Notes on Intuitionistic Fuzzy Sets
Print ISSN 1310–4926, Online ISSN 2367–8283
2023, Volume 29, Number 2, 208–217
DOI: 10.7546/nifs.2023.29.2.208-217

InterCriteria Analysis applied to the health problems declared by individuals in Bulgaria

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Received: 30 May 2023 **Revised:** 23 June 2023
Accepted: 6 July 2023 **Online First:** 16 August 2023

Abstract: In the current investigation the health problems in Bulgaria through the years 2008, 2014 and 2019 are observed. The datasets for self-reported chronic morbidity datasets by Eurostat data browser are used. InterCriteria Analysis (ICA) is applied to estimate the relationships between the health problems in different countries. The outcomes will present tendencies of chronic diseases appearance in the selected countries. The prevalence of health problems by countries and years is observed.

Keywords: InterCriteria Analysis, Chronic diseases, Health problems.
2020 Mathematics Subject Classification: 03E72.

1 Introduction

An application of InterCriteria Analysis (ICA) for chronic diseases prevalence is presented. ICA is a decision making method [3, 4] based on the theories of index matrices [2] and intuitionistic fuzzy sets [1, 5, 6]. Different extensions and applications of ICA are presented in the years [7–9, 12, 13]. The chronic diseases datasets are downloaded from the Eurostat website [11]. The data is a part of the European Health Survey System in the framework of the European Statistical System. The aim is to measure on a harmonised basis and with a high degree of comparability among EU Member States, the health status, life style (health determinants) and health care services use of the EU citizens. The survey includes the people aged 15 and over living within the selected non-institutionalized households. Proportion of the population reporting a chronic condition in the 12 months, [11].

2 InterCriteria Analysis applied to the health problems declared by individuals

The self-reported chronic morbidity datasets by Eurostat data browser are downloaded. The data is preprocessed to be suitable for ICA application. The diseases containing missing data for one of the years are removed. The current investigation is a part of series of papers for chronic diseases prevalence in different countries. The first research work, based on the health problems in Turkey, is already published [13]. The aim of the authors is to analyze the health problems in different countries and to compare them. The input dataset contains the following chronic diseases: diabetes, chronic depression, high blood pressure and asthma. The analyzed data is for the years 2008, 2014 and 2019. The countries that are included in the input dataset are: Belgium, Bulgaria, Czechia, Germany, Estonia, Greece, Spain, France, Cyprus, Latvia, Hungary, Malta, Austria, Poland, Romania, Slovenia, Slovakia and Turkey. The input datasets are presented as three-dimensional data cube (Figure 1).

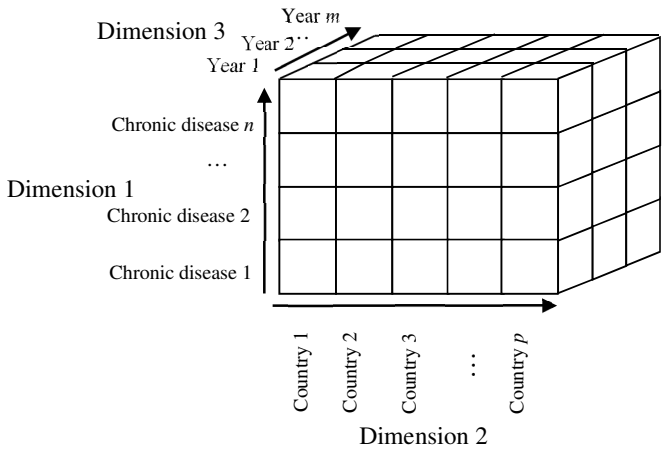

Figure 1. Three-dimensional data cube containing datasets for chronic diseases by counties in the years (European Health Interviews 2008, 2014, 2019)

2.1 InterCriteria Analysis applied to the health problems declared by individuals to investigate chronic diseases prevalence in different countries

ICA investigates the correlations between different countries according to their prevalence of chronic diseases declared by the individuals. The extension Aggredated IcRA of ICrAData software is used to analyze the three-dimensional data [10]. The three dimensions contains data for years of the European Health Surveys, Chronic Diseases and Countries. The chronic diseases prevalence in different countries is analyzed. The countries are grouped according to their similarity of chronic diseases prevalence. The intuitionistic fuzzy pairs, representing the degrees of memberships and degrees of non-memberships, are presented in Figure 2.

