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Configurational Analysis of Comprehensive Healthcare Quality: A Neutrosophic Set and fsQCA Approach

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Abstract. This study employs a nonlinear, neutrosophic approach to examine gaps in comprehensive healthcare by analyzing the interplay of Health Resource Availability (HRA), Professional Competence of Health Personnel (CPPS), and Accessibility and Response Time (ATR). Traditional statistical methods often fail to capture the uncertainty inherent in healthcare evaluations; this research addresses this by applying neutrosophic set theory to data from a survey of 15 professionals. fuzzy set qualitative comparative analysis (fsQCA) indicates that CPPS is a highly consistent (≈0.98) necessary condition for quality care, with HRA also being a strong necessary condition (≈0.89). As sufficient pathways, HRA individually (consistency ≈0.98, coverage ≈0.89), ATR individually (consistency ≈0.99, coverage ≈0.79), and combinations such as (HRA, CPPS) (consistency ≈0.99, coverage ≈0.86), alongside (HRA,CPPS,ATR), (HRA,ATR), and (CPPS,ATR) (all consistency ≈1.00), demonstrate robust routes to achieving quality care.This research contributes a nuanced understanding of healthcare system deficiencies by effectively managing indeterminacy. Findings suggest policies should enhance CPPS, ensure HRA, improve ATR, and foster their synergistic combinations to improve comprehensive healthcare quality. This work provides a foundation for future neutrosophic-based quality management in complex systems.

Keywords: Neutrosophic Set Theory, Fuzzy Set Qualitative Comparative Analysis (fsQCA), Healthcare Gap Analysis, Comprehensive Healthcare Quality, Configurational Analysis, Health Resource Availability

1. Introduction

Comprehensive quality of care provided by health systems is a guiding principle relative to social welfare, especially given the inequities for accessing such medical care. This study seeks to analyze deficiencies in comprehensive care via neutrosophic set theory, which allows for modeling uncertainty and handling competing evaluations among health professionals' perceptions. The contribution of this study is relative to evaluating where comprehensive care is deficient, with relative importance outcomes being resource availability, professionalism, and accessibility emerging as critical determinants of service quality perception. Deficient service quality has been shown to impact patient satisfaction and clinical outcomes [1], [2]. Therefore, examining this phenomenon will ensure a foundation for proper health policy development. For decades, if not centuries, health systems and health services have evolved—from a mere cure-oriented philosophy to one focusing on comprehensive care and equity, prevention, and rights of all citizens [3]. Yet structural deficiencies and concerns abound—from lack of resources to unreasonable wait times—with developments occurring at the global and regional levels. For example, in Latin America, access to medical services has always been an obstacle [4]. Historically, consistent assessment of deficiencies in comprehensive care has been challenging, indicating the need for innovative approaches.

Despite advances, healthcare systems face a critical problem: the inability to consistently guarantee comprehensive quality care. Professional perceptions, marked by uncertainty and contradictions, complicate the assessment of key factors such as staff competence or service accessibility. Previous studies have addressed these issues, but often with traditional methods that fail to capture the inherent indeterminacy of these systems [5], [6]. This raises a central question: how can neutrosophic sets model the interaction between resource availability, professional competence, and accessibility to improve the quality of comprehensive care? The challenge lies in understanding how these factors, which do not always act linearly, determine the perception of quality in healthcare services. The magnitude of this problem is evident in the widely reported gaps in access and inequalities in health outcomes [7]. The research question seeks to unravel the relationships between these variables and propose evidence-based solutions. This study focuses on a novel approach that transcends the limitations of conventional methods.

This research is significant due to the novelty of the approach taken and how it can be translated into the real world benefitting public health policy. By surveying and analyzing the opinions of professionals in the medical field, the research project highlights the most crucial areas in need of intervention. Yet, relative to the literature reviewed, findings such as increased training for staff and better access systems are championed to improve service. Yet without adequately reliable tools that assess uncertainty, translated intervention efforts fail in certain areas. Thus, using neutrosophic sets as a tool allows professionals to have a consistent way of assessing multiple factors, for the tool considers truth, falsity, and indeterminacy simultaneously. This is especially important in the field of medicine, for as a system, it involves countless variables that change over time, no longer making cause-and-effect analyses effective. Therefore, this research will effectively generate what exceeds human ability and conventional expertise and approaches to render an educated and reliable basis for decision-making in health services.

