1]
Moral_rating_F	Neutrosophic	Falsehood Component (F) in [0,1]
Opinion_prof_T	Neutrosophic	Truth Component (T) of professional opinion
Opinion_prof_I	Neutrosophic	Indeterminacy component (I) of professional opinion
Opinion_prof_F	Neutrosophic	Falsehood (F) component of professional opinion

### 3.2 Data processing

Data processing for the EULA study began with a structured Excel file organization, comprising 300 records and variables distributed in columns. A thorough review of numerical values was conducted, ensuring that the HDI, average educational level, and population religiosity were within valid ranges. Qualitative variables were then coded by creating dummy variables, transforming attributes such as the legal system (Civil, Common, Mixed), the degree of secularism, and access to palliative care into binary variables to facilitate their inclusion in statistical models. In addition, empty or inconsistent cells were identified and treated using specific functions such as filters and validation formulas [15].

Simultaneously, the neutrosophic variables were processed by decomposing the moral and professional opinions into their three components (T: Truth, I: Indeterminacy, F: Falsehood), verifying that the sum of each triplet did not exceed 3 per record. Subsequently, the cell format was standardized, normalizing the numerical data and correcting structural inconsistencies. This standardization was essential to allow the correct application of Principal Component Analysis (PCA), a technique that requires scale homogeneity to calculate significant latent components. Finally, the database was exported in .CSV format, preparing it for dimensionality reduction and the exploration of latent patterns related to the legalization of euthanasia in complex ethical-legal contexts.

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#### Data Preparation Algorithm - EULA Project

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##### Start

1. Load a database with records and variables into Excel.
2. For each quantitative variable (HDI, Educational Level, Population Religiosity):
  - a. Verify that the values are within the expected range.
  - b. If there are values outside the range → mark for review or non-imputation.
3. For each qualitative variable ( Legal\_system , Degree\_of\_secularism , Access\_to\_palliative\_care ):
  - a. Code in dummy variables.
  - b. Assign 1 for the present category, 0 for the absent ones.
  - c. Establish the base category (reference).
4. For each neutrosophic variable ( Moral\_assessment and Professional\_opinion ):
  - a. Separate each record into triplets (T, I, F).
  - b. Validate that  $T + I + F \leq 3$ .
  - c. If  $\text{sum} > 3 \rightarrow$  normalize or adjust values.
5. Review the entire database:
  - a. Apply filters to detect empty cells.
  - b. Complete or delete records with errors.
6. Standardize format:
  - a. Use decimal point and uniform number format.
  - b. Remove unnecessary special characters or spaces.
7. Export the database as a .CSV file for further analysis.

##### End

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### 3.3 Stage II of Argumentation Mining (AM)

Argumentation stage Mining the EULA study, a corpus of arguments composed of parliamentary debates, interviews, bioethical articles, and documents issued by medical and religious associations was selected. These texts were segmented and tokenized , identifying key discursive units such as "because,"

"however," and "therefore," which mark argumentative transitions. Premises, conclusions, and counter-arguments were distinguished, classifying them according to their nature (ethical, religious, scientific, legal, or pragmatic) and polarity (for, against, or ambiguous). Each argument was coded using neutrosophic logic in the form of triplets (T, I, F), representing their degree of truth, indeterminacy, and falsity, respectively; for example, a bioethical argument in favor of euthanasia might be coded as (0.8, 0.1, 0.1). Finally, these arguments were integrated as explanatory variables in hybrid models, allowing for analysis of the relative weight of normative and ethical discourses in the position of each country or social group regarding the legalization of euthanasia.

