Knowledge Capture to Monitor the Alignment of Hospital Processes and Applied Information Technologies

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Abstract: One of the most important tasks of every organisation manager is to systematically monitor processes in order to identify opportunities for improvements. In the case of public healthcare in Poland, such needs are enormous, while barriers include the necessary reconciliation of dissimilar needs of many stakeholders. The relationships between business processes and information technology (IT) presented in the literature demonstrate that their alignment is the key factor affecting organisation efficiency. It should, therefore, be assumed that the improved alignment of the hospital process and the applied IT has a positive impact on the process efficiency. The problem examined in this article is the knowledge capture that allows for the identification of areas where the alignment is insufficient. The research question is how to systematically monitor the scope and strength of IT support provided to the process. The article proposes an approach to monitoring the alignment between the process carried out in the hospital and the applied IT. This is to enable the identification of the areas where improvement initiatives are the most desirable in terms of process efficiency. The proposed approach was developed as a result of the action research carried out at the University Clinical Hospital (UCH) in Opole. The research included forms, interviews and experiments, enabling the development of a multi-stage action plan in order to capture knowledge on the degree of alignment of the process and the information technologies applied. The proposed approach combines popular and widely used solutions, such as the System Usability Scale (SUS), with the original ones based on the Lean Management concept. The idea of the developed approach is to gradually narrow down the area in which the improved alignment of the process and the IT technology applied will have a significant impact on the process efficiency. Therefore, labour-intensive procedures to capture detailed knowledge focused on areas where changes are the most desirable (expected). The article presents how the proposed approach could be used, on the example of the process of performing scheduled surgical procedures at the University Clinical Hospital in Opole. The main contribution of the article to the theory and practice of knowledge management is the development of a systematic approach to capturing tacit knowledge for the needs of improvement of hospital processes.

Keywords: knowledge capture, process monitoring, process improvement, process & IT alignment, System Usability Scale (SUS), action research, hospital

1. Introduction

Managing a public organisation such as a hospital requires reconciling the needs of many stakeholders, as well as complying with industry guidelines and legal requirements. Many limitations regarding actions aimed at improving the effectiveness of this type of organisation are present. The most important effect of the hospital's activities are the results of treatment and the quality of patient care. However, in the case of the public health service, as in the case in Poland, the efficiency of the hospital is also very important, as it determines patients' access to therapy. One of the most important directions of improvement in this respect is computerisation (Williams, et al. 2015). Its use makes it possible to reduce losses in the processes being carried out. However, However, the fact that not all IT solutions are useful enough be taken into account. In this respect, this is related, among other things, to their acceptance by the users and the extent to which they support the processes. Moreover, the applied IT solutions may lose their usefulness due to changes in procedures, methods of therapy or technologies. In such cases, there are gaps in alignment processes and IT solutions supporting their implementation. The gap between process and IT solutions should be understood as tasks in which the process is not sufficiently supported by IT solutions. This may be a result of the improper selection of the IT solution or the incomplete use of support offered by the IT solution, e.g. due to outdated process implementation procedures. The identification of such areas (activities and tasks carried out within the process) allows corrective actions, which in the long term will result in the improvement of hospital efficiency, to be taken. However, such an effect is only possible if the manager is aware of the gap between process and IT solutions. This requires the systematic acquisition of knowledge from employees involved in the processes. It is therefore necessary to periodically monitor the alignment of processes and IT solutions supporting them. In order to carry them out, it is necessary to develop an approach dedicated to the task, which would enable the collection of tacit knowledge

concerning the implementation of processes and their support by IT solutions. This knowledge results from the experience, information and intuition of health professionals who carry out such processes. From a practical point of view, medical personnel must not be overburdened with process analysis. On the other hand, it is the knowledge of these employees that enables the areas for improvement to be identified. The aim of the article is to present an original approach to knowledge acquisition that allows for monitoring the gap between the hospital process and IT solutions. The acquired knowledge is intended to identify areas where improvement initiatives are the most desirable in the context of process efficiency. The proposed approach was developed as a result of action research conducted at the University Clinical Hospital in Opole. The organisation of the article is as follows: SectionSection 2 discusses the issue of knowledge capture in hospitals pointing out the barriers for this process. Section 3 presents the research methodology taking the stages of research and its scope into account. Section 4 presents a developed approach to acquiring knowledge that enables the assessment of the hospital process alignment and the applied IT solutions. Section 5, on the other hand, provides conclusions and directions for further research.