The aims of the research are related to the question posed and are practically effective. First, the research aims to analyze the relationship between resources available, professional quality of staff, and accessibility/responsiveness to result in comprehensive care quality. Second, it aims to assess which combinations of the above yield better-perceived quality via neutrosophic sets. Ultimately, the research aims to provide practical solutions relative to findings for the improvement of healthcare systems. These three, clearly related to the progression of the article will render findings useful for scholars and practitioners. When comprehensive care deficiencies can be addressed in a new way, it will transform scholarship on healthcare systems worldwide and international attempts at more equitable, more effective treatment.

2. Preliminaries

2.1 Complexity theory, causality, and neutrosophic sets.

Interactions between variables are not always simple; rather, they frequently emerge through intricate, nonlinear patterns, as complexity theory suggests. This perspective tells us that the same cause can lead to divergent outcomes depending on the context in which it manifests. This theory highlights three key principles: conjunction, equifinality, and causal asymmetry [8]. The conjunction principle focuses on the collaboration between antecedent conditions that act together to produce an outcome, rather than operating independently to explain variability. Equifinality, on the other hand, suggests that a system can reach a specific end state through various initial conditions and distinct trajectories.

Causal asymmetry, on the other hand, suggests that while certain conditions can lead to the emergence of an outcome, their absence does not guarantee the absence of that outcome [9].

To illustrate this, consider a restaurant renowned for its high culinary quality. Although this quality may attract numerous customers, the establishment might face low attendance due to factors such as an unfavorable location or parking issues [10]. Conversely, a restaurant with average food might still attract many customers if it offers exceptional service, is in a strategic location, or has attractive entertainment options. This demonstrates that the relationship between variables such as the quality of food, location, and service, and the outcome—i.e., the number of customers—is by no means simple or constant. These principles highlight the complexity and instability in the relationship between conditions and outcomes. Furthermore, neutrosophy brings greater depth to the understanding of complex causality by introducing indeterminacy and uncertainty, which are inherent to social phenomena. Neutrosophic set theory, with its ability to handle indeterminacy, provides a more nuanced perspective for understanding these complex and dynamic relationships [11].

2.2. Neutrosophic Likert scales

Surveys using neutrosophic Likert scales [12, 13, 14] effectively measure the diversity of opinions and their influence on public policy and social discourse, capturing areas of consensus, disagreement, and ambivalence.

Below we present the fundamental definitions and concepts related to neutrosophic sets and single-valued neutrosophic sets.

Definition 1 ([15]). Let U be a discursive universe. $N = \{(x, T(x), I(x), F(x)) : x \in U\}$ is a neutrosophic set, denoted by a truth membership function, $TN : U \rightarrow]0-, 1+[$; an indeterminate membership function, $IN: U \rightarrow]0-, 1+[$; and a falsehood membership function, $FN : U \rightarrow]0-, 1+[$.

Single-valued neutrosophic sets provide a way to represent and analyze possible elements in the universe of discourse U

Definition 2 ([16]). Let U be a discursive universe. A single-valued neutrosophic set is defined as $N = \{(x, T(x), I(x), F(x)) : x \in U\}$, which is identified by a truth membership function, $TN : U \rightarrow [0,1]$; indeterminacy membership function , $IN : U \rightarrow [0, 1]$; and falsehood membership function , $FN : U \rightarrow [0,1], with\ 0 \leq TN(x) + IN(x) + FN(x) \leq 3$

Using neutrosophic scales with single-valued neutrosophic sets, responses are categorized according to the total of the True, Indeterminate, and False components as follows:

- $T + I + F < 1$: Incomplete
- $T + I + F = 1$: Complete
- $T + I + F > 1$: Contradictory

These values are obtained because, in many cases, opinions are incomplete or contradictory. This classification is one of the advantages of using neutrosophic methods, as it allows for a more nuanced understanding of the different degrees of truth, indeterminacy, and falsity in the responses.

