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INFLUENCE OF THE MEDICINAL PRODUCTS DISTRIBUTION MODEL AND IMPROVEMENTS TO PROCESSES ON THE WORKLOAD OF PHARMACEUTICAL AND NURSING STAFF AT HOSPITAL

Summary: The goal of the article is to present results of research aimed at evaluating the influence of distribution models of pharmaceuticals on hospital staff. The research was carried out in a Polish hospital, including ca. 1500 beds and 30 wards. Process analysis and mapping by means of the BPMN standard were used for the sake of the research. Logistics processes in the hospital pharmacy were analysed, including ward data. In order to obtain research data, hospital staff was observed and interviewed. The results of the research proved that the shift of the location where patient doses of pharmaceuticals are picked and use of an automated distribution device will not always contribute to the reduction of workload of staff in all processes.

Keywords: process analysis, distribution of medicines, workload of pharmaceutical staff.

JEL Classification: L3, L8.

Introduction

Managing the flow of medicinal products at a hospital is one of the most significant challenges of medical entities, due to the cost of medications and the issue of safety. The majority of Polish hospitals manage the flow of medicines with the use of a central pharmacy and the so-called ward pharmacies. A therapeutic standard applied in Europe is the unit-dose system (a system of individual doses for a patient) which consists in moving the point of picking medications for patients from wards to hospital's central pharmacy [Grześkowiak, 2011; Żuk, Stępniak, Bialik, 2017]. This medicine picking method is relatively often associ-

ated with an automated device, a medicine dispenser, which gives out single doses of medicine and, on the basis of doctor's order, assigns them to individual patients. The machine is placed in the hospital pharmacy, from where the medications in individual packages are transported to wards. Each dose is labelled with a bar code which nursing staff may use when dispensing the medicine to a patient.

Available reference books state that implementing a medicine dispenser at a hospital may bring a number of benefits, i.e. greater safety of a patient by eliminating mistakes resulting from wrong administration of drugs, lower level of medicine stock, among others due to eliminating the so-called ward pharmacies, fewer medicines that are out of date and reduction of workload of pharmaceutical and nursing staff [O'Brodovich, Rappaport, 1991; Karkowski, 2015, p. 153; Żuk, Stępniak, Bialik, 2017]. On the other hand, many researchers have shown a number of benefits resulting from the use of electronic doctor's orders combined with the scanning of bar codes located next to a patient's bed [Agrawal, 2009; Helmons, Wargel, Daniels, 2009; Bonkowski et al., 2013, Austin, Smith, Tariq, 2018]. However, there isn't any comparative research the results of which would allow stating if the benefits possible to achieve, due to the implementation of a medicine dispenser, would be unachievable with the use of other improvements in the process of managing the flow of medicines.

The aim of the paper is to present the results of studies concerning the influence of a medicine distribution model at a hospital and of technical, technological and organisational improvements on the workload of pharmaceutical and nursing staff. Primary goal of the study was to compare a model of distributing medicinal products in which doses for a patient are prepared by nurses in the ward with a model in which doses are customised at a hospital pharmacy with the use of a medicine dispensing machine. The study was to verify the second model in the context of greater efficiency and effectiveness of medicine distribution process, as well as reduction of hospital's costs as a result of reducing the workload of pharmaceutical and nursing staff from the moment of delivery acceptance, verifying the demand for ready-made medicines, picking medicinal products to specific wards, transferring the medicines to wards and their administration to patients. Another purpose of the study was to assess the possibility to achieve better efficiency and effectiveness of the process of managing the flow of medicinal products resulting through the implementation of technical, technological, and organisational improvements with the use of hospital's current ICT system.

1. Literature review (theoretical background)

Managing the flow of medicinal products at a hospital is one of the most significant challenges of medical entities. Pharmacotherapy is one of the most commonly applied therapies at hospitals, while medicines are the second, after salaries, most cost-intensive element of hospital operation [Religioni, 2016]. Considering the aspect related to the obligation to ensure proper patient service system, patient safety in particular, especially in the context of pharmacotherapy, managing the flow of medicinal products at a hospital is an exceptionally important area of hospital operation.

