Application of TOPSIS Method for Evaluation of IT Application in the Hospital

Janusz Wielki[1], Magdalena Jurczyk-Bunkowska[1] and Dariusz Madera[2]
[1]Opole University of Technology, Poland
[2]University Clinical Hospital in Opole, Poland
j.wielki@po.opole.pl
m.jurczyk-bunkowska@po.opole.pl
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Abstract: The article covers the issue of evaluation of IT application in a hospital. Various IT solutions support the process of carrying out virtually all hospital processes, including medical, logistics and management. They are all linked together, forming a Hospital Information System (HIS). Making decisions concerning its improvement and expansion requires an evaluation of its elements, as well as an assessment of the extent to which they satisfy user requirements, supporting the processes carried out. This type of evaluation can be carried out by commissioning an external audit. However, the nature of a hospital supports using the knowledge of HIS users, which needs to be acquired and processed. The objective of the article is to present the way user knowledge is processed in a synthetic assessment of the impact of IT applications on the quality and effectiveness of processes they support. Aggregation of knowledge obtained from questionnaire responses was carried out using the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), which is one of the most widely used techniques of multi-criteria decision-making. This technique is based on the assumption that the selected alternative should have the least distance to the positive ideal and the most distance to the negative ideal. However, for the purposes of this article TOPSIS was used in less typical way. The suggested approach to the evaluation of HIS elements is shown in detail on the basis of an IT application supporting administrative processes in a hospital. Knowledge about its functioning was collected from its users on the basis of a questionnaire, which encompassed 45 questions in total, covering 12 evaluation criteria. The responses were aggregated using TOPSIS for two indicators: impact of IT applications on the quality (1) and effectiveness (2) of the process. The resulting numerical value represents the distance between the evaluated application and the hypothetical best and worst solution. Placing the values of the evaluation indicators in the suggested matrix identifies HIS elements which require urgent changes. The method of processing user knowledge presented in the article was developed in connection with the need to develop the HIS at University Clinical Hospital in Opole (UCHiO). This method is, however, labour-intensive and therefore intended to large and complex organisations using many IT applications.

Keywords: IT applications, HIS (hospital information system), multi-criteria evaluation, synthesis of value measures, TOPSIS (technique for order preference by similarity to an ideal solution), strategy of software development