2.3 Proposed framework

To begin, it's essential to clearly define the desired outcome: precisely identify and describe the phenomenon, event, or condition you wish to explore. This step is essential because it establishes the approach and framework that will guide the subsequent analysis.

Next, proceed to develop neutrosophic Likert scales. These scales, in contrast to conventional scales that employ a fixed range of values (such as 1 to 5), incorporate additional dimensions of truth, indeterminacy, and falsity. Instead of simple numerical scores, neutrosophic scales use a triplet (T, I, F) for each option, where T represents the degree of truth, I the degree of indeterminacy, and F the degree of falsity. This method allows for a more nuanced and detailed assessment of participants' responses and perceptions.

Next, collect relevant data on the cases under study, using a variety of indicators or measures related to the defined outcome. Data collection must be thorough and accurate so that it adequately reflects the variables being analyzed. Use Neutrosophic Likert scales in questionnaires and surveys to obtain a more complete data set that more accurately captures the complexity of respondents' opinions and attitudes.

This detailed and refined approach ensures a deeper and more accurate interpretation of the results, thus facilitating a comprehensive understanding of the phenomenon in question.

Fuzzification: Finally, the obtained neutrosophic sets are transformed into equivalent fuzzy sets, following the procedure described in [17]. This step is essential for the subsequent analysis, allowing to handle the uncertainty and ambiguity inherent in the collected data. Let $AN = \{x, (TA(x), IA(x), FA(x)) : x \in X\}$an NS. Its equivalent fuzzy membership set is defined as $AF = \{(x, \mu A(x)) : x \in X\}$,where $\mu A(x) = s\left((TA(x), IA(x), FA(x)), (1,0,0)\right)$. Then, using the similarity equation proposed in,

$$\mu A(x) = 1 - \frac{1}{2}[(1 - T_A(x)) + \max\{I_A(x), F_A(x)\}] \quad (1)$$

Since the range of the similarity measure function is the unit interval [0,1], μA (x) ∈ [0,1] for all x ∈ X. Therefore, the membership function of the derived fuzzy set belongs to [0,1] and hence satisfies the property of a fuzzy set (FS) membership function.

1. **Analysis:** Perform fsQCA to identify which combinations of factors or conditions are associated with the presence or degree of the outcome. For data processing, fsQCA for Windows is used [18, 19].

The validity of the configuration is assessed by measuring the consistency and coverage values. Consistency is the measure of how reliably the set of paths produces the desired outcome. Coverage refers to the degree to which the outcome is clarified by this arrangement of paths [20]:

$$Consistency\ (Y_i \leq X_i) = \frac{\sum \min(X_i, Y_i)}{\sum Y_i} \quad (2)$$

$$Coverage\ (Y_i \leq X_i) = \frac{\sum \min(X_i, Y_i)}{\sum X_i} \quad (3)$$

where:

$X_i$is the membership value of case i in the set of causal conditions.

$Y_i$is the membership value of case iii in the result set.

Both are used in comparative analysis to evaluate the relationships between individual conditions, combinations of conditions, track configurations, and outcomes. Generally, values above 0.8 are considered to indicate a strong relationship [20].

3. Results.

The application of neutrosophic sets in health system analysis allows us to address the complexity inherent in this field, where relationships between variables are not always linear and are subject to uncertainty, indeterminacy, and contradictions.

The fundamental principles that stand out are:

- The conjunction: healthcare factors that work together
- Equifinality: Different pathways can lead to similar outcomes in healthcare
- Causal asymmetry: the presence of certain factors does not guarantee a result, nor does their absence exclude it.

Definition of the result

The defined result is the perception of **Quality in Comprehensive Health Care (CAIS)** .

