Fuzzy logic and its application in homoeopathic repertory

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Abstract

The increasing use of mathematics, engineering, data science and machine learning in healthcare and medical profession have improved accuracy and precision of decision making in clinical practice. Healthcare and disease models have helped this fraternity to enhance public outreach and health coverage. Fuzzy logic and neural networking are commonly use techniques in medical sciences and homoeopathy is not exception to this. The present study evaluated the patients response based on fuzzy calculations to determine the association and nonassociation of drug and symptoms with each other for creating more accurate gradation system for rubrics and to minimize the ambiguity that arises because of many confounding factors while selecting the remedy. Use of this technique had reduced time while selecting a rubric. Homoeopathy is an altenative and complementary medicine regularized by Ministry of AYUSH, Govt. of India. This is a holistic system of medicine based on certain natural laws of therapeutics. Repertory is like a dictionary or index of homeopathic medicines helps the physician in right remedial diagnosis. Many computer aided repertories have evolved in due course of time but the accuracy of the clinical judgment didn't improve. Fuzzy logic helped to accurately grade the remedies and symptoms with definite mathematical coefficient.

Key words: Fuzzy logic, Repertory, Homoeopathy, Rubrics, Members, Nonmembers

Introduction

Law of simplex is one of the cardinal principles of homeopathy. While choosing the remedy the law and principles involving in this process are definite and verifiable. However, their relevance to every individual case is a multifarious issue. The homeopathic repertory categorizes the information of remedies [1, 2, 3, and 4]. A choice made by Homeopath is highly reliant on the eminence of selected rubrics. The problem is that proving of various remedies are not complete and the same degree of remedies does not have similar meaning [5, 6]. Fuzzy logic is an artificial intelligence technique which is analogous to human thought process. The methods not only have several if-then rules, but also use from system with degree of association. After completion of mechanical repertorization, some automated decision systems are necessary to advocate the concluding single homeopathic remedy i.e. simillimum. This technique is helpful in determination of symptoms of the patient and their associations/non-association to his/her by routine case taking. Fuzzy logic complex can decipher to select a single medicine by priority of the symptoms not by the diseases for any patient. This study aims at accurate decision for selection of suitable remedy in Homeopathy using fuzzy logic [7]. Kharal et al, 2009 proposed the associations and non-associations of a drug with a given symptom through intuitionistic fuzzy sets (IFS). The author further concluded that a repertory of homeopathic symptoms and medicines is one of the most important sources of the practice and research in this science. For

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this purpose, IFS theory has been used to adapt Sanchez's approach for homeopathic drug selection.Kar et al, 2012 stated that to establish Homeopathy as a true science at par with others, systematization and standardization are prerequisites. Simultaneous usage of main terms of informational granulation and neural networks gives a bunch of new possibilities in designing of the mentioned specialized neural network. The fuzzy system can be qualified using selected rubrics to decrease the execution time while decision making for choice of single remedy.The objective of this study was to demonstrate the associations and non-associations of a homoeopathic remedies with a given symptom using intuitionistic fuzzy sets, to assess the impact of Sanchez's approach on decision making for selection of single remedy and to investigate rubrics and select the most useful ones sensitive to terms that a patient express while applying fuzzy expert system.

Materials and Methods

Study Design

This is an observational study type with 30 patients (Cases) enrolled in an cohort model with cross-sectional- retrospective time perspective.

Selection of patients (cases)

Inclusion criteria

1. Patient (case) in which detailed symptoms were recorded as per standard homoeopathic case taking proforma of hospital or research center.
2. Qualified symptoms which were likely to be converted to rubrics after detailed analysis for allocating degrees of associations and nonassociations.
3. Cases recorded in year October 2017 to September 2018 (1year) were included.

Exclusion criteria

1. Redundant case records.
2. Cases which were not repertorized.
3. Cases having prescription of multiple homoeopathic medicines

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Data Collection

Records of previous one year before commencement of the study were taken according to eligibility criteria as defined above. Actual clinical events were to be collected and scrutinized.