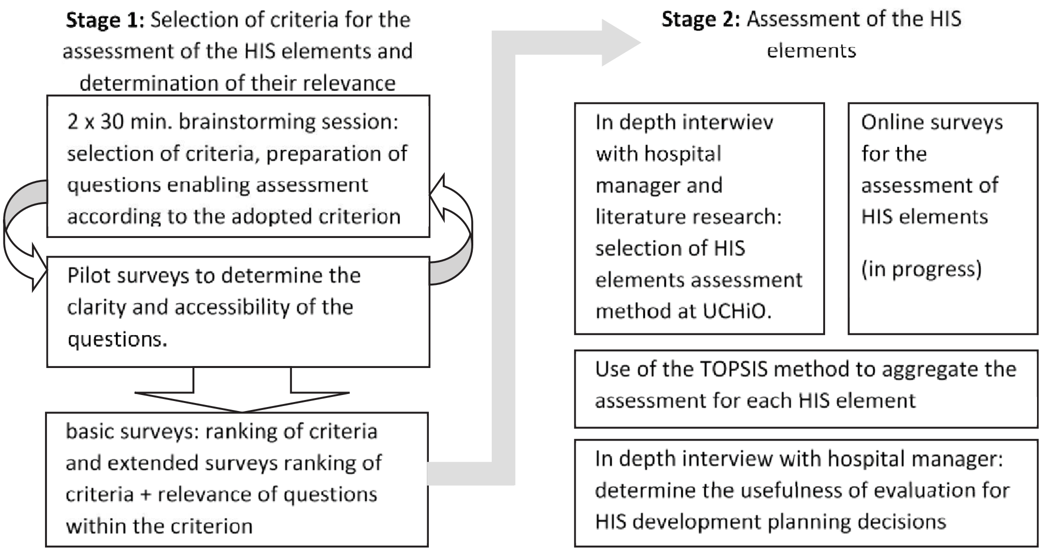
1. Introduction

Today, IT departments are an important, or even key, element of any organisation. This is also the case in hospitals, where they supervise and manage the Hospital Information System (HIS). A hospital information system is the general software for the integration of the data related to a patient, sending and exchanging patient’s general information among various hospital sections and other medical centres to speed up the patient’s treatment and therapy process, improve the quality, increase the satisfaction, and decrease the expenses (Malliarou, Zyga, 2009). Considering the extended effect of information technology in organizations and expenses related to information systems, there has been an increasing need for the evaluation of the quality of these services, primarily assessing the satisfaction felt by sers (Rostami et al, 2015). Evaluating the hospital information system leads to improving and developing it properly to users’ requirements and increasing the effectiveness and efficiency of the hospital. Since that information is a critical element for the effective development and management of health care services, managers of healthcare information systems should regularly monitor these systems and their performances directly, and place their decisions for the development, improving the health systems based on real problems existing in the health care area (Anderson, 1997). This includes decisions with different time horizons: short, medium and long term. Short-term decisions, which usually involve relatively low costs, are made as part of the IT department's work. On the other hand, long-term HIS decisions require the competences of the hospital management. Dealing with them requires knowledge of the organisation's needs and of the extent to which the current HIS in operation can meet current and future needs. In other words, HIS development planning requires knowledge of a hospital's strategic goals and the ability to assess the possibility of achieving them with existing software assets. It is a very complex and multidimensional issue, taking into account the size and diversity of the hospital organisation and the variety of software it uses. The managers of the hospital have knowledge about the planned directions of development of the organisation. However, they need tools to enable them to acquire and process knowledge about their software. They can obtain it by involving experts, but there is a worry that they will not be able to take into account the specific features of the organisation. Therefore, an approach is sought that allows for aggregating knowledge of the organisation's employees and using it to present an evaluation of the software to the manager in such a way that it can be used as the basis for making decisions concerning the development of HIS. It was decided to use the TOPSIS method to combine a number of independent evaluations. Its choice was dictated by the possibility of taking into account the significance of the criteria being considered (Boran et al., 2009).

The aim of this article is to show how the TOPSIS method was used to process knowledge on the impact of software used at University Clinical Hospital in Opole (UCHiO) on the processes carried out there. The proposed approach is intended to help make decisions regarding the planning of the development of HIS. To this end, knowledge was acquired in various functional departments of the hospital. It covers issues related to many different areas such as information security, service, convenience of access to information, but also software operating costs and others. This knowledge is possessed by employees who use software on a daily basis, as well as employees of the IT department. It was obtained from them through questionnaires. However, its use to make management decisions requires appropriate processing. It was decided to aggregate the acquired knowledge to provide the manager with two indicators that will enable them to comprehensively assess the HIS. These are indicators of the impact of software on the quality (1) and effectiveness (2) of the processes implemented. Thus, in the proposed approach, the D&M evaluation model, developed by DeLone and McLean (1992), was expanded. According to it, the six dimensions of IS success are the following: “system quality”, which measures technical success, “information quality”, which measures semantic success, and “use”, “user satisfaction”, “individual impacts”, and “organizational impacts”, which measure effectiveness success (Saghaeiannejad-Isfahani et al 2014). “Service quality" is also included in the updated model. The criteria taken into account in the evaluation of the HIS elements for UCHiO were established in previous studies. Obtaining the knowledge allowing for the evaluation of software according to the proposed criteria required the development of questions comprehensible to the surveyed users of the system. The criteria, as well as the related questions and their weightings, are set out in the section 3 of the article. The use of the TOPSIS method to determine the parameters for assessing the impact of software on quality and effectiveness is discussed in detail in section 4 of the article. Section 5 is used to show the matrix intended to enable the manager to make a comprehensive evaluation of the HIS. Its idea is to classify the elements of HIS in such a way as to support decision making regarding HIS development planning. The article was summed up with conclusions regarding the universality and limitations of the proposed approach.