	Belgium	Bulgaria	Czechia	Germany	Estonia	Greece	Spain	France	Cyprus
Belgium	⟨ 1.00, 0.00⟩	⟨ 0.60, 0.33⟩	⟨ 0.73, 0.20⟩	⟨ 0.83, 0.07⟩	⟨ 0.80, 0.13⟩	⟨ 0.77, 0.17⟩	⟨ 0.87, 0.07⟩	⟨ 0.73, 0.20⟩	⟨ 0.73, 0.17⟩
Bulgaria	⟨ 0.60, 0.33⟩	⟨ 1.00, 0.00⟩	⟨ 0.73, 0.27⟩	⟨ 0.73, 0.23⟩	⟨ 0.80, 0.20⟩	⟨ 0.83, 0.17⟩	⟨ 0.73, 0.27⟩	⟨ 0.67, 0.33⟩	⟨ 0.77, 0.20⟩
Czechia	⟨ 0.73, 0.20⟩	⟨ 0.73, 0.27⟩	⟨ 1.00, 0.00⟩	⟨ 0.83, 0.13⟩	⟨ 0.83, 0.13⟩	⟨ 0.90, 0.10⟩	⟨ 0.87, 0.13⟩	⟨ 0.87, 0.13⟩	⟨ 0.93, 0.03⟩
Germany (	⟨ 0.83, 0.07⟩	⟨ 0.73, 0.23⟩	⟨ 0.83, 0.13⟩	⟨ 1.00, 0.00⟩	⟨ 0.93, 0.03⟩	⟨ 0.90, 0.07⟩	⟨ 0.90, 0.07⟩	⟨ 0.80, 0.17⟩	⟨ 0.90, 0.10⟩
Estonia	⟨ 0.80, 0.13⟩	⟨ 0.80, 0.20⟩	⟨ 0.83, 0.13⟩	⟨ 0.93, 0.03⟩	⟨ 1.00, 0.00⟩	⟨ 0.97, 0.03⟩	⟨ 0.87, 0.13⟩	⟨ 0.87, 0.13⟩	⟨ 0.90, 0.07⟩
Greece	⟨ 0.77, 0.17⟩	⟨ 0.83, 0.17⟩	⟨ 0.90, 0.10⟩	⟨ 0.90, 0.07⟩	⟨ 0.97, 0.03⟩	⟨ 1.00, 0.00⟩	⟨ 0.90, 0.10⟩	⟨ 0.83, 0.17⟩	⟨ 0.93, 0.03⟩
Spain	⟨ 0.87, 0.07⟩	⟨ 0.73, 0.27⟩	⟨ 0.87, 0.13⟩	⟨ 0.90, 0.07⟩	⟨ 0.87, 0.13⟩	⟨ 0.90, 0.10⟩	⟨ 1.00, 0.00⟩	⟨ 0.73, 0.27⟩	⟨ 0.87, 0.10⟩
France	⟨ 0.73, 0.20⟩	⟨ 0.67, 0.33⟩	⟨ 0.87, 0.13⟩	⟨ 0.80, 0.17⟩	⟨ 0.87, 0.13⟩	⟨ 0.83, 0.17⟩	⟨ 0.73, 0.27⟩	⟨ 1.00, 0.00⟩	⟨ 0.83, 0.13⟩
Cyprus	⟨ 0.73, 0.17⟩	⟨ 0.77, 0.20⟩	⟨ 0.93, 0.03⟩	⟨ 0.90, 0.10⟩	⟨ 0.90, 0.07⟩	⟨ 0.93, 0.03⟩	⟨ 0.87, 0.10⟩	⟨ 0.83, 0.13⟩	⟨ 1.00, 0.00⟩
Latvia	⟨ 0.77, 0.17⟩	⟨ 0.83, 0.17⟩	⟨ 0.77, 0.23⟩	⟨ 0.90, 0.07⟩	⟨ 0.90, 0.10⟩	⟨ 0.87,0.13⟩	⟨ 0.83, 0.17⟩	⟨ 0.77, 0.23⟩	⟨ 0.80, 0.17⟩
Hungary	⟨ 0.70, 0.20⟩	⟨ 0.77, 0.20⟩	⟨ 0.93, 0.03⟩	⟨ 0.80, 0.13⟩	⟨ 0.83, 0.13⟩	⟨ 0.87, 0.10⟩	⟨ 0.83, 0.13⟩	⟨ 0.80, 0.17⟩	⟨ 0.87, 0.07⟩
Malta	⟨ 0.73, 0.20⟩	⟨ 0.73, 0.27⟩	⟨ 1.00, 0.00⟩	⟨ 0.83, 0.13⟩	⟨ 0.87, 0.13⟩	⟨ 0.90, 0.10⟩	⟨ 0.87, 0.13⟩	⟨ 0.87, 0.13⟩	⟨ 0.93, 0.03⟩
Austria	⟨ 0.80, 0.13⟩	⟨ 0.80, 0.20⟩	⟨ 0.80, 0.20⟩	⟨ 0.93, 0.03⟩	⟨ 0.93, 0.07⟩	⟨ 0.90, 0.10⟩	⟨ 0.87, 0.13⟩	⟨ 0.80, 0.20⟩	⟨ 0.83, 0.13⟩
Poland	⟨ 0.77, 0.17⟩	⟨ 0.83, 0.17⟩	⟨ 0.90, 0.10⟩	⟨ 0.90, 0.07⟩	⟨ 0.97, 0.03⟩	⟨ 1.00, 0.00⟩	⟨ 0.90, 0.10⟩	⟨ 0.83, 0.17⟩	⟨ 0.93, 0.03⟩
Romania	⟨ 0.57, 0.33⟩	⟨ 0.87, 0.10⟩	⟨ 0.83, 0.13⟩	⟨ 0.70, 0.23⟩	⟨ 0.77, 0.20⟩	⟨ 0.80, 0.17⟩	⟨ 0.70, 0.27⟩	⟨ 0.77, 0.20⟩	⟨ 0.80, 0.13⟩
Slovenia	⟨ 0.87, 0.07⟩	⟨ 0.73, 0.27⟩	⟨ 0.87, 0.13⟩	⟨ 0.97, 0.00⟩	⟨ 0.93, 0.07⟩	⟨ 0.90, 0.10⟩	⟨ 0.93, 0.07⟩	⟨ 0.80, 0.20⟩	⟨ 0.87, 0.10⟩
Slovakia	⟨ 0.73, 0.20⟩	⟨ 0.87, 0.13⟩	⟨ 0.87, 0.13⟩	⟨ 0.87, 0.10⟩	⟨ 0.93, 0.07⟩	⟨ 0.97, 0.03⟩	⟨ 0.87, 0.13⟩	⟨ 0.80, 0.20⟩	⟨ 0.90, 0.07⟩
Türkiye	⟨ 0.70, 0.20⟩	⟨ 0.77, 0.20⟩	⟨ 0.80, 0.17⟩	⟨ 0.83, 0.10⟩	⟨ 0.87, 0.13⟩	⟨ 0.87, 0.10⟩	⟨ 0.83, 0.13⟩	⟨ 0.73, 0.23⟩	⟨ 0.80, 0.13⟩