1. Data obtained**:**Case reports (patients)
2. Types of data were to be collected: Symptoms, errors, adverse events, near misses, non-routine events, routine events
3. Method of entering data: Computer devices

Primary steps for selection and elimination of rubrics

1. Two methods for selection of remedy: "Summation" and "Elimination".
2. In summation method homeopath assigned intensity to each selected rubric and degree of remedies of the rubric was multiplied by the determined intensity.
3. Ultimately, the product results were added to create index for each remedy.
4. For determining a remedy, the observer (homoeopath) searched in remedies with greater index to find the best simillimum.
5. In elimination method, a rubric which was big & solid, and everyone were to be agreed on what was selected i.e. it should have been an objective rubric and not subjective.
6. The selected rubrics were to be eliminated after their selection.

Final Steps for data analysis

1. Determination of symptoms of the patient and their associations/non-association.
2. Codification of homeopathic knowledge as an Intuitionistic Fuzzy Relation.
3. Determination of patient-drug relational strength through composition of intuitionistic fuzzy relations.
4. Computation of selection index SK for the final decision.

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Statistical/ Mathematical Analysis

All the mathematical analysis was performed using 'intuitionistic fuzzy sets' and by suitable computational methods. The score was generated for defining the association and non-association between symptoms, rubrics and remedies.

Results

Baseline Characteristics of the cohort

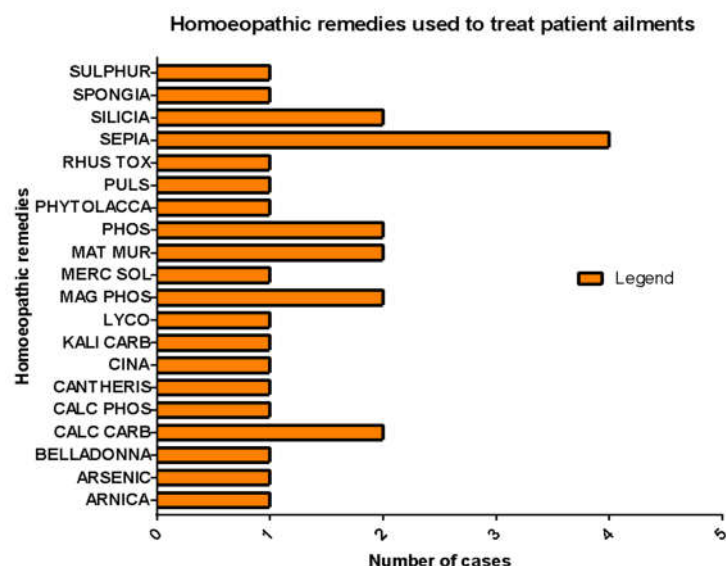The mean age of the study cohort was 26.7 (12.6) and there were total 12 (40%) males and 18 (60%) females.

Figure 1: Homoeopathic remedies used in retrospective patient cohort

Outcome measures:

Associations and non-associations of homoeopathic remedies with a given symptom using intuitionistic fuzzy sets:

The primary endpoint of the study was to calculate the members and non members for the each symptom for a particular remedy. The details are given in table1.

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Remedies (D)	Symptoms (S)			
	MIND – DULLNESS		MIND – IRRITABILITY	
	Members	Nonmembers	Members	Nonmembers
Arnica	0.7	0.1	0.8	0.2
Ars alb	0.7	0.1	0.7	0.2
Bry	0.6	0.3	0.5	0.2
Bell	0.5	0.3	0.7	0.2
Calc carb	0.5	0.5	0.6	0.3
Calc phos	0.9	0	0.5	0.4
Cantheris	0.7	0.1	0.7	0.3
Cina	0.5	0.4	0.8	0.1
Kali carb	0.2	0.4	0.9	0.1
Lyco	0.5	0.2	0.7	0.1
Mag phos	0.5	0.3	0.6	0.2
Merc sol	0.6	0.3	0.5	0.5
Nat mur	0.4	0.6	0.9	0
Phos	0.5	0.5	0.6	0.4
Phytolacca	0.1	0.8	0.5	0.4
Puls	0.4	0.5	0.8	0.2
Rhus tox	0.4	0.4	0.8	0.1
Sabadilla	0.5	0.5	0.4	0.3
Sepia	0.6	0.3	0.5	0.5
Silicia	0.6	0.4	0.3	0.7
Spongia	0.5	0.3	0.7	0.2
Sulph	0.4	0.6	0.6	0.3
AVERAGE	0.5	0.3	0.6	0.3

Table1. Members and nonmembers classified according symptoms and drugs.