Associated variables

Three main variables were considered:

1. **Health Resource Availability (HRA)** : Access to medical equipment, medications, trained personnel, and other resources needed to provide adequate care.
2. **Professional competence of health personnel (CPPS)** : Level of training, experience, technical skills and updated knowledge of health personnel.
3. **Accessibility and response time (ATR)** : Ease with which patients can access health services and the time it takes to receive care from the moment it is requested.

Data collection

A survey was conducted among 15 healthcare professionals from different healthcare institutions, using neutrosophic Likert scales to capture the different degrees of truth, indeterminacy, and falsity in their perceptions.

Data collected

Table 1. Survey data (neutrosophic values)

Professional	Health Resources Availability (DRS)	Professional Competence of Health Personnel (CPPS)	Accessibility and response time (ATR)	Quality in Comprehensive Health Care (CAIS)
1	(0.7, 0.3, 0.2)	(0.9, 0.2, 0.1)	(0.4, 0.5, 0.3)	(0.6, 0.3, 0.4)
2	(0.5, 0.4, 0.5)	(0.8, 0.3, 0.2)	(0.4, 0.4, 0.5)	(0.5, 0.4, 0.3)
3	(0.3, 0.6, 0.4)	(0.7, 0.2, 0.3)	(0.2, 0.7, 0.6)	(0.4, 0.5, 0.3)
4	(0.8, 0.1, 0.3)	(0.9, 0.1, 0.1)	(0.7, 0.3, 0.2)	(0.8, 0.2, 0.1)
5	(0.2, 0.7, 0.5)	(0.8, 0.2, 0.3)	(0.3, 0.6, 0.4)	(0.3, 0.5, 0.6)
6	(0.6, 0.3, 0.4)	(0.7, 0.3, 0.2)	(0.5, 0.4, 0.5)	(0.6, 0.4, 0.3)
7	(0.9, 0.1, 0.1)	(0.6, 0.4, 0.3)	(0.7, 0.2, 0.2)	(0.8, 0.2, 0.2)
8	(0.4, 0.5, 0.6)	(0.9, 0.1, 0.2)	(0.5, 0.5, 0.4)	(0.6, 0.3, 0.3)
9	(0.5, 0.4, 0.3)	(0.8, 0.2, 0.2)	(0.4, 0.6, 0.3)	(0.5, 0.4, 0.2)
10	(0.7, 0.3, 0.1)	(0.7, 0.3, 0.3)	(0.8, 0.2, 0.1)	(0.7, 0.3, 0.2)
11	(0.3, 0.7, 0.4)	(0.6, 0.3, 0.4)	(0.2, 0.8, 0.5)	(0.4, 0.5, 0.5)
12	(0.8, 0.2, 0.2)	(0.8, 0.3, 0.1)	(0.6, 0.3, 0.3)	(0.7, 0.2, 0.2)
13	(0.4, 0.6, 0.3)	(0.7, 0.2, 0.2)	(0.3, 0.7, 0.4)	(0.5, 0.4, 0.3)
14	(0.6, 0.3, 0.2)	(0.9, 0.1, 0.1)	(0.5, 0.4, 0.3)	(0.7, 0.3, 0.2)
15	(0.2, 0.8, 0.7)	(0.5, 0.5, 0.4)	(0.2, 0.6, 0.7)	(0.3, 0.6, 0.5)

Fuzzification

Applying the formula: $\mu A(x) = 1 - 1/2[(1 - TA(x)) + max\{IA(x), FA(x)\}]$

We obtain the following fuzzy values:

Table 2. Fuzzy values

Professional	**Health Resources Availability (DRS)**	**Professional Competence of Health Personnel (CPPS)**	**Accessibility and response time (ATR)**	**Quality in Comprehensive Health Care (CAIS)**
1	1−0.5×((1−0.7)+max(0.3,0.2))=0.70	1−0.5×((1−0.9)+max(0.2,0.1))=0.85	1−0.5×((1−0.4)+max(0.5,0.3))=0.45	1−0.5×((1−0.6)+max(0.3,0.4))=0.60