	Latvia	Hungary	Malta	Austria	Poland	Romania	Slovenia	Slovakia	Türkiye
Belgium	⟨ 0.77, 0.17⟩	⟨ 0.70, 0.20⟩	⟨ 0.73, 0.20⟩	⟨ 0.80, 0.13⟩	⟨ 0.77, 0.17⟩	⟨ 0.57, 0.33⟩	⟨ 0.87, 0.07⟩	⟨ 0.73, 0.20⟩	⟨ 0.70, 0.20⟩
Bulgaria	⟨ 0.83, 0.17⟩	⟨ 0.77, 0.20⟩	⟨ 0.73, 0.27⟩	⟨ 0.80, 0.20⟩	⟨ 0.83, 0.17⟩	⟨ 0.87, 0.10⟩	⟨ 0.73, 0.27⟩	⟨ 0.87, 0.13⟩	⟨ 0.77, 0.20⟩
Czechia	⟨ 0.77, 0.23⟩	⟨ 0.93, 0.03⟩	⟨ 1.00, 0.00⟩	⟨ 0.80, 0.20⟩	⟨ 0.90, 0.10⟩	⟨ 0.83, 0.13⟩	⟨ 0.87, 0.13⟩	⟨ 0.87, 0.13⟩	⟨ 0.80, 0.17⟩
Germany (	⟨ 0.90, 0.07⟩	⟨ 0.80, 0.13⟩	⟨ 0.83, 0.13⟩	⟨ 0.93, 0.03⟩	⟨ 0.90, 0.07⟩	⟨ 0.70, 0.23⟩	⟨ 0.97, 0.00⟩	⟨ 0.87, 0.10⟩	⟨ 0.83, 0.10⟩
Estonia	⟨ 0.90, 0.10⟩	⟨ 0.83, 0.13⟩	⟨ 0.87, 0.13⟩	⟨ 0.93, 0.07⟩	⟨ 0.97, 0.03⟩	⟨ 0.77, 0.20⟩	⟨ 0.93, 0.07⟩	⟨ 0.93, 0.07⟩	⟨ 0.87, 0.13⟩
Greece	⟨ 0.87,0.13⟩	⟨ 0.87, 0.10⟩	⟨ 0.90, 0.10⟩	⟨ 0.90, 0.10⟩	⟨ 1.00, 0.00⟩	⟨ 0.80, 0.17⟩	⟨ 0.90, 0.10⟩	⟨ 0.97, 0.03⟩	⟨ 0.87, 0.10⟩
Spain	⟨ 0.83, 0.17⟩	⟨ 0.83, 0.13⟩	⟨ 0.87, 0.13⟩	⟨ 0.87, 0.13⟩	⟨ 0.90, 0.10⟩	⟨ 0.70, 0.27⟩	⟨ 0.93, 0.07⟩	⟨ 0.87, 0.13⟩	⟨ 0.83, 0.13⟩
France	⟨ 0.77, 0.23⟩	⟨ 0.80, 0.17⟩	⟨ 0.87, 0.13⟩	⟨ 0.80, 0.20⟩	⟨ 0.83, 0.17⟩	⟨ 0.77, 0.20⟩	⟨ 0.80, 0.20⟩	⟨ 0.80, 0.20⟩	⟨ 0.73, 0.23⟩
Cyprus	⟨ 0.80, 0.17⟩	⟨ 0.87, 0.07⟩	⟨ 0.93, 0.03⟩	⟨ 0.83, 0.13⟩	⟨ 0.93, 0.03⟩	⟨ 0.80, 0.13⟩	⟨ 0.87, 0.10⟩	⟨ 0.90, 0.07⟩	⟨ 0.80, 0.13⟩