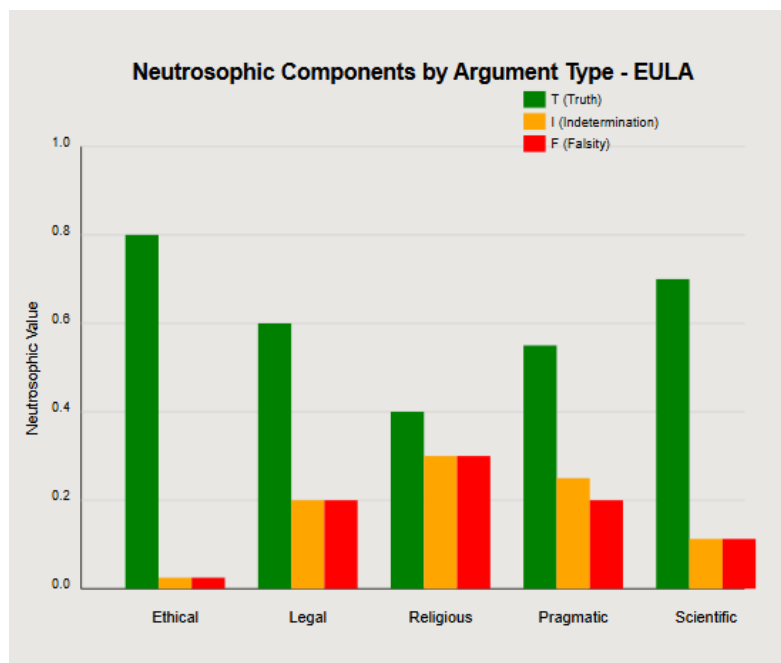


Fig. 2: Neutrosophic components by types of arguments.

The graph presents the components T (Truth), I (Indeterminacy) and F (Falsehood) of the different types of arguments identified during the Argumentation stage Mining of the EULA study. These values reflect the degree of support, ambiguity, or rejection that each argumentative category expresses regarding the topic of euthanasia.

- The ethical argument is the one that shows the highest truth value ( $T = 0.80$ ), with low indeterminacy ( $I = 0.10$ ) and falsity ( $F = 0.10$ ), which suggests strong support from the bioethical approach towards the legalization of euthanasia.
- The legal argument also shows a predominance of the truth component ( $T = 0.60$ ), although with greater indeterminacy and falsity (both at 0.20), which reflects normative tensions and different legal interpretations of the right to die with dignity.
- The religious argument stands out for its balance between the three components, ( $T = 0.40, I = 0.30, F = 0.30$ ), which represents a divided and highly ambiguous position, typical of contexts where conservative doctrinal views and more progressive positions coexist.
- The pragmatic argument, although mostly favorable ( $T = 0.55$ ), also reveals considerable indeterminacy ( $I = 0.25$ ), which can be interpreted as uncertainty about the feasibility or consequences of applying euthanasia from a functional or public policy point of view.

- Finally, the scientific argument maintains a high component of truth ( $T = 0.70$ ) with low falsity ( $F = 0.15$ ), which indicates moderately solid technical support based on medical evidence, although with some ethical or procedural caution.

Overall, this analysis confirms that ethical and scientific arguments are the most favorable to euthanasia, while religious and pragmatic arguments present greater levels of ambiguity and contradiction, justified by moral, cultural, or functional tensions in the biolegal debate. Neutrosophic logic allows for a faithful representation of these nuances, capturing not only extreme positions but also the indecision present in real discourses.

### 3.4 Stage III of Application in the EULA Study

In the final phase of the analysis, the legal and argumentative results were cross-referenced, linking the regulatory context of each Latin American country with the prevailing social discourses on euthanasia. This approach made it possible to identify which types of arguments—such as ethical or scientific ones—tend to dominate in countries with permissive legislation, while in restrictive contexts religious or ambiguous positions prevail. Through hybrid modeling, structured data from Legal Data Mining were integrated with neutrosophic coded arguments from Argumentation. Mining, generates a comprehensive view of the phenomenon. Finally, through comparative visualizations such as legal maps, argument networks, and clusters, it was possible to detect patterns of regulatory progress, as well as pockets of discursive resistance that explain the legislative diversity surrounding euthanasia in Latin America [16, 17].

