INTELLECTUAL MODEL FOR ANALYZING AND MANAGING PATIENT TRUST IN MEDICAL STAFF OF PRIMARY HEALTHCARE INSTITUTIONS

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Abstract: In the work, research was conducted on the development of an intellectual analysis model for determining the level of trust of patients in the medical staff of a primary medicine institution, for effective strategy and management on the example of the countries of the Visegrad Group (Czech Republic, Hungary, Poland, Slovakia). The research uses modern knowledge collection and presentation methods, applied in fuzzy set theory, system analysis, and expert evaluation. The main value of the model lies in the fact that it examines the question of evaluating the effectiveness of the management of primary medicine medical institutions, taking into account the level of trust of patients in the medical staff. The model provides an opportunity to comprehensively analyze the region and develop recommendations for state authorities to create strategies for improving the quality of medical medicine in outpatient facilities. At the level of primary medicine institutions, managers should develop strategies to create conditions in which patients' trust in medical personnel will grow. The developed model was verified and tested on real data of primary medicine patients in the countries of the Visegrad Group. An example of evaluation on fragments of data in four regions is illustrated.

Key words: trust of patients, primary medicine, management efficiency, intellectual analysis of knowledge, fuzzy modeling

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Introduction

Trust in medical personnel is one of the key factors in the successful provision of medical services and the overall level of patient satisfaction. Patients who trust the medical staff are more likely to return to the same institution for services, which increases loyalty and positively affects the reputation of the medical institution. Also, patients who trust their doctors are more likely to leave positive reviews and

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recommend the facility to others, contributing to the influx of new patients. Measuring the level of trust of patients in medical personnel can be part of strategic planning. This allows management to identify problem areas and develop measures to eliminate them. Trust in medical staff allows for more efficient planning and allocation of resources, including the time of doctors and nurses, as satisfied patients are less prone to conflict and complaints. Also, patients' trust in medical staff helps reduce stress and burnout among employees, reducing staff turnover.

Thus, trust in medical personnel is a critically important factor affecting the effectiveness of medical facilities. The strategy and management aim to create conditions in which patients' trust in medical personnel will grow, which in turn will contribute to the general improvement of the quality of medical services and the level of patient satisfaction.

The main goal of the conducted research is to develop a model of intellectual analysis for determining the level of trust of patients in the medical staff of a primary medicine institution, for effective strategy and management based on the example of the countries of the Visegrad Group (Czech Republic, Hungary, Poland, Slovakia).

Trust represents a construct that can be affected by many factors. It can be altered over time and can be perceived by the various population groups in a differentiated way, depending on previous experience with the healthcare service provided as well as the demand for it, the patients' health status, the sociodemographic indicators, and so on. Patients' confidence can also be influenced by the enforced healthcare policy of the countries, related to the availability of resources and insurance financial schemes (Gerhards et al. 2017). People can be concerned about the lack of healthcare sources as well as unavailability of healthcare depending on age, comorbidities, social and economic situation, and so on. Hence, investigation of the confidence factors and their changes is rudimentary for efficient management of healthcare facilities and for construction of optimal management strategies aimed at higher quality, healthcare service efficiency and sustainability of the healthcare system (Sousa-Duarte et al. 2020). These aspects are the basement of patients' satisfaction and loyalty necessary to ensure effective healthcare policy in the countries (van Dijk et al. 2021). Effective healthcare policies of the countries will enable reduction of regional health disparities not only within the individual countries, but also between the countries and thus, to ensure fulfillment of global health goals, including sustainable development goals (SDGs).

Literature Review

Investigating patients' confidence and its impact on quality and efficiency of healthcare has been in the attention of many research teams around the world for decades and the importance of this issue has been increasing. This is related not only to the increasing life expectancy of the population, but also to technological development in healthcare, an increase in morbidity and emergence of new diagnoses, epidemics, and pandemics. Although there are many research studies in this field, their comparison is considerably comprehensive for the methodological

aspects as well as the difference in the healthcare policies that are applied in the individual countries. Nevertheless, they provide a valuable platform to justify the need for investigating factors and development of systems that would help not only measure confidence, but also to implement information about status and development of confidence in management and the decision-making mechanisms in healthcare facilities. The following selected research studies also declare the difference in the impact of factors related to confidence and satisfaction. For instance, Dayan et al. (2022) suggest that service quality, speech form, and relationship to outpatient physician positively influence patient satisfaction and indirectly influence patient loyalty. According to the authors, satisfaction with the waiting time has no impact on the outpatients' satisfaction. An increase of the costs of switch to other healthcare providers can prevent patients from switching to other providers and thus, it creates the potential for false loyalty or so-called status of customer hostage.

