Relations between Inpatient Health Establishments' Capacity, Mortality Rates and Blood Donation Activity in Bulgaria Using Correlation and InterCriteria Analysis

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Abstract. The present paper aims to reveal linkages between the data regarding the inpatient health establishments that are allowed to operate with blood and blood products, data regarding the blood donation and blood transfusion capacity and mortality rates in Bulgaria. Among the data sources used for the study are both the National Statistics Institute of the Republic of Bulgaria and the information system for registration of blood donation activity in the country. The adopted data driven approach employs correlation analysis and the intuitionistic fuzzy sets based InterCriteria Analysis to draw comparisons and yield some important conclusions on national and regional level and outlie relevant trends from the period 2016–2022 year.

Keywords: Transfusion Haematology, Blood transfusion capacity, Correlation analysis, InterCriteria Analysis, Intuitionistic fuzzy interpretational triangle.

1 Introduction

Inpatient health establishments rely on sufficient blood donation and blood transfusion capacity to effectively treat patients. Blood transfusions are often critical in managing various medical conditions, such as severe injuries, surgeries, and certain illnesses. Having an adequate supply of blood ensures that inpatients receive the necessary transfusions when needed.

Blood donation plays a crucial role in maintaining sufficient blood transfusion capacity. Without regular donations from the community, blood banks may struggle to meet the demand for blood and blood products. In cases of emergencies or high-demand situations, a robust blood donation system becomes even more critical to address the needs of inpatients.

In summary, the relationship between inpatient health establishments, blood donation, and blood transfusion capacity is interconnected. Adequate blood donation rates are essential to ensure that inpatient health facilities can access the necessary blood products to provide quality care and potentially life-saving transfusions to their patients

2 Data Collection Methodology

In our current investigation, we are interested to explore the interrelations which blood donation and transfusion capacity in various regions of Bulgaria exhibit with other factors and indicators of the healthcare system and of the demographics of the country. We have specifically chosen to work with the following indicators: number of inpatient health establishments that are eligible to operate with blood and blood products (collect, store, transfuse), these are multiprofiled hospitals and specialized hospitals, the total numbers of beds therein, the number of beds per 1000 people of population, the mortality rate (per 1000), the total number of blood donations, the number of individual blood donors, litres of donated blood and number of blood donations per 1000. Each of these indicators is evaluated for the 28 administrative regions of the Republic of Bulgaria in each of the years from the evaluated period from the year 2016 to the year 2022. The motivation behind the selection of that period is related to the launching in 2015 of a nation-wide information system for the registration of the blood donation activity in Bulgaria.

Data about the numbers of inpatient health establishments (shortly IHE; here we specifically discern between multiprofiled and specialized IHEs) per region per year, and the respective numbers of patient beds therein, are collected from the National Statistical Institute [10]. This also is the source of data for the population size [11] and the mortality rate [12] per region per year. Data regarding the numbers of registered blood donations (both voluntary and family / replacement donation), individual blood donors and litres of blood donated were retrieved from the information system, partially available in [12] and additionally generated in the frames of the project KP-06-N72/8/2023 of the Bulgarian National Science Fund. For the needs of the study, some of the indicators were additionally calculated on the basis of the available data for the population size, and these are the numbers of IHE beds per 1000 people and the numbers of blood donors per 1000 people, respectively per region and per year.

Due to the heterogeneous data sources used in the analysis, the following minor remark is necessary. Regarding the administrative division in different data sources, there is almost full correspondence between (1) the administrative regions with respect to which National Statistical Institute stratifies its data, and (2) the subdivisions under the umbrella of the National Centre of Transfusion Haematology, like Regional Centres of Transfusion Haematology (five RCTHs: Sofia, Plovdiv, Varna, Stara Zagora, Pleven) which respectively contain Units of Transfusion Haematology (23 UTHs). The sole exception is the administrative region Montana where the local Unit of Transfusion Haematology is located not in the town of Montana but in the town of Lom instead (a UTH contained in the frames of Sofia RCTH). In this sense, in our analyses, the column is collectively titled “Montana / Lom” to reflect this minor nomenclatural difference.

3 InterCriteria Analysis

InterCriteria Analysis is a data-driven approach in decision support and decision making. For a dataset with evaluations of a set of objects against a set of criteria, it gives for every couple of two different criteria an intuitionistic fuzzy pair that estimates the degree of relation between them, thus representing an alternative to correlation analysis, but one that employs the paradigm of Atanassov's intuitionistic fuzzy sets. The method was first proposed in 2014 in [4] and applied since then to various problem area. Some of these, related to various aspects of transfusion haematology are papers [1–3, 5].