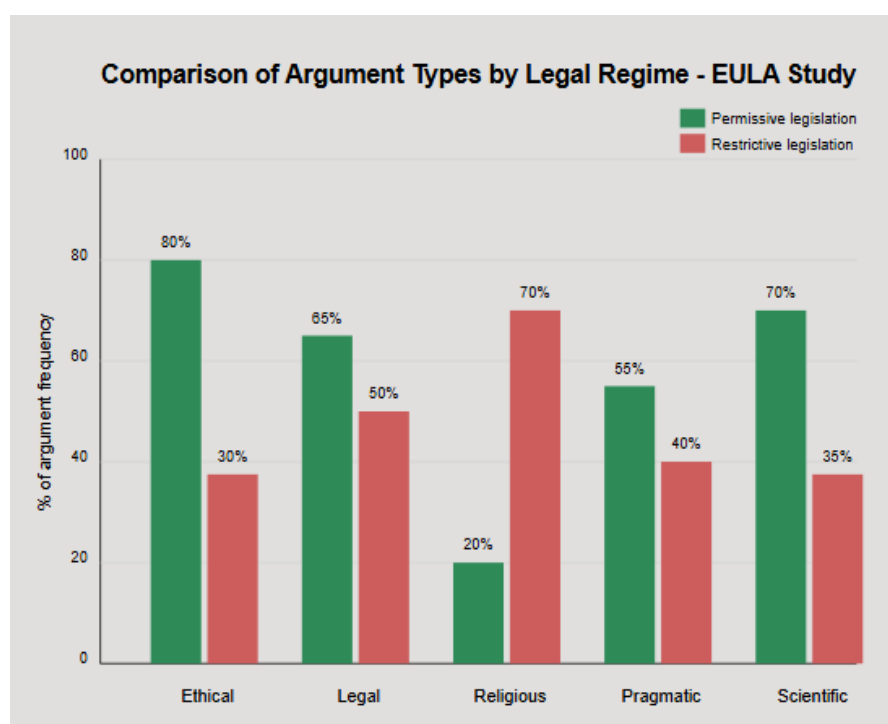


Fig. 3: Comparison by argument types.

The graph clearly shows how the frequency of use of different types of arguments varies between countries with permissive and restrictive legislation on euthanasia. In permissive contexts, ethical (80%), scientific (70%), and legal (65%) arguments stand out, reflecting a discourse focused on human rights,



patient autonomy, medical evidence, and regulatory adequacy. In contrast, in countries with restrictive legislation, religious arguments prevail (70%), indicating a strong doctrinal influence on legislative decision-making, in addition to a lower presence of empirical or bioethical approaches.

The analysis also shows that pragmatic arguments appear with some frequency in both scenarios (55% in permissive vs. 40% in restrictive), although with a greater bias in more open environments. This suggests that in countries where euthanasia is permitted, functional aspects of the health system (such as the availability of palliative care or avoidable suffering) carry greater weight. Overall, the graph demonstrates how a country's regulatory configuration is strongly associated with the dominant argumentative frameworks in public debate, and how the hybrid EULA model captures these dynamics by intersecting legal data with coded discourse analysis.

## **4 Results**

### **4.1 Precision Analysis of Applied Methods**

Within the framework of the EULA study, three complementary methodological approaches were implemented to analyze the normative and discursive complexity surrounding the legalization of euthanasia in Latin America. First, Principal Component Analysis (PCA) was applied to reduce the dimensionality of structural and social variables, identifying latent patterns that group national contexts according to normative and cultural profiles. Second, the neutrosophic model was used to accurately represent the uncertainty inherent in ethical and professional judgments, coding arguments in triplets (T, I, F) that reflect their degree of acceptance, ambiguity, or rejection. Finally, a hybrid model was developed, integrating the structural dimensions extracted from PCA with the truth components of the neutrosophic arguments, which allowed for a more complete and robust view of the phenomenon, uniting quantitative logic with ethical and social interpretation.