Shie et al. (2022) point to the relationship between the four variables: quality of health services, accessibility to services, trust, and loyalty. Their findings show that the higher the quality of health services, the higher the trust, promoting enhancement of the health services level and followingly, increasing the loyalty between physician and patient. Development of the tools to self-manage own health care can raise enthusiasm for maintaining own health and contribute to greater satisfaction with own treatment plan.

The sociodemographic indicators also influence change in patients trust and loyalty to physician in healthcare facilities. Some studies confirm that elderly patients, more educated, married, living in urban regions, in better health condition and with a contract with a family physician, show higher patient trust to physician (Li et al. 2022). Age, marital status, education, region, where they live, health status, and a contract with a family physician is a significant predictor of patient's trust. In many studies, the interconnectedness between trust and perceived quality of the provided healthcare services is visible that are directly related to the patient's expectations. For instance, Thom et al. (2002) confirmed that patients with a lower trust level in their physician are more likely to list unfulfilled requests for healthcare services.

In the recent period, communication has also played an important role in building trust between patient and physician. According to Chandra et al. (2018) both trust and communication are positively related to patient satisfaction and perceived quality of healthcare services. A patient-centered approach with effective communication skills and trust promotes better healthcare management that results in higher patient satisfaction.

Trust in physicians needs to be investigated in the other causal relationships as well. Oguro et al. (2021) confirmed that the family member's negative experiences with healthcare services have a long-term impact on patients' attitudes and emotions and hence, it is necessary to investigate the impact of family members' experiences on patients' trust in their own and general practitioners.

Although many studies point to a direct relationship between patients' trust in physicians and satisfaction with the health care provided (Adriansyah et al. 2021), enhancing a physician to patient interaction does not automatically guarantee higher trust and higher satisfaction. Shan et al. (2016) confirm that the patient's trust as the most significant predictor of his satisfaction is shaped by the perceived high quality of the services provided, empathetic and caring interpersonal interactions. Similarly, Abbasi-Moghaddam et al. (2019) consider consultations with physician the most significant predictor of patient satisfaction, how they are provided with information and in what environment they receive healthcare. According to the authors, the highest difference in service quality was related to the perception of the sensitivity dimension by patients and managers.

The appropriate training programmes for employees aimed at creating effective interactions and ensuring timely healthcare services are mentioned in the studies as frequent recommendations for enhancing healthcare quality. Some authors also recommend investments in the physical environment and technical equipment of outpatient department that can contribute to the perceived satisfaction of patients with the quality of the provided health services (Alrubaiee and Alkaa'ida, 2011; Thom et al. 2002).

The sociodemographic characteristics can be an important aspect in the differentiated perception of the healthcare services that is also related to a higher potential need for healthcare in elderly age. Trust in healthcare can be related to age, education, employment, income, existence of household, residence, and the various ideological aspects (Durmus and Akbolat, 2020; Farrokhi et al. 2023).

Usta and Korkmaz (2020) confirm that people over sixty years, with low education, unemployed, with low income, and people from rural areas have higher trust in the healthcare system. Trust in the healthcare system may also be related to a higher need for healthcare information in the periods of illness or elderly age, as well as social and economic uncertainties. These aspects are also intensively investigated in a relation to the health systems of the developing countries, where social and economic indicators play a significant role (Amankwah et al. 2019).

Kim et al. (2017) consider the treatment effectiveness to be an important factor in patients' satisfaction with the healthcare quality. According to the authors, the effectiveness of treatment had a more significant impact on patient satisfaction compared to facilities and environment, indirectly influencing satisfaction and directly influencing the intention to repetitive visit of a particular physician. New models of healthcare service delivery also point to the importance of examining waiting times, clinical contact period, trust, empathy, communication, and expectations when evaluating specialist healthcare service (Waters et al. 2016). Nguyen et al. (2021) explain the differential weight and strength of patient satisfaction factors such as emotion, function, social influence, and trust. According to these authors, emotions do not significantly affect customer perceived value and function does not significantly affect patient satisfaction.

