

Intuitionistic fuzzy approach for analysis the blood donation system in Bulgaria

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1. Introduction: In 2000, a reform in the transfusion system in Bulgaria was undertaken, with aim of centralized diagnostics and blood processing and improving the quality of the produced blood components. A work algorithm is followed, providing quality blood components for all health facilities in the country. According [12] Centers of transfusion hematology supply hospitals and complex oncology centers with diagnosed and processed blood and blood components. The Military Medical Academy and the hospitals, in which structure there are departments of transfusion hematology, supply the centers of transfusion hematology with the taken from them blood.

2. Application of the ICA method: The dataset from is organized in two index matrices:

index matrix with 10 rows (for the age groups) and 17 columns (for the years). The age groups are following: under 20 years, between 21 and 25 years, between 26 and 30 years, between 31-45, between 46-50, between 51-55, between 56-60, over 61, that are presented by sets of indices $X = \{x_1, x_2, \dots, x_{10}\}$. The years are from 2005 to 2021 and they are presented by sets of indices $Y = \{y_1, y_2, \dots, y_{17}\}$;

index matrix with: 29 rows (for the centers/departments of transfusion hematology) and 17 columns (for the years). The centers/departments of transfusion hematology are following: National Center of Hematology and Transfusion; Military Medical Academy; and Regional 4 centers for transfusion hematology (Plovdiv, Varna, Pleven, Stara Zagora) with territorial scope of their activity, that are presented by sets of indices $Z = \{z_1, z_2, \dots, z_{29}\}$. The years are from 2005 to 2021 and they are presented by sets of indices $Y = \{y_1, y_2, \dots, y_{17}\}$.

2.1. Application of the ICA method for age group:

After applying the ICA method, 45 IFPs were obtained, reflecting the degree of correlation between the age groups. Indexed matrices with membership part and non-membership part of the IFPs are given in Table 2 and Table 3.

2 pairs of criteria are in positive consonance: "41-45"-"51-55": $\langle 0,912; 0,088 \rangle$; "56-60"-"over 60": $\langle 0,851; 0,148 \rangle$.

12 pairs are in weak positive consonance: "41-45"-"46-50", "46-50"-"51-55", "31-35"-"41-45", "31-35"-"56-60", "36-40"-"46-50", "41-45"-"56-60", "51-55"-"56-60", "31-35"-"51-55", "31-35"-"over 60", "41-45"-"over 60", "51-55"-"over 60", "26-30"-"36-40". This means that these age groups are in very similar behavior.

The low age groups – "under 20" and "between 20 and 25" have the opposite behavior of the other age groups.

8 pairs of criteria are in weak dissonance, 17 pairs are criteria in dissonance, 5 pairs are in strong dissonance and 7 pairs are in weak negative consonance, 1 pair is in weak negative consonance. That means, that these pairs are independent from each other.

2.2. Application of the ICA method for centers/departments of transfusion hematology:

After applying the ICA method, 406 IFPs were obtained, reflecting the degree of correlation between the centers/departments of transfusion hematology.

3 pairs of criteria are in positive consonance: "Vratsa"-"Vidin": $\langle 0,882; 0,118 \rangle$; "Blagoevgrad"-"Lom": $\langle 0,868; 0,132 \rangle$, "Sofia Region"-"Vratsa": $\langle 0,853; 0,147 \rangle$.

35 pairs of criteria are in weak positive consonance.

70 pairs are in weak dissonance, 151 pairs of criteria are in dissonance, 139 pairs are in strong dissonance, 7 pairs are in weak negative consonance, 1 pair is in negative consonance.

Table 4. Result matrix with membership parts of the IFPs of the transfusion hematology centers/transfusion hematology departments.

