

InterCriteria Analysis applied to the Turkish Health and Social Protection datasets

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Abstract: In the current investigation InterCriteria Analysis is applied to the main diseases declared by individuals in 15-and-over age group in the last 12 months. The information is downloaded from the website of TurkStat – Turkish Statistical Institute. The received outcomes present dependencies between the distribution of the health problems in Turkey and their frequency in the years.

Keywords: InterCriteria Analysis, Index Matrix, Intuitionistic fuzzy sets, Health Problems, Diseases.

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1 Introduction to InterCriteria Analysis (ICA) and Turkish Health and Social Protection datasets

InterCriteria Analysis investigates dependencies between two or more criteria on the base of values relations for these criteria. In the other case ICA can determine the behavior between some objects according to their historical data. ICA is introduced in [3, 4]. ICA combines the methodologies of the intuitionistic fuzzy sets [1, 5] and index matrices [2]. The structure of information is presented in the form of index matrix. The intuitionistic fuzzy pairs, based on the intuitionistic fuzzy evaluations, are defined using the theory of intuitionistic fuzzy sets. The survey on theory and applications of ICA is presented in [7]. In the recent years the ICA is applied in different areas of interest to determine possible relationships between the data – education, medicine and healthcare, economics and finances, artificial intelligence [6, 8, 10 – 11].

In the current investigation ICA is applied to the main diseases declared by individuals in 15-and-over age group in the last 12 months in the Turkish Health and Social Protection Datasets. The information is downloaded from the website of TurkStat – Turkish Statistical Institute [13]. The dataset is preprocessed to remove the diseases containing missing data – Arthrosis, Kidney Problems, Alzheimer and High blood lipids (high cholesterol or triglycerides). The preprocessed data is presented in the Table 1.

Table 1. Input data for the percentage of main diseases/health problems declared by individuals in 15+ age group in the last 12 months, 2008–2019, after a preprocessing step

[15+ age]	2008	2010	2012	2014	2016	2019
Low back disorders (lumbago, back hernia, other back deflections)	22.5	16.4	12.8	33.0	27.1	29.7
High blood pressure (hypertension)	14.8	13.2	13.2	16.1	15.8	16.4
Neck disorders (neck pain, neck hernia, other neck deflections)	11.5	7.8	6.0	21.3	18.1	20.5
Allergy , such as rhinitis, eye inflammation, dermatitis, food allergy or other (allergic asthma excluded)	7.8	6.4	3.7	12.1	10.8	12.3
Diabetes	5.9	6.2	6.8	9.0	9.1	10.2
Asthma (allergic asthma included)	4.8	5.2	5.1	7.9	7.8	8.9
Coronary heart disease (angina pectoris, chest pain, spasm)	6.3	4.7	4.4	8.5	6.5	7.2
Chronic obstructive pulmonary disease (Chronic bronchitis, emphysema)	2.2	4.4	3.0	7.7	7.3	7.1
Urinary incontinence , problems in controlling the bladder	4.6	3.2	2.4	7.5	5.9	7.8
Depression	4.1	2.8	2.1	11.0	7.2	9.0
Myocardial infarction (heart attack)	1.9	1.2	1.0	2.0	2.1	2.2
Stroke (cerebral haemorrhage, cerebral thrombosis)	1.1	1.1	0.9	0.8	0.9	0.8
Cirrhosis of the liver , liver dysfunction	1.1	0.5	0.4	1.6	1.5	1.6

The presented dataset is used to investigate the main diseases tendencies in the years. Dependencies between the separate health problems are analyzed. The results present the connection between the main diseases and their appearance in the years.

2 Application of the ICA over the health problems datasets in Turkey

The ICA is applied to the Turkish main diseases datasets using the ICrADa software [9]. The first investigation determines dependencies between the health problems. In the application of the Intercriteria Analysis by Diseases, the following abbreviations are used:

- **C01** – Low back disorders (lumbago, back hernia, other back defections);
- **C02** – High blood pressure (hypertension);
- **C03** – Neck disorders (neck pain, neck hernia, other neck defections);
- **C04** – Allergy, such as rhinitis, eye inflammation, dermatitis, food allergy or other (allergic asthma excluded);
- **C05** – Diabetes;
- **C06** – Asthma (allergic asthma included);
- **C07** – Coronary heart disease (angina pectoris, chest pain, spasm);
- **C08** – Chronic obstructive pulmonary disease (Chronic bronchitis, emphysema);
- **C09** – Urinary incontinence, problems in controlling the bladder;
- **C10** – Depression;
- **C11** – Myocardial infarction (heart attack);
- **C12** – Stroke (cerebral hemorrhage, cerebral thrombosis);
- **C13** – Cirrhosis of the liver, liver dysfunction.