2. Research methodology

The article is based on case studies. They were carried out in March 2019 at the University Clinical Hospital in Opole. It is the largest hospital in the region offering inpatient and outpatient care. Inpatient care has been provided for more than 400 patients in 16 wards. In addition, 15 outpatient clinics offer specialist medical assistance. Diagnostics and treatment are supported by imaging diagnostics, laboratory rehabilitation and microbiology. Since 2018, the hospital has been cooperating with the University of Opole in the training of students of the newly opened medical faculty. This cooperation has intensified the development of a unit aimed at ensuring high quality medical services and student education. One of the determinants of effective implementation of the set tasks is to ensure an efficient HIS. It includes software supporting medical processes (information system for patient care) and management processes (managerial information system). They include various types of IT systems from different suppliers supporting different processes. These are, for example, components of managerial information system are among others: human resources management system, finance and budgetary systems, general administration information system & office automation. However, the information system for patient care, which includes among others: patient administration/management system (registration, scheduling, resource allocation), electronic medical record, laboratory information system, blood banking information system, radiology information system, quality and productivity management application, infection prevention and control application, clinical data extraction and reporting application, is much more extensive and diverse. The HIS at UCHiO consists of software purchased and implemented over the last 15 years. Some of them may continue to be operated, but most of them should be expanded or replaced by new ones to better meet current and future requirements. The evaluation of the elements (components) of the HIS was carried out according to the scheme shown in fig. 1.



Source: Own elaboration

Figure 1: Structure of research concerning the evaluation of HIS elements at UCHiO

The first stage of the research was aimed at selecting the evaluation criteria and determining their significance. It was carried out with the use of the knowledge of hospital employees – users of the software. It consisted of two main parts. The first part consisted of two brainstorming sessions with the participation of hospital IT staff and scientists, supported by additional pilot surveys. During the surveys, criteria for assessing the elements of the HIS were established and questions to address them were proposed. They made it possible to obtain knowledge from the employees on the impact of the evaluated IT systems on the quality and effectiveness of the processes they supported. Most of the questions were formulated so that the employees could answer them using the five-step Likert scale extended with the not applicable answer, indicated when they did not have the knowledge necessary to make an evaluation. The developed on-line surveys were addressed exclusively to employees who use a specific IT system and to IT department employees. The second stage of the research concerned the determination of the significance of the proposed criteria in the evaluation. For this purpose, the knowledge of the employees acquired through two types of online surveys was also used: the "basic" survey, where software users defined a ranking of criteria, and the "extended" survey, where selected employees indicated the significance of the question within the evaluation of a given criterion. The results of these stages are presented in the next section of the article. The method of evaluation of HIS elements using TOPSIS presented in this article is directly related to the second stage of the research. It included acquiring knowledge and transforming it into a software evaluation allowing for management decisions to be made. This stage is still ongoing. In its entirety, it will include the evaluation of 17 elements of the HIS by more than 130 employees. The results of the partial evaluations of each HIS element obtained from the online surveys will be aggregated into two indicators. An example of creating synthetic measures of software impact evaluation on the quality and efficiency of the process was discussed in detail on the example of software supporting administrative and financial processes. For commercial reasons, the name of the software and the results of all surveys were not disclosed, and only the evaluation methodology was presented on the example of 8 selected surveys.

3. Applied criteria for the evaluation of HIS elements at UCHiO

Assessing the functioning of HIS requires the development of a knowledge management system in this area. The best source of knowledge on the impact of software on the processes implemented by the hospital are its employees. They use the software on a daily basis to perform the tasks entrusted to them. A hospital is an organisation in which sharing knowledge is routine. The culture of this organisation is strongly connected with the processes of creation, collection, organisation, diffusion, application and exploitation of knowledge concerning various aspects. Therefore, employees have no resistance to sharing it. When creating the knowledge management system for the HIS evaluation, it was decided to use the knowledge of the employees. It was collected through online surveys, which included the questions shown in Tables 1 and 2, excluding questions related to criterion C11. Knowledge of the cost of operating the software was acquired directly from the hospital administration. Tables 1 and 2 also show in bold the importance of the criteria that make up the evaluation of the impact of the software on the quality and efficiency of the process. The relevance of each question to the evaluation of the criterion to which it is linked is also indicated. This relevance is related to the type of processes that the software supports. In other words, the importance of the criteria themselves, as well as the relevance of the questions, depends on whether the software supports medical or administrative processes. Therefore, 3 classes of software included in the UCHiO HIS were distinguished: software supporting basic medical processes (1), supporting peripheral medical processes such as laboratory diagnostics, pharmacy, radiology (2) and supporting administrative and financial processes (3).