Professional	Health Resources Availability (DRS)	Professional Competence of Health Personnel (CPPS)	Accessibility and response time (ATR)	Quality in Comprehensive Health Care (CAIS)
2	1−0.5×((1−0.5)+max(0.4,0.5))=0.50	1−0.5×((1−0.8)+max(0.3,0.2))=0.75	1−0.5×((1−0.4)+max(0.4,0.5))=0.45	1−0.5×((1−0.5)+max(0.4,0.3))=0.55
3	1−0.5×((1−0.3)+max(0.6,0.4))=0.35	1−0.5×((1−0.7)+max(0.2,0.3))=0.70	1−0.5×((1−0.2)+max(0.7,0.6))=0.25	1−0.5×((1−0.4)+max(0.5,0.3))=0.45
4	1−0.5×((1−0.8)+max(0.1,0.3))=0.75	1−0.5×((1−0.9)+max(0.1,0.1))=0.90	1−0.5×((1−0.7)+max(0.3,0.2))=0.70	1−0.5×((1−0.8)+max(0.2,0.1))=0.80
5	1−0.5×((1−0.2)+max(0.7,0.5))=0.25	1−0.5×((1−0.8)+max(0.2,0.3))=0.75	1−0.5×((1−0.3)+max(0.6,0.4))=0.35	1−0.5×((1−0.3)+max(0.5,0.6))=0.35
6	1−0.5×((1−0.6)+max(0.3,0.4))=0.60	1−0.5×((1−0.7)+max(0.3,0.2))=0.70	1−0.5×((1−0.5)+max(0.4,0.5))=0.50	1−0.5×((1−0.6)+max(0.4,0.3))=0.60
7	1−0.5×((1−0.9)+max(0.1,0.1))=0.90	1−0.5×((1−0.6)+max(0.4,0.3))=0.60	1−0.5×((1−0.7)+max(0.2,0.2))=0.75	1−0.5×((1−0.8)+max(0.2,0.2))=0.80
8	1−0.5×((1−0.4)+max(0.5,0.6))=0.40	1−0.5×((1−0.9)+max(0.1,0.2))=0.85	1−0.5×((1−0.5)+max(0.5,0.4))=0.50	1−0.5×((1−0.6)+max(0.3,0.3))=0.65
9	1−0.5×((1−0.5)+max(0.4,0.3))=0.55	1−0.5×((1−0.8)+max(0.2,0.2))=0.80	1−0.5×((1−0.4)+max(0.6,0.3))=0.40	1−0.5×((1−0.5)+max(0.4,0.2))=0.55
10	1−0.5×((1−0.7)+max(0.3,0.1))=0.70	1−0.5×((1−0.7)+max(0.3,0.3))=0.70	1−0.5×((1−0.8)+max(0.2,0.1))=0.80	1−0.5×((1−0.7)+max(0.3,0.2))=0.70
11	1−0.5×((1−0.3)+max(0.7,0.4))=0.30	1−0.5×((1−0.6)+max(0.3,0.4))=0.60	1−0.5×((1−0.2)+max(0.8,0.5))=0.20	1−0.5×((1−0.4)+max(0.5,0.5))=0.45
12	1−0.5×((1−0.8)+max(0.2,0.2))=0.80	1−0.5×((1−0.8)+max(0.3,0.1))=0.75	1−0.5×((1−0.6)+max(0.3,0.3))=0.65	1−0.5×((1−0.7)+max(0.2,0.2))=0.75
13	1−0.5×((1−0.4)+max(0.6,0.3))=0.40	1−0.5×((1−0.7)+max(0.2,0.2))=0.75	1−0.5×((1−0.3)+max(0.7,0.4))=0.30	1−0.5×((1−0.5)+max(0.4,0.3))=0.55
14	1−0.5×((1−0.6)+max(0.3,0.2))=0.65	1−0.5×((1−0.9)+max(0.1,0.1))=0.90	1−0.5×((1−0.5)+max(0.4,0.3))=0.55	1−0.5×((1−0.7)+max(0.3,0.2))=0.70
15	1−0.5×((1−0.2)+max(0.8,0.7))=0.20	1−0.5×((1−0.5)+max(0.5,0.4))=0.50	1−0.5×((1−0.2)+max(0.6,0.7))=0.25	1−0.5×((1−0.3)+max(0.6,0.5))=0.35