It comes as no surprise, therefore, that people managing medical institutions are willing to introduce improvements in the discussed area. The majority of Polish hospitals manage the flow of medicines with the use of a central pharmacy and the so-called ward pharmacies. Polish literature describing issues related to medicine management frequently criticises such a model, providing evidence that it favours errors, i.a. wrong administration medicines, collecting excessive or out-of-date stock and greater labour intensity for pharmaceutical and nursing staff.

Polish sources include statements that in many European hospitals such a model of medicine distribution gives way to a model in which doses for a patient are prepared at a hospital pharmacy, also with the use of a medicine dispenser. Owing to the use of bar codes and electronic orders, that solution may undoubtedly contribute to a number of benefits such as greater safety of a patient through eliminating mistakes resulting from wrong drug administration, reducing medicine stock, among others by eliminating ward pharmacies, limiting the amount of out-of-date products and reducing the workload of pharmaceutical and nursing staff [O'Brodovich, Rappaport, 1991; Karkowski, 2015, p. 153; Żuk, Stępniak, Bialik, 2017].

On the other hand, many foreign researchers have proven a number of benefits resulting from the use of electronic doctor's orders combined with the scanning of bar codes next to patients' beds [Agrawal, 2009; Helmons, Wargel, Daniels, 2009; Bonkowski et al., 2013; Foo et al., 2017; Wulff Risoer, Lisby, Soerensen, 2017; Austin, Smith, Tariq, 2018], with an assumption that medicines are picked by nurses in the ward. Research carried out over 20 years ago showed that when data is entered manually through a keyboard, there is 1 mistake per 100 characters, and when bar codes are scanned, there is 1 mistake per 10 million characters [Puckett, 1995].

In the author's opinion, critical assessment of the medicine distribution model applied at Polish hospitals does not result directly from choosing the place of customising single doses for a patient, but it may be an effect of insufficient maturity of hospitals' ICT infrastructure in the scope of supporting the medicine flow process. A research carried out in Polish hospitals in 2014 by the Health Care IT Systems Centre showed that only 44% of hospitals applied medical IT solutions of integrated nature as part of one central IT system. As for the remaining part of hospitals, integration concerned selected organisational units (16%), while 115 of hospitals did not have any IT solutions. Thus, the vast majority (75%) of medical entities does not apply international standards of electronic medical documentation. Introducing a medicine dispensing machine assisting in medicine flow management might therefore contribute to distorted values of the benefits. According to the author of the present article, a similar benefit may be achieved by introducing electronic orders and scanning bar codes next to patients' beds which can be done by modifying hospital's existing ICT system, providing pharmaceutical and nursing staff with mobile devices, without the need to buy a medicine dispenser.

The cost or purchasing such a device is also of great importance. It is between PLN 5 million and PLN 20 million. The research has shown, on the other hand, that the purchase of the device is most profitable for hospitals with 600-700 beds or more [Nicolaou-Ghekas, 2013]. The data proves that nearly 130 out of 300 biggest medical entities in Poland, which had the highest revenues in 2014, have more than 600 beds [Jakubiak, 2014, p. 1]. It means that for approx. 85% of Polish hospitals this solution is uneconomic.

The purpose of the research was to fill the gap and provide results of comparative studies which would allow stating whether achieving benefits possible to obtain by implementing a medicine dispensing machine would be possible by introducing different types of improvements in the medicine flow management process.

2. Research methodology

The research was carried out at a Polish medical institution with approx. 1500 beds and 30 wards, and it involved applying process analysis. Process analysis and mapping was performed on the basis of process research methodology with the use of the BPMN 2.0 standard. iGrafx software was applied to conduct the modelling and the simulation of analysed processes. The test covered six subprocesses concerning the process of managing the flow of medicinal products. Employees' workload was analysed in detail.

Apart from identifying the possibility to introduce organisational changes at the level of hospital pharmacy, the goal of the analysis was to assess whether it would be reasonable to implement an automated medicine distribution system which would pick medicine doses at a hospital pharmacy on the basis of an electronic doctor's order from the ward. To this end, from all administrations of medicinal products to patients, a specific number of them, in packages that can be picked with the use of a medicine dispensing machine, were selected and analysed. The percentage share of such administrations in all medicine administrations is approx. 65%.