Table 1: Criteria for assessing the impact of a given software on the quality of the process together with survey questions and the weighting of the criteria and the importance of the questions for the three classes of systems

Criteria for assessing the impact of software on the quality of the process (C1-C6) Questions to learn about the impact of software on process quality (Q1.1-Q6.4)	**significance**		
	(1)	**(2)**	**(3)**
Security of information used in the process (C1)	**0,26**	**0,18**	**0,14**
Q1.1. The software ensures the confidentiality of patient data and information.	0,4	0,4	0,4
Q1.2. The strength of the user authentication mechanisms used in the software is satisfactory.	0,2	0,2	0,2
Q1.3. The application guarantees that the data have not been changed or deleted in an unauthorised manner.	0,3	0,3	0,3
Q1.4. Data backup is automatic and disaster recovery is prompt and fast.	0,1	0,1	0,1
Ease of application use (C2)	**0,21**	**0,15**	**0,20**
Q2.1. How long did it take you to familiarise yourself with the system at a basic level?	0,2	0,2	0,2
Q2.2. The graphic design of the application is clear.	0,2	0,2	0,2
Q2.3. The application offers efficient help mechanisms.	0,1	0,1	0,1
Q2.4. The use of the application significantly shortens the time required to carry out the process.	0,2	0,2	0,2
Q2.5. How many language versions of the application are available?	0,1	0,1	0,1
Q2.6. Number of necessary consultations with IT specialist or another employee on a monthly basis.	0,2	0,2	0,2
Resistance to human errors (C3)	**0,17**	**0,13**	**0,16**
Q3.1. The application has efficient prompts and auto-completion mechanisms.	0,3	0,3	0,4
Q3.2. The application identifies and signals uncommon values.	0,4	0,4	0,4
Q3.3. The application eliminates the occurrence of deficiencies in documentation.	0,4	0,4	0,3
Reliability and efficiency (C4)	**0,17**	**0,12**	**0,16**
Q4.1. For how many hours is the application not available per month?	0,3	0,3	0,3
Q 4.2. The application provides access to various statistics on failure rates.	0,4	0,4	0,4
Q 4.3. The speed of the application is satisfactory regardless of the load.	0,4	0,4	0,4
After-sales service (C5)	**0,06**	**0,20**	**0,15**
Q5.1. The level and availability of training courses is satisfactory.	0,3	0,2	0,2
Q5.2. Average service time in case of failure.	0,3	0,2	0,4
Q5.3. The software vendor ensures the configuration of new hardware in a short time.	0,2	0,4	0,1
Q 5.4. The supplier has a good and well-established position in the market.	0,2	0,2	0,3
Integration (C6)	**0,13**	**0,22**	**0,17**
Q6.1. The application works correctly with other IT systems in the hospital.	0,4	0,4	0,4
Q6.2. The logic of the application corresponds to the process carried out in reality.	0,2	0,1	0,4
Q6.3. The software fully cooperates with the devices used in the process.	0,4	0,5	0,2

Source: Own elaboration

Table 2: Criteria for assessing the impact of a given software on the quality of the process together with survey questions and the weighting of the criteria and the importance of the questions for the three classes of systems

Criteria for assessing the impact of software on the quality of the process (C7-C12) Questions to learn about the impact of software on process quality (Q7.1-Q12.4)	**significance**		
	(1)	**(2)**	**(3)**
Simplification of documentation preparation (C7)	**0,28**	**0,26**	**0,23**
Q7.1. The application offers ready-made text blocks and templates.	0,2	0,4	0,2
Q7.2. The application enables sharing patient data among medical personnel (reduction of data duplication).	0,4	0,4	0,3
Q7.3. The application significantly speeds up the creation of standard documentation.	0,3	0,1	0,4
Q7.4. The software enables effective use of a speech recognition system.	0,1	0,1	0,1