Latvia	⟨ 1.00, 0.00⟩	⟨ 0.73, 0.23⟩	⟨ 0.77, 0.23⟩	⟨ 0.90, 0.10⟩	⟨ 0.87, 0.13⟩	⟨ 0.77, 0.20⟩	⟨ 0.90, 0.10⟩	⟨ 0.90, 0.10⟩	⟨ 0.87, 0.10⟩
Hungary	⟨ 0.73, 0.23⟩	⟨ 1.00, 0.00⟩	⟨ 0.93, 0.03⟩	⟨ 0.77, 0.20⟩	⟨ 0.87, 0.10⟩	⟨ 0.83, 0.10⟩	⟨ 0.83, 0.13⟩	⟨ 0.83, 0.13⟩	⟨ 0.77, 0.17⟩
Malta	⟨ 0.77, 0.23⟩	⟨ 0.93, 0.03⟩	⟨ 1.00, 0.00⟩	⟨ 0.80, 0.03⟩	⟨ 0.90, 0.10⟩	⟨ 0.83, 0.13⟩	⟨ 0.87, 0.10⟩	⟨ 0.87, 0.13⟩	⟨ 0.80, 0.17⟩
Austria	⟨ 0.90, 0.10⟩	⟨ 0.77, 0.20⟩	⟨ 0.80, 0.03⟩	⟨ 1.00, 0.00⟩	⟨ 0.90, 0.10⟩	⟨ 0.70, 0.27⟩	⟨ 0.93, 0.07⟩	⟨ 0.87, 0.13⟩	⟨ 0.83, 0.13⟩
Poland	⟨ 0.87, 0.13⟩	⟨ 0.87, 0.10⟩	⟨ 0.90, 0.10⟩	⟨ 0.90, 0.10⟩	⟨ 1.00, 0.00⟩	⟨ 0.80, 0.17⟩	⟨ 0.90, 0.10⟩	⟨ 0.97, 0.03⟩	⟨ 0.87, 0.10⟩
Romania	⟨ 0.77, 0.20⟩	⟨ 0.83, 0.10⟩	⟨ 0.83, 0.13⟩	⟨ 0.70, 0.27⟩	⟨ 0.80, 0.17⟩	⟨ 1.00, 0.00⟩	⟨ 0.70, 0.27⟩	⟨ 0.87, 0.13⟩	⟨ 0.77, 0.17⟩
Slovenia	⟨ 0.90, 0.10⟩	⟨ 0.83, 0.13⟩	⟨ 0.87, 0.10⟩	⟨ 0.93, 0.07⟩	⟨ 0.90, 0.10⟩	⟨ 0.70, 0.27⟩	⟨ 1.00, 0.00⟩	⟨ 0.87, 0.13⟩	⟨ 0.87, 0.13⟩
Slovakia	⟨ 0.90, 0.10⟩	⟨ 0.83, 0.13⟩	⟨ 0.87, 0.13⟩	⟨ 0.87, 0.13⟩	⟨ 0.97, 0.03⟩	⟨ 0.87, 0.13⟩	⟨ 0.87, 0.13⟩	⟨ 1.00, 0.00⟩	⟨ 0.90, 0.07⟩
Türkiye	⟨ 0.87, 0.10⟩	⟨ 0.77, 0.17⟩	⟨ 0.80, 0.17⟩	⟨ 0.83, 0.13⟩	⟨ 0.87, 0.10⟩	⟨ 0.77, 0.17⟩	⟨ 0.87, 0.13⟩	⟨ 0.90, 0.07⟩	⟨ 1.00, 0.00⟩