μ	NCHT	District of Sofia	Blagoevgrad	Vratsa	Vidin	Kyustendil	Lom	Pernik	Plovdiv	Kardzhali	Pazardzhik	Smolyan	Has-kovo	St. Zagora	Sliven	Yambol	Burgas	Varna	Silistra	Dobrich	Targovishte	Shumen	Pleven	V. Tar novo	Gab-rovo	Lovech	Raz-grad	Ruse	VMA
NCHT	1.00	0.75	0.82	0.67	0.67	0.49	0.78	0.80	0.76	0.50	0.80	0.83	0.48	0.54	0.52	0.58	0.72	0.74	0.56	0.50	0.82	0.61	0.59	0.52	0.56	0.65	0.44	0.58	0.73
District of Blagoevgrad	0.75	1.00	0.82	0.87	0.86	0.61	0.80	0.79	0.70	0.41	0.71	0.64	0.29	0.59	0.55	0.67	0.66	0.82	0.54	0.61	0.76	0.62	0.43	0.55	0.68	0.68	0.33	0.50	0.75
Vratsa	0.82	0.82	1.00	0.74	0.78	0.56	0.88	0.80	0.80	0.46	0.81	0.75	0.37	0.59	0.54	0.65	0.75	0.78	0.62	0.55	0.82	0.69	0.54	0.55	0.60	0.65	0.37	0.58	0.72
Vidin	0.67	0.87	0.74	1.00	0.90	0.63	0.69	0.71	0.69	0.39	0.68	0.56	0.32	0.60	0.52	0.63	0.54	0.78	0.52	0.69	0.66	0.63	0.41	0.56	0.68	0.68	0.32	0.39	0.69
Kyustendil	0.67	0.86	0.78	0.90	1.00	0.71	0.73	0.73	0.74	0.36	0.75	0.54	0.24	0.68	0.55	0.69	0.62	0.81	0.58	0.72	0.71	0.67	0.39	0.51	0.76	0.75	0.32	0.42	0.75
Lom	0.49	0.61	0.56	0.63	0.71	1.00	0.50	0.52	0.54	0.36	0.54	0.35	0.39	0.67	0.59	0.68	0.44	0.62	0.58	0.85	0.51	0.67	0.37	0.58	0.76	0.71	0.45	0.46	0.62
Pernik	0.78	0.80	0.88	0.69	0.73	0.50	1.00	0.82	0.76	0.50	0.78	0.78	0.41	0.55	0.54	0.61	0.78	0.80	0.59	0.48	0.80	0.69	0.56	0.56	0.59	0.63	0.41	0.61	0.71
Plovdiv	0.80	0.79	0.80	0.71	0.73	0.52	0.82	1.00	0.72	0.48	0.71	0.75	0.41	0.50	0.52	0.60	0.67	0.73	0.54	0.52	0.81	0.65	0.59	0.56	0.59	0.66	0.43	0.57	0.67
Kardzhali	0.76	0.70	0.80	0.69	0.74	0.54	0.76	0.72	1.00	0.48	0.78	0.72	0.40	0.63	0.46	0.65	0.69	0.78	0.67	0.60	0.76	0.58	0.59	0.52	0.65	0.68	0.48	0.50	0.68
Pazardzhik	0.50	0.41	0.46	0.39	0.36	0.36	0.50	0.48	0.48	1.00	0.50	0.65	0.74	0.49	0.59	0.48	0.55	0.41	0.54	0.36	0.53	0.42	0.78	0.50	0.43	0.29	0.63	0.66	0.36
Smolyan	0.80	0.71	0.81	0.68	0.75	0.54	0.78	0.71	0.78	0.50	1.00	0.73	0.39	0.66	0.45	0.59	0.81	0.82	0.64	0.57	0.84	0.56	0.52	0.41	0.61	0.66	0.38	0.56	0.75
Has-kovo	0.83	0.64	0.75	0.56	0.54	0.35	0.78	0.75	0.72	0.65	0.73	1.00	0.56	0.46	0.45	0.48	0.78	0.65	0.59	0.39	0.76	0.55	0.73	0.52	0.47	0.51	0.51	0.65	0.63
St. Zagora	0.48	0.29	0.37	0.32	0.24	0.39	0.41	0.41	0.40	0.74	0.39	0.56	1.00	0.50	0.64	0.50	0.45	0.29	0.50	0.39	0.42	0.46	0.75	0.58	0.36	0.42	0.73	0.67	0.31
Sliven	0.54	0.59	0.59	0.60	0.68	0.67	0.55	0.50	0.63	0.49	0.66	0.46	0.50	1.00	0.56	0.64	0.60	0.65	0.62	0.71	0.58	0.55	0.49	0.37	0.69	0.69	0.50	0.48	0.61
Yambol	0.52	0.55	0.54	0.52	0.55	0.59	0.54	0.52	0.46	0.59	0.45	0.45	0.64	0.56	1.00	0.67	0.46	0.48	0.53	0.57	0.54	0.58	0.58	0.66	0.58	0.61	0.60	0.62	0.50