The results for the degrees of memberships and the degrees of non-memberships are presented in the Table 2 and Table 3. The degrees of memberships and the degrees of non-membership form the intuitionistic fuzzy pairs, representing dependencies and independencies between the health problems.

Table 2. Degrees of memberships between the health problems data

μ -table	C01	C02	C03	C04	C05	C06	C07	C08	C09	C10	C11	C12	C13
C01	1.00	0.87	1.00	0.93	0.67	0.80	1.00	0.80	0.93	1.00	0.87	0.13	0.93
C02	0.87	1.00	0.87	0.93	0.73	0.80	0.87	0.67	0.93	0.87	0.87	0.07	0.87
C03	1.00	0.87	1.00	0.93	0.67	0.80	1.00	0.80	0.93	1.00	0.87	0.13	0.93
C04	0.93	0.93	0.93	1.00	0.73	0.87	0.93	0.73	1.00	0.93	0.93	0.13	0.93
C05	0.67	0.73	0.67	0.73	1.00	0.87	0.67	0.73	0.73	0.67	0.80	0.07	0.67
C06	0.80	0.80	0.80	0.87	0.87	1.00	0.80	0.87	0.87	0.80	0.80	0.07	0.80
C07	1.00	0.87	1.00	0.93	0.67	0.80	1.00	0.80	0.93	1.00	0.87	0.13	0.93
C08	0.80	0.67	0.80	0.73	0.73	0.87	0.80	1.00	0.73	0.80	0.67	0.13	0.73
C09	0.93	0.93	0.93	1.00	0.73	0.87	0.93	0.73	1.00	0.93	0.93	0.13	0.93
C10	1.00	0.87	1.00	0.93	0.67	0.80	1.00	0.80	0.93	1.00	0.87	0.13	0.93
C11	0.87	0.87	0.87	0.93	0.80	0.80	0.87	0.67	0.93	0.87	1.00	0.20	0.87
C12	0.13	0.07	0.13	0.13	0.07	0.07	0.13	0.13	0.13	0.13	0.20	1.00	0.20
C13	0.93	0.87	0.93	0.93	0.67	0.80	0.93	0.73	0.93	0.93	0.87	0.20	1.00

Table 3. Degrees of non-memberships between the main diseases data

ν -table	C01	C02	C03	C04	C05	C06	C07	C08	C09	C10	C11	C12	C13
C01	0.00	0.07	0.00	0.07	0.33	0.20	0.00	0.20	0.07	0.00	0.13	0.67	0.00
C02	0.07	0.00	0.07	0.00	0.20	0.13	0.07	0.27	0.00	0.07	0.07	0.67	0.00
C03	0.00	0.07	0.00	0.07	0.33	0.20	0.00	0.20	0.07	0.00	0.13	0.67	0.00
C04	0.07	0.00	0.07	0.00	0.27	0.13	0.07	0.27	0.00	0.07	0.07	0.67	0.00
C05	0.33	0.20	0.33	0.27	0.00	0.13	0.33	0.27	0.27	0.33	0.20	0.73	0.27
C06	0.20	0.13	0.20	0.13	0.13	0.00	0.20	0.13	0.13	0.20	0.20	0.73	0.13
C07	0.00	0.07	0.00	0.07	0.33	0.20	0.00	0.20	0.07	0.00	0.13	0.67	0.00
C08	0.20	0.27	0.20	0.27	0.27	0.13	0.20	0.00	0.27	0.20	0.33	0.67	0.20
C09	0.07	0.00	0.07	0.00	0.27	0.13	0.07	0.27	0.00	0.07	0.07	0.67	0.00
C10	0.00	0.07	0.00	0.07	0.33	0.20	0.00	0.20	0.07	0.00	0.13	0.67	0.00
C11	0.13	0.07	0.13	0.07	0.20	0.20	0.13	0.33	0.07	0.13	0.00	0.60	0.07
C12	0.67	0.67	0.67	0.67	0.73	0.73	0.67	0.67	0.67	0.67	0.60	0.00	0.67
C13	0.00	0.00	0.00	0.00	0.27	0.13	0.00	0.20	0.00	0.00	0.07	0.67	0.00

The results of ICA application over the datasets for main diseases/health problems declared by individuals in the 15+ age group in the last 12 months from the Turkish Health and Social Protection Datasets are presented in Table 4. According to the distribution of the degrees of positive consonance, dissonance and negative consonance, proposed in [3], there are:

- 7 pairs of main diseases in strong positive consonance,
- 33 pairs of health problems in positive consonance,
- 12 pairs of main diseases in weak positive consonance,
- 14 pairs of health problems in weak dissonance,
- 2 pairs of main diseases in weak negative consonance, and
- 10 pairs of health problems in negative consonance.