Here, ICA is run on a dataset containing the data for 28 administrative regions of Bulgaria for each of the years from 2016 to 2022 collected for the following 12 criteria: C1: 2016 – Blood donations (total); C2: 2016 – Blood donors (individual); C3: 2016 – Litres of donated blood; C4: 2016 – Multiprofiled IHE; C5: 2016 – Multiprofiled IHE – beds; C6: 2016 – Specialized IHE; C7: 2016 – Specialized IHE – beds; C8: 2016 – Region population; C9: 2016 – Blood donations per 1000; C10: 2016 – Multiprofiled IHE – beds per 1000; C11: 2016 – Specialized IHE – beds per 1000; C12: 2016 – Mortality rate per 1000. The calculations are performed using the ICA software developed by Mavrov, [7–9].

For the sake of brevity, we will only give the results for the ICA membership table (μ) due to the observed proximity of the ICA elements to the hypotenuse, that is proximity between their degrees μ and $1 - \nu$. Also, we will give only the results for the two endpoints of the investigated period, the years 2016 and 2022.

Table 1. Results of the InterCriteria Analysis (ICA) for the year 2016 applied to the dataset of 28 administrative regions of Bulgaria for the collected 12 criteria with inpatient health establishments' capacity, mortality rates and blood donation activity rates (memberships)

2016: μ	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
C1	1.000	0.952	0.997	0.661	0.741	0.630	0.653	0.757	0.796	0.585	0.524	0.315
C2	0.952	1.000	0.955	0.675	0.757	0.664	0.669	0.788	0.765	0.579	0.540	0.272
C3	0.997	0.955	1.000	0.664	0.743	0.630	0.651	0.759	0.794	0.587	0.521	0.312
C4	0.661	0.675	0.664	1.000	0.783	0.656	0.664	0.717	0.529	0.598	0.548	0.312
C5	0.741	0.757	0.743	0.783	1.000	0.688	0.709	0.823	0.606	0.696	0.561	0.373
C6	0.630	0.664	0.630	0.656	0.688	1.000	0.796	0.762	0.495	0.431	0.638	0.294
C7	0.653	0.669	0.651	0.664	0.709	0.796	1.000	0.757	0.537	0.521	0.817	0.354
C8	0.757	0.788	0.759	0.717	0.823	0.762	0.757	1.000	0.553	0.521	0.577	0.331
C9	0.796	0.765	0.794	0.529	0.606	0.495	0.537	0.553	1.000	0.608	0.466	0.397
C10	0.585	0.579	0.587	0.598	0.696	0.431	0.521	0.521	0.608	1.000	0.516	0.561
C11	0.524	0.540	0.521	0.548	0.561	0.638	0.817	0.577	0.466	0.516	1.000	0.447
C12	0.315	0.272	0.312	0.312	0.373	0.294	0.354	0.331	0.397	0.561	0.447	1.000

Table 2. Results of the InterCriteria Analysis (ICA) for the year 2022 applied to the dataset of 28 administrative regions of Bulgaria for the collected 12 criteria with inpatient health establishments' capacity, mortality rates and blood donation activity rates (memberships)

2022: μ	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
C1	1.000	0.974	0.984	0.712	0.854	0.696	0.712	0.865	0.810	0.598	0.537	0.201
C2	0.974	1.000	0.963	0.712	0.860	0.704	0.720	0.870	0.799	0.603	0.545	0.188
C3	0.984	0.963	1.000	0.714	0.860	0.698	0.722	0.870	0.804	0.598	0.548	0.212
C4	0.712	0.712	0.714	1.000	0.770	0.630	0.672	0.712	0.616	0.585	0.537	0.259
C5	0.854	0.860	0.860	0.770	1.000	0.693	0.725	0.825	0.767	0.704	0.566	0.288
C6	0.696	0.704	0.698	0.630	0.693	1.000	0.807	0.765	0.542	0.434	0.651	0.241
C7	0.712	0.720	0.722	0.672	0.725	0.807	1.000	0.765	0.611	0.529	0.815	0.312
C8	0.865	0.870	0.870	0.712	0.825	0.765	0.765	1.000	0.675	0.532	0.579	0.246
C9	0.810	0.799	0.804	0.616	0.767	0.542	0.611	0.675	1.000	0.693	0.489	0.288
C10	0.598	0.603	0.598	0.585	0.704	0.434	0.529	0.532	0.693	1.000	0.503	0.500
C11	0.537	0.545	0.548	0.537	0.566	0.651	0.815	0.579	0.489	0.503	1.000	0.450
C12	0.201	0.188	0.212	0.259	0.288	0.241	0.312	0.246	0.288	0.500	0.450	1.000

In the next section, we will discuss in more details the results which were specifically important for us to track. In Tables 1,2 the interested reader may see though some other interesting patters that are worth discussing.