Burgas	0.58	0.67	0.65	0.63	0.69	0.68	0.61	0.60	0.65	0.48	0.59	0.48	0.50	0.64	0.67	1.00	0.54	0.63	0.70	0.68	0.63	0.49	0.43	0.52	0.73	0.69	0.42	0.55	0.60
Varna	0.72	0.66	0.75	0.54	0.62	0.44	0.78	0.67	0.69	0.55	0.81	0.78	0.45	0.60	0.46	0.54	1.00	0.69	0.61	0.43	0.75	0.58	0.59	0.42	0.52	0.55	0.49	0.65	0.69
Silistra	0.74	0.82	0.78	0.78	0.81	0.62	0.80	0.73	0.78	0.41	0.82	0.65	0.29	0.65	0.48	0.63	0.69	1.00	0.60	0.66	0.77	0.63	0.44	0.52	0.72	0.71	0.38	0.48	0.82
Dobrich	0.56	0.54	0.62	0.52	0.58	0.58	0.59	0.54	0.67	0.54	0.64	0.59	0.50	0.62	0.53	0.70	0.61	0.60	1.00	0.61	0.62	0.42	0.56	0.51	0.64	0.55	0.59	0.59	0.61
Targovishte	0.83	0.64	0.75	0.56	0.54	0.35	0.78	0.75	0.72	0.65	0.73	1.00	0.56	0.46	0.45	0.48	0.78	0.65	0.59	0.39	0.76	0.55	0.73	0.52	0.47	0.51	0.51	0.65	0.63
Shumen	0.48	0.29	0.37	0.32	0.24	0.39	0.41	0.41	0.40	0.74	0.39	0.56	1.00	0.50	0.64	0.50	0.45	0.29	0.50	0.39	0.42	0.46	0.75	0.58	0.36	0.42	0.73	0.67	0.31
Pleven	0.54	0.59	0.59	0.60	0.68	0.67	0.55	0.50	0.63	0.49	0.66	0.46	0.50	1.00	0.56	0.64	0.60	0.65	0.62	0.71	0.58	0.55	0.49	0.37	0.69	0.69	0.50	0.48	0.61
V. Tar novo	0.52	0.55	0.54	0.52	0.55	0.59	0.54	0.52	0.46	0.59	0.45	0.45	0.64	0.56	1.00	0.67	0.46	0.48	0.53	0.57	0.54	0.58	0.58	0.66	0.58	0.61	0.60	0.62	0.50
Gabrovo	0.58	0.67	0.65	0.63	0.69	0.68	0.61	0.60	0.65	0.48	0.59	0.48	0.50	0.64	0.67	1.00	0.54	0.63	0.70	0.68	0.63	0.49	0.43	0.52	0.73	0.69	0.42	0.55	0.60
Lovech	0.72	0.66	0.75	0.54	0.62	0.44	0.78	0.67	0.69	0.55	0.81	0.78	0.45	0.60	0.46	0.54	1.00	0.69	0.61	0.43	0.75	0.58	0.59	0.42	0.52	0.55	0.49	0.65	0.69
Razgrad	0.74	0.82	0.78	0.78	0.81	0.62	0.80	0.73	0.78	0.41	0.82	0.65	0.29	0.65	0.48	0.63	0.69	1.00	0.60	0.66	0.77	0.63	0.44	0.52	0.72	0.71	0.38	0.48	0.82
Ruse	0.56	0.54	0.62	0.52	0.58	0.58	0.59	0.54	0.67	0.54	0.64	0.59	0.50	0.62	0.53	0.70	0.61	0.60	1.00	0.61	0.62	0.42	0.56	0.51	0.64	0.55	0.59	0.59	0.61
VMA	0.83	0.64	0.75	0.56	0.54	0.35	0.78	0.75	0.72	0.65	0.73	1.00	0.56	0.46	0.45	0.48	0.78	0.65	0.59	0.39	0.76	0.55	0.73	0.52	0.47	0.51	0.51	0.65	0.63
	0.48	0.29	0.37	0.32	0.24	0.39	0.41	0.41	0.40	0.74	0.39	0.56	1.00	0.50	0.64	0.50	0.45	0.29	0.50	0.39	0.42	0.46	0.75	0.58	0.36	0.42	0.73	0.67	0.31
	0.54	0.59	0.59	0.60	0.68	0.67	0.55	0.50	0.63	0.49	0.66	0.46	0.50	1.00	0.56	0.64	0.60	0.65	0.62	0.71	0.58	0.55	0.49	0.37	0.69	0.69	0.50	0.48	0.61
	0.52	0.55	0.54	0.52	0.55	0.59	0.54	0.52	0.46	0.59	0.45	0.45	0.64	0.56	1.00	0.67	0.46	0.48	0.53	0.57	0.54	0.58	0.58	0.66	0.58	0.61	0.60	0.62	0.50
	0.58	0.67	0.65	0.63	0.69	0.68	0.61	0.60	0.65	0.48	0.59	0.48	0.50	0.64	0.67	1.00	0.54	0.63	0.70	0.68	0.63	0.49	0.43	0.52	0.73	0.69	0.42	0.55	0.60
	0.72	0.66	0.75	0.54	0.62	0.44	0.78	0.67	0.69	0.55	0.8																		