2. Knowledge capture in hospital

In this article, knowledge is understood as a set of insights, experiences and procedures considered to be correct and true, and therefore guiding people's thoughts, behaviour and communication (van der Spek, Spijkervet, 1997). Knowledge management (KM) is “the process of getting the right information to the right person at the right time. It involves knowledge creation and sharing” (Chandra, Iyer, Raman, 2015). Micro-scale knowledge management focuses on the capture, structuring and use of knowledge at local levels (Vergison, 2001). Knowledge capture is defined as the process of retrieving either explicit or tacit knowledge that resides within people, artefacts, or organisational entities (Hegazy, Ghorab, 2015).

The acquisition of knowledge on process improvement opportunities is the foundation of Japanese management methods (Angelis, Fernandes 2007) aimed at the continuous improvement of the organisation. Hospital organisations are knowledge-intensive environments involving rapidly changing medical technologies, and requiring tools, skills, and methods with more knowledge resources (Lee, 2017). Barriers to knowledge management in public organisations, such as hospitals, result from their excessive bureaucratic and hierarchical structure. Processes are carried out by many functional units that are reluctant to provide information. Kothari and et.al. (2011) distinguish between barriers to knowledge management in health care units at the individual and organisational level. The barriers at the individual level are: employee turnover, information overload, improper training, and lack of motivation. The barriers at the organisational level are: organisational structure, taking a long time to implement KM, lack of resources, and employees and KM conflicting goals. The developed approach to knowledge capture, presented later in this article, has been developed with a view to reducing these barriers. It is based on the assumption that the practices of sharing and transferring knowledge should be adapted to specific organisations (Seba, Rowley, Delbridge, 2012).

The acquisition and formalisation of tacit human knowledge is a complex and very time-consuming task and therefore constitutes a major area of research in knowledge engineering. Its aim is to develop methods and tools to facilitate the quick and easy acquisition of knowledge from an expert (Anagnostakis, Ritchie, et al., 2016). This publication contributes to this research stream. The proposed and presented approach to knowledge capture was developed due to the need to monitor the possibilities of improving the efficiency of hospital processes. This requires gaining knowledge from the employees and, on the basis of this knowledge, assessing the degree of process alignment and the applied IT solutions. Due to the volatility of the social, legal and technological environment these activities must fit into the idea of continuous improvement and not be carried out incidentally. Thus, appropriate mechanisms for capturing knowledge from within the organisation are necessary, tailored to the specifics of the organisation. The essence of the proposed approach is to gradually refine the captured knowledge so that the increased efforts and burden on the employees are focused on areas where improvement is most important for the organisation.

3. Research methodology

The problem of acquiring knowledge from health professionals requires a deep understanding of conditions, and the way this is solved depends on many factors, which are identifiable only on the basis of personal observations. Therefore, an embedded case study method has been used as a research method, which allows the research problem to be put in a real context. The personal motivation to conduct the research was the involvement of the hospital’s director, who was looking for opportunities to increase the efficiency of the hospital's work

without reducing the quality of patient care. These studies are part of a larger hospital information system development planning project. They have been carried out for the past two years. The project included an audit of IT solutions applied at the University Clinical Hospital (UCH) in Opole (Wielki, Jurczyk-Bunkowska, Madera, 2019). This research has led to observations which have been taken as assumptions for further work.

1. The need to periodically monitor the effectiveness of process support by the applied IT solutions.
2. The least possible burden on health professionals in the process of obtaining knowledge from them regarding the functioning of information systems.

The research presented in this article was carried out for the process of implementation of planned surgical procedures. The individual stages of the research and data collection methods used in the research are presented in Figure 1.