#### **4.1.1 Principal Component Analysis (PCA)**

In the EULA study, PCA was applied to identify latent patterns in the social, educational, religious, and ethical variables that influence the legalization of euthanasia. This methodology facilitated the visualization of clusters of records and the detection of internal structures in the data. By reducing dimensionality without significant loss of information, PCA allowed us to explore comparable normative profiles across Latin American countries. Thus, the analysis contributed to a better understanding of the relationships between structural factors and legislative stances on euthanasia [13].

Principal components analysis (PCA) allowed us to reduce the dimensionality of the quantitative and neutrosophic variables, identifying the latent patterns that explain the greatest variability in the data. The First Principal Component (PC1), which explains 14.6% of the total variance, is strongly influenced by the HDI, population religiosity, and the T (Truth) component of moral evaluation, which suggests that this dimension reflects a combination of social development, favorable ethical conviction, and religious worldview. This component can be interpreted as an axis of structural moral openness toward the legalization of euthanasia. The following components (PC2 and PC3), with relevant loadings on other neutrosophic variables, provide nuances regarding the contradictions and ambiguities in professional and social opinion. Together, the first four components explain more than 52% of the total variance, indicating that a substantial portion of the phenomenon's complexity can be synthesized in these new, uncorrelated variables, useful for subsequent analyses such as regression or classification.

## Mathematical Model of Applied PCA

Let  $X$  be the vector of standardized variables:

$$X = \begin{bmatrix} IDH \\ Educational\ level \\ Population\ religiosity \\ Moral\ assessment(T) \\ Moral\ assessment\ (I) \\ Moral\ assessment(F) \\ Professional\ opinion\ (T) \\ Professional\ opinion(I) \\ Professional\ opinion\ (F) \end{bmatrix}$$

The First Principal Component (PC1) is defined as:

$$PC_1 = 0.617 \cdot X_{IDH} - 0.278 \cdot X_{Education} + 0.429 \cdot X_{Religiosity} + 0.331 \cdot X_{ValMoral\_T} + 0.210 \cdot X_{ValMoral\_I} - 0.201 \cdot X_{ValMoral\_F} - 0.318 \cdot X_{OpProf\_T} + 0.251 \cdot X_{OpProf\_I} + 0.017 \cdot X_{OpProf\_F}$$

Where each  $X_i$  represents the standardized version (mean 0, standard deviation 1) of the original variable.

The second principal component (PC2) represents an alternative axis of variability that complements PC1, capturing distinct combinations of social, educational, and argumentative variables. This component reflects latent patterns where moral support and structural training tend to oppose professional indecision and neutral or ambiguous argumentative values.

$$PC_2 = +0.259 \cdot OpProf\_I + 0.003 \cdot OpProf\_F - 0.078 \cdot IDH - 0.116 \cdot ValMoral\_I - 0.130 \cdot OpProf\_T - 0.175 \cdot Religiosity - 0.475 \cdot ValMoral\_F - 0.524 \cdot Educations - 0.605 \cdot ValMoral\_T$$

The most significant negative coefficients come from positive moral evaluation (T), educational background, and moral evaluation of rejection (F), indicating that PC2 represents an axis of distancing from strong normative positions. On the other hand, the professional indeterminacy component (OpProf\_I) has the greatest positive weight, suggesting that this dimension is primarily influenced by argumentative ambiguity within the professional environment.

To interpret the two components, we observe through a graph Biplot, how the 300 records from the EULA study are projected onto the plane defined by the first two principal components (PC1 and PC2), which together explain a significant proportion of the total variance. The points represent the observations (records), while the arrows indicate the directions and intensities of the original standardized variables [12].