The various perceptions of patient satisfaction can be influenced not only by the regional characteristics, but also by the healthcare facility type (private versus state healthcare providers). This fact is confirmed by the research studies conducted within public healthcare providers (Liu et al. 2021) as well as private ones (Pathak, 2017; Fatima et al. 2018). Public hospitals can show significant deficiencies in the quality of services provided (Majele et al. 2024), and failure to address them can lead to increased patient dissatisfaction, increased infections, longer recovery times, and higher mortality rates. The ambition of healthcare policies in the individual countries is to reduce the differences in the healthcare service quality provided by state and private health care providers and thus, to improve the regional and economic availability of healthcare service. Various insurance mechanisms play an important role in the healthcare policies of the individual countries.

System efficiency, the introduction of standard operating procedures, as well as increasing investments in electronic healthcare service systems, which have an impact on the timely provision of health services, including the reduction of waiting times, have been increasingly promoted in the recent period. Patients' satisfaction and their trust in the medical staff also impact the willingness to pay for an above-standard health service and engagement (Ai et al. 2022).

Many other aspects of the healthcare service quality are also investigated in the research studies that can reveal new causal relations in the processes of improving the healthcare service quality. For instance, it was found that the exterior design of healthcare facilities is not associated with patient satisfaction or trust, while interior decoration and cleanliness as well as atmosphere is directly associated with them in healthcare services (Ai et al. 2022).

The patients often associate the different types of healthcare facilities with the different levels of the healthcare services provided. Cho et al. (2020) pointed out the differences in the evaluation of the healthcare service quality by patients within university healthcare services, community clinics and hospitals. Patients perceived a higher quality of healthcare services in community primary care facilities than in hospitals. According to Manulík et al. (2016), patients from state healthcare facilities had higher expectations from contacts with medical personnel than patients from private healthcare facilities. Chegini et al. (2022) confirmed that patients of private health facilities trust physicians more as those ones living in rural areas. The authors also confirm the relationship of decreasing trust of patients in physicians if communication between physicians and patients is erroneous. Nevertheless, Al-Neyadi et al. (2018) confirm that the perceived patients' satisfaction with the provided service quality does not differ between private and state healthcare facilities. The most important evaluation dimension for the both types of healthcare facilities is security. High-quality healthcare services lead to satisfied patients. Hence, the differences between types of healthcare facilities in the perception of the healthcare services quality should be minimal in healthcare systems (Singh and Dixit, 2020).

Healthcare providers may perceive healthcare quality attributes differently than patients that may be related to the different levels of expectations (Campos et al. 2017). Knowing the perception of the quality of services by patients makes it possible to examine their potential loyalty as well. According to Lin et al. (2004), potential loyalty is related to tangibility, reliability, responsiveness, assurance, and empathy. The importance of these factors is also confirmed by Jonkisz et al. (2022). The patient treatment type can also influence the different perceptions and evaluations of the healthcare service quality (Lee and Kim, 2017). The perception of the healthcare quality can also vary depending on the environment and state (Mohammed et al. 2016). Hence, it is important to investigate the impact of patients' experiences on the perception of the healthcare service quality and interventions that influence patients' decision-making processes and their loyalty to healthcare facilities.

Information technologies can also influence the perceived healthcare service quality. Kisekka and Giboney (2018) examined how privacy concerns reduced the frequency of patient access to health records that may impact the perceived healthcare service quality. Healthcare facilities should implement optimal security measures to increase trust and thus, to reduce privacy concerns that will have an impact improving healthcare service quality. The effectiveness of the information exchange for patients can be supported by various innovations in health information technology. Xie et al. (2020) point to the interconnectedness of health information technology and patient satisfaction and trust with these trajectories, possessing many complex relationships that need to be further explored.

The outcomes of the mentioned research studies allowed us to define the elementary research platform for the analytical processes, whose aim was development of an intellectual analysis model for determining the level of trust of patients in the medical staff of a primary medicine institution, for effective strategy and management on the example of the countries of the Visegrad Group.