Criteria for assessing the impact of software on the quality of the process (C7-C12) Questions to learn about the impact of software on process quality (Q7.1-Q12.4)	**significance**		
	(1)	**(2)**	**(3)**
Convenient access to information (C8)	**0,28**	**0,23**	**0,23**
Q8.1. The software increases the readability of the documentation (also applies to redundancy of information).	0,3	0,4	0,3
Q8.2. The software offers simplified patient identification, for example using biometrics.	0,3	0,3	0,1
Q8.3. The software can be used via tablets or smartphones.	0,2	0,1	0,1
Q8.4. The software enables visualising data, for example in the form of charts and tables.	0,2	0,2	0,5
Monitoring process costs (C9)	**0,1**	**0,08**	**0,22**
Q9.1. The software enables checking equipment utilisation.	0,2	0,4	0,2
Q9.2. The software enables determining the use of materials in specific time periods and based on specific tasks	0,2	0,2	0,3
Q9.3. The software has functions supporting the management of process costs, for example by signalling irregularities during the process or repeated tasks.	0,2	0,2	0,3
Q9.4. The software enables statistical data analysis.	0,4	0,2	0,2
Readiness for providing e-services (C10)	**0,05**	**0,16**	**0,09**
Q10.1. The software enables sharing and sending electronic documentation.	0,2	0,3	0,3
Q10.2. The software efficiently works with e-registration in the scope of planning and scheduling of tasks.	0,2	0,3	0,4
Q10.3. The software allows for the remote placement of orders and collecting results.	0,6	0,4	0,3
Cost of operating the software (C11)	**0,1**	**0,11**	**0,14**
Q11.1. What is the annual cost of the license?	0,2	0,2	0,5
Q11.2. What is the annual cost of software failures?	0,5	0,5	0,2
Q 11.3. What is the annual cost of maintenance services?	0,3	0,3	0,3
Availability of analytical functions and smart search (C12)	**0,18**	**0,15**	**0,10**
Q12.1. The software makes it easy to create reports.	0,3	0,4	0,4
Q12.2. The software offers the option for advanced search and filtering information.	0,4	0,3	0,1
Q12.3. The software offers ranking functions.	0,1	0,1	0,3
Q12.4. The software has automatic process analysis functions to identify bottlenecks and unusual events.	0,2	0,2	0,2

Source: Own elaboration

4. Using the TOPSIS method for evaluating chosen elements of HIS in UCHiO

TOPSIS (Technique for Order Preference by Similarity to an Ideal Solution), originally introduced by Hwang and Yoon in 1981 belongs to the group of pattern linear ordering methods of multidimensional objects. It is a sophisticated ranking technique implemented in various information technology applications of science and engineering (Ataei 2013), (Behzadian et al 2012). A characteristic feature of this method is a way to evaluate a synthetic criterion's values, which takes into consideration the distance of an evaluated object from a positive-ideal solution as well as from a negative-ideal solution. TOPSIS makes full implementation of attribute data, provides a cardinal ranking of alternatives, and does not request attribute preferences to be independent. To apply this technique, attribute values must be numeric, monotonically non-increasing or nondecreasing, and have commensurable units (Chen, Hwang 1992). TOPSIS can be used to calculate synthetic index based on a set of diagnostic variables (Balcerzak, Pietrzak 2016). Thus, it takes into account the effects of all determinants of multivariate phenomenon. In the case of TOSPSIS the synthetic index is defined as the similarity to positive ideal solution and remoteness from the negative ideal solution. The TOPSIS method for aggregating evaluations and calculating the value of a synthetic measure of software impact on process quality and efficiency was used for the purposes of this paper. The calculation example presented in this section refers to software supporting administrative and financial functions. Table 3 shows the results of surveys and calculations leading to the evaluation of software according to criterion C2. They were selected because they include variables of different types including stimulants and dis-stimulant. The variables. $x_{Q2.2}$, $x_{Q2.3}$, $x_{Q2.4}$ and $x_{Q2.5}$ can be considered as stimulants, which means that the higher their value, the more positive the impact of the software on the process. Variables $x_{Q2.1}$, and x_{Q2} were considered to be dis-stimulant, which means that high values indicate the negative impact of the software on the process. The variables were normalised with classic normalisation procedure based on average and standard deviation. For the empirical research the dis-stimulants were transferred into stimulants. The calculation of the standardised evaluation for such variables was made according to the following formulas:

$r_{Qi.j} = w_{Qi.j} * \sum_{k=1}^{l} \frac{r_{Sk}}{l}$,

where:
$r_{Qi.j}$ standardised evaluation taking into account the significance of Qi.j question in the evaluation of Ci criterion
w_{Qij} - significance of question Qi.j for Ci criterion,
l - number of people who answered the question Qi.j,
r_{Sk+} – standardised evaluation for stimulants, r_{Sk-} - standardised evaluation for dis-stimulants

$r_{Sk+} = \frac{s_{kQi.j}}{\sqrt{\sum_{k=1}^{l} S_{kQi.j}^2 + S_{+poz}^2 + S_{neg}^2}}$, $\quad r_{Sk-} = 1 - \frac{s_{kQi.j}}{\sqrt{\sum_{k=1}^{l} S_{kQi.j}^2 + S_{pos}^2 + S_{neg}^2}}$

