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APPLICATION OF CONCEPTS OF THE ANALYTIC HIERARCHY PROCESS IN DECISION-MAKING

Tibor KRENICKY
Technical University of Kosice

Liudmyla HREBENYK, Vadym CHERNOBROVCHENKO
Sumy State University

Abstract:
The Analytical Hierarchy Process (AHP) is one of the multi-criteria methods with tools that are effective for decision-making in complementary or alternative medicine (CAM). This approach, in combination with other available methods, such as the Utrecht Method, allows medical professionals and patients themselves to take a balanced choice of special treatment and health control. This is particularly important for pregnant women who suffer from nausea and vomiting during pregnancy (NVP). The mechanisms of toxicosis occur, and the way of treatment have certain uncertainties. The decision-making process for therapeutic care must consider several factors, the determination of which is the result of collaboration between the patient and the healthcare provider. This paper presents the results of a decision-making study regarding the use of the ginger medicinal plant in helping a woman with NVP symptoms. The research was conducted using the original questionnaire according to the methodology proposed by the developers of the Utrecht Method. The chosen respondents were healthcare professionals with experience in treating NVP and pregnant women. The Analytical Hierarchy Process (AHP) capabilities in decision-making were shown in an example of analyzing the benefits, risks, and side effects of using ginger during pregnancy. The combination of two methodological approaches allowed to successfully connect the proven facts of using CAM therapy with the subjective assessment of all stakeholders. The study demonstrates that this approach successfully uses decision-making by structuring hierarchical decision elements and weighing the criteria involved in the decision-making issue. The article examines the practicality and effectiveness of using AHP when making decisions regarding the treatment and improvement of the condition of pregnant women with NVP, and summarizes the quantitative and qualitative indicators of the effectiveness of this method. The presented combination of two methodological approaches in decision-making allows for choosing an optimized medical strategy for supporting pregnant women through CAM therapy.

Key words: *multicriteria decision-making, hierarchical analysis, analytic hierarchy process, health technology assessment*

INTRODUCTION

Currently, more people of various age groups are migrating for work or because of war conflicts. In particular, the second is often why it, unfortunately, happens without appropriate medical documentation. Simultaneously, many of these people have an effort to integrate into the work process. However, the work environment also often imposes increased demands, the non-compliance of which can reduce the effectiveness of the given performance, indisposition for work or even a threat to health and life. Commonly, for this reason, without the possibility of a prompt assessment by a qualified health professional, the correct evaluation of the state of health is increasingly in demand.

Furthermore, collective or individual feeding of workers can, under certain circumstances, pose a risk to both workers and, e.g., fetuses of pregnant women. Such risks are significantly increased during the limited operation of communal dining, well-known last years due to hygienic restrictions. In these conditions, workers are exposed to increased pressure to maintain a healthy lifestyle without disrupting the work schedule in production facilities.

Additionally, little is known about the ethical and professional considerations and weighing the benefits and risks in the daily routine of standard, complementary and alternative medicine. Health professionals face many challenges in making ethical and professional decisions in everyday practice.

Along with the development of meta-analysis as a tool for generalizing research and scientific literature, there has renewed interest in broader forms of quantitative analysis, which combines proof from different research plans or evidence on several parameters. They have been proposed under various headings: the trust profile, cross-synthesis, hierarchical analysis models, and generalized synthesis of evidence. Thomas L. Saaty developed one of the multi-criteria decision-making methods originally, which was called the Analytic Hierarchy Process (AHP) [1]. In the 1980s, the scientist worked to develop an approach to a selection of experts, which later gave impetus to the continuous improvement and study of AHP.

AHP is a method of pairwise comparison of criteria that considers respondents' psychology and a mathematical approach. This method is based on the assumption of a subjective approach since people are not always consistent in their thoughts. Input data for analysis can be quantitative (weight, price, temperature, etc.) and qualitative (well-being, feelings, assumptions based on life experience, etc.). Such flexibility and relative universality in use make AHP quite popular in decision-making. The ratio scales are obtained from the basic eigenvectors, and the consistency index is the result of the basic eigenvalue.

The Analytic Hierarchy Process has a unique niche in its use in group decision-making. It can be useful in different spheres of life as a business, government activity, industry, healthcare, and education.