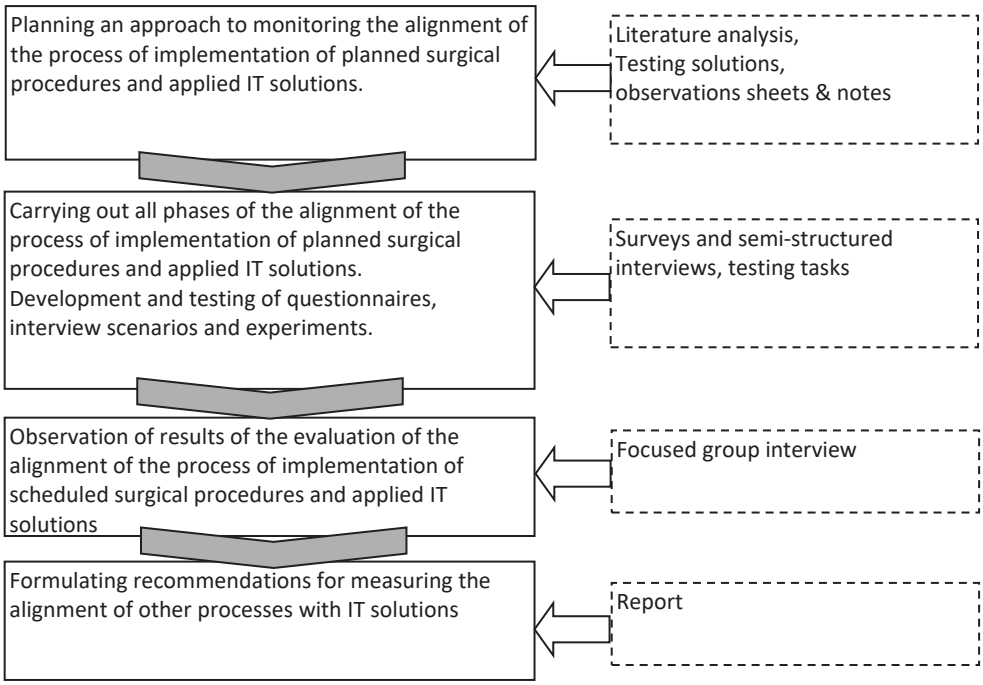

Figure 1: Stages of research on the approach to monitoring and analysis of the alignment of the hospital process and the applied IT solutions.

After a series of studies on the process of scheduled surgical procedures and registration in specialist clinics, the studies were suspended due to the epidemic situation.

4. Capturing knowledge for monitoring and analysing the gap between the hospital process and the IT solution

The idea of the proposed approach to monitoring and gap analysis of the hospital process alignment and the IT solutions supporting it is a multistage approach. It allows for the gradual specification of the acquired knowledge and focus on those areas where improvements will be most important. The subsequent stages of the approach are presented in Figure 2. The transition to each subsequent stage is determined by the results obtained in the previous stage. This ensures that detailed knowledge, which is time-consuming to capture, is available in areas with the greatest potential for improvement.

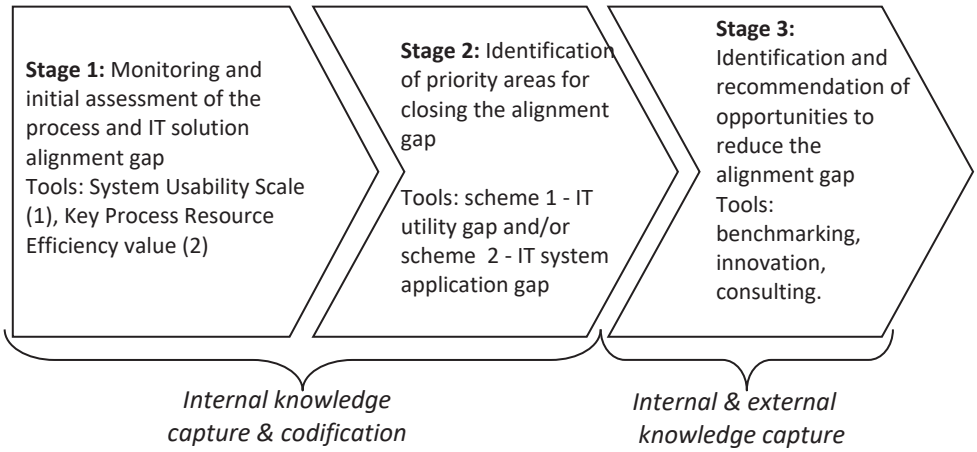

Figure 2: Stages of acquiring and refining knowledge in order to identify and reduce the gap between the hospital process and the applied IT solutions

