Zdrowie Publiczne i Zarządzanie 2018; 16 (3): 149–154
www.ejournals.eu/Zdrowie-Publiczne-i-Zarzadzanie, doi:10.4467/20842627OZ.18.017.10430

Study of the impact of implementing an electronic prescription with barcode scanning on the time of response to the patient's needs in the field of pharmacotherapy

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Abstract

According to estimated data, an average Polish hospital manages about 130 thousand pharmaceutical products. The main problem related to pharmacotherapy in hospitals is real-time access to up-to-date data, which determines the correct treatment process. This paper presents the results of research aimed at forecasting the outcome of implementing e-prescriptions in conjunction with barcode scanning on the time of response to a patient's needs for pharmacotherapy. The research was conducted in two hospitals by means of a business process analysis and the BPMN 2.0 standard. The analysis was concentrated on the drug administration process, taking into consideration the labour and service times of the process. Special attention was given to evaluating the possibilities of getting real-time access to information regarding the type, location and inventory level of pharmaceutical products. The research proved that implementing e-prescriptions in conjunction with barcode scanning could lead to reductions of the average working and service time.

Key words: **barcodes, electronic prescription, patient service, pharmacotherapy**

Słowa kluczowe: **elektroniczne zlecenie lekarskie, obsługa pacjenta, farmakoterapia**

Ministerstwo Nauki i Szkolnictwa Wyższego

Przygotowanie do wydania elektronicznego finansowane w ramach umowy 641/P-DUN/2018 ze środków Ministra Nauki i Szkolnictwa Wyższego przeznaczonych na działalność upowszechniającą naukę.

Introduction

Pharmacotherapy is one of the methods used in hospital treatment processes. According to the data from IMS Health Ltd., the value of the sales of medicinal products to hospitals in Poland in 2015 amounted to 4,178,267,321 PLN [1] and the increase in such costs, over recent years, is a global trend reported by the Organization for Economic Cooperation and Development [2]. According to estimates about 130,000 medicinal products are managed by the average Polish hospital [3]. After salaries, drugs are the second costliest element of hospital operation [4].

In the context of the process of patient service, the flow of medicinal products is a vital aspect of all the in-hospital logistic processes. The flow is accompanied by relevant information supporting the decision-making for the basic hospital processes – the treatment process and the patient's medical service. Effective and efficient integration of the following subsystems, the supply of healthcare products and patient movement, impacts on the provision of the appropriate response time to the patient's needs for pharmacotherapy [5]. In addition, proper management of the flow of medicinal products, supported by adequately selected mobile tools and correctly config-

ured IT solutions, may result in greater effectiveness and efficiency in the management of drug stocks.

The basic problem in health care, especially in the field of hospital pharmacotherapy, is access to current data in real time, which are the foundation for correct diagnosis and the entire treatment process. When the processes are supported by a teleinformation system, the requirement to manually enter data into the system creates the risk of error, which would result in an increase in the costs of implementing the processes and preclude access to reliable data. According to the research, drug therapy is burdened with the greatest risk of error [6].

Research aimed at assessing the degree of computerisation in Polish hospitals, including the level of their readiness to keep medical records in electronic form, clearly illustrates the problem. It is the lack of sufficient support for teleinformatic solutions, especially in the administering of medicines to the patient. The level of computerisation is very diverse and in most cases inadequate from the point of view of making the particular process automatic and electronic. There are still hospitals, especially smaller ones, which do not have support from an IT system. However, some hospitals have systems, which prevent the exchange of data with other units [7].

In addition, the lack of rapid access to reliable data in real time disrupts the information flow about the stock level of medicinal products, which poses a potential threat to a patient's safety and may extend the response time to meet the needs for pharmacotherapy. This may result in either, the lack of specific products, or a problem related to excessive and/or date expired stocks. The inability to update the IT system in real time causes a lack of available data on medicinal products and patients. In addition, the lack of comprehensive data and the impossibility of participants in the in-hospital logistic processes sharing them, lead to information gaps, duplicated activities and a longer time in responding to the patient's needs, including pharmacotherapy [8].

An important step towards reducing the response time to the patient's needs for pharmacotherapy is electronisation of the process by the application of electronic prescriptions [9]. Defining the assumptions of electronisation of medical documents is an important step towards improving the work of hospitals and the safety of hospitalised patients. In the author's opinion, during discussion on the subject and the formulation of the assumptions and requirements related to electronic medical records, there is no general concern about the quality of data included in the medical documentation. The degree of efficiency and effectiveness of developing electronic processes is highly dependent on the ability to automate the creation, processing and sharing of data, which constitute the backbone of medical documents. The methods used to obtain specific data significantly influence the quality of electronic medical documents. The advantage of automatic creation and data entry into the hospital's teleinformation system by means of barcode scanning over the manual input by a computer keyboard should be taken into account [10].

