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ROBOTIZATION – THE PROCESS OF IMPLEMENTING MEDICAL INNOVATION

Introduction

The implementation of innovations concerns organizations operating in various spheres of social and economic life. In this respect, the strategic perspective plays a special role. Strategic innovation consists of generating new ideas, discovering ideas in the surrounding reality, understanding the problems being solved, urgently solving current and urgent problems, being open to unknown ideas, entering new areas of activity, learning from mistakes, searching, identifying and building good practices [Dyduch, 2015: 31]. In this respect, it seems that technological innovations significantly increase the competitiveness of organizations [Brzezinski, 2015].

Innovation in the delivery of health services is defined as a set of behaviors, procedures, and working methods, as well as related technologies and administrative systems, that are: perceived as new by some key stakeholders, related to the provision or support of health care, related to the discontinuity of existing practice, aimed at improving health outcomes, administrative efficiency and profitability – implemented through planned and coordinated activities individuals, teams or organizations. Innovation in healthcare can be defined as the introduction of a new concept, idea, service, process or product. At the same time, it should be emphasized that all these actions are undertaken in order to improve treatment, diagnosis, education, better access to services, better prevention and testing, together with long-term increases in quality, safety, improved outcomes, efficiency and cost reduction [Hunger, Hunger, 2014: 76]. The development of technology and the implementation of innovative solutions in the field of medicine and pharmacy are one of the priorities of modern

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science. Every year, innovative solutions appear that can significantly affect the effectiveness of diagnostics and therapy of many diseases, which translates significantly into an increase in life expectancy [Sarecka-Hujar et al., 2016: 15].

In this context, the implementation of technological innovations in healthcare entities is becoming an interesting research area. The aim of the article is to evaluate the process of implementation of medical innovations. This process has been analyzed using the example of the Leszek Giec Upper Silesian Medical Center of the Medical University of Silesia in Katowice.

1. Innovation in medicine

The need for innovation in most sectors of the economy, including healthcare, is undeniable. Modern medical technologies are a permanent element of modern medicine, and their use is crucial in modernizing health care and improving the health of societies [Jończyk, 2013: 42].

Schumpeter was the first to emphasize the importance of innovation in the process of creating new combinations from existing resources. Since then, innovation has become an important factor in entrepreneurship. Within the entrepreneurial orientation, the innovation dimension reflects an organization's propensity to go beyond established rules and technologies by fostering new ideas, innovation, experimentation, and creative processes [Wiklund et al., 2009,]. It can take many forms, with the most obvious manifestation being the result of intensive research and development. Thus, innovation takes many forms and is central to the entrepreneurial orientation, as it reveals which organizations have the ability to achieve a competitive advantage. Changes in the external environment require public organizations, including hospitals, to adopt innovative approaches to solving emerging problems that result from demographic, social, and technological changes [Hunger, 2016: 66].

In the field of research on innovation in hospitals, four basic groups of studies can be identified. The first group consists mainly of research conducted by economists, treating hospitals in terms of their production function and generally comparing them to enterprises (this trend is most popular in the United States). The primary goal is to mobilize resources and combine them in the production process to create a specific product. In the case of healthcare, this refers a set of actions aimed at restoring or improving the health of patients. Research within this group has drawn particular attention to the problems of innovation in the context of health economics, bureaucracy and agency theory. The second group of studies treats hospitals as collections of medical innovations (technological and pharmacological). This research focuses on the diffusion of innovations, their life cycle, and their (financial and social) impacts. In this vein, attention is drawn to the fact that the introduction and dissemination of

innovations in health care should be preceded by a cost-benefit analysis, both in the socio-demographic and financial and organizational contexts, which would promote a more rational use of funds allocated to healthcare. The third group of studies concerns hospital innovations in terms of information systems. In the literature on the subject, innovation in the service sector often comes down to new information and communication systems. Among the technological innovations used by hospitals, two main groups are most often distinguished. The first group consists of hybrid health technologies, which combine information and communication technologies with other technological elements, such as in robotics. The second group consists of information and communication technologies that facilitate access to healthcare remotely (primarily telemedicine). The fourth group of studies concerns the concept of the hospital as a provider of comprehensive health care services. This concept reflects a shift in hospital management toward placing greater emphasis on linking medical services to the stakeholders of those services. Research pays particular attention to the patient, who is a consumer of a comprehensive set of medical services, suggesting that the efforts of the healthcare providers should be directed not only toward meeting the patient's needs but also those of their family [Jończyk, 2013: 43–45].