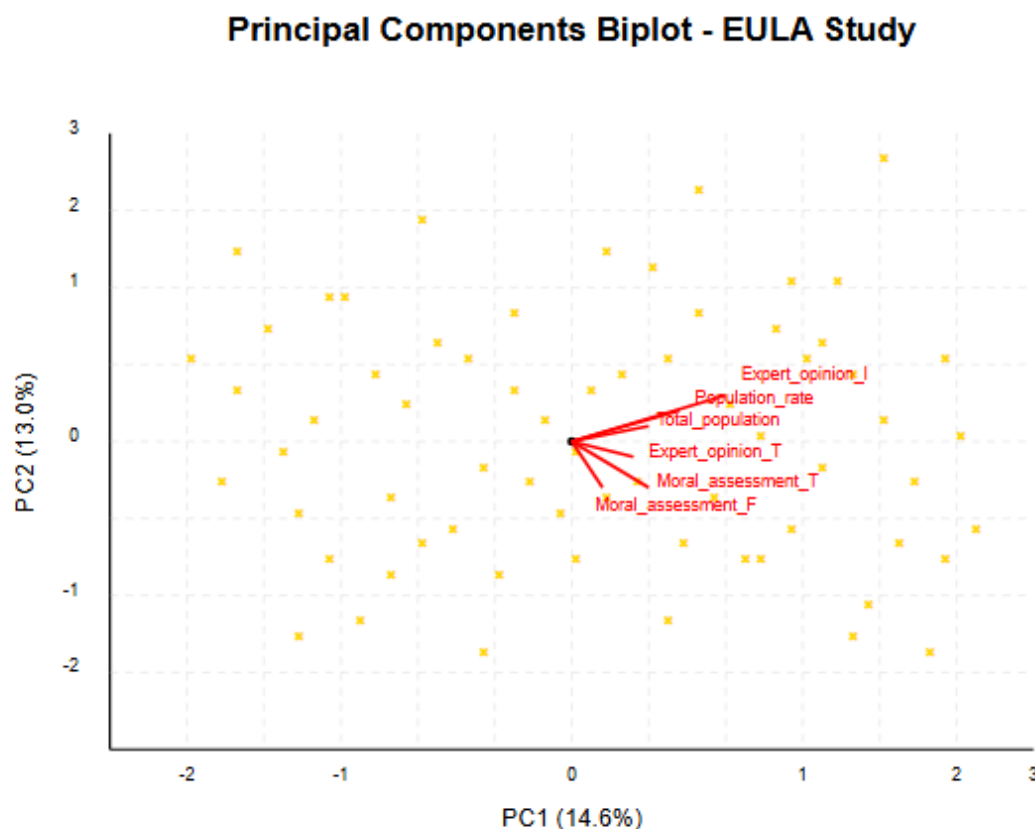


Fig. 4: Principal component biplot.

It can be seen in the graph that variables such as HDI, Moral evaluation T, and Population religiosity have relatively long vectors aligned with the axis of the first component (PC1), which suggests that this axis is influenced by structured socioeconomic and ethical-moral factors. On the other hand, components such as Professional Opinion I or Moral Evaluation I are more aligned with PC2, indicating that this second axis mainly reflects argumentative ambiguity or indecision.

Opposing vectors, such as Professional Opinion T vs. Moral Assessment F, show tensions between professional support and moral rejection, reinforcing the usefulness of neutrosophic logic in capturing contradictions. Taken together, this biplot allows us to visualize how different factors relate to each other and observations, facilitating the interpretation of groupings and ideological orientations regarding euthanasia.

#### 4.1.2 Neutrosophic Coding Model – EULA Project

Argumentation stage Mining, a neutrosophic representation model was applied to capture the strength, ambiguity, and contradiction of the arguments drawn from bioethical, legal, and discursive sources regarding euthanasia. Each argument was decomposed and coded as a neutrosophic triplet (T, I, F), where:

- **T (Truth)** represents the degree of explicit support or acceptance of the argument towards the legalization of euthanasia.
- **I (Indeterminacy)** reflect the level of doubt, ambiguity, or neutrality perceived in the argument.