The starting point for the analysis was the process of handling the demand of wards for ready-made medicines and the identification of bottlenecks in subprocesses related to the distribution of medicinal products carried out in the so-called grey part of the hospital. The approach "from general overview to specific details" allowed having a bird's-eye view of the entire area related to handling demand of a ward in order to identify the potential for optimisation in terms of managing the flow of medicinal products at a pharmacy and in the context of possible implementation of a medicine dispenser. From all identified subprocesses, five of them, with the largest optimisation potential and which, as a result of implementing a medicine dispenser, might influence process efficiency, were subject to simulation. They were:

- acceptance of deliveries of ready-made medicines,
- verification of demand for ready-made medicines,
- picking ready-made medicines at a hospital pharmacy,
- release of ready-made medicines to wards,
- picking and release of ready-made medicines to a patient in a ward.

The analysis covered isolated processes and focused on bottlenecks and restrictions. The first stage of analysis defined business roles participating in the processes. Then, process activities and events were assigned to suitable roles and connected into sequences as part of a workflow. Information flows, which accompanied the workflow, were also analysed and represented on maps. As a result, process maps were created. All simulations used data obtained in interviews with hospital staff. The data concerned:

- the number of employees handling a specific process, divided to business roles,
- the number or process-related transactions (e.g. deliveries, releases, and administrations of medicines to a patient) during one hospital shift.

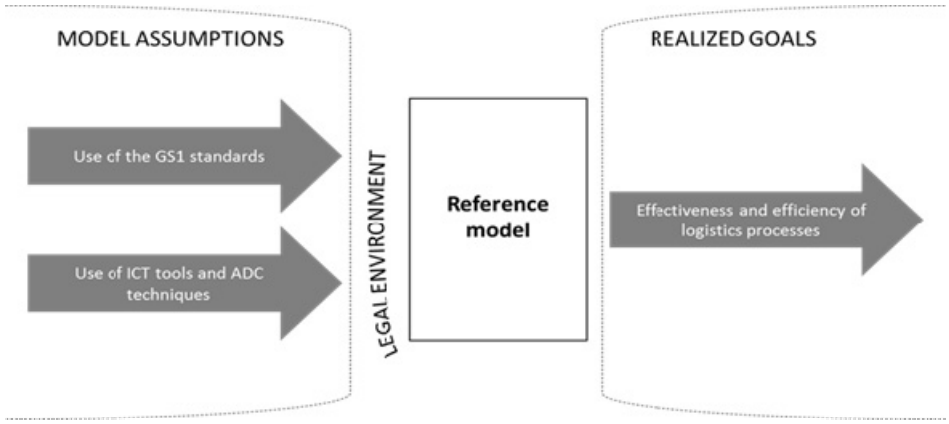
For the purpose of conducting process simulations, simulation models were built for mapped processes and parameters for all process activities and events were entered. In particular, the duration of specific tasks was defined. It was done mainly with the use of a function of normal and uniform distribution in a time interval specified during an interview. Other parameters entered included the parameters that steer the flow at decision gates – probability for a specific decision, which determines further process flow, to be taken.

Each of the processes tested was represented in the following models:

- current state (AS IS),
- current state providing for the implementation of a medicine dispenser (UD)[1] without the implementation of other improvements (AS + UD),
- target state, providing for improvements of technical, technological, and organisational nature (TO BE),
- target state, providing for improvements of technical, technological, and organisational nature and the implementation of a medicine dispenser (TO BE + + UD).

The purpose of modelling was to identify bottlenecks and suggest improvements which may contribute to better efficiency and effectiveness of the process of managing the flow of medicinal products at the studied hospital based on the assumptions presented in Figure 1.

Figure 1. Assumptions regarding improvements of logistic processes at a hospital



[1] Abbreviation for "unit-dose".