The defined "right decision" helps in choosing the best way to achieve the final result during decision-making that meets the criteria of the goal and the problem understanding. This method creates a comprehensive and rational basis for structuring the problem when making a decision. People who use AHP first divide their problems by deciding on a hierarchical table of the easier-to-understand subproblems. Each subproblem can be analyzed independently. The components of the hierarchy can express any range of decision-making problems: material or nontangible, measured in detail or generally estimated, well or unwell understood. It can be anything related to the decision. After the hierarchy building, those who make complex decisions successively assess all segments, comparing them in pairs to understand their impact on the segment above them in the hierarchy. Persons or teams making analyses of the elements can use specific data about them, but they usually apply their opinion of the relative significance of each component.

A distinctive feature of AHP is that human judgment can be used in estimates, not just basic information. The Analytic Hierarchy Process converts estimates into digital values that can already be processed and compared throughout the problem. Numerical weight or priority is displayed for each segment of the hierarchy, which allows you to compare completely different and often incomparable segments rationally and consistently. This feature distinguishes AHP from other methods of complex decision-making.

In the final stage of the process, numerical priorities are calculated for each alternative solution. These figures reflect the relative ability of the alternatives to achieve the goal of decision-making. Therefore, they provide an opportunity to consider different areas of action directly.

The problems of the research topic are quite relevant because making difficult, and "correct" decisions in the medical field is pretty acute on the agenda due to the constant emergence of new diseases or mutations in already known infections. Therefore, scientists constantly improve their experience, skills, and knowledge in all areas. AHP has a particular application in medicine, as evidenced by numerous experiments, surveys, scientific papers, and articles in well-known international scientific journals [2, 3, 4].

Note that until 1988, relatively few articles were published about the practical use of AHP. Since 1997, the level of publication activity in this direction has increased to approximately three articles per year. Research articles and studies can be summarized under the following categories: health assessment, patient engagement, therapy/treatment, diagnosis, organ transplantation, project management, human resources, and policies [5]. Comparing the number of articles in each category allows for leading positions in such areas as evaluation and selection of projects and technologies, patient participation, therapy/treatment, and health care.

AHP is a perspective approach in medicine for patient-physician decision-making, evaluation, choice of therapy and treatment, and evaluation of health technologies and policies.

LITERATURE REVIEW

In everyday clinical practice, there are many cases when pregnant women and health professionals are disinclined to use traditional drugs, particularly in the first trimester of pregnancy [6]. Women and/or their healthcare providers may choose complementary or alternative medicine (CAM) therapies. An example can be using ginger to treat NVP (nausea and vomiting in pregnancy), i.e., toxicosis [7]. Applying medicinal plants has evolved into one of the most popular CAM methods. Historically, the prolonged use of medicinal plants generated a general idea of their relative safety for treatment [8]. This opinion is supported by advertising on the benefits of products of natural origin [9].

Moreover, the existence of this myth is helped by those healthcare workers who generate the idea of more excellent safety of "natural medicines" compared to traditional ones [7, 8]. Contrary to existing opinion, note that medicinal plants contain substances that can be similar to conventional medicines in terms of chemical structure and biological effects. These compounds may have similar pharmacological mechanisms and side effects as conventional

drugs. Additionally, as with traditional medicines, it is necessary to consider the dangerous daily dose, which is much more challenging in this case. Therefore, when prescribing medicinal plants for treatment, practically confirmed indications and algorithms of use are considered. Based on the available side effects, contraindications for their use should also be considered, particularly if it concerns children and pregnant women. Therefore, when prescribing medicinal plants to patients, they recommend the desired time, dose, number of administration times, and ways of entry into the body [9, 10].

In the presence of alternatives, the choice of specific therapeutic approaches involves an assessment of all possible benefits and potential risks. Weighing the potential benefits over the possible risks is crucial when choosing a particular therapeutic option. In treating any pathology, the usual terms such as choice, self-control, consistency, and informed decision-making have been used [11, 12]. In modern medicine, it is assumed that the information provided by the patient is necessary for making final decisions. The explanation stems from the treatment goal, which is to improve the patient's quality of life. Recognizing these basic principles of therapy significantly influences the entire system of providing services in the health care system. Particularly, patients are increasingly involved in weighing all the possible benefits and potential risks of available treatments. Moreover, patients and their health care providers work together to overcome the problems through shared decision-making.

In the presence of concomitant pathologies, it can be challenging to make a treatment decision. Patients who are aware of this usually leave the final decision to their healthcare provider. Simultaneously, there are many who consider it necessary to use joint decision-making. In any case, the patient should be informed about the need to assess the benefits and risks when choosing a treatment option [13]. It is safe to say that well-informed patients may have fewer misconceptions about treatment and expected outcomes, be aware of potential benefits, better manage unwanted side effects, and have a more manageable approach to their daily lives [14, 15, 16, 17, 18, 19].