Analysis of necessary conditions
An analysis was performed to test the consistency and coverage of each condition:

Table 3. Analysis of necessary conditions

Tested conditions	Consistency	Coverage
Health Resources Availability (DRS)	0.8870	0.9813
Professional Competence of Health Personnel (CPPS)	0.9774	0.7900
Accessibility and response time (ATR)	0.7910	0.9859
Quality in Comprehensive Health Care (CAIS)	1.0000	1.0000

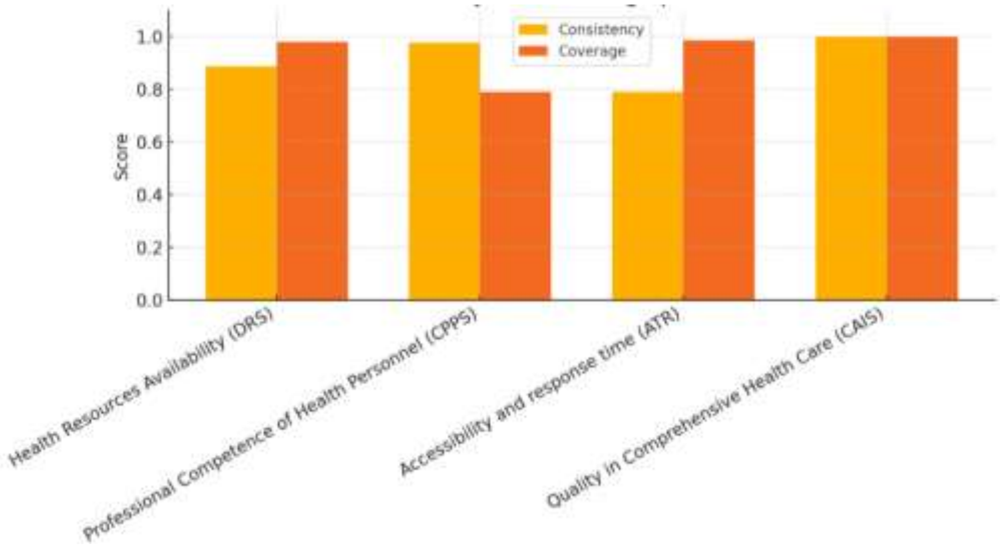

Figure 1. Consistency and coverage levels for each evaluated health system condition.

Further examination of the necessary conditions (Table 3) reveals that "Quality in Comprehensive Health Care (CAIS)," when assessed as a necessary condition for itself as the outcome, yielded perfect scores for both consistency and coverage. Specifically, the consistency for CAIS as a necessary condition for the CAIS outcome was 1.0000, and its coverage was also 1.0000.

A consistency value of 1.0000 in this context signifies that all instances of the outcome (CAIS) are perfectly encompassed by the condition (CAIS). This is theoretically expected, as an outcome is always a perfect subset of itself (Yi≤Yi for all cases i). Similarly, a coverage value of 1.0000 indicates that the condition (CAIS) is entirely "covered" by or relevant to the outcome (CAIS), meaning all instances of the condition are associated with instances of the outcome $(\min \sum(Yi, Yi) = \sum Yi)$.

While these perfect scores confirm the integrity of the calculation when a condition is identical to the outcome, they are analytically trivial to identify distinct, empirically substantive necessary conditions. Such a finding primarily serves as a baseline or a point of methodological self-reference within the fsQCA framework, confirming that an outcome is, by definition, necessary for itself. The interpretation of non-trivial necessary conditions, therefore, relies on evaluating other factors (like DRS, CPPS, and ATR) where consistency values are high but not necessarily 1.0000 due to inherent empirical complexities, and coverage values indicate varying degrees of relevance.