The assumptions are as follows:

- compliance with legal requirements (providing for planned legal amendments) in terms of identification of medicinal products in the European Union;
- proper information-related, technical, and technological conditions allowing the generation and processing of documents in an electronic form, as well as registration of events within the process in real time;
- application of GS1 standards to identify and exchange data on medicinal products:
  - identification of medicinal products in consumer packages[2]: EAN-13 code, with the use of GTIN (Global Trade Item Number);
  - identification of medicinal products in consumer packages: GS1 DataMatrix code with the use of GTIN, serial/batch number, expiry date, individual serial number[3];
  - identification of medicinal products in collective packages[4]: GS1-128 code, collective package number – SSCC (Serial Shipping Container Code) number of the product included in the collective package (GTIN), the number of units included in the collective package, serial/batch number, expiry date;
  - identification of returnable containers/packages: GS1 DataMatrix code, GRAI number Global Returnable Asset Identifier;
  - location identification: GS1-128 code, GLN (Global Location Number);
- application of standard transaction documents compliant with GS1.

3. Research findings and discussion

The research has brought the following results.

3.1. Acceptance of deliveries of ready-made medicines

Identified restrictions within the studies process under the "AS IS" approach include, above all, a large number of manual activities and the need to perform multiple visual verifications of deliveries on the basis of paper documents. The type, batch and expiry date of accepted goods are verified visually.

[2] Marking applied by the manufacturer.
[3] Marking applied by the manufacturer with reference to medicinal products subject to the requirement of serialisation as related to anti-fraud Directive 2011/62/EU, see Appendix 2.
[4] Marking applied by the supplier to the hospital.

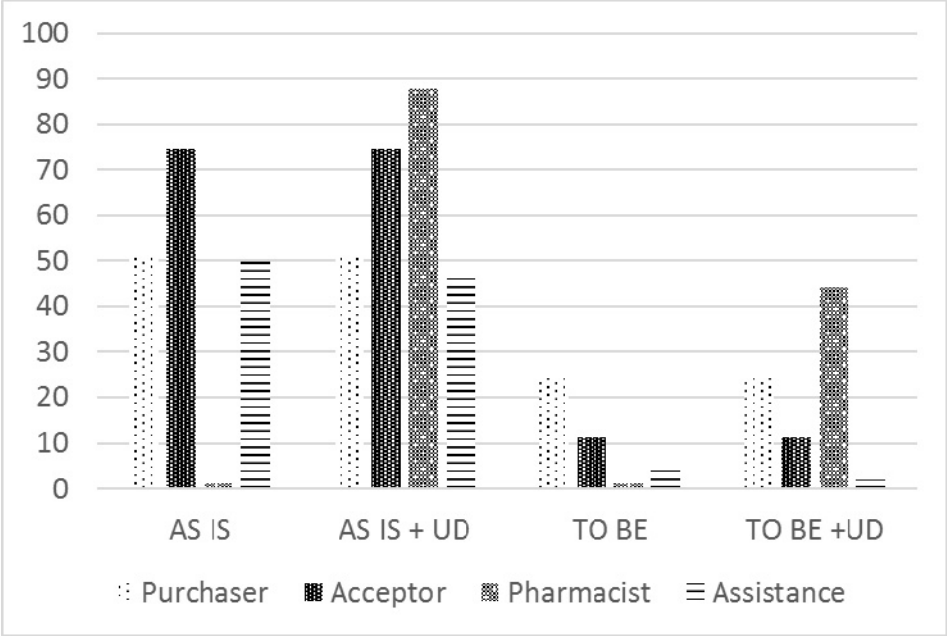
The obligation to enter data concerning deliveries to the ICT system manually also contributes to increased labour intensity.

Recommended organisational changes provide for supporting the ICT system in terms of delivery acceptance identification, verification of their compliance with the order, and automatic confirmation of their acceptance to the pharmacy in the ICT system.

Simulations results have shown that the implementation of a medicine dispenser without the introduction of suggested changes would increase the workload of pharmaceutical staff who feed the machine with medicinal products. Much greater benefits can be achieved by introducing organisational changes and solutions in the area of automatic identification and bar code scanning on the basis of existing IT infrastructure of a hospital pharmacy.

Figure 2 presents the results of comparing simulations of processes of accepting ready-made medicines focusing on the workload of staff (in %) in the form of a graph.