In this context, it should be noted the importance of Quality Management Principles (QMP), which is no exception to medicine [20]. When prescribing CAM treatment, health care workers often face decision-making problems regarding the quality of products and services, which requires careful evaluation before their inclusion in the service delivery process. Specialized guidelines do not contain tools for assessing potential benefits and risks affecting the effectiveness and safety of health services. They practically only mention ethical aspects of professional practice in healthcare. Additionally, there is little discussion in the literature of ethical and professional algorithms when choosing treatment options using traditional medicine or CAM in a doctor's daily practice. Researchers are trying to correct existing gaps in this direction carefully. That is why the Center for Biomedical Ethics and Law (Netherlands) proposed a method known as the Utrecht Method. This method was developed for ethical and professional discussions [21, 22, 23]. To support decision-making in the context of the need to scale the available benefits and potential risks, the use of a combination of qualitative and quantitative approaches is quite proper. This combination allows to asses all benefits and risks, and ranks them to achiv the key goal when making a decision [24].

To support decisions in conditions of uncertainty, especially when there are several goals in the treatment process, various approaches to multi-criteria decision analysis (MCDA) are used [25]. An analysis of the literature indicates that the Analytic Hierarchy Process is one of the most popular approaches because it provides the tools to incorporate all the benefits and risks of treatment consistently. Additionally, AHP combines the importance of differences in priorities in obtaining therapy results [26]. Usually, in traditional decision-making processes, the importance of each decision component is not clearly expressed. In this sense, in medical practice, AHP creates the conditions for a transparent decision-making process in which the patient and doctor can understand and demonstrate the basic foundations of their choice.

GOAL OF THE STUDY

This study aimed to consider the possibility of using the Analytic Hierarchy Process for sound decision-making and to study its feasibility as an effective tool to reduce subjectivity and uncertainty of goals, particularly in health-assessment decision-making. The current study clarifies the application and combination of the Analytic Hierarchy Process (AHP) under challenging decisions making by using the example of treatment with ginger of nausea and vomiting in pregnancy (NVP). Summarizing the quantitative and qualitative indicators of this method's effectiveness will increase the confidence in its use in the everyday practice of medical workers in case of risks when prescribing complementary or alternative medicine (CAM) therapy.

OBJECTS AND METHODS OF RESEARCH

Studies of the use and combination of AHP in solving problems, in general, are as follows:

1. Using the approach of cognitive engineering to conduct a hierarchical analysis of tasks to understand the complex decisions when choosing over-the-counter drugs [10]. Adults are responsible for making over-the-counter treatment decisions because providers are unaware of their consumption. These treatment decisions are complex: people should focus on changes in the body, developed comorbidities, and complex treatment regimens when choosing the proper over-the-counter medication. However, little is known about how people make such decisions.
2. Combination and use of the Utrecht Method and the Analytic Hierarchy Process to promote professional and ethical discussion and decision-making in CAM: a practical example of a stakeholder group [11].

The Utrecht Method is a reflective discussion tool that

considers professional and/or ethical dilemmas healthcare professionals face in their daily practice. This method involves compliance by medical professionals and patients with specific normative provisions that can be taken into account during the discussion.

3. Conducting the survey of pregnant women and healthcare workers was on the basis of the Questionnaire containing eight questions was drawn. Questions were composed following the proposed methodology in the Utrecht method. The direction of the survey was traditional for the methodology. The survey letter began with the question "what should I do?" and ended with advice on how to act in a specific situation. Scores were obtained from 10 participants (response rate = 100%). All the respondents were interviewed face-to-face.

The following participated in the survey:

1) two female gynecologists who had more than ten years of experience in counseling pregnant women, including regarding the safe use of ginger for treating NVP;
2) three pharmacists (two women and one man) who had more than ten years of experience working in pharmacies and quite often recommended CAM medicines to pregnant women;
3) three herbalists were men with more than fifteen years of experience in this field, who sold medicinal plants to pregnant women and instructed them in the preparation of extracts;
4) two pregnant women with more than three previous pregnancies.