In connection with the above, the use of electronic prescriptions has a much greater impact when supported by automated data collection techniques, particularly barcode scanning. By definition, automatic data collection means "the direct input of data into a computer system or other microprocessor-controlled device without using a keyboard, using a specific ADC technique (…)" [11]. Research carried out more than 20 years ago showed that 1 error occurs per 100 characters with keyboard manual data entry, but when scanning barcodes, there is only 1 error per 10 million characters [12]. Therefore, the implementation of even the most advanced IT system will not exhaust the possibilities for rationalising the patient's pharmacotherapy service if the data used for the process are entered mainly manually. In addition, certain activities may be duplicated, which may lead, for example, to documents existing in both paper and electronic forms. Moreover, there are research results which show that the implementation of IT solutions in health care does not always lead to an improvement in the level of patient service [13].

The aim of the paper is to present the results of research on the impact of the implementation of electronic prescriptions and barcode scanning on the response time to meet the patient's needs for pharmacotherapy. The study was aimed at assessing the course of the process of preparing and administering medicines to the patient, paying attention to the average working time and service time in the process. Particular attention was paid to evaluating the possibility of obtaining data on the type, location and level of pharmaceutical stocks in real time or close to real time.

Research method

The study was conducted in two Polish hospitals, in two hospital wards (one in each hospital). The first hospital, Hospital A, has approximately 1,500 beds and 30 wards. The second hospital, Hospital B, has 700 beds and 13 wards. In both hospitals, Healthcare Information Systems (HIS) are used. The study was carried out using process analysis and process mapping. The analysis and mapping of processes were carried out on the basis of the methodology of process research developed by the Institute of Logistics and Warehousing. The methodology used the BPMN 2.0 standard for process mapping. In order to model and simulate the analysed processes, the iGrafx software was used.

The study involved the process of administering drugs to the patient – from the issue of the prescription, through the preparation of medicines for the patient, administering them to the patient and recording their administration in the ICT system, or on a paper document. The following measures were assessed in detail:

- Average working time – time including the implementation of all process activities without waiting time.
- Average service time – time including the implementation of all process activities along with the waiting time.

Particular attention was paid to the evaluation of the possibility of obtaining data on the type, location and level of pharmaceutical stocks in real time or close to real time. Isolated processes were analysed, focusing on bottlenecks and constraints. In the first step of the analysis, the personnel participating in the processes were identified. Next, the actions and process events were assigned to those undertaking them and they were combined into sequences by the flow of work. The information flows which accompanied the flow of work were analysed and mapped. In this way, process maps were created.

In all simulations, the data used were obtained through interviews with hospital staff and the observations made, i.e. the data on:

- the number of employees supporting a given process, divided into business roles;
- the number of the so-called process transactions (e.g. administering medication to a patient) during one hospital shift.

Each of the studied processes was recorded using the following models:

- current status (AS IS);
- target status (TO BE).

Time parameters for the TO BE models were introduced on the basis of the author's expert knowledge and experience resulting from implementation of the project in hospitals. Modelling was aimed at identifying bottlenecks in the current processes and defining the course of processes in the target status. The target status was to implement:

- electronic prescriptions;
- techniques of automatic data collection, i.e. barcodes;
- mobile devices to undertake process activities in a remote manner.

The purpose of modelling was to assess the possible impact of implementing an electronic prescribing system and barcodes on the response time to meet the patient's needs for pharmacotherapy.

Results

It was assumed that the target processes (TO BE) in both hospitals should be automated – using the electronic prescribing system, barcodes and mobile devices, allowing the nursing staff automatically to:

- verify the compliance of administered medicines with the electronic prescription;
- positively identify the patient at the bed (bedside-scanning);
- check the expiry date, batch number, etc.;
- record administering the patient's medication and the batch number of an administered drug,
- update the ward's medicinal stock level.

1. Hospital A

The process analysis in the current approach (AS IS) enabled basic shortcomings to be identified:

- Despite the availability of documents in an electronic form, paper documents are additionally/ simultaneously used for the purpose of servicing the process, which generates duplication of activities.
- Drug control (compliance with the prescription, expiry dates, batch numbers, etc.) is carried out manually and by visual inspection, which creates the risk of nursing staff making an error.
- The administration of drugs to the patient is registered in the IT system with an average delay of 4 hours, which makes it impossible to obtain rapid and reliable information on the location, level and type of pharmaceutical stock. In addition, it does not guarantee that the information on the batch number of administered medicines registered in the IT system complies with the physical administration.
- The data in the system are updated manually, which involves the risk of introducing errors.