In the case of medical services, including medical procedures, both financial and non-financial effects should be assessed when evaluating the legitimacy of their implementation and potental financing from public funds [Achiro, 2022; Creixans Tenas, Arimany-Serrat, 2018]. The same applies to the implementation of innovations in hospitals [Leotta, Ruggeri, 2017], including in particular technological innovations, [Turchetti, 2009] and the adaptation of the evaluation system in this area, taking into account the specificities of the healthcare sector [Mathy et al., 2023]. A separate research strand focuses on the ecosystem of medical innovations, including those related to the creation of medical clusters [Kulkov, 2021].

Such implementations must therefore be aimed at achieving positive effects, mainly of a medical and economic nature [Hass-Symotiuk, 2021]. The state plays a very important role in this process, as increased expenditure on research and implementation contributes to the development of the entire medical sector [Pawłowska, 2015: 108]. Strengthening the ability to adapt and implement innovations generally improves the functioning of healthcare system entities, enhances operational efficiency, competitiveness, and ensures the appropriate quality of services provided, while adapting them to changing social and technological needs. However, it is also important to note the potential two-way impact of innovation on the efficiency of the health care system by influencing its cost determinants in relation to the valuation of products implemented using innovative solutions [Dymut, Dymut, 2018: 66].

The positive effects of implementing innovations in a healthcare entity can be considered from the perspective of: organization (simplification of work, comprehensive offer), the treatment process (less invasive methods of treatment, greater precision

of service delivery) and the patient (shorter length of stay, higher quality of services provided) [Pawłowska, 2015: 109]. An important issue is also the financial evaluation of the implemented medical technology in the early phase, which mostly falls short due to the need to acquire experience and proficiency, but offers strategic advantages in the perspective [Bartelmes et al., 2009].

2. Robotization

The healthcare sector relies on research to develop and improve the tools and practice of clinical and management activities. However, the most difficult challenge is adopting and disseminating innovation, countering resistance to proposed changes, and supporting staff readiness to innovate. Embracing innovation typically involves more than just implementing it – it requires understanding the relationship between people and technology, mobilizing and engaging staff to adopt, and encouraging them to think about how innovation will make their jobs easier. In addition, it is necessary to examine how new health technologies will affect the health status of patients, hospitalization waiting time, lengths of hospital stays, the demand for and consumption of health services, the productivity of human resources, and the efficiency of healthcare providers [Krsnik, Erjavec, 2023: 292].

Research conducted on the effectiveness of robotization processes in the healthcare sector concerns the use in a specific medical specialization [Chang et al., 2015] and the change in the model of functioning of a medical service as a result of the use of telemedicine elements [Alzaabi, Hasan, 2022]. More broadly, they concern the classic cost-benefit analysis of new health technologies [Boltürk, Haktanır, 2023]. Recent research in this area also concerns the use of artificial intelligence in the robotization of medical procedures [Dhatterwal et al., 2023].

Robotics is an interdisciplinary field of science, combining knowledge in the field of mechanics, automation, computer science, sensory science and cybernetics. It focuses on supporting selected activities performed by surgeons through the use of available technical tools. Medical robotics, a rapidly developing field, encompasses the use of medical and rehabilitation robots. A medical robot is a tool in the hands of a surgeon, enabling surgical operations in very difficult anatomical areas of the human body with exceptional precision. In most cases, medical robots are telemanipulators that combine the actions of a doctor with the precise movements of an effector Using specific control mechanisms, the doctor decides the tasks to be performed, while the robotic arm executes these instructions with high accuracy.. Medical robots are also used to help patients and people with disabilities. They are used in many areas of medicine. These include, but are not limited to: – surgical robots – their main advantage is the extraordinary precision of the procedure and the lower risk

of error; – rehabilitation robots – a group of medical robots designed to help people with disabilities and elderly patients or those immobilized after surgery; – passive navigation robots – their application is mainly found in neurosurgery, they are aimed at precise positioning and maintaining the appropriate path of instruments during surgery; – active navigation robots – their task is to perform tasks assigned by the operator [Zdrojewicz et al., 2014].