Figure 2. Results of comparing simulations of processes of accepting ready-made medicines focusing on the workload of staff (in %)

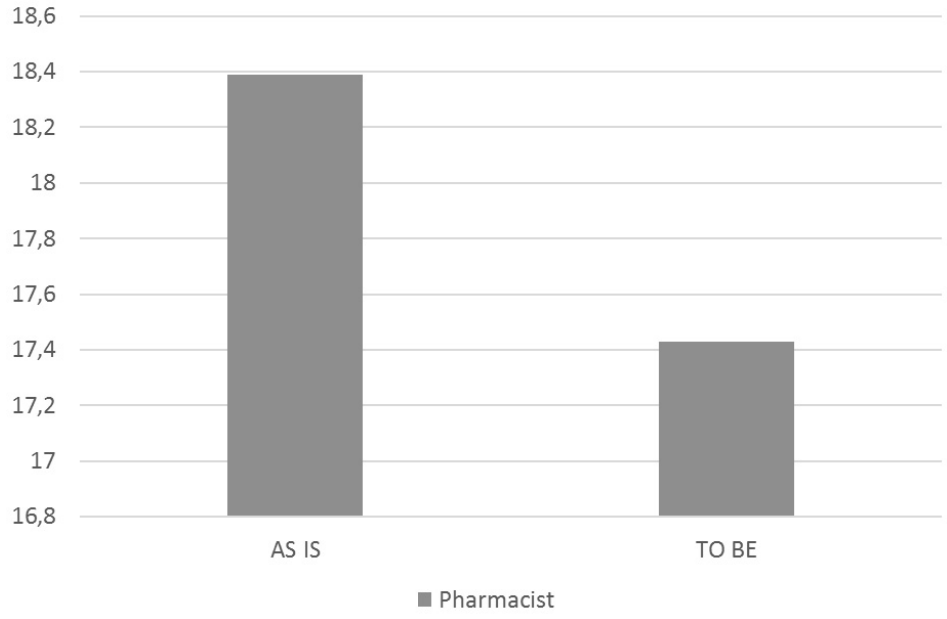


3.2. Verification of demand for ready-made medicines

One of the bottlenecks as part of the studied processes is the compulsory analysis of ward demand by pharmaceutical staff. Lack of knowledge in the ward on the availability of medicinal products in the pharmacy results in the pharmacy's obligation to verify and modify ward demand. Furthermore, lack of possibility to group demands of wards causes the pharmacy's activities to overlap. Next, absence of system support and IT infrastructure (as well as mobile devices) results in an obligation to print individual ward demands.

The recommended solution would therefore be to enable the nursing staff in the ward to inspect warehouse stocks of medicinal products available in the pharmacy, and grant them access to information on available medicine substitutes. The IT system should allow the ward to automatically generate orders on the basis of actual data from the pharmacy, and to pass it further for the pharmacy's approval, with the possibility to make modifications, according to specified criteria. In this process, introducing a medicine dispenser would not significantly affect the verification of demand for ready-made medicines. Results of the simulation have been presented in Figure 3.

Figure 3. Results of comparing simulations of processes of verifying demand for ready-made medicines, focusing on the workload of staff (in %)