4.1 Monitoring process alignment and applied IT solutions

The task of the first stage of the proposed approach is to monitor the process and the applied IT solutions. As a result, managers receive a signal about potential irregularities – an unacceptable gap in the alignment process and IT solutions. The monitoring was carried out on the basis of a systematic research of two values: the effectiveness of the use of a key process resource (1) and the acceptance of IT solutions by the employees (2). The first value has been regularly monitored on a monthly basis for over a year.

For planned surgical procedures, the key resource is the operating suite. To perform the calculations, the time between the input and output of the operating team was measured for each of the 9 operating suites. The efficiency index was calculated on a monthly basis, as the difference between the available time and the time of the surgical procedure increased by the normal time to prepare the operating suite. For example: in January, in one of the 9 operating suites at the UCH in Opole, 78 planned surgical procedures were carried out, with a total time of 5,600 minutes. The standard time between the surgical procedures necessary to clean and prepare the surgical theatre is 30 minutes, i.e. 2,340 minutes for all procedures performed in a month. The surgical theatre for scheduled surgeries wasavailable for 8 hours a day (from 7.00 am to 3.00 pm), i.e. 10,080 minutes in January. Thus, the efficiency of the use of this resource in January was as follows:

$$E_{kr} = \frac{5600\ min + 2340\ min}{10080\ min} \cdot 100\% = 78{,}8\%$$

The expected value of this indicator by the Management Board is 85%, which signals the need to analyse the possibilities of improving the process.

The second monitored parameter was the evaluation of utility of the applied IT solutions. The System Usability Scale (SUS) was selected for this purpose. It is a proven tool and has been used for this purpose for years (Lewis, 2018). This measurement was carried out by means of an electronic questionnaire, containing questions verified in the survey translated into Polish (Borkowska, Jach, 2016). Seven selected people of different ages and functions were asked to complete the survey. On the basis of the five-point Likert scale, they answered the following 10 questions:

1. I think that I would like to use this IT system frequently.
2. I found the IT system unnecessarily complex.
3. I thought the IT system was easy to use.
4. I think that I would need the support of a technical person to be able to use this IT system.
5. I found that the various functions in this IT system were well integrated.
6. I thought there were too many inconsistencies in this IT system.
7. I would imagine that most people would learn to use this IT system very quickly.
8. I found the IT system very cumbersome to use.
9. I felt very confident using the IT system.
10. I needed to learn a lot of things before I could get going with this IT system.

These questions did not require technical knowledge to understand them. This enabled the medical professionals to answer them effortlessly.
The value of the SUS index was calculated on the basis of the median from the obtained answers. The following points were awarded: strongly disagree: 1 point, disagree: 2 points, neutral: 3 points, agree: 4 points, strongly agree: 5 points.

$$SUS_{score} = (X + Y) \cdot 2{,}5 \quad (1)$$

where:

- X = sum of the points for all odd-numbered questions - (minus) 5,
- Y = 25 - (minus) the sum of the points for all even-numbered questions.

The SUS score defined the usability performance in the aspects of effectiveness, efficiency, and overall ease of use. According to the guidelines (Bangor, Kortum Miller, 2009) the obtained results were interpreted as follows: worst imaginable = 12.5; awful = 20.3; poor = 35.7; OK = 50.9; good = 71.4; excellent = 85.5; best imaginable = 90.9.

4.2 Assessment of the process alignment gap and applied IT solutions

Both the SUS and the efficiency of the key process resource have been used to monitor all hospital processes. The frequency of monitoring will depend on the importance of the process for the organisation. The proposed solutions are not time-consuming and burden medical workers to a very small extent. They allow the size of the alignment gap of the process and applied IT solutions to be detected (Fig. 3), which significantly affects the efficiency of the process. The alignment gap is defined as the difference between a situation in which the efficiency of a key process resource is 100% and the utility assessment of IT solutions is 100 points. Obviously, any gap in the alignment is an opportunity for improvement, but adopting limits to values of monitored values where they are considered acceptable has been decided. For the efficiency of the use of the key process resource it is 85% (resulting from the experience of the manager), while for the SUS it is 71.4 resulting from research on this indicator (Bangor, Kortum Miller, 2009).