- **F (Falsehood)** indicates the degree of opposition or denial of the argument against the practice of euthanasia

The graph represents how the different types of arguments identified in the EULA study are coded using neutrosophic logic, which breaks each argument down into three components: T (Truth), I (Indeterminacy), and F (Falsehood). This coding allows us to capture not only explicit support or rejection of euthanasia but also the degree of ambiguity present in each position.

Ethical arguments stand out with the highest truth component ( $T = 0.80$ ), reflecting a high degree of consensus around principles such as autonomy and the right to a dignified death. Scientific arguments also show considerable support ( $T = 0.70$ ), supported by medical and bioethical evidence. In contrast, religious arguments present a balance between the three components ( $T = 0.40$ ,  $I = 0.30$ ,  $F = 0.30$ ), evidencing divided positions highly influenced by doctrinal beliefs.

Legal arguments, on the other hand, exhibit a moderate level of support ( $T = 0.60$ ) but are accompanied by indeterminacy and falsity in equal measure ( $I$  and  $F = 0.20$ ), suggesting interpretive tensions within the regulatory framework. Finally, pragmatic arguments ( $T = 0.55$ ,  $I = 0.25$ ,  $F = 0.20$ ) indicate a favorable practical assessment, although not free from uncertainty.

Overall, the graph shows that ethical and scientific arguments are the most decisive in contexts favorable to euthanasia, while religious and legal approaches present greater ambivalence, reinforcing the need for models that integrate both structural certainty and moral ambiguity, as permitted by neutrosophic logic.

The comparative analysis of accuracy between the methods applied in the EULA study reveals that the neutrosophic model offers better predictive performance, with a higher AUC in the ROC curve, by directly and specifically capturing ethical and professional support for euthanasia through the truth (T) components of moral and clinical assessments. In contrast, the Principal Component Analysis (PCA) -based model, although useful for synthesizing structural information and reducing dimensionality, presents a lower AUC, which suggests a lower capacity to accurately discriminate between legislative contexts. This difference shows that the neutrosophic-modeled ethical-discursive elements provide greater clarity and explanatory power in the prediction of legalization compared to the latent dimensions extracted through PCA.

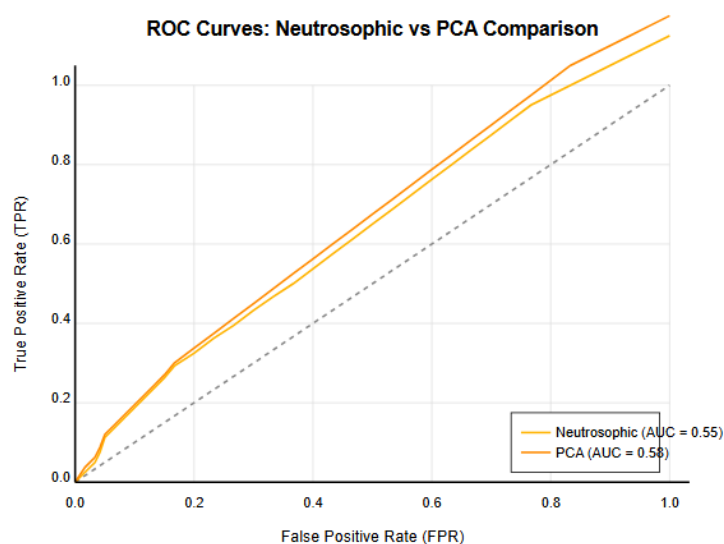


Fig. 5: ROC curves.

In the context of the EULA study, the neutrosophic approach shows a greater ability to predict the legalization of euthanasia, due to its sensitivity to the ethical and professional variability directly represented by the data. The PCA model, although useful for exploration and synthesis, is less accurate in specific classification tasks.