Figure 2. Resulting intuitionistic fuzzy pairs for countries relationships according to the selected chronic diseases

Obviously, the ICA application determines similar behavior between the most pairs of countries. Small part of the selected countries is independent. ICA determines 7 pairs of countries in strong positive consonance, 64 pairs of countries in positive consonance, 59 pairs of countries in weak positive consonance, 20 pairs of countries in weak dissonance and 2 pairs of countries in dissonance (Table 1). The pairs of countries in strong positive consonance, positive consonance and weak positive consonance have similar chronic diseases prevalence in the years. The countries in weak dissonance and dissonance are independent according to the prevalence of chronic diseases. There are not observed relationships between them.

Table 1. Number of resulting intuitionistic fuzzy pairs for countries relationships according to the selected chronic diseases

Type of correlations	Number of pairs of criteria
strong positive consonance [0.95; 1.00]	7
positive consonance [0.85; 0.95)	64
weak positive consonance [0.75; 0.85)	59
weak dissonance [0.67; 0.75)	20
dissonance [0.57; 0.67)	2
strong dissonance [0.43; 0.57)	-
dissonance [0.33; 0.43)	-
weak dissonance [0.25; 0.33)	-
weak negative consonance [0.15;0.25)	-
negative consonance [0.05;0.15)	-
strong negative consonance [0.00;0.05)	-

The outcomes from ICA application are presented in the following paragraphs of the current research work. Resulting pairs of countries are segmented in the fields of strong positive consonance, positive consonance, weak positive consonance, dissonance and weak dissonance. The countries are grouped according to their chronic disease prevalence in time. The pairs of countries in **strong positive consonance** have the following form:

- Estonia-Greece ⟨0.97, 0.03⟩,
- Czechia-Malta ⟨1.00, 0.00⟩,
- Estonia-Poland ⟨0.93, 0.03⟩,
- Greece-Poland ⟨1.00, 0.00⟩,
- Germany-Slovenia ⟨0.97, 0.00⟩,
- Greece-Slovakia ⟨0.97, 0.03⟩,
- Poland-Slovakia ⟨0.97, 0.03⟩.

The counties in strong positive consonance have similar chronic diseases prevalence in time. Obviously, the health problems are distributed in the same way. There are 7 pairs containing 8 different countries. Estonia, Poland, Greece and Slovakia form the first group of dependent countries according to chronic diseases tendencies. The pairs Czechia-Malta and Germany-Slovenia have similar behavior of health problems prevalence.

The countries in **positive consonance** have a reasonable degree of similarities. They are also dependent. Thereafter, the countries in positive consonance are related according to the health problems prevalence in time. The pairs of countries in positive consonance have the following form:

- Germany-Estonia ⟨0.93, 0.03⟩ ,
- Czechia-Greece ⟨0.90, 0.10⟩ ,
- Germany-Greece ⟨0.90, 0.07⟩,
- Belgium-Spain ⟨0.87, 0.07⟩,
- Czechia-Spain ⟨0.87, 0.13⟩,
- Germany-Spain ⟨0.90, 0.07⟩,
- Estonia-Spain ⟨0.87, 0.13⟩,
- Greece-Spain ⟨1.00, 0.00⟩,
- Czechia-France ⟨0.90, 0.10⟩,
- Estonia-France ⟨0.87, 0.13⟩,
- Czechia-Cyprus ⟨0.93, 0.03⟩,
- Estonia-Cyprus ⟨0.90, 0.07⟩,
- Greece-Cyprus ⟨0.93, 0.03⟩,
- Spain-Cyprus ⟨0.87, 0.10⟩,
- Germany-Latvia ⟨0.90, 0.07⟩,
- Estonia-Latvia ⟨0.90, 0.10⟩,
- Greece-Latvia ⟨0.87, 0.13⟩,
- Czechia-Hungary ⟨0.93, 0.03⟩,
- Greece-Hungary ⟨0.87, 0.10⟩,
- Cyprus-Hungary ⟨0.87, 0.07⟩,
- Czechia-Slovenia ⟨0.87, 0.13⟩,
- Estonia-Slovenia ⟨0.93, 0.07⟩,
- Estonia-Malta ⟨0.87, 0.13⟩,
- Greece-Malta ⟨0.90, 0.10⟩,
- Spain-Malta ⟨0.87, 0.13⟩,
- France-Malta ⟨0.87, 0.13⟩,
- Cyprus-Malta ⟨0.93, 0.03⟩,
- Latvia-Malta ⟨0.77, 0.23⟩,
- Germany-Austria ⟨0.93, 0.03⟩,
- Estonia-Austria ⟨0.93, 0.07⟩,
- Greece-Austria ⟨0.90, 0.10⟩,
- Spain-Austria ⟨087, 0.13⟩,
- Latvia-Austria ⟨0.90, 0.10⟩,
- Czechia-Poland ⟨0.90, 0.10⟩,
- Germany-Poland ⟨0.90, 0.07⟩,
- Spain-Poland ⟨0.90, 0.10⟩,
- Latvia-Poland ⟨0.87, 0.13⟩,
- Hungary-Poland ⟨0.87, 0.10⟩,
- Malta-Poland ⟨0.90, 0.10⟩,
- Austria-Poland ⟨0.90, 0.10⟩,
- Cyprus-Poland ⟨0.93, 0.03⟩,
- Bulgaria-Romania ⟨0.87, 0.10⟩,
- Belgium-Slovenia ⟨0.87, 0.07⟩,
- Greece-Slovenia ⟨0.90, 0.10⟩.