Based on the above, the scientific hypothesis of this study focuses on the functional capabilities of the proposed tool and the predicted results of its implementation. It can be formulated as follows: the developed model of intellectual analysis is functional and effectively assesses patients' trust in primary care medical personnel; in the selected region there is a relationship between the overall degree of effectiveness of management of primary care institutions and patients' trust in medical personnel.

Research Methodology

Consider some region R to evaluate the general level of trust of patients in the medical staff of primary medicine. The set of patients $P = \{p_1; p_2; \dots; p_n\}$ are the respondents of the research questionnaire who expressed their attitude regarding trust in the medical staff according to some set of evaluation criteria $K = \{K_1; K_2; \dots; K_m\}$. This model is presented in the form of an operator:

$$\Sigma(R, P, K) \to f(lt, DE). \quad (1)$$

As a result of the operator's work, based on the input data, the initial values of f are obtained, namely: lt – a generalized quantitative assessment of patients' trust in the medical staff of primary medicine in the studied region; DE – linguistic assessment of the effectiveness of the management of primary medicine institutions within the studied region.
To present the intelligence analysis model, two management subjects are introduced: the system analyst is the person responsible for setting up all assessment processes; a decision-maker (DM) is a person who, based on the obtained results, concludes (recommendations, scenarios) regarding increasing the trust of patients in the medical staff of primary medicine at the regional level.

The model of intellectual analysis processes the opinions of patients and moves from individual knowledge to collective knowledge at the regional level. Therefore, first, based on the set of criteria $K = \{K_j; j = \overline{1,m}\}$, which is classified into l groups $G_1; G_2; \dots; G_l$, data is collected from respondents according to various aspects of trust in medical personnel. This set is open, so the model does not depend on their number, which makes it adaptive. Data collection from patients takes place in the form of an integer score $E \in [0; 10]$, which is obtained based on the answer to the question about the trust of patients in the medical staff of primary medicine. Based on theoretical-multiple generalization, the formation of a set of evaluation criteria was carried out, and they were classified into groups.

G_1 – Quality of medical services:

K_{11} – How would you generally rate the work of the medical staff who treated you? (from 0 – “Worst rating” to 10 – “Best rating”).

K_{12} – Did you have the opportunity to participate in the decision-making about your health as you wished? (from 0 – “I did not participate at all” to 10 – “I was involved as much as possible”).

G_2 – Empathy and communication:

K_{21} – Did you have enough time to discuss your health issues with health professionals? (from 0 – "There was not enough time at all" to 10 – "There was enough time").

K_{22} – Did you feel enough respect and empathy when communicating with the medical staff? (from 0 – "Did not feel" to 10 – "Feeled").

K_{23} – Did the medical staff respect your cultural or religious beliefs? (from 0 – "Not respected at all" to 10 – "Respected and given a lot of respect").

K_{24} – Did the medical staff treat you politely? (from 0 – "They were not polite at all" to 10 – "They were very polite").

G_3 – Convenience and availability of medical services:

K_{31} – How convenient was it to make an appointment with a doctor? (from 0 – "Very difficult" to 10 – "Extremely comfortable").

K_{32} – Was the state of your health easily explained by medical workers? (from 0 – "It was not clear" to 10 – "Everything was clear").

G_4 – Security and privacy:

K_{41} – Did you feel enough privacy when discussing your health with the medical staff at the outpatient clinic? (from 0 – "I did not feel privacy" to 10 – "I needed privacy").

K_{42} – Did you feel enough trust in the medical staff? (from 0 – "Did not feel trust" to 10 – "Trust was necessary").

Based on the expressed impressions of patients according to the above criteria, a set of input data E is obtained, within the proposed groups for the researched region R. First, a convolution of the obtained scored points takes place in the section of patients $p_i, i = \overline{1,n}$:

$$\delta_u(p_i) = \sum_{j=1}^{m_u} E_{ji}. \quad (2)$$

m_u – the number of criteria in the group $u, u = \overline{1,l}$, $\delta_u(p_i) \in [a_u, b_u]$.