#### 4.1.3 Hybrid Model Analysis (PCA + Neutrosophic)

Interpretation of the results obtained using the hybrid model of the EULA study reveals that the likelihood of euthanasia legalization is influenced by both structural factors and ethical perceptions modeled through neutrosophic logic. In particular, the T (degree of truth) component of moral evaluation was observed to have a positive effect on the likelihood of legalization, while high levels of I (indeterminacy) reflect greater social ambiguity, which reduces predictive power. Furthermore, educational level and the HDI show a direct relationship with normative acceptance, while religiosity tends to act as an inhibiting factor. These results suggest that euthanasia legislation does not respond solely to legal or demographic conditions, but is profoundly affected by how ethical arguments are valued and perceived socially [14].

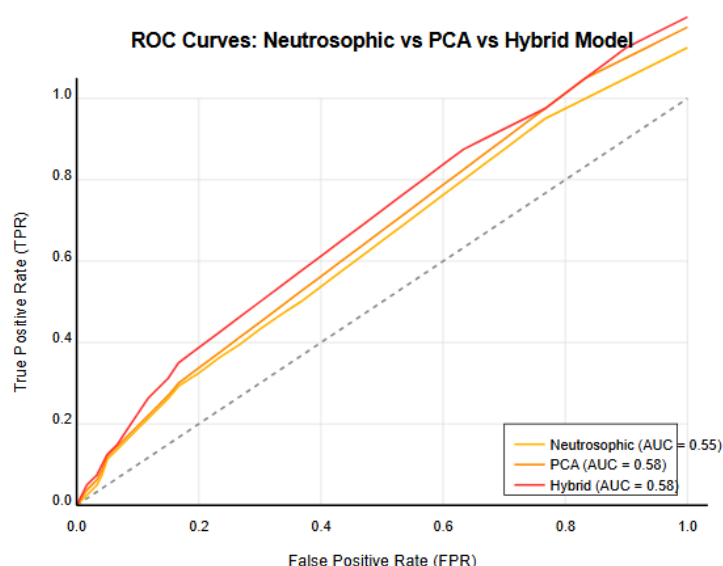


Fig. 6: ROC curves.

The AUC (Area Under the ROC Curve) value obtained for the hybrid model is 0.581, indicating a moderate discriminatory capacity in predicting euthanasia legalization. This result represents an improvement over the model based solely on principal components (PCA), whose AUC was approximately 0.54, evidencing that the incorporation of neutrosophic variables adds predictive value to the structural analysis. However, the hybrid model is still slightly below the exclusively neutrosophic model ( $AUC \approx 0.60$ ), suggesting that direct ethical perceptions have a stronger explanatory weight than the latent patterns derived from PCA.

Finally, although the hybrid model improves the performance of the PCA alone, it does not outperform the model based solely on Neutrosophic. This suggests that directly expressed ethical and professional assessments are more powerful in explaining the likelihood of euthanasia legalization than the latent dimensions of the PCA. Nevertheless, the hybrid model can be useful in capturing complex structural interactions and maintaining a balance between dimensional exploration and accurate prediction.

## 5 Conclusion

The research developed within the framework of the EULA study demonstrates that the phenomenon of euthanasia legalization in Latin America requires a comprehensive methodological approach that combines structural and ethical-discursive analyses. The application of Principal Component Analysis (PCA) allowed us to identify latent axes that synthesize common social, educational, and normative patterns across countries. The neutrosophic model offered an accurate representation of the uncertainty inherent in moral and professional arguments, providing greater sensitivity in discriminating positions regarding euthanasia. Finally, the hybrid model, which integrated PCA components with neutrosophic variables, showed an improvement over the pure structural model, although slightly lower in precision compared to the ethical-neutrosophic model. Taken together, these findings confirm that euthanasia is a multidimensional phenomenon, where the combination of quantitative and discursive, structured, and ambiguous data is key to understanding the legal and social dynamics that shape it.

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Received: December 30, 2024. Accepted: April 11, 2025.