$S_{kQi.j}$ evaluation (value of responses) regarding question Qi.j provided by respondent *k*
S_{pos} value of evaluation for an ideal solution
S_{neg} value of evaluation for a negative ideal solution

For example, the mean normalised evaluation for question Q2.2 (stimulant) $r_{Q2.2}$ was calculated as follows:

$$r_{S1} = \frac{S1_{Q2.2}}{\sqrt{\sum_{k=1}^{8} S_{kQ2.2}{}^2 + S_{pos}^2 + S_{neg}^2}} = \frac{3}{10,77} = 0,28$$

$$r_{Q2.2} = w_{Q2.2} * \sum_{k=1}^{8} \frac{r_{Sk}}{8} = 0,2 * \frac{0,28 + 0,37 + 0,37 + 0,19 + 0,28 + 0,19 + 0,37 + 0,37}{8} = 0,06$$

The essence of determining a synthetic evaluation using the TOPSIS method is to determine the distance between the existing solution, the positive ideal solution, as well as the negative ideal solution. The positive ideal rate (x_{pos}) and negative ideal rate (x_{neg}) were created by standardising the best possible evaluation and the worst possible evaluation that respondents could give. These are shown in Table 3.

Table 3: Example evaluation of a system supporting administrative and financial processes for the “Ease of use” (C2) criterion, based on responses from 8 questionnaires (S1-S8)

	Weight (w)/ rate Q by S	S1	S2	S3	S4	S5	S6	S7	S8	Positive ideal rate (S9)	Negative ideal rate (S10)	Rate – variable $x_{Qn.n}$ (average S1-S8)	$\sqrt{\sum_{i=1}^{10} S_i^2}$
Q2.1	0,2	18	12	6	10	8	10	16	9	0	40	$X_{Q2,1}$ =	52,01
normalized rate Q2.1		0,13	0,15	0,18	0,16	0,17	0,16	0,14	0,17	***0,20***	***0,05***	0,16	
Q2.2	0,2	3	4	4	2	3	2	4	4	5	1	$X_{Q2,2}$ =	10,77
normalized rate Q2.2		0,06	0,07	0,07	0,04	0,06	0,04	0,07	0,07	***0,09***	***0,02***	0,06	
Q2.3	0,1	3	3	4	3	4	3	2	3	5	1	$X_{Q2,3}$ =	10,34
normalized rate Q2.3		0,03	0,03	0,04	0,03	0,04	0,03	0,02	0,03	***0,05***	***0,01***	0,03	
Q2.4	0,2	3	3	4	4	5	4	3	4	5	1	$X_{Q2,4}$ =	11,92
normalized rate Q2.4		0,05	0,05	0,07	0,07	0,08	0,07	0,05	0,07	***0,08***	***0,02***	0,06	
Q2.5	0,1	2	2	2	2	2	2	2	2	6	1	$X_{Q2,5}$ =	8,31
normalized rate Q2.5		0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	***0,07***	***0,01***	0,02	
Q2.6	0,2	2	4	0	3	2	5	4	1	0	20	$X_{Q2,6}$ =	21,79
normalized rate Q2.6		0,18	0,16	0,20	0,17	0,18	0,15	0,16	0,19	***0,20***	***0,02***	0,18	
normalized rate C2		0,47	0,49	0,58	0,49	0,55	0,47	0,47	0,55	x_{c2pos}= 0,70	x_{c2neg}= 0,12	x_{c2}= **0.51**	

Source: Own elaboration

Calculate the separation measures for each alternative. The separation of each alternative from the positive ideal alternative is:

$D_{pos} = \sqrt{\sum_{i=1}^{m}(x_{Ci} * w_i - x_{Cipos} * w_i)^2}$, *i=1,…,m*

Similarly, the separation of each alternative from the negative ideal alternative is:

$D_{neg} = \sqrt{\sum_{i=1}^{m}(x_{Ci} * w_i - x_{Cineg} * w_i)^2}$, *i=1,…,m*

Table 4: Evaluation and weights according to criteria pertaining to the impact of software on process quality