Set matching analysis

Table 4. Set matching analysis

Conditions	Coincidence
DRS, CPPS, ATR	0.4367
DRS, CPPS	0.5133
DRS, ATR	0.4500
CPPS, ATR	0.4567

The set matching analysis shows how the different evaluated conditions are interrelated on average across the cases:

- **DRS, CPPS, and ATR overlap:** The coincidence for the combination of all three factors (Health Resources Availability, Professional Competence of Health Personnel, and Accessibility and Response Time) is 0.4367. This value, being the lowest among the analyzed combinations, indicates a more limited level of average overlap or co-occurrence when all three conditions are considered simultaneously.
- **DRS and CPPS Matching:** The match between Health Resources Availability (DRS) and Professional Competence of Health Personnel (CPPS) is 0.5133. This is the highest value among all evaluated combinations, suggesting that, on average, the co-occurrence of adequate resources and competent professionals is the most pronounced among the analyzed interactions.
- **DRS and ATR agreement:** The combination of Health Resources Availability (DRS) and Accessibility and Response Time (ATR) shows a coincidence of 0.4500. This value indicates the average level of overlap between these two factors.
- **CPPS and ATR Match:** The match between Professional Competence of Health Personnel (CPPS) and Accessibility and response time (ATR) is 0.4567. This value is slightly higher than that for the DRS and ATR combination, suggesting a similar degree of average co-occurrence between the presence of well-trained professionals and accessible services.

These Coincidence values offer a perspective on the extent to which these conditions tend to present together in the studied cases. The combination of Health Resources Availability (DRS) and Professional Competence (CPPS) demonstrates the greatest average overlap.

Subset/ Superset Analysis

Table 5. Results of the subset/ superset analysis

Terms (Términos X)	Consistency (Consistencia X→Y)	Coverage (Cobertura X→Y)	Set (Media)
DRS, CPPS, ATR	1	0.7399	0.87
DRS, CPPS	0.9935	0.8644	0.929
DRS, ATR	1	0.7627	0.8814
CPPS, ATR	1	0.7739	0.887
DRS	0.9813	0.887	0.9342
CPPS	0.79	0.9774	0.8837
ATR	0.9859	0.791	0.8885

The subset/superset analysis provides insights into the consistency and coverage of different conditions and their combinations as sufficient paths to achieving quality in comprehensive health care (CAIS).

- **Combinations of Conditions leading to CAIS:**
    - The combinations of (DRS, CPPS, ATR), (DRS, ATR), and (CPPS, ATR) all demonstrate perfect consistency (1.0000) in leading to the outcome. This indicates that when these

combinations of conditions are present at high levels, quality in comprehensive health care is also consistently achieved at high levels. Their respective coverage values are substantial (0.7399 for DRS, CPPS, ATR; 0.7627 for DRS, ATR; and 0.7739 for CPPS, ATR), signifying that these multi-condition pathways account for a considerable portion of the instances of high-quality care.
    - The combination of (DRS, CPPS) also shows exceptionally high consistency (0.9935) and strong coverage (0.8644), marking it as a very reliable pathway to quality care that explains a large part of the outcome.
- **Individual Conditions leading to CAIS:**
    - Health Resources Availability (DRS) as an individual path exhibits very high consistency (0.9813) and high coverage (0.8870). This positions DRS alone as a robust and empirically important pathway towards achieving quality comprehensive health care.
    - Accessibility and Response Time (ATR) also demonstrates very high consistency (0.9859) as a sufficient condition, with good coverage (0.7910), reinforcing its importance in producing the outcome.
    - Professional Competence of Health Personnel (CPPS), when considered as a sole sufficient condition, shows a lower consistency (0.7900) compared to DRS and ATR. However, it has the highest coverage (0.9774) among all individual and combined terms, indicating that while high CPPS alone doesn't guarantee high CAIS in every instance, its presence (or variations in it) accounts for the largest proportion of the outcome's instances.