4 Main results

4.1 Inpatient health establishments' capacity vs Blood donation rates

The number of beds in inpatient health establishments and blood donation activity rates can be related in a few ways. The number of hospital beds in a given area can indicate the demand for blood in that area: more hospital beds may suggest a higher demand for blood transfusions, which could increase the need for blood donations. In addition, areas with more hospital beds may result in higher public awareness and more active participation in blood donation campaigns, underlying the importance of blood donation due to closer proximity to healthcare facilities. Finally, in times of emergencies or natural disasters, the number of available hospital beds may impact the need for blood donations to treat the injured, showcasing a relationship between hospital capacity and blood donation activity.

These general considerations seem well reflected in the available data from our study, specifically the indicators number of beds in Multiprofiled IHEs per 1000, number of beds in Specialized IHEs per 1000 and blood donation rates per 1000. The ICA results (illustrated on Figure 1) show:

- Dissonance between ‘Specialized IHEs beds per 1000’ and ‘Blood donation rates per 1000’, yet with a positive trend towards the intuitionistic fuzzy Truth $\langle 1,0 \rangle$ over the period of seven years.
- Weakly positive ICA consonance between ‘Multiprofiled IHEs beds per 1000’ and ‘Blood donation rates per 1000’ with a more well pronounced positive trend towards the intuitionistic fuzzy Truth $\langle 1,0 \rangle$ over the period of time;

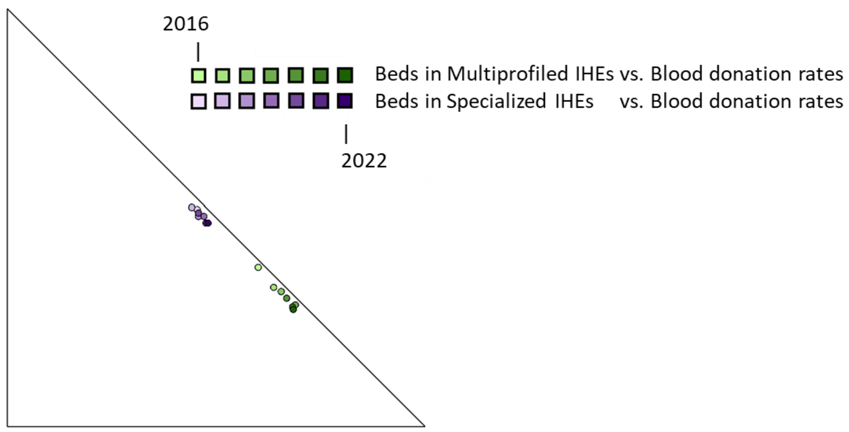


Fig. 1. InterCriteria Analysis results for the period 2016–2022 between the pair of criteria ‘Beds in Multiprofiled IHEs per 1000’ and ‘Blood donation rates per 1000’ and between the pair of criteria ‘Beds in Specialized IHEs per 1000’ and ‘Blood donation rates per 1000’

3.2 Inpatient health establishments vs Mortality rates

Access to adequate healthcare facilities and services can improve the likelihood of survival for individuals who need medical treatment. In areas with fewer hospital beds or limited access to healthcare services, mortality rates may be higher due to delays in receiving necessary medical care. Additionally, the quality of care provided in healthcare establishments having larger capacity can also impact mortality rates. However, it is noteworthy that mortality rates can be influenced by a variety of factors, including the overall health of the population, prevalence of certain diseases, availability of preventative care, and socioeconomic factors. Therefore, while there may be a correlation between inpatient health establishments and mortality rates, it is likely just one of many factors that contribute to overall health outcomes.