Assessing the economics of robotic surgery will be an increasingly common trend [Moss, Halkos, 2017]. The implementation of robots would likely benefit patients, physicians, and hospitals and could be the new standard of practice in most hospitals, however, the cost barrier is a major factor hindering their widespread adoption [Ashford et al., 2015]. Surgeons should ensure that the device is used to maximize clinical applications for both patients and subsequent physicians. It can be assumed that in the future, the most expensive tooling factor will become more affordable due to competition in the industry, thus improving the cost-effectiveness of this technology [Liberman et al., 2012]. The implementation of innovation is very complicated and requires the involvement of specialist knowledge, a large number of material and financial resources. A properly prepared implementation project brings double benefits to the organization. The most important one is the implemented technology, on the basis of which the organization provides products/services that meet the needs of customers and increase its wealth. A less noticeable, but equally important benefit is the experience gained and the knowledge of how to effectively implement projects. The implementation of innovation is the culmination of the entire process and is a measure of the quality of tasks performed at earlier stages. Not every project is successful, and the reason for failures can be found both in the technology itself and in the organization of the implementation process. Failure for an organization is primarily the interruption of the implementation or non-implementation of the technology, but also the implementation of the technology which, instead of bringing the expected profits, exposes the organization to financial losses [Frąś, 2013: 185].

3. Case Study

The process of introducing medical robots into the clinical activity of the hospital was examined using the example of the Leszek Giec Upper Silesian Medical Center of the Medical University of Silesia in Katowice (hereinafter referred to as the Hospital or GCM). The hospital is an organization engaged in medical activities, including teaching and research tasks in connection with the provision of health services. It also focuses on t the implementation of new medical technologies and treatment methods [Act on medical activity, 2011].

The case study was chosen as a research method to gain an in-depth understanding of the reasons behind the actions taken within a specific organization [Wójcik, 2013; Grzegorczyk, 2015]. The research covers the period from August 2023 to January 2024, during which the hospital decided to start the process of implementing robotization in four medical specialties at GCM. The first stage of this process, carried out in cardiology and orthopedics, was also analyzed. To examine the process, data from the financial and accounting area were used, particularly maintained as part of cost accounting [Regulation of the Miniter of the Health…, 2015]. Statistical data recorded with the use of GCM IT systems for recording and reporting services, as well as documents concerning the structures and organization of GCM, including the Statute [Statute of GCM…, 2017], Organizational Regulations [2018], and Accounting Policy [Director's Ordinance, 2018]. In addition, interviews were conducted with the coordinators of the studied areas and the Director of Treatment at GCM. The main questions about the project experience were formulated as follows:

- What are the main barriers to the implementation of robotics in cardiology and orthopedics?
- What is the process of preparation for the first treatments (e.g., training, tests, etc.)?
- What are the most significant benefits for patients and healthcare providers?
- What are the prospects for the development of robotic solutions in the fields of cardiology and orthopedics?

The proposal to start the process of implementing interventional procedures with the use of medical robots into the clinical activity of the GCM was initiated by the interdisciplinary team for the implementation of new medical technologies, established at the Hospital. The team included, among others, scientists and practitioners from the aforementioned fields of medicine. The team proposed starting the process of implementing these innovations in four medical areas: cardiology, orthopedics, surgery, and laryngology. The conclusions were based on scientific reports highlighting the medical benefits of using medical robots to perform surgeries, the rapid technological progress in devices designed to assist doctors during surgeries, and the increasing implementation of these systems in Polish healthcare entities.