The countries in the area of positive consonance have similar tendencies of health problems appearance in time. They have analogous chronic diseases prevalence declared by individuals. All countries except Slovakia and Turkey are correlated in the group. Thereafter, the most countries have more similar tendencies in chronic diseases appearance. Obviously, the chronic diseases prevalence in Bulgaria is similar to Romania.

The next group contains countries in **weak positive consonance**. These countries have a little dependency. They may have close relationships according to one chronic disease and in the same time they may have independence with other health problem. They are not similar enough. These countries have weak dependencies according to chronic diseases prevalence in time. The countries in weak positive consonance can switch to the zone of positive consonance or in the field of dissonance in the next years. They need deeper observation to conclude their constant behavior. Obviously, all countries without exception are correlated in weak positive consonance. Thereafter, the chronic diseases prevalence is not so different in different countries. The closest countries in weak positive consonance are Slovenia-Turkey, Spain-Turkey, Estonia-Turkey and Romania-Slovakia. Thereafter, we can conclude that Slovenia, Spain, Estonia and Turkey have weak relationships such as the countries Romania-Slovakia. Bulgaria have close relationships with countries as Estonia, Greece, Cyprus, Hungary, Latvia, Austria and Poland according to the chronic disease prevalence.

- Belgium-Germany ⟨0.83, 0.07⟩,
- Czechia-Germany ⟨0.83, 0.13⟩,
- Belgium-Estonia ⟨0.80, 0.13⟩,
- Bulgaria-Estonia ⟨0.80, 0.20⟩,
- Belgium-Greece ⟨0.77, 0.17⟩,
- Bulgaria-Greece ⟨0.83, 0.17⟩,
- Germany-France ⟨0.80, 0.17⟩,
- Greece-France ⟨0.83, 0.17⟩,
- Bulgaria-Cyprus ⟨0.77, 0.20⟩,
- France-Cyprus ⟨0.83, 0.13⟩,
- Belgium-Latvia ⟨0.77, 0.17⟩,
- Bulgaria-Latvia ⟨0.83, 0.17⟩,
- Czechia-Latvia ⟨0.77, 0.23⟩,
- France-Latvia ⟨0.77, 0.23⟩,
- Cyprus-Latvia ⟨0.80, 0.17⟩,
- Spain-Latvia ⟨0.83, 0.17⟩,
- Bulgaria-Hungary ⟨0.77, 0.20⟩,
- Germany-Hungary ⟨0.80, 0.13⟩,
- Estonia-Hungary ⟨0.83, 0.13⟩,
- Spain-Hungary ⟨0.83, 0.13⟩,
- France-Hungary ⟨0.80, 0.13⟩,
- Germany-Malta ⟨0.83, 0.13⟩,
- Latvia-Malta ⟨0.77, 0.23⟩,
- Belgium-Austria ⟨0.80, 0.13⟩,
- Hungary-Turkey ⟨0.77, 0.13⟩,
- Malta-Turkey ⟨0.80, 0.17⟩,
- Austria-Turkey ⟨0.83, 0.13⟩,
- Romania-Turkey ⟨0.77, 0.17⟩,
- Slovenia-Turkey ⟨0.87, 0.13⟩,
- Czechia-Estonia ⟨0.83, 0.13⟩,
- Bulgaria-Austria ⟨0.80, 0.20⟩,
- Czechia-Austria ⟨0.80, 0.20⟩,
- France-Austria ⟨0.80, 0.20⟩,
- Cyprus-Austria ⟨0.83, 0.13⟩,
- Hungary-Austria ⟨0.77, 0.20⟩,
- Malta-Austria ⟨0.80, 0.03⟩,
- Belgium-Poland ⟨0.77, 0.17⟩,
- Bulgaria-Poland ⟨0.83, 0.17⟩,
- France-Poland ⟨0.83, 0.17⟩,
- Czechia-Romania ⟨0.83, 0.13⟩,
- Estonia-Romania ⟨0.77, 0.20⟩,
- Greece-Romania ⟨0.80, 0.17⟩,
- France-Romania ⟨0.77, 0.20⟩,
- Cyprus-Romania ⟨0.80, 0.13⟩,
- Latvia-Romania ⟨0.77, 0.20⟩,
- Hungary-Romania ⟨0.83, 0.10⟩,
- Malta-Romania ⟨0.83, 0.13⟩,
- Poland-Romania ⟨0.80, 0.17⟩,
- France-Slovenia ⟨0.80, 0.20⟩,
- Hungary-Slovenia ⟨0.83, 0.13⟩,
- France-Slovakia ⟨0.80, 0.20⟩,
- Romania-Slovakia ⟨0.87, 0.13⟩,
- Hungary-Slovakia ⟨0.83, 0.13⟩,
- Bulgaria-Turkey ⟨0.77, 0.20⟩,
- Czechia-Turkey ⟨0.80, 0.17⟩,
- Germany-Turkey ⟨0.83, 0.10⟩,
- Estonia-Turkey ⟨0.87, 0.13⟩,
- Spain-Turkey ⟨0.87, 0.13⟩,
- Cyprus-Turkey ⟨0.80, 0.13⟩.