According to the results of the conducted InterCriteria Analysis, the indicators of number of beds per 100 in Multiprofiled IHEs and in Specialized IHEs are both in dissonance with the indicator of mortality rate per 1000 population. With the intuitionistic fuzzy pairs plotted near the middle of the hypotenuse of the interpretational triangle location, there is also no outlined trend over the period of seven researched years, which can be traced in the way the relations in the previous subsection. The comparison between the two pairs of criteria (Figure 2) shows:

- Weakly negative ICA consonance to dissonance (or weakly negative to no correlation) for both pairs of indicators;
- No traceable trend over the period of seven researched years in any of the two pairs of indicators.

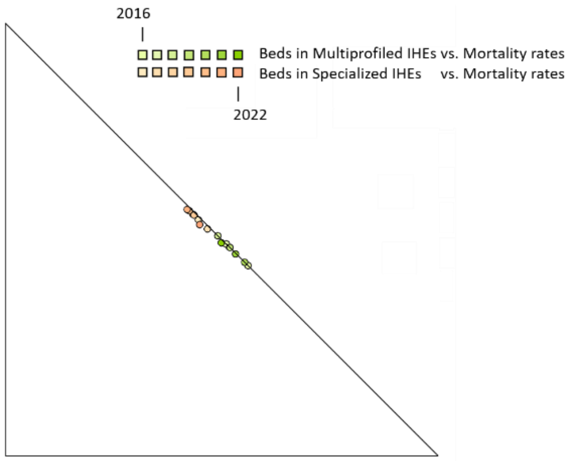


Fig. 2. InterCriteria Analysis results for the period 2016–2022 between the pair of criteria 'Beds in Multiprofiled IHEs per 1000' and 'Mortality rates per 1000' and between the pair of criteria 'Beds in Specialized IHEs per 1000' and 'Mortality rates per 1000'

4.3 Blood donation rates vs Mortality rates

This section presents the most notable and interesting findings from the conducted research. In general, blood donation rates can have a significant impact on mortality rates: by increasing blood donation rates, the availability of blood for transfusions can be improved, which is crucial for treating various conditions like accidents, surgeries, and certain diseases. When blood is readily available, patients in need are more likely to receive timely and appropriate care, reducing the risks and levels of mortality.

Additionally, regular blood donation has benefits for the donors themselves. It can help reduce the risk of various health conditions, such as coronary artery disease [6], by lowering iron levels in the body. Donating blood also stimulates the production of new blood cells for replenishment, which can have a positive impact on overall health and well-being.

Finally, blood donors benefit from the obligatory testing for HIV, hepatitis B and C and syphilis (anti-HIV, HBsAg, anti-HCV, ELISA tests), as they receive the results for free shortly after the donation and can thus monitor their own health status. Therefore, overall, higher blood donation rates are associated with better healthcare outcomes and can contribute to lower mortality rates in a population.

Based on the collected data for Bulgaria for the period 2016–2022, blood donation rates and mortality rates exhibit certain changes in the correlation from weakly negative in the years 2016–2019 to moderately negative in the years 2020–2022, meaning that though relatively low (and depending on numerous other factors), the higher the blood donation activity, the lower the mortality. This is shown on national level in the following Table 3 and Figure 3, presenting both the correlation coefficients plotted in a line graph, and the InterCriteria analysis pairs as points onto the intuitionistic fuzzy interpretational triangle.

Table 3. Blood donations per 1000 vs. Mortality per 1000 for Bulgaria: Results from the correlation analysis (COR) and InterCriteria Analysis (ICA) for the period 2016–2022

	2016	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
COR	–0.2213	–0.3238	–0.2038	–0.2254	–0.2859	–0.3350	–0.4636
ICA	⟨0.39,0.60⟩	⟨0.38,0.60⟩	⟨0.41,0.58⟩	⟨0.41,0.59⟩	⟨0.36,0.62⟩	⟨0.33,0.67⟩	⟨0.29,0.70⟩