In the second step, data is compared using intelligent knowledge analysis based on membership functions. This will reduce the subjectivity of the data received from patients. According to the research logic, it is proposed to apply membership functions to uncertainties of the "high level" type. They are used to blur decision

boundaries and are described in terms of S-shaped membership functions. Such functions are easily parameterized, allowing them to be configured to reproduce different forms and gradations of belonging. For example, a quadratic S-spline is as follows:

$$\mu_u(p_i) = \begin{cases} 0, & if \quad \delta_u(p_i) \le a_u; \\ 2\left(\frac{\delta_u(p_i)-a_u}{b_u-a_u}\right)^2, & if \quad a_u < \delta_u(p_i) \le \frac{a_u+b_u}{2}; \\ 1-2\left(\frac{b_u-\delta_u(p_i)}{b_u-a_u}\right)^2, & if \quad \frac{a_u+b_u}{2} < \delta_u(p_i) < b_u; \\ 1, & if \quad \delta_u(p_i) \ge b_u. \end{cases} \tag{3}$$

For the proposed criteria groups G_1, G_3, G_4 the membership function will look like this:

$$\mu_{1,3,4}(p_i) = \begin{cases} 0, & if \quad \delta_{1,3,4}(p_i) \le 0; \\ \frac{1}{200}\left(\delta_{1,3,4}(p_i)\right)^2, & if \quad 0 < \delta_{1,3,4}(p_i) \le 10; \\ 1-\frac{1}{200}\left(20-\delta_{1,3,4}(p_i)\right)^2, & if \quad 10 < \delta_{1,3,4}(p_i) < 20; \\ 1, & if \quad \delta_{1,3,4}(p_i) \ge 20. \end{cases} \tag{4}$$

For a group with four criteria G_2, the membership function is as follows:

$$\mu_2(p_i) = \begin{cases} 0, & if \quad \delta_2(p_i) \le 0; \\ \frac{1}{800}(\delta_2(p_i))^2, & if \quad 0 < \delta_2(p_i) \le 20; \\ 1-\frac{1}{800}(40-\delta_2(p_i))^2, & if \quad 20 < \delta_2(p_i) < 40; \\ 1, & if \quad \delta_2(p_i) \ge 40. \end{cases} \tag{5}$$

Thus, normalized scores $\mu_u(p_i) \in [0;1]$ are obtained for patients p_i within the criteria groups regarding their trust in the medical staff of primary medicine.

In the third step, the DM introduces weighting factors $\{\omega_1, \omega_2, \dots, \omega_l\}$ to each group of criteria from the interval [1; 10]. Since the calculation takes place in the evaluation space [0;1], normalized weights are derived:

$$\overline{\omega_u} = \frac{\omega_u}{\sum_{u=1}^{l}\omega_u}, u = \overline{1,l}; \overline{\omega_u} \in [0;1]. \tag{6}$$

In the fourth step, using a convolutional approach, an aggregated quantitative assessment of trust in the medical staff of primary medicine is derived by patients. DM can choose one of the convolutions for calculation:

$$\lambda_1(p_i) = \frac{1}{\sum_{u=1}^{l} \frac{\overline{\omega_u}}{\mu_u(p_i)}}. \quad (7)$$

$$\lambda_2(p_i) = \prod_{u=1}^{l} (\mu_u(p_i))^{\overline{\omega_u}}. \quad (8)$$

$$\lambda_3(p_i) = \sum_{u=1}^{l} \overline{\omega_u} \cdot \mu_u(p_i)). \quad (9)$$

$$\lambda_4(p_i) = \sqrt{\sum_{u=1}^{l} \overline{\omega_u} \cdot (\mu_u(p_i))^2}. \quad (10)$$

The obtained values are normalized and characterize the general level of trust of patients p_i, $i = \overline{1,n}$ in medical personnel.

In the fifth step, a generalized quantitative assessment of patients' trust in the medical staff of primary medicine in the studied region is derived – lt:

$$lt(R) = \frac{1}{n} \cdot \sum_{i=1}^{n} \lambda(p_i). \quad (11)$$

The obtained estimate is normalized by $lt(R) \in [0; 1]$. It is noted that with this approach it is possible to obtain knowledge of patient's trust in medical personnel at the level of a medical institution or the entire country.