Table 4. Results for the main diseases dependencies of the people in Turkey

Type of correlations	Number of pairs of criteria
strong positive consonance [0.95; 1.00]	7
positive consonance[0.85; 0.95)	33
weak positive consonance [0.75; 0.85)	12
weak dissonance [0.67; 0.75)	14
dissonance [0.57; 0.67)	-
strong dissonance [0.43; 0.57)	-
dissonance [0.33; 0.43)	-
weak dissonance [0.25; 0.33)	-
weak negative consonance [0.15;0.25)	2
negative consonance [0.05;0.15)	10
strong negative consonance [0.00;0.05]	-

According to the obtained outcomes the pairs of health problems in strong positive consonance, positive consonance and weak positive consonance present similar distribution of the main diseases registration. The pairs of health problems in weak dissonance determine the neutral behavior each other. Pairs of main diseases in weak negative consonance and negative consonance have the opposite properties of the health problems distribution among the people in Turkey.

The pairs of health problems in strong positive consonance are:

- **Low back disorders** (lumbago, back hernia, other back defections) – **Allergy**, such as rhinitis, eye inflammation, dermatitis, food allergy or other (allergic asthma excluded);
- **Low back disorders** (lumbago, back hernia, other back defections) – **Chronic obstructive pulmonary disease** (Chronic bronchitis, emphysema);
- **Allergy**, such as rhinitis, eye inflammation, dermatitis, food allergy or other (allergic asthma excluded) – **Chronic obstructive pulmonary disease** (Chronic bronchitis, emphysema);
- **Allergy**, such as rhinitis, eye inflammation, dermatitis, food allergy or other (allergic asthma excluded) – **Depression**;
- **Low back disorders** (lumbago, back hernia, other back defections) – **Myocardial infarction** (heart attack);
- **Allergy**, such as rhinitis, eye inflammation, dermatitis, food allergy or other (allergic asthma excluded) – **Myocardial infarction** (heart attack);
- **Coronary heart disease** (angina pectoris, chest pain, spasm) – **Myocardial infarction** (heart attack).

The pairs of health problems in negative consonance are:

- **Low back disorders** (lumbago, back hernia, other back defections) – **Cirrhosis of the liver**, liver dysfunction
- **High blood pressure** (hypertension) – **Cirrhosis of the liver**, liver dysfunction;
- **Neck disorders** (neck pain, neck hernia, other neck defections) – **Cirrhosis of the liver**, liver dysfunction;
- **Allergy**, such as rhinitis, eye inflammation, dermatitis, food allergy or other (allergic asthma excluded) – **Cirrhosis of the liver**, liver dysfunction;
- **Diabetes** – **Cirrhosis of the liver**, liver dysfunction;
- **Asthma** (allergic asthma included) – **Cirrhosis of the liver**, liver dysfunction;
- **Coronary heart disease** (angina pectoris, chest pain, spasm) – **Cirrhosis of the liver**, liver dysfunction;
- **Chronic obstructive pulmonary disease** (Chronic bronchitis, emphysema) – **Cirrhosis of the liver**, liver dysfunction;
- **Urinary incontinence**, problems in controlling the bladder – **Cirrhosis of the liver**, liver dysfunction;
- **Depression** – **Cirrhosis of the liver**, liver dysfunction;
- **Myocardial infarction** (heart attack) – **Cirrhosis of the liver**, liver dysfunction;

Obviously, there are dependencies between the main diseases in strong positive consonance. The health problems have similar distribution. The outcomes for the main diseases in negative consonance present opposite behavior of the health problems distribution according to the main disease *Cirrhosis of the liver, liver dysfunction*. The exception is the health problem *Stroke (cerebral hemorrhage, cerebral thrombosis)*.

The results of the ICA application to the health problem datasets in Turkey are presented in the following Figure 1.

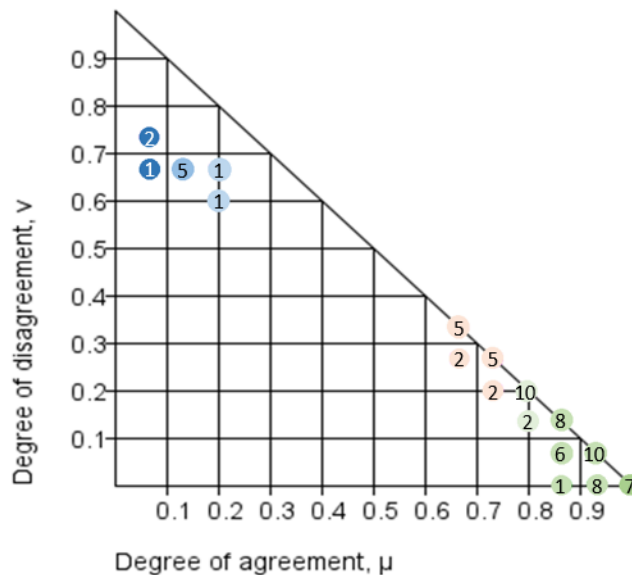


Figure 1. Results for health problems dependencies interpreted in the intuitionistic fuzzy triangle

The ICA is also applied to the main diseases datasets in Turkey to investigate the tendencies of the health problems distribution in the years. In the ICrADa software option *Transpose* is used to transpose the matrices of data and thus ICA analyzes the input datasets by years.