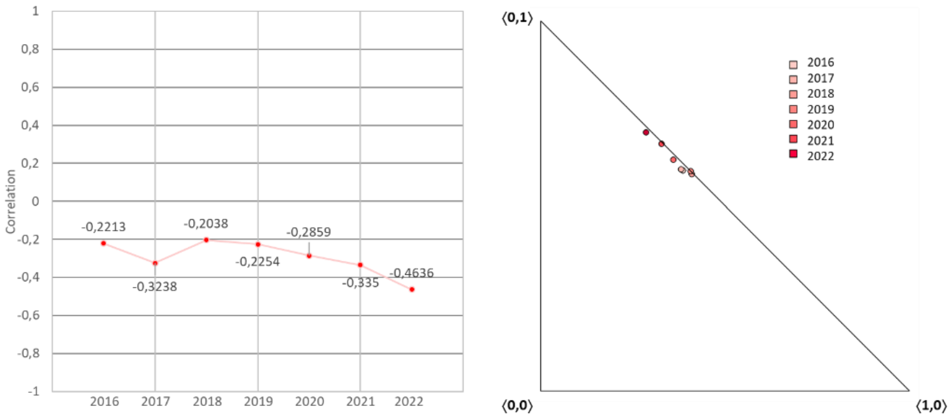


Fig. 3. Blood donations per 1000 vs. Mortality per 1000 for Bulgaria illustrated: Results from the correlation analysis (left) and InterCriteria Analysis (right) for 2016–2022

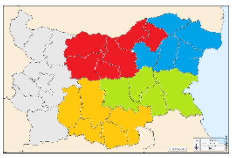
The data are further elaborated on a regional level. For the sake of better comprehension, the data from the different units in the five Regional CTHs are grouped by colour (Sofia NCTH – grey, 8 records; Plovdiv RCTH– orange, 5 records; Stara Zagora – green, 4 records; Varna – blue, 5 records; Pleven – red, 6 records). In the Table 4 below, for each of the years 2016–2022, the data are sorted first by 'Blood donation rate per 1000' (in descending order) and then by 'Mortality rate per 1000' (in ascending order), thus having the best performing regions for the respective year on the top rows of the table, i.e., ones with highest blood donation and lowest mortality. As it can be easily seen, there are some repeating patterns regarding the distribution of the regions, the best and worst performing ones, and can be indicative for the decision makers on national and regional level regarding to where efforts are most urgently needed to reverse the negative trends.

Table 4. Blood donation per 1000 and Mortality rate per 1000 for the 28 regions of Bulgaria grouped by RCTH, for the period 2016–2022

2016	Blood donation per1000	Mortality per 1000	2017	Blood donation per1000	Mortality per 1000	2018	Blood dona-tion per1000	Mortality per 1000	2019	Blood dona-tion per1000	Mortality per 1000
Plovdiv	32.8	14.6	S. Zagora	38.1	14.7	S. Zagora	38.3	14.7	Ruse	37.8	19.4
Sofia (city)	29.4	11.7	Ruse	34.6	18.8	Ruse	37.9	18.8	S. Zagora	37.6	14.6
Varna	24.4	12.9	Targovishte	28.5	11.6	Targovishte	29.6	11.7	Targovishte	29.9	11.8
Smolyan	23.9	15.0	Dobrich	24.8	12.9	Sofia (city)	26.0	15.7	Sofia (city)	26.1	15.9
Sofia (district)	23.2	18.1	Sofia (city)	24.7	16.3	V. Tarnovo	25.1	16.5	Dobrich	25.2	12.7
Vidin	22.5	23.1	V. Tarnovo	24.7	16.6	Sofia (district)	25.0	18.4	Sofia (district)	24.8	18.3
Blagoevgrad	21.1	12.6	Sofia (district)	23.4	18.4	Dobrich	24.6	13.1	Silistra	24.5	17.1
Targovishte	19.9	16.2	Silistra	20.8	16.5	Haskovo	23.0	23.2	V. Tarnovo	24.2	16.5
Pazardzhik	19.3	15.0	Haskovo	20.6	22.7	Yambol	22.8	18.7	Pleven	22.4	21.8
Silistra	18.3	16.0	Blagoevgrad	20.4	13.3	Blagoevgrad	21.9	13.2	Blagoevgrad	21.9	13.3
Montana/Lom	18.0	21.3	Yambol	19.1	17.8	Silistra	21.5	17.4	Haskovo	21.5	22.9
Shumen	16.7	14.6	Plovdiv	18.7	16.0	Smolyan	20.6	15.6	Smolyan	20.8	15.3
Dobrich	15.0	15.5	Varna	18.1	16.3	Pleven	20.1	21.7	Yambol	19.9	18.0
Vratsa	14.8	18.8	Sliven	18.1	17.1	Varna	19.7	16.3	Varna	19.1	17.0
Kardzhali	14.3	12.6	Smolyan	17.6	15.3	Burgas	18.9	13.4	Plovdiv	18.9	15.8
Kyustendil	14.3	19.9	Pleven	17.6	21.1	Sliven	18.9	18.0	Sliven	18.8	17.7
Pernik	13.3	19.2	Burgas	17.5	13.8	Plovdiv	18.1	15.0	Burgas	18.5	13.9
Pleven	12.7	18.5	Kyustendil	16.7	20.9	Kyustendil	17.8	20.0	Vratsa	17.9	15.6
S. Zagora	12.4	16.1	Lovech	15.9	16.7	Vratsa	16.4	16.0	Kyustendil	17.0	19.7
Haskovo	10.4	16.4	Kardzhali	15.9	20.1	Kardzhali	15.8	19.8	Lovech	15.9	16.8
Sliven	8.4	14.6	Vratsa	15.3	15.7	Montana/Lom	14.6	12.8	Kardzhali	15.7	19.8
Ruse	8.3	16.5	Montana/Lom	15.1	13.0	Lovech	14.2	16.6	Razgrad	13.9	20.4
Gabrovo	7.1	19.1	Razgrad	12.7	19.9	Razgrad	13.6	19.6	Pazardzhik	13.3	20.6
Yambol	6.7	17.1	Pazardzhik	12.5	20.7	Pernik	12.4	19.7	Montana/Lom	13.2	12.6
Burgas	5.6	13.2	Vidin	11.2	17.0	Vidin	12.2	16.4	Vidin	13.1	16.7
Lovech	4.3	19.3	Gabrovo	10.2	17.8	Pazardzhik	12.1	20.3	Pernik	12.8	20.9
V. Tarnovo	4.1	16.8	Pernik	8.9	21.1	Gabrovo	11.5	17.4	Gabrovo	12.3	17.5
Razgrad	2.9	16.2	Shumen	8.4	17.0	Shumen	10.4	17.0	Shumen	11.8	16.9