The decision to initiate this innovative project was made following a teleological analysis, which evaluated the expected benefits for patients and medical staff when planning its budget.

Aim of the project – the aim of the project was to start the process of implementing medical robots into the medical activity of GCM.

Legal basis – the implementation of new technologies and treatment methods is inscribed in the scope of medical activity [Act on Medical Activity, 2011] and may be carried out as part of GCM's scientific and research activities, in compliance with the requirements of the Medical Devices Act [2022].

Expected clinical benefits – the key assumption of the project is to enable GCM patients to have access to new medical technologies.

Expected organizational benefits – to ensure the ongoing development of the Hospital and its active participation in technological progress, it is essential to train surgical teams in the use of advanced technologies, including medical robots and systems that support physicians.

Financial evaluation – to prepare the financial analysis of the project, a market study was conducted to evaluate the feasibility and terms of temporarily acquiring medical robots.. It was agreed that devices for performing cardiac and orthopedic procedures could be transferred to the Hospital under loan agreements, with the Hospital responsible for covering the costs of disposable robot equipment. The National Health Fund (hereinafter referred to as the National Health Fund) did not include services performed using medical robots in its valuation of procedures in invasive cardiology and orthopedics, as established by the Hospital Settlements with Hospitals. Therefore, the costs incurred for procedures performed with these systems, compared to traditional techniques, were borne by the Hospital.

The financial and teleological analysis for each of the planned process formed the basis for the decision to initiate the acquisition of robots. This decision aimed to facilitate the organization's education process, particularly by training surgical teams in performing invasive cardiology and orthopaedic surgeries using innovative techniques.

After GCM concluded the loan agreements[1], the Hospital prepared procedures for planning and performing procedures using medical robots, as well as obtaining appropriate patient consents[2]. A key moment was the training of GCM staff, carried out by the lending party.

4. Invasive cardiology procedures

In the study period, 15 cardiac procedures were performed at GCM using a medical robot. Statistical and cost data (focusing on direct costs) for these procedures were compared with data from 15 procedures of the same type performed using traditional methods. A summary of the average values is presented in table 1.

[1] In order to carry out cardiac procedures, the agreement for the loan of the R-One Robotic Platform medical robot from the manufacturer Robocath was concluded for the period from 01.09.2023 to 05.01.2024. For orthopedic treatments, the loan agreement for the CORI Surgical System manufactured by Smith & Nephew was concluded for the period from 28.09.2023 to 27.10.2023.

[2] Procedure no. P/LK3/03.

Table 1. Statistical and cost data on cardiology procedures performed using a medical robot and traditional technique

Average for	Days of stay	Treatment time [h]	Number of doctors at the procedure	Number of nurses at the procedure	Number of technicians at the procedure	Robot Disposable Accessories	Specialist materials. cardiologist	Other materials
15 treatments with a robot	4	1.18	2	2	1	2,700.00	2,129.04	1,501.43
15 robotless treatments	4	1.03	1	2	1	0	2, 108.52	1,435.66

Source: in-house analysis based on GCM data.

Data on procedures performed using the innovative technique show that these procedures lasted 15% longer than those in the control group. This difference is attributed to the medical teams' learning curve when operating the device. The use of a medical robot designed for cardiology procedures requires two doctors, which represents a significant difference compared to traditional technology, especially for procedures during on-call shifts. These procedures were also more expensive by PLN 2,700.00, corresponding to the cost of disposable robot equipment. For other factors, such as the number of days of patient hospitalization, the number of other staff in the treatment team, and the cost of materials, the values between the groups were comparable.

The coordinator of the process of implementing robotization into the clinical practice of cardiology GCM, cardiologist and professor of medicine, answering a question about the barriers to the implementation of this project, pointed to two problems. The first is the nature of the treatments. The robot available in the study period was dedicated to[3] procedures with a low and medium degree of complexity. At GCM, more than 50% of procedures are performed urgently[4] in patients with multiple comorbidities that require the use of additional devices [5]for which robotic support devices are not optimally prepared. The second problem is the need for two doctors to participate in such a procedure, while on-call procedures are performed by one doctor with a team of technicians and nurses. The process coordinator also pointed out the benefits of using the robot, namely the high precision of manipulating the guides and devices, and highlighted the 95% reduction in ionizing radiation for the main operator of the procedure. The precision in implanting the devices, and thus less traumatization of the vessel walls, and consequently the lower probability of an adverse end result of the treatment, as well as the reduction of exposure to ionizing

[3] Coronary procedures.