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Resolving patient-drug relational strength through opus of intuitionistic fuzzy relations (IFR):

The case was repertorized using RADAR Version 10.0 software. Following rubrics were considered,

s_1 = [Synthesis] [Mind] DULLNESS

s_2 = [Synthesis] [Mind] IRRITABILITY

Normal repertorization gave the following 22 drugs as, the most likely to be indicated: Arn, Ars. Alb, Bry, Bell, Cal carb, Cal phos, cantharis, sena, kali carb, lyco, mag phos, mer sol, natrum mur, phos, phytolacca, puls, rhust tox, sabadilla, sepia, silicia, spongia and sulphur. The IFR from S to D of homeopathic knowledge is denoted as K_{SD}. The details of the IFR K_{SD} (IHK) are given in table 2.

	Arnica		Ars alb		Bry		Bell		Calc carb		Calc phos		Cantheris		Cina		Kali carb		Lyco		Mag phos		Merc sol		Nat mur		Phos		Phyto. D.		Puls		Rhus tox		Sabadilla		Sepia		Silicia		Spongia		Sulph	
	M	NM	M	NM	M	NM	M	NM	M	NM	M	NM	M	NM	M	NM	M	NM	M	NM	M	NM	M	NM	M	NM	M	NM	M	NM	M	NM	M	NM	M	NM	M	NM	M	NM	M	NM	M	NM
S1	0.7	0.1	0.7	0.1	0.6	0.3	0.5	0.3	0.5	0.5	0.9	0	0.7	0.1	0.5	0.4	0.2	0.4	0.5	0.2	0.5	0.3	0.6	0.3	0.4	0.6	0.5	0.5	0.1	0.8	0.4	0.5	0.4	0.4	0.5	0.5	0.6	0.3	0.6	0.4	0.5	0.3	0.4	0.6
S2	0.8	0.2	0.7	0.2	0.5	0.2	0.7	0.2	0.6	0.3	0.5	0.4	0.7	0.3	0.8	0.1	0.9	0.1	0.7	0.1	0.6	0.2	0.5	0.5	0.9	0	0.6	0.4	0.5	0.4	0.8	0.2	0.8	0.1	0.4	0.3	0.5	0.5	0.3	0.7	0.7	0.2	0.6	0.3

Table No. 2 The IFR K_{SD} (IHK), [M, Membership; N, Nonmembership]

Knowledge applied to Case (KoC):

The max-min-max or max-average composition R_{PD} of C_{PS} with the IFR K_{SD} denoted by $R = KoC$ Result (R) = Knowledge applied to Case signifies the patient-drug relation as an IFS on D with the membership and nonmembership functions, respectively, given by $\forall d \in D$. The details of $R=KoC$ is given in Table 3.

Arnica	Ars alb	Bry	Bell	Calc carb	Calc phos	Cantheris	Cina	Kali carb	Lyco	Mag phos	Merc sol	Nat mur	Phos	Phyto. D.	Puls	Rhus tox	Sabadilla	Sepia	Silicia	Spongia	Sulph

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M/NM	Value
M	0.4
NM	0.2
M	0.4
NM	0.2
M	0.3
NM	0.3
M	0.4
NM	0.3
M	0.3
NM	0.5
M	0.5
NM	0.4
M	0.4
NM	0.3
M	0.4
NM	0.4
M	0.5
NM	0.4
M	0.4
NM	0.2
M	0.3
NM	0.3
M	0.3
NM	0.5
M	0.5
NM	0.6
M	0.3
NM	0.5
M	0.3
NM	0.8
M	0.4
NM	0.5
M	0.4
NM	0.4
M	0.3
NM	0.5
M	0.3
NM	0.5
M	0.3
NM	0.7
M	0.4
NM	0.3
M	0.3
NM	0.6