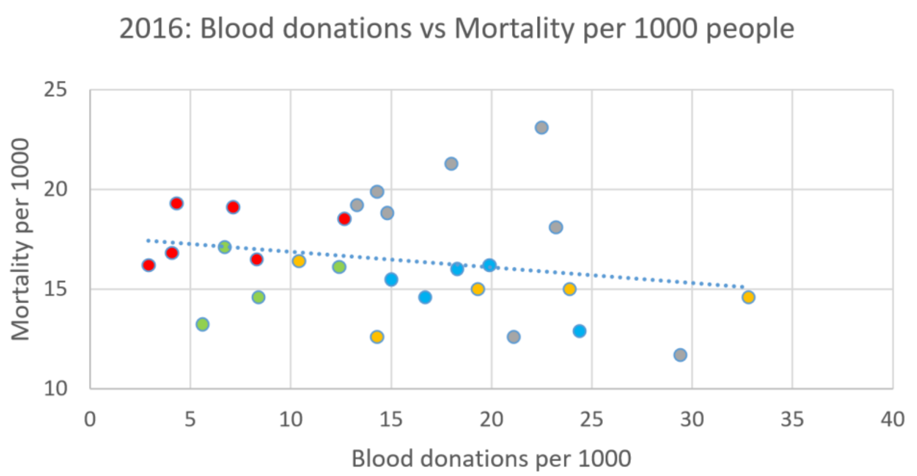
Contd.

2020	Blood donation per1000	Mortality per 1000	2021	Blood donation per1000	Mortality per 1000	2022	Blood donation per1000	Mortality per 1000
Ruse	35.8	21.7	Ruse	38.4	26.6	S. Zagora	40.5	17.1
S. Zagora	32.3	17.4	S. Zagora	37.5	20.6	Ruse	40.3	22.1
Targovishte	25.8	13.4	Targovishte	28.3	16.8	Targovishte	31.0	13.4
Sofia (city)	24.3	20.5	Sofia (city)	27.6	22.6	Dobrich	29.2	16.1
Dobrich	23.0	14.7	Dobrich	24.5	18.1	Sofia (city)	26.4	19.7
Silistra	22.4	20.5	Silistra	24.3	24.9	V. Tarnovo	25.6	19.5
V. Tarnovo	22.1	19.0	Blagoevgrad	21.1	19.3	Silistra	25.3	22.1