Criterion	Significance (w_i)	Rate (x_{Ci})	Ideal (x_{Cipos})	Negative Ideal	$X_{Ci}*w_i$	$X_{Cipos}*w_i$	$X_{Cineg}*w_i$	$(x_{Ci}*w_i-x_{Cipos}*w_i)^2$	$(x_{Ci}*w_i-x_{Cineg}*w_i)^2$
C1	0,26	0,3	0,46	0,09	0,078	0,1196	0,0234	0,001731	0,002981
C2	0,21	0,51	0,7	0,12	0,1071	0,147	0,0252	0,001592	0,006708
C3	0,17	0,31	0,58	0,12	0,0527	0,0986	0,0204	0,002107	0,001043
C4	0,17	0,46	0,72	0,16	0,0782	0,1224	0,0272	0,001954	0,002601
C5	0,06	0,49	0,69	0,17	0,0294	0,0414	0,0102	0,000144	0,000369
C6	0,13	0,32	0,39	0,08	0,0416	0,0507	0,0104	8,28E-05	0,000973
				Σ				0,00761	0,014675
								D_{pos_q}= 0,087234	**D_{neg_q}= 0,121141**

Source: Own elaboration

The value of synthetic measure of the impact of software on process quality ($R_{quality}$) can be obtained by combining the proximity to the positive ideal solution and the remoteness from the negative ideal solution, given with equation:

$$R_{quality} = \frac{D_{neg\_q}}{(D_{pos\_q} + D_{neg\_q})}, 0 < R_{quality} < 1$$

$$\mathrm{R}_{\mathrm{quality}} = \frac{0{,}121141}{(0{,}087234 + 0{,}121141)} = 0{,}58136$$

Table 5: Evaluation and weights according to criteria pertaining to the impact of software on process efficiency

Criterion	Significance (w_i)	Rate (x_{Ci})	Ideal (x_{Cipos})	Negative Ideal (x_{Cineg})	$X_{Ci}*w_i$	$X_{Cipos}*w_i$	$X_{Cineg}*w_i$	$(x_{Ci}*w_i-x_{Cipos}*w_i)^2$	$(x_{Ci}*w_i-x_{Cineg}*w_i)^2$
C7	0,23	0,2	0,49	0,10	0,046	0,1127	0,023	0,004449	0,000529
C8	0,23	0,31	0,44	0,09	0,0713	0,1012	0,0207	0,000894	0,00256
C9	0,22	0,18	0,47	0,09	0,0396	0,1034	0,0198	0,00407	0,000392
C10	0,09	0,3	0,45	0,09	0,027	0,0405	0,0081	0,000182	0,000357
C11	0,14	0,69	1	0,53	0,0966	0,14	0,0742	0,001884	0,000502
C12	0,10	0,29	0,51	0,10	0,029	0,051	0,01	0,000484	0,000361
				Σ				0,011963	0,004701
								D_{pos_e}= 0,109376	**D_{neg_q}= 0,068567**

Source: Own elaboration

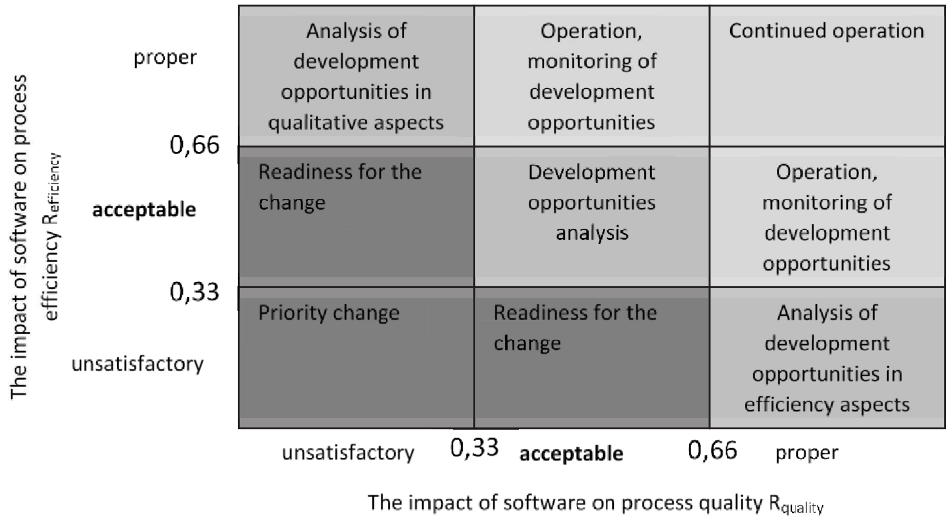
In a similar way, a synthetic indicator of the impact of software on the efficiency of the process was calculated.