The results of the conducted simulations are shown in **Figures 1** and **2**.

2. Hospital B

The process analysis in the current approach enabled the basic shortcomings to be identified:

- The initial document in the process is the doctor's prescription on paper, the creation, analysis and im-

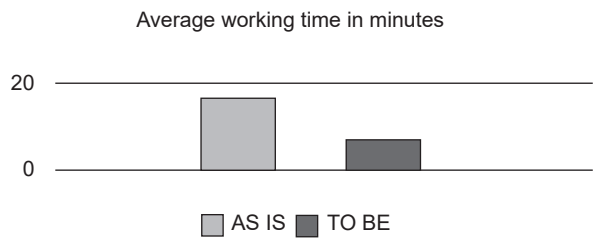

Figure 1. *The results of the simulation of the process of preparing and administering medicines to the patient in the ward in terms of average working time in Hospital A.*

Source: Own study.

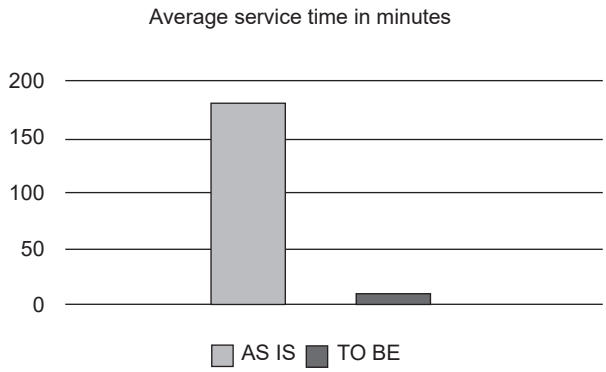

Figure 2. *The results of the simulation of the process of preparing and administering medicines to the patient in the ward in terms of the average service time in Hospital A.*

Source: Own study.

plementation of which is time-consuming and gives rise to a greater risk of an error being made.
- Drug control (compliance with the doctor's prescription, expiry date, batch number, etc.) is done manually and by visual inspection, which creates the risk of an error being made by the nursing staff.
- The administration of the specific medicines to the patient is entered on a paper record card, and the data are not put into the system. This completely prevents the rapid and automatic acquisition of data on the pharmacotherapy history. In addition, this approach significantly extends the time necessary to obtain the data on the material costs of the patient's treatment.
- Information on the batch of the medication given to the patient is not collected which, in the case of information about drugs withheld or withdrawn from the market, makes it impossible to identify the group of patients who were given the specific medicines during their period of hospitalisation.

The results of the conducted simulations are shown in **Figures 3** and **4**.

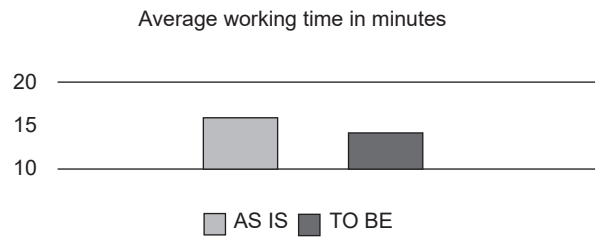

Figure 3. *The results of the simulation of the process of preparing and administering medicines to the patient in the ward in terms of average working time in Hospital B.*

Source: Own study.

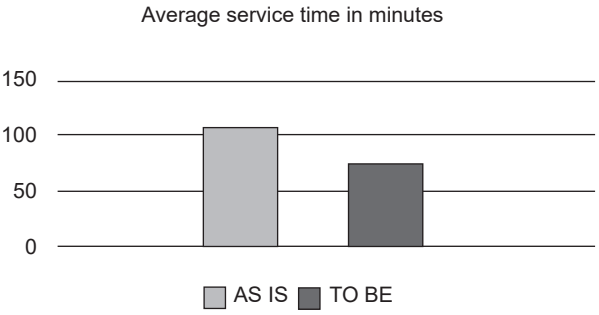

Figure 4. *The results of the simulation of the process of preparing and administering medicines to the patient in the ward in terms of service time in Hospital B.*

Source: Own study.

The studies in the two hospitals revealed that the implementation of electronic prescriptions and barcode scanning will reduce the time of responding to the patient's needs for pharmacotherapy. The predicted changes are presented in **Table I**.

Significant differences between the predicted changes in the average working time and average service time result from the lack of an analogous approach to the organisation of the process of the preparing and administering of medicines to the patient. In Hospital A, the delay in updating the data in the ICT system is relatively long (4 hours), which significantly affects the average service time of the process. The results of the simulation showed that working time will be reduced by more than half, when implementing the assumptions of the target model. In the case of the process service time, much greater reduction will be achieved because the delay in entering data into the hospital's ICT system will be eliminated.