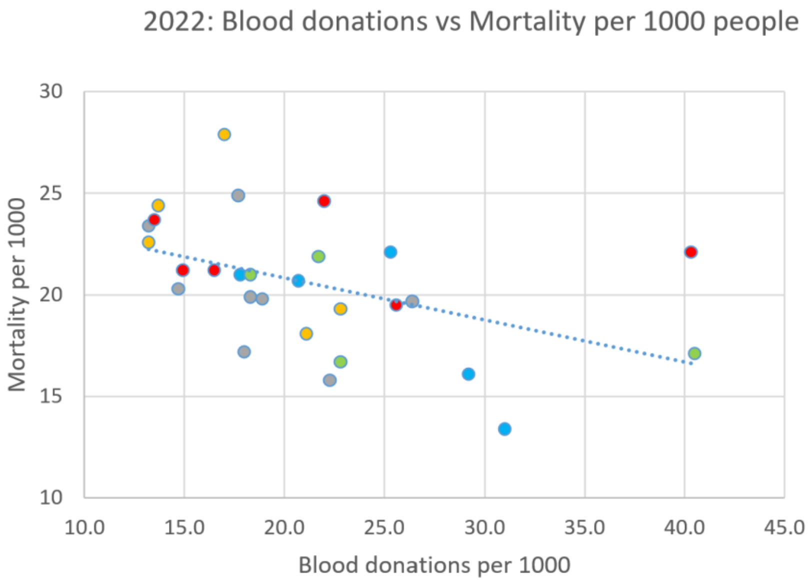


2020	Blood donation per1000	Mortality per 1000	2021	Blood donation per1000	Mortality per 1000	2022	Blood donation per1000	Mortality per 1000
Yambol	19.6	20.9	V. Tarnovo	21.1	22.9	Burgas	22.8	16.7
Sliven	19.1	21.4	Pleven	20.2	30.8	Plovdiv	22.8	19.3
Blagoevgrad	19.0	16.4	Sliven	19.6	25.6	Blagoevgrad	22.3	15.8
Burgas	18.8	15.1	Smolyan	19.5	20.9	Pleven	22.0	24.6
Pleven	18.3	25.5	Burgas	19.0	18.2	Sliven	21.7	21.9
Smolyan	17.9	18.1	Plovdiv	18.7	22.3	Smolyan	21.1	18.1
Sofia (district)	17.9	21.2	Sofia (district)	17.7	24.5	Varna	20.7	20.7
Plovdiv	17.2	19.1	Vratsa	16.9	22.3	Vratsa	18.9	19.8
Vratsa	16.2	18.1	Yambol	16.8	23.8	Sofia (district)	18.3	19.9
Haskovo	16.1	27.7	Varna	15.4	24.1	Yambol	18.3	21.0
Varna	15.3	19.7	Shumen	15.2	24.7	Montana/Lom	18.0	17.2
Kyustendil	15.2	24.0	Haskovo	15.0	32.3	Shumen	17.8	21.0
Montana/Lom	14.1	14.4	Kyustendil	14.7	27.9	Kyustendil	17.7	24.9
Kardzhali	13.3	22.3	Lovech	14.3	23.4	Haskovo	17.0	27.9
Shumen	13.1	21.5	Montana/Lom	13.8	17.5	Lovech	16.5	21.2
Lovech	13.0	19.1	Gabrovo	12.9	24.8	Gabrovo	14.9	21.2
Vidin	12.9	19.7	Kardzhali	12.8	28.0	Vidin	14.7	20.3
Razgrad	12.0	23.0	Vidin	12.5	23.1	Pazardzhik	13.7	24.4
Gabrovo	11.7	19.5	Pernik	11.7	27.2	Razgrad	13.5	23.7
Pernik	11.4	22.5	Pazardzhik	11.2	28.6	Kardzhali	13.2	22.6
Pazardzhik	10.6	24.0	Razgrad	10.8	28.4	Pernik	13.2	23.4

The respective correlation charts, for the endpoints of the period, t he years 2016 and 2022, are given in Figure 4 (a,b) below.



(a)



(b)

Fig. 4. Correlation charts for the indicators Blood mortality per 1000 vs. Mortality per 1000, for the years 2016 (a) with $r_{2016} = -0.2213$, and 2022 (b) with $r_{2022} = -0.4636$.

5 Conclusion

The present paper employs a data-driven approach, correlation analysis and InterCriteria analysis to investigate the potential relations between the capacity of inpatient health establishments that are allowed to operate with blood and blood products, the rates of blood donation (both voluntary and family / replacement) and mortality rates in Bulgaria for a seven-year period from 2016 to 2022. The most significant results, derived from the data retrieved for the 28 administrative regions of the country, are noted between the criteria ‘Blood donation rates per 1000’ and ‘Mortality rates per 1000’, exhibiting weakly negative to moderately negative correlation, respectively weakly negative to negative ICA consonance. The results are visualized on the intuitionistic fuzzy interpretational triangle and in correlation charts, as well as given on regional level on annual basis (Table 4). While the actual relationship might be influenced by various local factors, policies, and community engagement efforts, the findings reinforce the need for more systematic actions towards raising the blood donation culture in Bulgaria, especially in the repetitively ill performing regions, thus yielding positive results with respect to reducing mortality rates.