In the sixth step, a linguistic evaluation of the management effectiveness of primary medicine institutions within the studied region is performed. For this, the term set $DE = \{de_1; de_2; de_3; de_4; de_5\}$ is proposed to compare the formalized conclusion with the generalized quantitative assessment of patients' trust in primary medicine medical personnel in the studied region: if $lt(R) \in [0; 0.2)$ then de_1 = "the efficiency of management of primary medicine institutions is very low"; if $lt(R) \in [0.2; 0.5)$ then de_2 = "efficiency of management of primary medicine institutions is low"; if $lt(R) \in [0.5; 0.7)$ then de_3 = "efficiency of management of primary medicine institutions is average"; if $lt(R) \in [0.7; 0.85)$ then de_4 = "efficiency of management of primary medicine institutions is high"; if $lt(R) \in [0.85; 1]$ then de_5 = "efficiency of management of primary medicine institutions is very high". A systems analyst can change decision levels using real-world data sets.

Research Results and Discussion

The intellectual analysis model for determining the level of trust of patients in the medical staff of a primary medicine institution was verified and tested on real data in the countries of the Visegrad Group (Czech Republic, Hungary, Poland, Slovakia) (Data from patients of primary medicine). The conducted research is an integral part of a large project aimed at analyzing the quality of medical medicine in outpatient

and inpatient medical institutions. The main goal of the study is the formation of recommendations for the creation of strategies for improving the quality of medical medicine. The project developed a research questionnaire with 118 questions. This was made possible thanks to the cooperation between the Faculty of Mining, Ecology, Process Control and Geotechnologies of the Technical University of Košice, VVC Bionformatika, University Science Park TECHNICOM, the Faculty of Management and Economics of Tomas Bata University in Zlín, Uzhhorod National University and with other important as research, and professional institutions, as well as with providers of medical services. Data collection was conducted between January and April 2024 and included data from patients. The input data meets all the requirements for forming a sample of statistical data. The respondents correspond to different demographic characteristics, covering different social classes. During the research, experiments were conducted using the entire available data sample and the developed model. To demonstrate the results and ensure the possibility of model reproduction by other researchers, an example of evaluation on data fragments is provided.

An example of assessing the level of trust of patients in the medical staff of a primary medicine institution is given according to the proposed model of intellectual analysis in four regions from different countries V4: R_1: Trenčín Region (Slovakia) – 31 patients; R_2: Vysočina Region (Czech Republic) – 39 patients; R_3: Pomeranian Voivodeship (Poland) – 49 patients; R_4: Szabolcs-Szatmár-Bereg county (Hungary) – 34 patients.

According to the proposed evaluation criteria, patients expressed their attitude regarding trust in the medical staff of primary medicine. Thus, all the input data of the study, which are given in (Data from patients of primary medicine), are obtained. For example, fragments of respondents' assessments for the Trenčín Region are shown in Table 1.

Table 1. Fragments of input data for the Trenčín Region

Group	Criteria	p_{2513}	p_{2529}	p_{2531}	p_{2532}	…	p_{2637}
G_1	K_{11}	10	10	10	10	…	10
	K_{12}	10	8	10	10	…	10
G_2	K_{21}	5	8	10	9	…	10
	K_{22}	4	9	10	10	…	10
	K_{23}	0	9	10	10	…	6
	K_{24}	10	10	8	10	…	10
G_3	K_{31}	4	7	7	9	…	8
	K_{32}	8	9	10	8	…	10
G_4	K_{41}	10	9	9	10	…	10
	K_{42}	10	10	10	8	…	10

Note: where $p_{2513}, p_{2529}, p_{2531}, p_{2532}, p_{2637}$ – respondents of the study

After receiving the input data, in the first step, the received scored points are rolled up in the section of patients according to formula (2). In the second step, the data is compared using the intellectual analysis of knowledge based on one-dimensional membership functions according to formulas (4)-(5), respectively, for four groups of criteria. Fragments of the results of these calculations for the Trenčín Region are presented in Table 2. For all other studied regions, the results (Data from patients of primary medicine).