The simulation results for Hospital B showed, however, that working time will not be significantly shortened, because of the different organisation of the process. Therefore, the time difference between the process service times with regard to AS IS and TO BE is not significant. The reason for this is that the average AS IS process service time does not include the time spent entering data about medicines given to the patient into the ICT system, because nursing staff do not undertake these activities. However, it seems reasonable to assume that if the data was entered manually into the system in the so-called free time, the difference would be similar to that in Hospital A.

In addition, the predicted changes are influenced by the volume of medicinal products given to patients in the studied wards and the manner of their distribution in the hospitals where the analyses were undertaken. In Hospital A, the nursing staff prepare and administer medication only to a single patient, and then they repeat the process to prepare and administer medication for the next patient. However, in Hospital B, the nursing staff prepare the medication for many patients, which enables the administration of medicines to these patients to be undertaken without the need to return to the duty room after each patient. This significantly reduces the working and process service times.

In addition, while summarising the simulation results, it should be recognised that the results of the changes will be visible not only in the context of the parameters examined. The introduction of electronic prescriptions and barcode scanning will also contribute to quality enhancements, such as:
- The increased transparency of the internal distribution chain of medicinal products and improvement in the level of patient service by facilitating access to data on the level, type and location of stocks for the purpose of:
  - implementing the withdrawal process of medicinal products;
  - limiting the number of overdue products;
  - limiting the number of product shortages.

	Hospital A			Hospital B		
Measure	**"AS IS"**	**"TO BE"**	**Change[1]**	**"AS IS"**	**"TO BE"**	**Change**
Average working time in minutes	17.25	7.35	**–57.39%**	15.97	14.11	**–11.65%**
Average service time in minutes	182.40	9.00	**–95.07%**	106.20	73.80	**–30.51%**

Table I. *The comparison of simulation results for the tested measures in Hospital A and Hospital B.*
Source: Own study.

- Improving patients' safety and the ease of nurses' work by introducing a mechanism to verify the accuracy of medication preparation in the context of an individual medical order card.

Changes in the qualitative approach require additional analyses, which will be carried out after the implementation of the proposed changes in the studied hospitals.

Discussion and conclusions

The research has shown that the implementation of electronic prescriptions and barcode scanning has a direct impact on the time of response to the patient's need for pharmacotherapy. In addition, the research has shown that to ensure an adequate level of patient service in the field of pharmacotherapy, the electronisation of the process of preparing and administering medicines to patients is an extremely important feature for improvements in the hospital service. Thus, it will be possible to achieve the so-called Five Rights of Medication Administration: the right patient, the right drug, the right dose, the right route and the right time [14].

The implementation of a system of electronic prescriptions supported by barcodes is in line with European developments. It also forms part of the trend of activities to establish solutions and mechanisms to improve the patient's safety and reduce the time required to respond to the patient's needs for pharmacotherapy. However, in order to fully meet the needs of patients, provide staff with the appropriate time to respond to their needs and to facilitate the decision-making process in real time, the information must be timely, credible and complete. Meanwhile, the research results presented in this paper and other studies carried out in Poland and elsewhere in Europe show that access to reliable data is not easy, because data collection on paper prevents, or at least significantly hinders effective and efficient aggregation, data processing and sharing [15].

The use of technical and technological advancements for identification, collection and data sharing in real time enables a dynamic approach to the management of the flow of medicinal products in the context of patients' safety and hospital efficiency to be taken [16, 17]. This approach also contributes to the unification of activities for recording process events in real time. However, as shown by the author's research and selected previous studies, the lack of comprehensive support from the ICT system necessitates manual data collection which involves the risk of errors, as well as the duplication of many activities, e.g. keeping records in both a paper and an electronic form [18].

In connection with the above, attention should be paid to the role of process analysis to properly shape the course of the process of preparing and administering medicines to the patient. A thorough analysis of this process results in positive outcomes from the point of view of a comprehensive approach to the process of patient service. It allows for a clear understanding of the limitations and difficulties in the current processes and indicates the directions for making changes and improvements. However, its absence leads to situations in which, despite the availability of technical and technological solutions, the implemented processes are ineffective and inefficient. Previous studies have shown that a poorly designed, incorrectly used, or inefficiently implemented IT system not only does not enhance patient safety, but contributes to an increase in the number of errors made through the phenomenon referred to as technology-induced errors [19].

Note

[1] In each case, the result was calculated as a percentage of the difference between the duration of the process in terms of "AS IS" and "TO BE" during the process of the "AS IS" approach. The reduction of time in the "TO BE" process is marked with a minus sign (–).

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