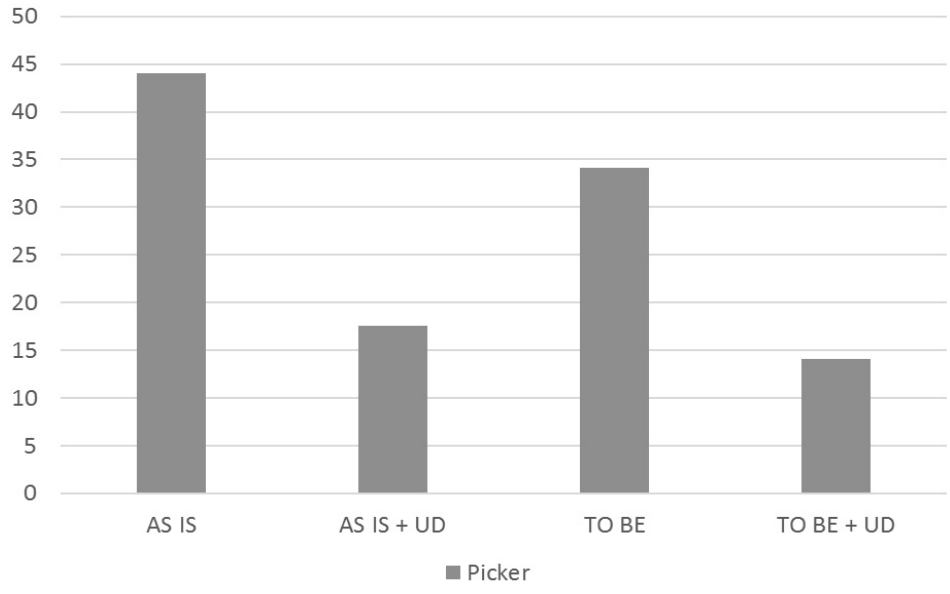
Source: ILiM's own study, 2018.

3.3. The picking of ready-made medicinal products at a hospital pharmacy

The greatest flaw of the process in its current state is the use of paper documents and visual inspection of collected medicines. In results in increased labour intensity and may cause mistakes resulting from unintended human errors. In the recommended target approach, the process should be supported by the IT system and mobile devices in a way which would allow medicine picking on the basis of declared demand, available in an electronic form, by scanning bar codes on packages, with the use of mobile terminals. Additional scanning of bar codes, which should be placed in storage areas, will make it possible to automatically register the place which specific medicinal products have been collected from. The implementation of the solution would avoid the obligation to search the pharmacy manually for a particular medicinal product.

Simulations results have shown that in the case of this process, the greatest benefits would be achieved by implementing both elements: changes with the use of the available IT system, and a medicine dispenser. Results of the simulation have been presented in Figure 4.

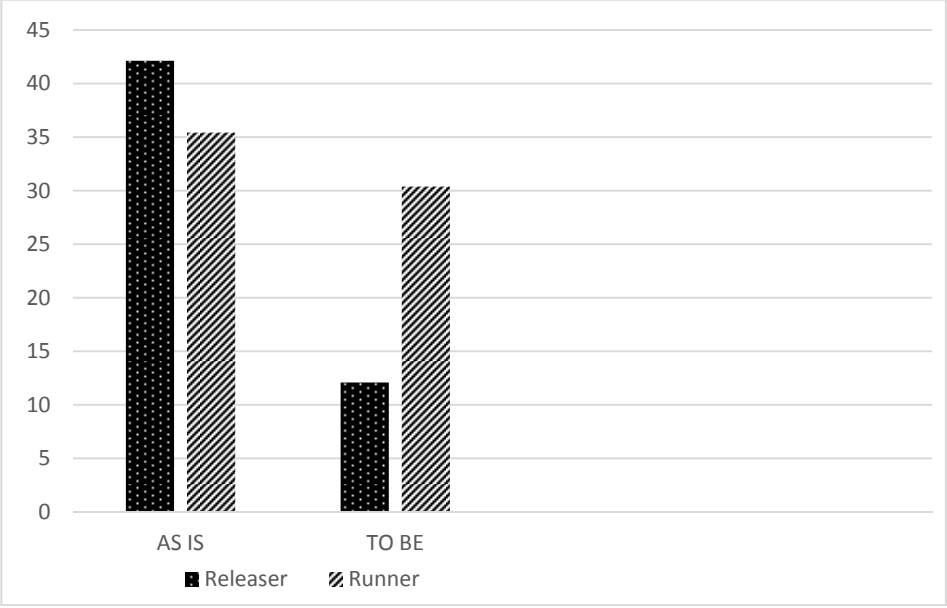
Figure 4. Results of comparing simulations of processes of picking ready-made medicines from a hospital pharmacy, focusing on the workload of staff (in %)



3.4. Release of ready-made medicines to wards

The greatest shortcomings of the present process are the visual inspection of releases, using paper documents and the lack of automatic registration of releases of transport packages to runners. According to the recommendation, the ICT system should allow handling the process and register the release to the runner on the basis of electronic documents and bar code scanning only. The correct content of transport packages should be verified in the ward, upon the delivery of demand by a runner. In this process, introducing a medicine dispensing machine would not affect the process or labour intensity. Results of the simulations have been presented in Figure 5.