Table 2. Fragments of calculated data for Trenčín Region

Group	Value	p_{2513}	p_{2529}	p_{2531}	p_{2532}	…	p_{2637}
G_1	δ_1	20	18	20	20	…	20
	μ_1	1	0.98	1	1	…	1
G_2	δ_2	19	37	36	37	…	36
	μ_2	0.451	0.989	0.98	0.989	…	0.98
G_3	δ_3	12	16	16	18	…	18
	μ_3	0.68	0.92	0.92	0.98	…	0.98
G_4	δ_4	20	19	19	18	…	20
	μ_4	1	0.995	0.995	0.98	…	1

Note: where $\delta_1, .., \delta_5$ – convolution of input points; $\mu_1, .., \mu_5$ are normalized scores

At the third step, the DM sets the weighting coefficients $\{10;\ 9;\ 8;\ 9\}$ to each group of criteria. Normalized weights are calculated according to formula (6): $\overline{\omega_1} = 0.28$; $\overline{\omega_2}$ =0.25; $\overline{\omega_3}$ =0.22; $\overline{\omega_4}$ =0.25.

In the next step, using the average convolution according to formula (9), an aggregated quantitative assessment of patients' trust in the medical staff of primary medicine is derived in the section of patients. Fragments of the obtained values in the studied regions are as follows: R_1: $\lambda_3(p_{2513}) = 0.79$; $\lambda_3(p_{2529}) = 0.97; \ldots;\ \lambda_3(p_{2637}) = 0.99$. R_2:$\lambda_3(p_{12}) = 0.5$; $\lambda_3(p_{109}) = 0.95; \ldots;\ \lambda_3(p_{1836}) = 0.88$. R_3: $\lambda_3(p_{2345}) = 0.99$; $\lambda_3(p_{2354}) = 0.38; \ldots;\ \lambda_3(p_{2416}) = 0.95$. R_4: $\lambda_3(p_{1965}) = 0.46$; $\lambda_3(p_{1971}) = 0.98; \ldots;\ \lambda_3(p_{2280}) = 0.63$.

In the fifth step, a generalized quantitative assessment of patients' trust in the medical personnel of primary medicine in the studied region is derived according to formula (11): $lt(R_1) = 0.89$; $lt(R_2) = 0.86$; $lt(R_3) = 0.8$; $lt(R_4) = 0.8$.

In the final step, a linguistic evaluation of the management effectiveness of primary medicine institutions within the studied regions is derived by comparing the values of the generalized quantitative assessment of patients' trust in medical personnel to the DE term set. It turns out that the researched regions R_1 and R_2 belong to the interval $[0.85; 1]$ then "efficiency of management of primary medicine institutions is very high". Other regions R_3 and R_4 to the interval $[0.7; 0.85)$ and will receive – "efficiency of management of primary medicine institutions is high".

Thus, in the studied regions, knowledge was obtained about the trust of patients in the medical staff of primary medicine, and as a result, the degree of effectiveness of the management of primary medicine institutions within the studied regions. The acquired knowledge can be used to develop future recommendations to improve the quality of medical services in ambulatory medicine facilities.

This research uses modern methods of knowledge collection and representation applied in fuzzy set theory, system analysis, and expert evaluation. The use of such mathematical tools makes it possible to improve the validity of management decisions. The main value of the intellectual model lies in the fact that it investigates the issue of evaluating the effectiveness of the management of primary medicine medical institutions, considering the level of trust of patients in the medical staff. All model settings were tested on real data. The results of the simulation are a generalized quantitative assessment of patients' trust in medical personnel in the studied region and a linguistic assessment of the effectiveness of management of primary medicine medical institutions. This provides an opportunity to comprehensively analyze the region and develop recommendations for state authorities to create strategies for improving the quality of medical medicine in outpatient facilities. At the level of primary medicine institutions, managers should develop strategies to create conditions in which patients' trust in medical personnel will increase. Patients' trust investigation is extremely important for setting the management processes and optimal strategies to ensure patients' satisfaction as well as higher quality and efficiency of provided healthcare services (Chauhan and Campbell, 2021; Ahenkora et al. 2019). Underestimating these aspects can lead to increasing regional disparities in health indicators as well as various negative social and economic impacts (Kovacs et al. 2019; Krot and Rudawska, 2021).

The developed model is easily adjusted and adapted to different regions and countries, since the set of criteria for evaluating patients' trust in medical personnel is open, and the model itself does not depend on their number. In addition, the model uses membership functions in the context of intelligent knowledge analysis, which makes it possible to adjust decision-making levels. The model is based on the theory of fuzzy sets, which allows to the improvement of the quality of incoming expert evaluations and to move from individual knowledge regarding the trust of patients to medical personnel to collective knowledge, both at the level of individual medical institutions and the level of an entire region or state.