Table No. 3: Using max-average composition, $R = KoC$ is computed as, [M, Membership; N, Nonmembership]

Computation of selection index SK for the final decision:

The first and second selection index indicates towards use of Arnica in cases with the two symptoms, as along with the consideration of totality of symptoms; whereas the third selection index indicates the prioritizing of Nat. mur. and phytolacca decandra, which can be used as the indicated remedy when the cases include the above two symptoms. The index was computed using the formulas for the final decision on homoeopathic remedy. The details of computation of selection index S_K is given Table 4.

	Arnica	Ars alb	Bry	Bell	Calc carb	Calc phos	Cantheris	Cina	Kali carb	Lyco	Mag phos	Merc sol	Nat mur	Phos	Phyto. D.	Puls	Rhus tox	Sabadilla	Sepia	Silicia	Spongia	Sulph
Ski1	0.2	0.15	0	0.05	-0.2	0.05	0.05	0	0.05	0.15	0	-0.2	-0.15	-0.2	-0.55	-0.1	0	-0.25	-0.2	-0.4	0.05	-0.3
Ski2	0.3	0.25	0.15	0.2	0.05	0.25	0.2	0.2	0.25	0.25	0.15	0.05	0.15	0.05	-0.15	0.15	0.2	0	0.05	-0.05	0.2	0
Ski3	0.3	0.275	0.3	0.325	0.4	0.425	0.325	0.4	0.425	0.275	0.3	0.4	0.525	0.4	0.525	0.45	0.4	0.375	0.4	0.5	0.325	0.45

Table 4: $Sk_i = 1, 2, 3$ are as follows

Discussion

The design had cross-sectional retrospective approach. Initially 55 case records were screened and conscription of 30 cases was done on the basis of eligibility criteria. Cases recorded in year

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October 2017 to September 2018 (1year) were included. The primary objective of this study was to demonstrate the associations and non-associations of homoeopathic remedies with a given symptom using intuitionistic fuzzy sets. While secondary objectives were to assess the impact of Sanchez's approach on decision making for selection of single remedy and to investigate rubrics and select the most useful ones as homeopathy is very sensitive to terms that a patient expresses while applying fuzzy expert system. After demonstrating the degree of association and nonassociation, the product results were added to create index for each remedy and remedies with greater index were found the best simillimum. One similar study had shown comparable outcome based on IFS, which resulted in to deciding calcarea carb as a chosen drug. The study decided members and nonmembers for total of six symptoms and out of ten drugs (Calc-c; Puls; Lyc; Am-c; Nux-v; Sil; Sep; Sulph; Cham; Con), Cal-C was selected with utmost conviction. This study was totally based on Sachez's intuitionistic fuzzy sets and computed intuitionistic fuzzy relations and selection index for every remedy. The Kent and Boricke repertories for comparison and analysis were used [8]. This study also calculated members and nonmembers for all 22 remedies for 2 symptoms namely dullness and irritability and finally calculated selection index prioritizing the Arnica, natrummur and phytolacca as indicated remedies. The retrospective observational study design was a limitation for additional hesitation calculation and similarly the selection bias also cannot be ruled out. There was lot of variation at baseline parameters preventing homogeneity of the data and outcome. This study definitely serves as harbinger for all future studies for evaluation of exact scores and finding the similimum.

Conclusion

The homoeopathic repertory presents us with a number of remedies with their varying gradation for a particular rubric. The appropriateness to select any remedy has to be determined with the help of totality of symptoms but the preciseness to select the similimum can be achieved using the tool of IFS. As repertory is the tool helping to reaching the close coming remedies but the final selection of similimum always depends on the various factors and the totality, the modified Sanchez technique and the three-way symptom index formulae model can be a tool to develop a more reliable process in selection of similimum.

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