Figure 5. Results of comparing simulations of processes of releasing ready-made medicines to wards focusing on the workload of staff (in %)



3.5. Picking and release of ready-made medicines to a patient in a ward

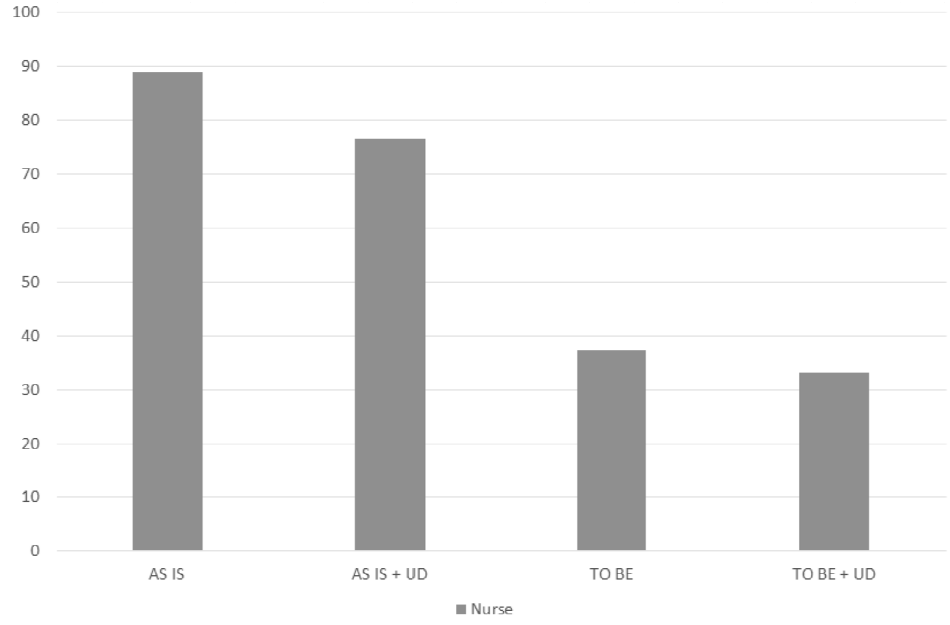
Process analysis in the current approach indicates its basic shortcomings resulting from the absence of support from the IT system. Activities conducted within the IT system (e.g. order analysis) are initiated as a result of manual activities performed by an employee, and not as a result of automatic reading of

the data from bar codes. It extends the duration of the process and makes it more labour-intensive. Moreover, despite the availability of documents in an electronic form, paper documents are additionally used during process execution.

According to the recommendation, the process should be more automated and it should allow the nursing staff to automatically verify compliance of administered medicines with the doctor's order in an electronic form. The process should involve the scanning of bar codes of medicines, patients, and nurses in order to enable automatic registration of events and future reconstruction of their course.

In this process, it would be most beneficial to introduce suggested changes on the basis of existing software together with the implementation of a medicine dispenser. However, attention should be drawn to the fact that these benefits are on a slightly higher level than the ones resulting from the implementation of organisational changes only, with the use of the present IT system. Results of the simulation have been presented in Figure 6.

Figure 6. Results of comparing the simulation of the process of picking and release of ready-made medicines to a ward patient referring to the workload of employees (in %)



Conclusions

Results of the research have shown that moving the place of picking medicine doses for a patient and using a medicine dispenser will not contribute to the reduction of workload of pharmaceutical and nursing staff in all analysed processes to the same degree.

Results of the simulation have shown that implementing a medicine dispensing machine without introducing suggested organisational, technical, and technological changes in the delivery acceptance process will cause increased labour-intensity with reference to pharmacists feeding the machine with medicinal products and the obligation to employ more people (2 per shift on average). Much greater benefits in the delivery acceptance process can be achieved by introducing organisational changes and solutions in the area of automatic identification and bar code scanning by means of proper modification of existing IT infrastructure of a hospital pharmacy.