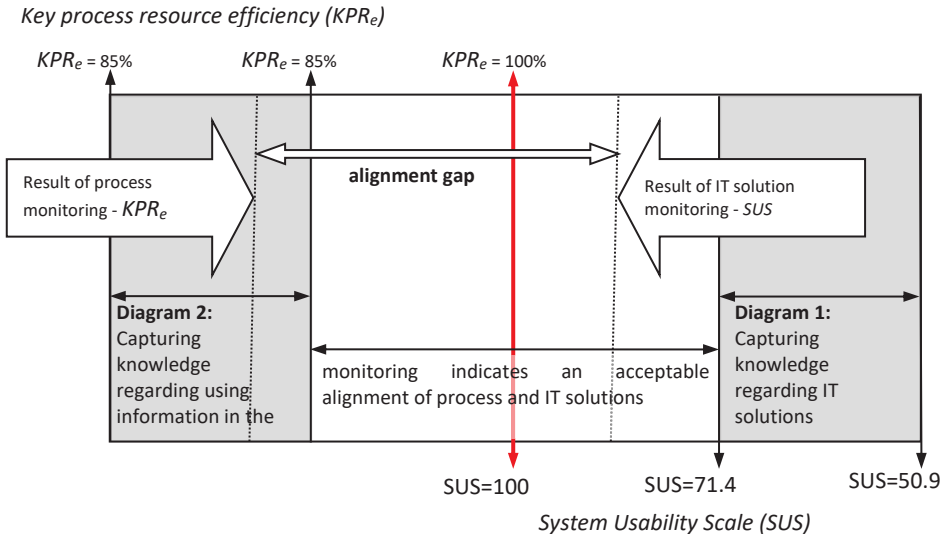

Figure 3: Identification of the type of alignment gap between the process and applied IT solutions

The accepted limits of acceptability of the values of the monitored indicators provide a framework for the next steps to be taken. The following options are possible depending on the obtained results.

1. KPR_e is at an acceptable level (white area in Fig. 3) and at the same time the SUS value is at an acceptable level (white area in Fig. 3). In this case, no further action is necessary. The alignment of the process and IT solutions is considered satisfactory.
2. KPR_e is at an acceptable level (white area in Fig. 3) and at the same time the SUS value is at an acceptable level (grey area in Fig. 3 or outside the area). In such a case, acquiring detailed knowledge about the usability of the IT solutions applied in the process is required. It is obtained by an IT staff member on the basis of the question and experiment scheme marked later in the article as Scheme 1 (Scheme 1). This knowledge is to identify reasons for the low perceived usability of IT solutions for employees.

3. KPR_e is not at an acceptable level (grey area in Fig. 3 or outside the area) and at the same time the SUS value is at an acceptable level (white area in Fig. 3). This is the option that was presented in Fig. 3. In such a case it is necessary to capture knowledge about the process losses caused by insufficient access to information. Knowledge capture on the basis of the interview and observation patterns marked later in the article as Scheme 2 (Scheme 2) is carried out by an employee who deals with internal audits in the hospital. It identifies areas of losses resulting from insufficient access to information during the process.
4. KPR_e is not at an acceptable level (grey area in Fig. 3 or outside the area) and at the same time the SUS value is at an acceptable level (grey area in Fig. 3 or outside the area). This is an emergency, which means a huge gap between the process and IT solutions. Such a situation requires far-reaching measures, not only improvements. The knowledge captured in such a case is to lead rather to re-engineering the process based on far-reaching changes in the process or changing the IT solutions supporting it.