We faced some limitations in our study due to the use of different types of membership functions, their tuning parameters, and different types of convolutions. In addition, the setting of the decision levels depends on the real data, which can lead to ambiguity in the obtained results. However, these limitations do not affect the knowledge gained within the framework of the study. The high rationality of the obtained results confirms the advantages of the developed model, and their reliability is ensured by the correct and justified use of mathematical theory. The scientific results obtained during the research confirm the proposed hypothesis.

The study outcomes are beneficial for healthcare policymakers, experts dealing with the processes of creating healthcare strategies and plans (Chauhan and Campbell, 2021), managers in healthcare facilities, as well as for experts dealing with the human resource management (Groenewegen et al. 2019). Besides these benefits, the study outcomes will support creation of benchmarking systems in the field of quality, efficiency, and patient satisfaction, enabling national and international comparisons. They will also enable development of trust indicators in healthcare facilities, which will reflect dynamic technological development and growing demands of patients for quality and healthcare efficiency. Last but not least, the study contributes to understanding the importance of development of intellectual information models and other methodologies necessary for improving management processes in healthcare facilities.

Conclusion

A model of intellectual analysis of determining the level of trust of patients in the medical staff of a primary medicine institution was developed for effective strategy and management based on the example of the countries of the Visegrad Group (Czech Republic, Hungary, Poland, Slovakia). The model includes 10 evaluation criteria regarding patients' trust in medical personnel, which are divided into 4 groups, namely: quality of medical services; empathy and communication; convenience and availability of medical services; security, and privacy. The model is based on intelligent knowledge analysis using membership functions and consists of six steps. Also, using a convolutional approach, knowledge of trust in the medical staff of primary medicine in the studied region and the effectiveness of the management of primary medicine institutions is obtained.

The developed model was verified and tested on real data of primary medicine patients in the countries of the Visegrad Group. An example of evaluation on data fragments with a total of 153 patients in four regions is illustrated: Trenčín Region (Slovakia); Vysočina Region (Czech Republic); Pomeranian Voivodeship (Poland); Szabolcs-Szatmár-Bereg county.

Further research of the problem is seen in the development of knowledge acquisition models to help managers create strategies to improve the quality, efficiency, and availability of primary medicine. It is also planned to develop software for easy practical use of the model by all interested parties.

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INTELEKTUALNY MODEL ANALIZY I ZARZĄDZANIA ZAUFANIEM PACJENTÓW DO PERSONELU MEDYCZNEGO PLACÓWEK PODSTAWOWEJ OPIEKI ZDROWOTNEJ

Streszczenie: W pracy przeprowadzono badania nad opracowaniem modelu analizy intelektualnej w celu określenia poziomu zaufania pacjentów do personelu medycznego instytucji podstawowej opieki zdrowotnej, dla skutecznej strategii i zarządzania na przykładzie krajów Grupy Wyszehradzkiej (Czechy, Węgry, Polska, Słowacja). W badaniach wykorzystano nowoczesne metody gromadzenia i prezentacji wiedzy, stosowane w teorii zbiorów rozmytych, analizie systemowej i ocenie eksperckiej. Główna wartość modelu polega na tym, że bada on kwestię oceny efektywności zarządzania placówkami medycyny podstawowej, biorąc pod uwagę poziom zaufania pacjentów do personelu medycznego. Model daje możliwość kompleksowej analizy regionu i opracowania zaleceń dla władz państwowych w celu stworzenia strategii poprawy jakości medycyny w placówkach ambulatoryjnych. Na poziomie placówek medycyny podstawowej menedżerowie powinni opracować strategie tworzenia warunków, w których zaufanie pacjentów do personelu medycznego będzie rosło. Opracowany model został zweryfikowany i przetestowany na rzeczywistych danych pacjentów podstawowej opieki zdrowotnej w krajach Grupy Wyszehradzkiej. Zilustrowano to przykładem ewaluacji na fragmentach danych w czterech regionach.

Słowa kluczowe: zaufanie pacjentów, medycyna podstawowa, efektywność zarządzania, intelektualna analiza wiedzy, modelowanie rozmyte