Panelists were provided with a summary containing information on ginger's safety and potential efficacy for treating NVP. The data presented were collected from the Natural Medicines Comprehensive Database, the Cochrane Database of Systematic Reviews, and summaries of relevant systematic reviews and scientific articles. Copies of the documents were provided to the discussion participants upon request. The research algorithm assumed the need to consider the ethical aspect. All respondents who participated in the survey provided written informed consent to participate in the study.

The debate participants were asked to make pairwise comparisons using the Questionnaire on a 9-point scale. A higher numerical value should be assigned to a characteristic (benefit, risk, side effect) with a higher relative value than other characteristics provided for comparison. Respondents were asked, in a pairwise comparison, to consider the probability of each existing benefit, risk, and side effect of using ginger. A comparative assessment of all characteristics was carried out in four stages. In the first stage, participants were asked to pairwise compare 12 potential benefits: the relief of NVP, cough, and flu; increased lactation and appetite; lowering the concentration of cholesterol and glucose in the blood; stabilization of blood pressure, relief of dyspepsia, improvement of sleep and skin condition; the reduction of pain symptoms in the joints.

In the second stage, participants worked to pairwise rate 15 potential side effects of ginger: risk of bleeding, cardiac arrhythmia, heartburn, duodenal ulcer, irritable bowel syndrome, hypotension, hypoglycemia, itchy skin, dehydration, belching, thirst, sweating, fever, headache, and diarrhea.

The work at the third stage consisted of a pairwise evaluation of three potential risks of using ginger for pregnancy and fetal development: the possibility of miscarriage, disruption of intrauterine development, and the development of hypoglycemia in the fetus. In the final stage, potential benefits, side effects, and risks were compared in pairwise comparisons. The individual scores of each respondent were used in the calculation for the comparison matrices in the Microsoft Excel spreadsheet software. Comparative weight indicators and their consistency coefficients, were calculated using mathematical formulas proposed by Thomas L. Saati [1].

4. Mathematical and statistical methods became the scientific basis of selective observation.

The hypothesis that the study population's general variance equals a particular expected value was tested based on the sample variance.

Suppose a sample is taken from a specific general population, where *n* is the sample volume, and s^2 is the unbiased sample variance for this volume. If it is necessary to test the hypothesis about the equality of the general variance to the hypothetical general variance, that is:

$$\begin{matrix} H_0: \sigma^2 = \sigma_0^2, \\ H_1: \sigma^2 \neq \sigma_0^2, \end{matrix} \quad (1)$$

where:

σ^2 is the unknown general variance,

σ_0^2 the hypothetical value of the general variance,

then it is necessary to calculate the observed value of the Pearson x_i -squared test (χ^2):

$$\chi^2_{спост} = \frac{(n-1)\cdot s^2}{\sigma_0^2}, \quad (2)$$

and to find the critical point $\chi^2_{кр}(\alpha, k)$ from the critical points table $\chi^2$is distribution for the level of significance α and the number of degrees of freedom $k = n - 1$.

The population variance σ_2 is estimated based on the sample variance s^2.

In that case, if $\chi^2_{спост} > \chi^2_{кр}$, the null hypothesis H_0 is rejected in favor of the alternative. If $\chi^2_{спост} < \chi^2_{кр}$ the null hypothesis is taken.

To quantitatively characterize the compliance of the frequency of occurrence of a certain event with a particular value, it is advisable to use the hypothesis of comparing the observed and standard frequency of occurrence of the event. Suppose there are *n* independent experiments, the probability of occurrence of event *p* in which is constant but unknown. From this population, the relative frequency of the number of certain events *m* in the total number of n units is found. It is necessary to check the hypothesis that the sampling frequency *p = m/n* is equal to the hypothetical frequency p_0, i.e:

$$\begin{matrix} H_0: p = p_0, \\ H_1: p \neq p_0, \end{matrix} \quad (3)$$

where:

p_0 is the hypothetical frequency.

It is necessary to determine the value of the criterion to test this hypothesis at a certain level of significance α:

$$V_{спосm} = \frac{\left(\frac{m}{n} - p_0\right)\cdot\sqrt{n}}{\sqrt{p_0 \cdot q_0}} \quad (4)$$

and from Table of Laplace Transforms, it is needed to find the critical point ukp from the equation:

$$\Phi(u_{KP}) = \frac{1-\alpha}{2} \quad (5)$$

If $V_{спосm} > u_{KP}$, we reject the null hypothesis H_0, when $V_{спосm} > u_{KP}$ we accept the hypothesis H_0.