4.3 Knowledge acquisition for identifying areas of poor alignment process & IT solutions

In the second stage of the process and IT solution alignment analysis, knowledge was acquired through questionnaires marked as Scheme 1 and Scheme 2. They were developed in an electronic version. In view of the assumption that the burden on clinical staff was as low as possible, it was decided that they should be completed by the IT staff member (Scheme 1) and the internal auditor (Scheme 2). Such solutions resulted from communication problems with medical professionals in the area of IT-related issues. These factors contributed to the reluctance of medical professionals to share their knowledge through online surveys.

Table 1 presents the scope of knowledge capture on the utility of IT solutions. It is acquired by an IT staff member. They use interviews, tests and observations, and introduce assessments using a tablet-based questionnaire.

Table 1: Diagram of IT system analysis in terms of usability

Criterion designation	Criterion name	Grading scale
Reliability and availability of information (R&A)		
R&A.1	Software speed test under load	Time of sending and receiving requests
R&A.2	Service time in the event of failure	Median response time (number of hours)
R&A.3	Access to information from various devices, e.g. tablet, phone	Grades from 0 to 4
R&A.4	Test of staff knowledge of the software (task for selected persons: standard, occasional, special)	Grade weight: 0.5 * number of minutes for standard task + 0.3 * number of minutes for occasional task + 0.2 * number of minutes for special task
R&A.5	Searching and filtering information	The sum of five component grades
R&A.6	Access to information on other processes	The sum of four component grades
Functionality of IT solutions (F)		
F.1	Adequacy of help and autocomplete tools	The sum of two component grades
F.2	Combining process logic and application logic	The sum of four component grades
F.3	Identifying and indicating incorrectly entered values	Grades from 0 to 4
F.4	Relationship between IT and the equipment used in the process	Grades from 0 to 4
F.5	Improvement in documentation preparation	The sum of five component grades
F.6	Monitoring progress in the process	Grades from 0 to 4
F.7	Remote control and acceptance of tasks	Grades from 0 to 4
Information security (S)		
S.1	Strength of the identification, authorisation and authentication tools	Grades from 0 to 4
S.2	Data integrity	Grades from 0 to 4
S.3	Audit regarding employee involvement in information security based on event simulation	Grades from 0 to 4
S.4	Compliance of security features with legal requirements for hospitals	Grades from 0 to 4

Scheme 2 aims at gaining knowledge to identify areas where access to information is insufficient and determines losses. The internal auditor fills in the appropriate questionnaire on the basis of interviews with: a doctor, ward nurse and scrub nurse, and their own observations. The size of the potential loss is evaluated due to its importance for the efficiency of the use of the key process resource. In the case of planned surgical procedures, this is an operating suite. Figure 4 shows the logic underlying the assessment of the significance (materiality) of losses when they occur. The red fields indicate these tasks in the process when a medical team ready for surgery in the operating suite. The yellow field is a fragment of the process, in which the key resource of the process is reserved for performing necessary tasks that do not add value. These are tasks related to cleaning, disinfection and preparation works. The green field is the part of the process where the key resource is not used. The auditor uses the employees' knowledge to estimate the amount of loss and ticks the appropriate box in the questionnaire. The auditor may also make additional comments. For all questions in Scheme 2 an analogical method was used to assess the significance of loss.

Waiting for access to patient's medical data stored outside the IT system ($t_{1.1}$)	**Implementation of the procedure**	**Preparation of the room, equipment and materials**	**Preparation of the patient for surgery**
	$t_{1.1} < 3$ min	$t_{1.1} < 3$ min	$t_{1.1} < 3$ min
	3 min < $t_{1.1} \leq 10$min	3 min < $t_{1.1} < 10$min	3 min < $t_{1.1} \leq 10$min
	$t_{1.1} > 10$min	$t_{1.1} > 10$min	$t_{1.1} > 10$min

Figure 4: Example of a questionnaire for gathering knowledge on process losses due to the lack of appropriate access to information.

Table 2 presents the questions of Scheme 2 - enabling identification of losses resulting from insufficient scope of process information support by the IT solution.

Once the knowledge is collected, it is aggregated through mechanisms used in the questionnaires. It facilitates the identification of areas where improvements will be most important for the effectiveness of the process.