The countries in the area of **weak dissonance** have a little independency each other. They have unrelated behavior in time. These countries do not have opposite properties. They do not have similarity. The prevalence of chronic diseases is not related. The countries are independent according to chronic diseases prevalence in time. Countries except Estonia, Greece, Poland and Latvia are included in the group of countries in weak dissonance. Chronic diseases prevalence in Bulgaria is independent according to the health problems tendencies in the countries Czechia, Germany, Spain, France, Malta and Slovenia. The pairs of countries in weak dissonance have the following form:

- Belgium-Czechia ⟨0.73, 0.20⟩,
- Bulgaria-Czechia ⟨0.73, 0.27⟩,
- Bulgaria-Germany ⟨0.73, 0.23⟩,
- Bulgaria-Spain ⟨0.73, 0.27⟩,
- Belgium-France ⟨0.73, 0.20⟩,
- Bulgaria-France ⟨0.67, 0.33⟩,
- Spain-France ⟨0.73, 0.27⟩,
- Belgium-Cyprus ⟨0.73, 0.17⟩,
- Belgium-Hungary ⟨0.70, 0.20⟩,
- Latvia-Hungary ⟨0.73, 0.23⟩,
- Bulgaria-Malta ⟨0.73, 0.27⟩,
- Germany-Romania ⟨0.83, 0.13⟩,
- Spain-Romania ⟨0.70, 0.27⟩,
- Austria-Romania ⟨0.70, 0.27⟩,
- Bulgaria-Slovenia ⟨0.73, 0.27⟩,
- Romania-Slovenia ⟨0.77, 0.17⟩,
- Belgium-Slovakia ⟨0.73, 0.20⟩,
- Belgium-Turkey ⟨0.70, 0.20⟩,
- France-Turkey ⟨0.73, 0.23⟩.
- Belgium-Malta ⟨0.73, 0.20⟩.

Two pairs of countries in **dissonance** are determined. Obviously, Belgium, Bulgaria and Romania have independent chronic diseases prevalence. Bulgaria have not relationships with Belgium according to chronic diseases prevalence.

- Belgium-Bulgaria ⟨0.60, 0.33⟩,
- Belgium-Romania ⟨0.57, 0.33⟩.

Obviously, there are chronic diseases with similar prevalence between the individuals in the countries. The independent health problems appearance is also determined. The pairs of chronic diseases in dissonance and weak dissonance are independent. The outcomes from ICA application for chronic diseases prevalence are presented in the intuitionistic fuzzy triangle (Figure 3).

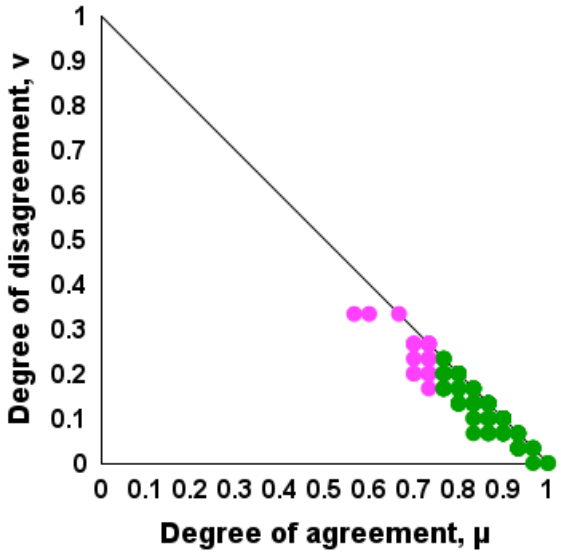

Figure 3. Chronic diseases prevalence in the countries visualized into the intuitionistic fuzzy triangle

2.2 InterCriteria Analysis applied to the health problems declared by individuals to investigate chronic diseases relationships

The second ICA application is performed to investigate the relationships between chronic diseases prevalence. The intuitionistic fuzzy pairs after ICA application are presented in Figure 4.