RESEARCH RESULTS AND DISCUSSION

Traditional and alternative medicine methods are used to relieve symptoms that can reduce the quality of life during pregnancy. NVP can be a serious problem for a woman, which leads to a malfunction of the body's organs and systems, depression, toxic effects on the fetus, loss of work capacity, and sometimes even pregnancy termination. For treating NVP, it is recommended to use ginger, vitamin B_6, antihistamines, dopamine antagonists, corticosteroids and others [27, 28]. A pregnant woman in a difficult physiological state faces the choice of the most optimal therapeutic support for her.

This study chose a treatment approach that is based on the well-known fact that ginger is beneficial for the relief of NVP symptoms. At present, there is no scientific explanation for improving the condition of a pregnant woman with NVP when using ginger. Therefore, this medical approach to treatment is most optimally suitable for assessing the feasibility of using AHP for decision-making. AHP was used to investigate how strong the arguments in the case of decision making to use ginger to treat NVP.

Respondents made pairwise comparisons to analyze alternatives to simplify decision-making. Such an approach allows determining the relative weight of advantages for evaluating the therapeutic effect. Additionally, it minimizes side effects and risks for the pregnancy and the developing fetus.

Thus, the treatment priority analysis was conducted based on the analysis of the benefits of ginger, potential side effects, and risks for the pregnant woman and the developing fetus when using this medicinal plant. A study of the benefits of ginger concluded that the relief of NVP symptoms has the highest weight (30.7%±16.6%). A one-way analysis of variance (ANOVA) with multiple comparisons (Bonferroni test) showed that this score was significantly higher than the others (p1-value < 0.001). Multiple comparisons showed a statistically significant difference in the severity of dyspepsia relief ratings compared with all other benefits (p-value < 0.001). Exceptions were cough relief (p-value = 1.000) and flu (p-value = 0.890). Scores for the relief of cough and flu symptoms did not differ significantly (p-value > 0.05). Simultaneously, they had statistical differences compared with the reduction of joint pain (p-value < 0.05) and improvement of skin condition (p-value < 0.05). 0.01).

The result of comparing the observed share with the hypothetical share of the population is given below.

The sample variance is $s^2 = 3.98$.

The calculated value of criterion χ_2 is

$$\chi^2_{спосm} = \frac{(n-1)\cdot s^2}{\sigma_0^2} = \frac{(20-1)\cdot 3.98}{2} = 37.81.$$

Since the alternative hypothesis has the form of equality, it is necessary to establish the left and right critical points. In this study, for 19 degrees of freedom, there are a left critical point $\chi^2_{лів\_кр} = 8.91$ and a right critical point $\chi^2_{прав\_кр} = 32.9$. The observed value exceeds the right critical point, so there is a reason to reject the hypothesis of the equality of the sample variance of the hypothetical one.

The result of testing hypotheses about the population share is shown below.

From Table of Laplace Transforms, we find the critical point $u_{kp} = 2.99$. Since the calculated value of the criterion does not exceed the critical one, there is no reason to reject the null hypothesis. Therefore, the results of observations can be considered acceptable. A detailed assessment of the weight of potential benefits is shown in Fig. 1.

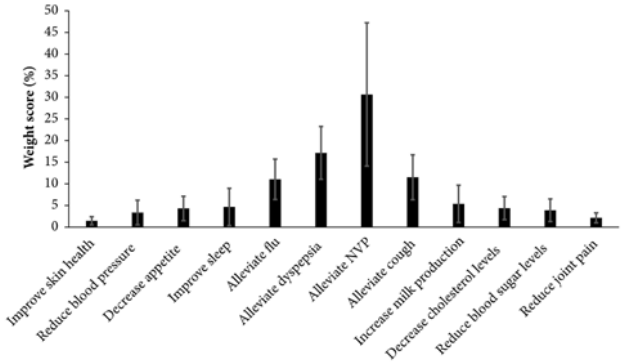

Fig. 1 Evaluation of the benefits of using ginger during pregnancy

The assessment of side effects showed that the risk of bleeding was significantly higher (p-value < 0.001) than others manifestations (24.7%±13.5%). The results of the estimation of the appearance of cardiac arrhythmia and dehydration were not statistically significant (p-value > 0.05). Analysis of cases of heartburn occurrence (14.8%±6.6%) was significantly higher than all other possible side effects (p-value < 0.01), except for duodenal ulcer (p-value = 0.145) and irritable bowel syndrome. p-value = 1.000). A detailed evaluation of the severity of potential undesirable side effects is shown in Fig. 2.