[4] Life-threatening conditions.

[5] Devices for crushing calcium deposits in the arteries, catheters for intracoronary imaging, or the simultaneous insertion of two stents or coronary balloons.

radiation, were also pointed out as benefits of the implemented medical technology by the Director of Treatment at GCM.

The analysis of clinical, organizational and financial data was the basis for suspending further implementation of this innovation into the clinical practice of GCM, until the manufacturer eliminates the current technical limitations of the robot.

5. Orthopedic surgery procedures

In the study period, 10 orthopedic procedures (primary knee arthroplasty) were performed at the Hospital with the use of a medical robot. Statistical and cost data (including direct costs) for these procedures were compared with data from 15 surgeries of the same type, performed using the traditional technique. As in the case of the cardiology procedures described above, data from the financial, accounting and statistical areas of GCM were used for the analysis. A summary of the mean values for surgeries performed using the traditional technique and the use of a medical robot is presented in the table 2.

Based on data on surgeries performed using a medical robot compared to the control group, i.e., 12 procedures of the same type, it was established that patients completed hospital treatment at the same time in both groups. Also, the number of doctors and nurses in the operating teams was the same in both groups. Similarly, the direct material costs of the operations were comparable across both groups. On the other hand, differences between the groups were noted in the position of treatment time and costs of disposable robot equipment. For each operation with the use of a medical robot, it is necessary to use disposable equipment, the average cost of which in the studied group of operations was PLN 3,135.20. A difference in mean values also occurred during the treatments. Robotic surgeries lasted 47% longer than controls, which is related to the initial phase of learning how the orthopedic surgeons are learning how to perform surgeries using the innovative method.

Table 2. Statistical and cost data on orthopedic surgery operations performed using a medical robot and traditional technique

Average for	Days of stay	Treatment time [h]	Number of doctors at the procedure	Number of nurses at the procedure	Robot Disposable Accessories	Specialist Materials orthopedic	Other materials
10 treatments with a robot	7.4	2.06	3.20	2	3, 135.20	4, 875.12	903.21
12 robotless treatments	7.3	1.4	3.25	2	0	4,987.62	795.90

Source: in-house analysis based on GCM data.

The coordinator of the process of implementing robotic technology into the clinical practice of orthopedic surgery GCM, orthopedic surgeon and professor of medicine, answering a question about the barriers to the implementation of this project, pointed to the lack of financing by the National Health Fund for operations with the use of a medical robot. Among the benefits of using robots, the professor included the ability to accurately plan operations in real time, including accurate planning of bone cutting and milling, and the ability to precisely position implants. Among the benefits of using this technique, the professor also mentioned providing the operator with real-time information on soft tissue tension, balance of the operated joint, or information on the reconstruction of limb length and offset of the implanted joint. Among the disadvantages of the device at his disposal, the professor listed, in addition to the higher costs described above, the need for preoperative imaging in the case of using computed tomography and a relatively long learning curve.

The clinical benefits associated with the use of innovative surgical methods, the need to ensure systematic performance of surgeries with innovative techniques due to the long training cycle of doctors performing the procedures and the need to gain experience were the justification for recommending further procedures with the use of a medical robot. Due to the availability of devices from other suppliers, it was proposed to acquire another model of the robot for use.

Conclusion

GCM has a long lasting tradition of using medical robots. In 2001, the first medical robot in Eastern Europe was used in the cardiac surgery operating theatre, where it served as an assistant in surgeries, such as coronary artery bypass grafting performed using minimally invasive method. Its primary task was to hold and guide an endoscopic camera for observing the inside of the patient's body, following the operator's instructions.