	Diabetes	Chronic depression	High blood pressure	Chronic lower respiratory diseases (excluding asthma)	Asthma
Diabetes	⟨ 1.00, 0.00⟩	⟨ 0.56, 0.41⟩	⟨ 0.57, 0.42⟩	⟨ 0.52, 0.45⟩	⟨ 0.71, 0.25⟩
Chronic depression	⟨ 0.56, 0.41⟩	⟨ 1.00, 0.00⟩	⟨ 0.44, 0.55⟩	⟨ 0.69, 0.27⟩	⟨ 0.70, 0.26⟩
High blood pressure	⟨ 0.57, 0.42⟩	⟨ 0.44, 0.55⟩	⟨ 1.00, 0.00⟩	⟨ 0.50, 0.48⟩	⟨ 0.41, 0.56⟩
Chronic lower respiratory diseases (excluding asthma)	⟨ 0.52, 0.45⟩	⟨ 0.69, 0.27⟩	⟨ 0.50, 0.48⟩	⟨ 1.00, 0.00⟩	⟨ 0.63, 0.34⟩
Asthma	⟨ 0.71, 0.25⟩	⟨ 0.70, 0.26⟩	⟨ 0.41, 0.56⟩	⟨ 0.63, 0.34⟩	⟨ 1.00, 0.00⟩

Figure 4. Intuitionistic Fuzzy Pairs for chronic disease prevalence

The obtained results of ICA application are the following: 3 pairs of chronic diseases in weak dissonance, 2 pairs of chronic diseases in dissonance and 5 pairs of chronic diseases in strong dissonance. The pairs of chronic diseases in weak dissonance are “Chronic depression-Chronic lower respiratory diseases (excluding asthma)”, “Diabetes-Asthma”, “Chronic depression-Asthma”. The pairs of chronic diseases in dissonance are “Diabetes-High blood pressure” and “High blood pressure-Asthma”. The pairs of chronic diseases in strong dissonance are “Diabetes-Chronic depression”, “Chronic depression-High blood pressure”, “Diabetes-Chronic lower respiratory diseases (excluding asthma)”, “High blood pressure-Chronic lower respiratory diseases (excluding asthma)” and “Chronic lower respiratory diseases (excluding asthma)-Asthma”. According to the obtained results we can conclude that the chronic diseases prevalence is independent in different countries for the selected years. There are not relationships between chronic diseases prevalence in the countries.

The outcomes from ICA application for chronic diseases prevalence are presented in the intuitionistic fuzzy triangle (Figure 5). All intuitionistic fuzzy pairs are visualized in the area of strong dissonance, dissonance and weak dissonance. The health problems prevalence is independent.

3 Conclusion

In the current paper a study for health problems in time is presented. ICA is applied to determine the dependencies between the chronic diseases prevalence in different countries. The investigation is a second part of series of papers analyzing the health problems tendencies in different countries. In the first paper, the health problems in Turkey are investigated. In the current investigation dependencies of chronic diseases prevalence in the Europe are analyzed.

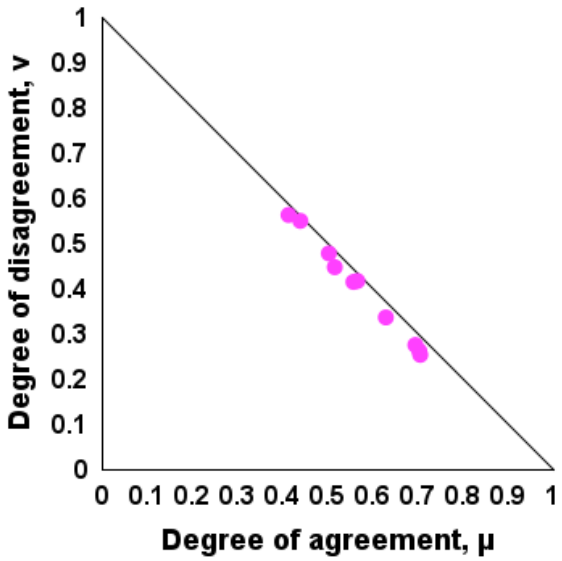

Figure 5. Intuitionistic fuzzy pair for chronic diseases prevalence by sex in the intuitionistic fuzzy triangle

Acknowledgements

The authors are thankful for the support provided by the European Regional Development Fund and the Operational Program "Science and Education for Smart Growth" under contract UNITe No. BG05M2OP001-1.001-0004-C01 (2018-2023).

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