Table 2: Diagram of process analysis in terms of the scope of support from IT solutions

No.	Type of waste	Waste identification questions
1	Waste of waiting	Waiting for access to a patient's medical data stored outside the IT system
		Waiting to obtain the patient's required consents (permits) to conduct medical procedures
		Absence of some members of the surgical team (e.g. waiting for a person due to the unconfirmed date of the surgical procedure
		Waiting on the availability of the medical equipment needed for the surgery
		Inadequate internal communication, lack of information about the postponement of the surgery, e.g. due to patient infection
2	Waste of transport	Transfers between different operating theatres (staff, patients, materials) due to changes in the schedule and failure to maintain an adequate communication channel
		Unnecessary handling of biological samples or other materials due to failure to maintain an adequate communication channel
		Transport of paper documentation due to failure to maintain an adequate communication channel
3	Waste of motion	Sub-optimal location of IT system desks, e.g. the need to return to the office to enter data
		Room inspection procedures (e.g. completion of cleaning work is not communicated) due to poor communication
		Lack of access to instructions for performing tasks, such as disinfection, cleaning and preparation for surgery
		Search for medical records
4	Waste of over-processing	Time spent keeping records in an electronic and paper form (duplication of records)
		Oversized diagnostic procedures resulting from incomplete access to information.
		Preparation of unnecessary forms and overviews
		Redundant control due to lack of access to information
5	Waste of inventory	Providing substitute staff, resources and/or materials due to the lack of access to information on real-time availability
		Expired drugs or materials
6		Patient misidentification
		Misreading medical prescriptions

No.	Type of waste	Waste identification questions
	Waste of defects/faults/deficiencies	"Manual" processing of documentation
		"Manual" preparation of the schedule of surgeries
7	Waste of over-production	Duplication of medical or organisational activities
		Redundant documentation – not required by law
		Redundant arrangements outside the IT system
		Multiple entries of the same data
8	Waste of human potential	Employees are not properly motivated to use the IT software
		Lack of procedures to obtain comments and suggestions for improving IT software functionality

4.4 Formulating recommendations leading to improved alignment of process and IT solutions

The third stage was to propose changes to improve the alignment of the process and IT solutions used in it. They were formulated by the IT department employees and the internal auditor in cooperation with individuals involved in the process. A report was prepared, the template of which assumed the presentation of information on results of the two previous stages, as well as the indication of improvement options and the formulation of recommendations. Knowledge of improvement opportunities was acquired both inside the hospital and outside. It mainly covered practices used in other processes or other hospitals. Knowledge is also acquired as a result of advice obtained e.g. from IT companies or consultations with employees of universities. These two paths can lead to process or organisational innovations that reduce the gap between process and IT solutions. The proposed solution options are assessed against the following criteria: scope for potential improvement, cost of solution, organisational difficulties, implementation time. On the basis of a report prepared in this manner, a decision is made to introduce changes.

5. Conclusions

This article addresses a very important and difficult subject of knowledge management in hospitals. The article illustrates how to obtain knowledge from within an organisation leading to the improvement of processes. It is obvious that many companies rely on this approach. However, it is unusual among public health units including hospitals. The main assumptions for the developed approach were minimizing the time spent by medical professionals on transferring knowledge, involving them in improving the process, developing solutions that lead to continuous improvement. There is not much research of this kind so far. The original approach presented in this paper, which allows for the acquisition of knowledge for the purpose of improving processes carried out in the hospital, is at the initial stage of verification. However, the preliminary results of the research already show that the focus on adjusting hospital processes with the used IT solutions offers an opportunity for process improvement. This approach makes medical professionals more eager to share their knowledge because they don't seem to feel even indirectly responsible for insufficient effectiveness. Considering the efficiency of the process through the prism of effectiveness of their support with IT solutions is accepted by medical professionals. They are naturally more focused on the individual care of the patient than on process efficiency. By gaining their knowledge regarding the alignment of IT solutions to the requirements of the process, it is possible to plan system development by improving individual processes.

The developed solutions presented in this article have been tested on several processes at the University Clinical Hospital (UCH) in Opole. However, they cannot yet be recommended as fully proven knowledge acquisition mechanisms. Nevertheless, conclusions from the carried out work so far encourage their continuation and extension. The intention of the authors is to also verify the approach in other hospitals.

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