After many years, during a period of intensive development in medical technologies, including robotization, the Hospital has resumed the implementation of medical robots in clinical practice. However, due to the lack of funding for procedures performed with medical robots in cardiology and orthopedics, the aim of the project is to train hospital staff, including doctors, nurses, technicians, sterilization staff, medical electronics engineers, and IT specialists. The costs of this project are borne entirely by the Hospital.

After the completion of the stage of robotization implemented described in this article, further ongoing development of this technique is planned in the field of orthopedic surgeries, as well as initiation of robotization in general and vascular surgery and laryngology. In cardiology, however, the project will be temporarily

suspended due to the technological limitations of the currently available robot and its inadequacy in meeting the clinical and organizational needs of the Hospital. Based on the study, the following scheme of the medical innovation implementation process was formulated. As a practical implication, the diagram of the medical innovation process was formulated on the basis of the study.

Diagram of the process of implementing medical innovations into the clinical activity of the hospital:

1. Teleological analysis
2. Financial analysis.
3. Decision to start a robotization project (temporary implementation for verification purposes)
4. Preparation for implementation (performing surgeries with a medical robot)
5. Formulation of procedure for robot usage:
   5.1. Indications for the use of the robot
   5.2. Customization of patient consent forms
6. Designation and training of a team. (Personnel training conducted by the manufacturer's representatives)
7. Implementation of the project
8. Decision to continue or discontinue the project

On the other hand, as a theoretical implication, a verified approach to analyzing the use of robotization as a medical innovation in the early phase of its implementation can be identified. It should be noted, however, that this analysis was verified only on the example of a selected medical entity.

Technological progress, which enables clinical tasks to be performed with higher quality- safer and more effective for both patients and medical teams – should be consistently translated into practice. Nevertheless, it is essential to verify and assess its applicability for each individual unit, taking into account its organizational specificity and the role it plays within the healthcare system. This approach allows for the formulation of directions for future research, which should consider a longer time horizon, comparisons between different healthcare entities, and the evaluation of both financial and non-financial effects.

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ROBOTIZATION – THE PROCESS OF IMPLEMENTING MEDICAL INNOVATION

Abstract

Innovation plays an important role in the functioning of various types of organizations. A particularly sensitive aspect is the process of implementing innovations, which is characterized by specific challenges, especially in the case of technological innovations. In this context, the implementation of technological innovations in healthcare entities emerges as an interesting research area. This article aims to evaluate the process of implementing medical innovations, analyzed through the case of Leszek Giec Upper Silesian Medical Center of the Medical University of Silesia in Katowice. The research covers the period from August 2023 to January 2024, during which the hospital decided to start the process of implementing robotization in four areas of medical practice. Based on the presented case study, appropriate recommendations were formulated.

Keywords: innovation, robotization, hospital, medicine

JEL classification codes: I11, I18, K23

ROBOTYZACJA – PROCES WDRAŻANIA INNOWACJI MEDYCZNYCH

Streszczenie

Innowacje odgrywają istotną rolę w funkcjonowaniu różnego typu organizacji. Szczególnie newralgicznym elementem jest proces wdrażania innowacji, który ma swoją specyfikę, zwłaszcza w przypadku innowacji technologicznych. W tym kontekście ciekawym obszarem badawczym staje się wdrażanie innowacji technologicznych w podmiotach leczniczych. Celem artykułu jest ocena procesu wdrażania innowacji medycznych. Proces ten przenalizowany został na przykładzie Górnośląskiego Centrum Medycznego im. Leszka Gieca Śląskiego

Uniwersytetu Medycznego w Katowicach. Przeprowadzone badania obejmują okres od sierpnia 2023 r. do stycznia 2024 r., tj. okres, w którym w szpitalu podjęta została decyzja o rozpoczęciu procesu wdrażania robotyzacji do czterech zakresów medycznych. Na podstawie zaprezentowanego studium przypadku sformułowano stosowne rekomendacje.

Słowa kluczowe: innowacyjność, robotyzacja, szpital, medycyna

JEL Classification: I11, I18, K23