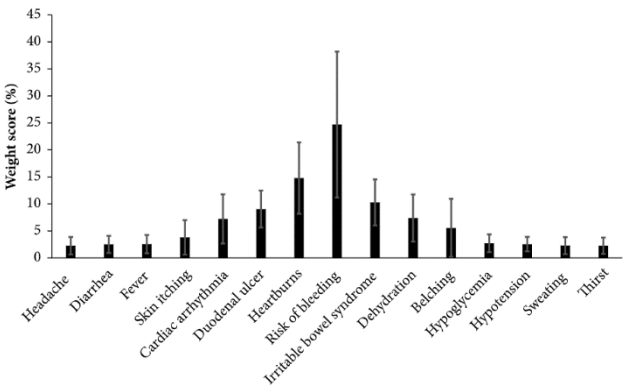

Fig. 2 Evaluation of side effects from the use of ginger by pregnant women

Estimates of the risk of miscarriage (45.8%±3.8%) and the risk of fetal developmental disorders (41.6%±3.6%) were significantly higher (p-values < 0.001) than fetal hypoglycemia. Detailed evaluation of the weight of potential risks to the fetus and pregnancy are shown in Fig. 3.

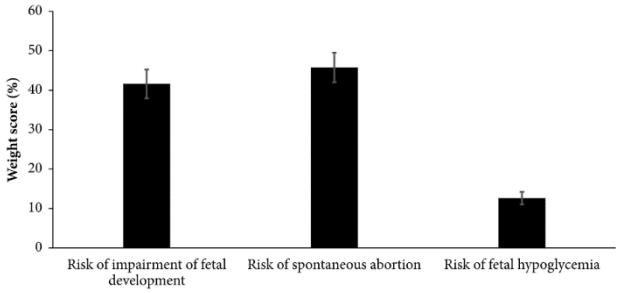

Fig. 3 Evaluation of the risks of using ginger for the fetus and pregnancy

During a comparison of the benefits with risks and side effects to the fetus and pregnancy, it was found that the former had a significantly higher (p-value < 0.001) weight (72.3%±5.2%). Details of the weight evaluation are shown in Fig. 4.

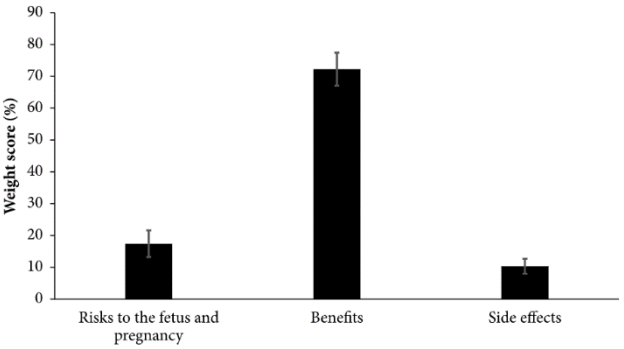

Fig. 4 Evaluation of the benefits, side effects and risks of using ginger during pregnancy

These results demonstrate the successful combination of the Utrecht Method and AHP for supporting a common solution in the practice of alternative medicine.

CONCLUSIONS

The performed research and analysis of the above factors convincingly showed the feasibility of using the Analytic Hierarchy Process for difficult medical or managerial decisions in the medical field. This method is well used and has very positive results because it allows to trace the available alternatives and in uncertainty to choose the most promising strategies and tools that need to be used. However, in making any decision, there is always an element of subjectivity related to the human factor. Therefore, the use of the Analytic Hierarchy Process gives to make the decision-making process completely transparent. The versatility of AHP and the ability to combine it with other analytical methods yield even better results in making "correct" essential decisions and the maximum exclusion of dangerous factors in decision-making in the medical field.

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Tibor Krenicky
ORCID ID: 0000-0002-0242-2704
Technical University of Kosice
Faculty of Manufacturing Technologies
Sturova 31, 08001 Presov, Slovakia
e-mail: tibor.krenicky@tuke.sk

Liudmyla Hrebenyk
ORCID ID: 0000-0002-1510-0763
Sumy State University
Medical Institute
40007 Sumy, Ukraine
e-mail: l.hrebenyk@med.sumdu.edu.ua

Vadym Chernobrovchenko
ORCID ID: 0000-0003-4209-5709
Sumy State University
Rymskogo-Korsakova st. 2
40007 Sumy, Ukraine