$$R_{efficiency} = \frac{0{,}068567}{(0{,}109376 - 0{,}068567)} = 0{,}385329$$

The synthetic evaluation of the administrative and financial system is not too high. It can be considered as a percentage of the degree to which the expectations of IT system support in a given process are satisfied. Given this perspective, the surveyed software satisfies the expectations related to the impact on quality in 58%, while the impact on process efficiency is satisfactory in 38%. By analysing the values in Tables 4 and 5 in more detail, it can be seen that the greatest distance between software evaluation and ideal software evaluation concerns criteria C3, (resistance to human error) and C7 (simplification of preparing documentation). This should prompt searching for solutions to overcome these deficiencies. However, this type of analysis should primarily be carried out for systems that are worth developing. This will apply in particular to those elements of the HIS which have a high synthetic evaluation in terms of one parameter and an average in terms of the other. The identification of such elements as well as support for long-term decisions related to HIS development planning are to support the software classification matrix.

5. Classification of HIS elements for parameters of impact of IT applications on quality and efficiency

The software making up the HIS usually includes more than a dozen or even several dozen applications supporting various tasks. Determining synthetic indicators of the impact of these applications on the quality and efficiency of the processes should support the manager in making decisions in the medium- and long-term perspective. This concerns primarily the planning of the development of HIS in line with the hospital development strategy. Hospitals with limited financial resources must determine which changes should be given the highest priority. What is more, they must define their needs well in advance, so that funds can be spent in a transparent and legal manner. This requires a systemic approach to HIS development planning decisions from the management. For this purpose, a matrix for the classification of HIS elements was proposed, presented in fig. 2. The idea is to visualise the evaluation of HIS as a whole, so that the manager can assess the scope and priority of the necessary changes.



Source: Own elaboration

Figure 2: Synthetic evaluation-based decision support matrix for HIS components

By including synthetic evaluations of the impact of the software on the quality and efficiency of the process, the manager can determine:

- HIS components that need to be changed right away;
- HIS components, which will require changes in the nearest future – the analysis of the market of suppliers of this type of systems should be started right away;
- HIS components, which can be developed to better support the processes – the analysis of these changes can be carried out using the knowledge gained during the system evaluation;
- HIS components that can be operated, but should be monitored by the IT department for possible development opportunities;
- HIS components that should be operated in the future and for which licenses should be renewed under the current conditions.

6. Conclusions

The use of the TOPSIS method to determine synthetic indicators of the impact of software on the quality and efficiency of supported processes seems to be a universal solution. It can be used not only in hospitals but also in companies, offices, schools and other organisations. However, the time spent on synthetic evaluation measures seems to be justified only in the case of large and complex organisations, with managers having to make decisions in relation to an information system that includes many different types of IT applications. In the case of smaller organisations based on a single integrated IT system, the proposed method of analysis seems unreasonable. The assumption for the developed approach to software evaluation was to base it on the foundation of the knowledge of employees and the evaluation of their satisfaction. This, on the one hand, requires a system that enables the organisation to gather this knowledge, but on the other hand, it eliminates the need to use external knowledge. Entrusting the evaluation to experts, for example a consulting company, is easier and faster. However, an external look, often based on routine procedures, may disregard some crucial issues specific to a given organisation, for example taking into account staff fluctuations, competencies or procedures and behaviours characteristic of the organisation. While pointing out the advantages of acquiring knowledge from employees, it should be noted that the willingness to share said knowledge will differ between organisations. In this regard, the hospital should be seen as an above-average entity, where work ethics are based on sharing knowledge. The advantage of the proposed approach to the evaluation of the HIS system is that it allows the manager to fully analyse its elements from ground up. The matrix enables them to identify strengths and weaknesses of the system, and insight into evaluation tables helps them to determine the reasons for this evaluation. Thanks to this, a report prepared in accordance with the proposed approach can be used to work out plans with different time frames. Management may consider system changes on the basis of a matrix visualising the evaluation of all HIS components. However, it may also decide to drill down into the evaluation of a single system, considering the possibility of upgrading the software. The ongoing work on the issue of HIS development planning is focused on the formulation of HIS development objectives. They concern the search for a scientific approach that will make it possible to answer the question of what changes will guarantee the expected usefulness of HIS in the perspective of strategic hospital development. Like in the studies presented in this paper, the knowledge gained from the hospital staff is supposed to be the crucial element. Thus, it can be said that by doing so, the organisation develops an organisational knowledge management system, which enables planning its development through systematic computerisation.

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