In Table 5 and Table 6 are presented the degrees of membership and the degrees of non-membership between the years in a pairwise manner.

Table 5. Degrees of memberships between the pairs of years

μ -table	2008	2010	2012	2014	2016	2019
2008	1.00	0.94	0.87	0.90	0.88	0.90
2010	0.94	1.00	0.94	0.90	0.94	0.90
2012	0.87	0.94	1.00	0.83	0.87	0.83
2014	0.90	0.90	0.83	1.00	0.94	0.95
2016	0.88	0.94	0.87	0.94	1.00	0.94
2019	0.90	0.90	0.83	0.95	0.94	1.00

Table 6. Degrees of non-memberships between the pairs of years

ν -table	2008	2010	2012	2014	2016	2019
2008	0.00	0.05	0.12	0.09	0.10	0.09
2010	0.05	0.00	0.06	0.10	0.06	0.10
2012	0.12	0.06	0.00	0.17	0.13	0.17
2014	0.09	0.10	0.17	0.00	0.06	0.05
2016	0.10	0.06	0.13	0.06	0.00	0.06
2019	0.09	0.10	0.17	0.05	0.06	0.00

The obtained pairs of years are presented in Table 7. There are:

- 1 pair of years in strong positive consonance,
- 12 pairs of years in positive consonance, and
- 2 pairs of years in weak positive consonance.

Thereafter the distribution of the main diseases in the years is similar.

Table 7. Outcomes for registered main diseases in the years

Type of correlations	Number of pairs of criteria
strong positive consonance [0.95; 1.00]	1
positive consonance [0.85; 0.95)	12
weak positive consonance [0.75; 0.85)	2

The pairs of years in the strong positive consonance and positive consonance feature similar health problems distribution in the years. The main diseases are registered similarly in the years. The most correlated years are 2014-2019.

The pairs of years 2008-2010, 2008-2012, 2010-2012, 2008-2014, 2010-2014, 2008-2016, 2010-2016, 2012-2016, 2014-2016, 2008-2019, 2010-2019, 2016-2019 are in positive consonance. These years exhibits dependencies of health problems distribution.

The pairs of years in weak positive consonance are 2012-2014, 2012-2019. They feature a weak tendency of similar main diseases distribution.

The results of ICA application for the main diseases by the years are visualized in the intuitionistic fuzzy triangle (Figure 2).

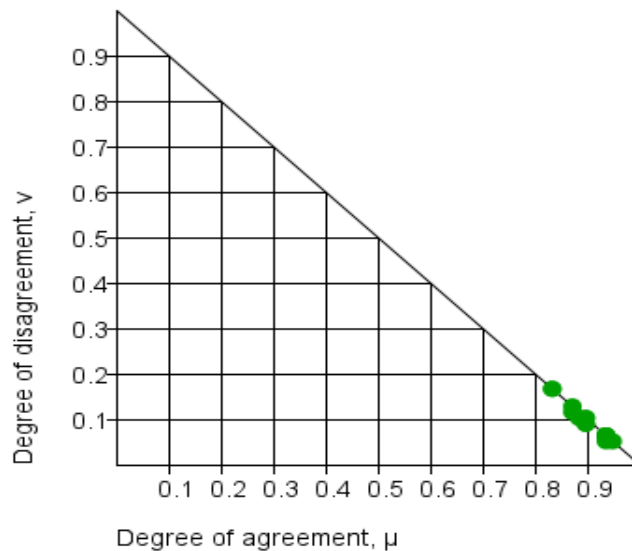


Figure 2. Results from ICA for the health problems by the years

3 Conclusion

In the current investigation an application of the ICA over the datasets for the main diseases declared by individuals in 15-and-over age group in the last 12 months in Turkey is presented.

The information from the website of TurkStat – Turkish Statistical Institute is used. The results of the ICA application present dependencies between the health problems distribution in Turkey. The second ICA application determines the similar health problems distribution in the years. The results present the constant presence of the main diseases in the time. The further research suggestion is to join this research with some statistical analyses including intuitionistic fuzzy regression analysis.

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