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References

1. Andreev, N., & Atanassova, V. (2021). InterCriteria Analysis of the Blood Group Distribution of Patients of Saint Anna Hospital in 2015–2019. *In: Atanassov K.T. et al. (eds) Advances and New Developments in Fuzzy Logic and Technology. IWIFSGN 2019. Advances in Intelligent Systems and Computing*, Vol. 1308, pp. 158–165. Springer, Cham. DOI: 10.1007/978-3-030-77716-6_14.
2. Andreev, N., Sotirova, E., & Ribagin, S. (2018). Intercriteria analysis of data from the centers for transfusion haematology in Bulgaria. *Comptes Rendus de l’Academie Bulgare des Science*, 72(7), 982–990. DOI: 10.7546/CRABS.2019.07.17.
3. Andreev, N., Vassilev, P., Ribagin, S. & Sotirov, S. (2019). InterCriteria Analysis of data for blood collection in the Transfusion Hematology Department, University Hospital St. Anna, Sofia, *Notes on Intuitionistic Fuzzy Sets*, 25(2), 88–95. DOI: 10.7546/nifs.2019.25.2.88-95.
4. Atanassov, K., Mavrov, D., & Atanassova, V. (2014). Intercriteria Decision Making: A New Approach for Multicriteria Decision Making Based on Index Matrices and Intuitionistic Fuzzy Sets. Issues in Intuitionistic Fuzzy Sets and Generalized Nets, 11, 1–8.
5. Atanassova, V., Andreev, N., & Dimitriev, A. (2023). InterCriteria Analysis of the Geographic Distribution of the ABO System Blood Groups in the Patients of the University Hospital “Saint Anna”, Sofia, Bulgaria, from 2015 to 2021. In: Sotirov, S., Pencheva, T., Kacprzyk, J., Atanassov, K.T., Sotirova, E., Ribagin, S. (eds) *Recent Contributions to Bioinformatics and Biomedical Sciences and Engineering. BioInfoMed 2022*. Lecture Notes in Networks and Systems, vol 658, pp. 84–97. Springer, Cham. DOI: 10.1007/978-3-031-31069-0_10.
6. Guo, S., Mao, X., Li, X, & Ouyang, H. (2022). Association between iron status and incident coronary artery disease: A population based-cohort study. *Scientific Reports*. 12(1), Article No. 17490. DOI: 10.1038/s41598-022-22275-0.
7. Mavrov, D. (2015). Software for InterCriteria Analysis: Implementation of the main algorithm. *Notes on Intuitionistic Fuzzy Sets*, 21(2), 77–86.
8. Mavrov, D., Radeva, I., Atanassov, K., Doukovska, L., & Kalaykov, I. (2015). InterCriteria Software Design: Graphic Interpretation within the Intuitionistic Fuzzy Triangle. *Proceedings of the Fifth International Symposium on Business Modeling and Software Design*, pp. 279–283. DOI: 10.5220/0005888202790283.
9. Mavrov, D. (2015-2016). Software for intercriteria analysis: Working with the results. *Annual of “Informatics” Section, Union of Scientists in Bulgaria*, 8, 37–44.
10. National Statistical Institute of the Republic of Bulgaria (2024). *Beds in inpatient health establishments by type of beds, statistical zones and statistical regions*. Available online at:

https://www.nsi.bg/en/content/3314/beds-inpatient-health-establishments-type-beds-statistical-zones-and-statistical-regions-3112
11. National Statistical Institute of the Republic of Bulgaria (2024). *Population by districts, municipalities, place of residence and sex*. Available online at: https://www.nsi.bg/sites/default/files/files/data/timeseries/Pop_6.1.1_Pop_DR_EN.xls
12. National Statistical Institute of the Republic of Bulgaria (2024). *Deaths by districts, municipalities and sex*. Available online at: https://www.nsi.bg/sites/default/files/files/data/timeseries/Pop_2.1._mortality_DR_EN.xls
13. National Centre of Transfusion Haematology of the Republic of Bulgaria (2024). Statistics. Available online at: https://ncth.bg/statistika/

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