The gap analysis in comprehensive health care, using neutrosophic set theory and the parameters, has yielded significant findings:

- From the necessity analysis (Table 3), **Professional Competence of Health Personnel (CPPS)** emerges as a highly crucial necessary condition (consistency ≈ 0.9774) for achieving quality care. This underscores the fundamental importance of robust training, continuous professional development, and maintaining high standards for healthcare personnel. **Health Resources Availability (DRS)** also stands out as a strong necessary condition (consistency ≈ 0.8870).
- From the sufficiency analysis Table 5), it is evident that multiple pathways can consistently lead to high-quality comprehensive care. Notably, **Health Resources Availability (DRS)** on its own is a highly consistent and broadly covering sufficient condition.
- Combinations of conditions, such as **(DRS, CPPS)**, exhibit very high consistency and coverage as sufficient paths. Furthermore, the combinations **(DRS, CPPS, ATR)**, **(DRS, ATR)**, and **(CPPS, ATR)** achieve perfect consistency in leading to the outcome, with substantial coverage, indicating that these multifaceted interactions are particularly powerful in fostering quality care.
- While **Accessibility and Response Time (ATR)** is a highly consistent sufficient condition on its own, and a moderately consistent necessary one with very high coverage as a necessary factor, its role is often synergistic with other conditions.
- The **Professional Competence of Health Personnel (CPPS)**, while paramount as a necessary condition, shows lower consistency as an individual sufficient path compared to DRS or ATR. However, its extremely high coverage as a sufficient path suggests its pervasive relevance in explaining the outcome.

These findings suggest that health system improvement policies should focus on a multi-pronged strategy:

- Continue to strengthen training, continuous updating programs, and competency frameworks for all healthcare personnel, recognizing CPPS as a near-perfect necessary condition.
- Prioritize ensuring high **Health Resources Availability (DRS)**, as it functions as a strong necessary condition and a highly consistent individual pathway to quality care.
- Enhance **Accessibility and Response Time (ATR)**, given its high consistency as a sufficient condition and its very high coverage as a necessary factor.
- Foster the combined presence of these conditions, particularly ensuring that available resources are complemented by competent staff (DRS and CPPS), and that professional competence is supported by accessible systems (CPPS and ATR), as these combinations demonstrate very high (often perfect) consistency in achieving quality outcomes.

The use of neutrosophic sets has made it possible to capture the inherent complexity of the health system, where the relationships between factors are nonlinear and subject to uncertainty and indeterminacy. This methodology, when applied with consistently derived data, offers a valuable tool for analyzing gaps and guiding evidence-based health policies.

4. Conclusions

This study, employing a neutrosophic set-based gap analysis of comprehensive healthcare, reveals critical insights based on parameters. The **professional competence of health personnel (CPPS)** stands out as an exceptionally strong necessary condition (consistency ≈ 0.98) for quality care. **Health Resources Availability (DRS)** also demonstrates high consistency as a necessary condition (≈ 0.89), and both DRS and **Accessibility and Response Time (ATR)** show very high empirical relevance (coverage ≈ 0.98) as necessary factors.

In terms of sufficiency, the analysis indicates that multiple pathways can consistently lead to high-quality comprehensive care. **DRS** as an individual condition (consistency ≈ 0.98, coverage ≈ 0.89) and the combination of **(DRS, CPPS)** (consistency ≈ 0.99, coverage ≈ 0.86) emerge as particularly robust sufficient pathways. Furthermore, combinations such as **(DRS, CPPS, ATR)**, **(DRS, ATR)**, and **(CPPS, ATR)** achieve perfect (1.0000) or near-perfect consistency as sufficient configurations, highlighting the power of these synergistic interactions, albeit with varying degrees of coverage explaining the outcome. While CPPS alone shows lower consistency for sufficiency (≈ 0.79), its remarkably high coverage (≈ 0.98) underscores its pervasive influence in accounting for instances of quality care.

These findings suggest that policies aimed at improving comprehensive healthcare should prioritize enhancing CPPS due to its critical necessity, ensuring robust DRS which is strong for both necessity and sufficiency, and improving ATR, which is a highly consistent sufficient condition and a highly relevant necessary factor. Strategic focus on the effective combination of these elements is also paramount. The application of neutrosophic set theory proved valuable in this context, adeptly managing the inherent uncertainties and ambiguities in expert assessments within complex healthcare systems.

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