Simulation results have proven that in terms of the process of picking medicines to specific wards, the biggest benefits may be achieved by implementing changes in using the available IT system and the medicine dispenser at the same time.

In the area of medicine picking, the greatest benefits would be achieved by introducing suggested changes on the basis of existing software together with the implementation of the medicine dispenser. However, attention should be drawn to the fact that these benefits are on merely a slightly higher level than the ones resulting from the implementation of organisational changes with the use of the present IT system.

It should be borne in mind that not all medicines available as part of hospital formulary can be distributed by means of a medicine dispensing machine. What is more, from the medical point of view it is not possible to entirely eliminate stocks of medicines in wards, where life-saving medications must always be available. On the basis of information obtained from interviews with nurses, it seems that this form of medicine distribution paradoxically makes the work of this group of staff less comfortable.

Process modelling and simulations performed have shown that the introduction of organisational, technical, and technological changes on the basis of hospital's available software, after proper modifications and purchase of mobile devices, will bring the following improvements:

- reduced labour intensity at individual stages of the process by:
  - shortening the duration of processes,
  - eliminating overlapping activities,
  - replacing the number of paper documents with documents in an electronic form (e.g. the paper equivalents of selected electronic documents, such as orders from wards);
- greater transparency of internal medicinal products distribution chain and improved patient service by ensuring access to data concerning the level, type and location of stock in warehouses and clinics in order to be able to:
  - withdraw medicinal products faster,
  - reduce the number of out-of-date products,
  - eliminate product shortages;
- introduce a mechanism verifying the correctness of medicine picking in the context of the demand of wards and the comfort of pharmaceutical staff's work.

The implementation of changes entails specific costs. They are mostly the costs of modifications in the HIS system, which depend on terms of cooperation with the provider of the IT system supporting the management of the flow of medicinal products. The IT system should be characterised by specific functions which allow implementing the assumptions of the developed referential model, particularly the application of GS1 standards and ADC (Automatic Data Capture) technologies at the hospital. It seems, however, that the cost of changes will be lower than the cost of purchasing and installing a medicine dispensing machine. Furthermore, improvements will cover the entire process of managing the flow of medicinal products at a hospital.

Making use of technical and technological achievements as well as available GS1 global standards in the area of data identification, collection and sharing in real time also makes it possible to assume a dynamic approach in managing the flow of medicinal products in the context of patient safety and the operation of a hospital. This approach also contributes to unification in terms of registering process events in real time, according to European and global trends in creating interoperational solutions based on global standards in different areas.

The research carried out is a basis for further detailed works related to the verification of effects of simulations conducted as part of the research process. Above all, verification should cover modelling efficiency assessment criteria. The introduction of specific assumptions of the target solution has shown the need to develop efficiency criteria of individual medicinal products distribution models in the context of operational and strategic decisions made by hospitals.

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WPŁYW MODELU DYSTRYBUCJI PRODUKTÓW LECZNICZYCH ORAZ USPRAWNIEŃ PROCESOWYCH NA OBCIĄŻENIE PERSONELU FARMACEUTYCZNEGO I PIELĘGNIARSKIEGO W SZPITALU

Streszczenie: Celem artykułu jest prezentacja wyników badań nad wpływem modelu dystrybucji produktów leczniczych w szpitalu na obciążenie personelu szpitalnego. Badanie zostało przeprowadzone w polskim podmiocie leczniczym, liczącym ok. 1500 łóżek i 30 oddziałów. W badaniach wykorzystano analizę procesową i mapowanie procesów przy użyciu standardu BPMN. Analizie poddano wybrane procesy logistyczne na poziomie apteki centralnej szpitala, z uwzględnieniem danych z oddziałów. Dane do badań uzyskano w wyniku wywiadu i obserwacji personelu szpitalnego. Wyniki badań wykazały, że przesunięcie miejsca kompletacji dawek leków dla pacjenta i zastosowanie automatu lekowego nie przyczyni się do zmniejszenia obciążenia personelu farmaceutycznego i pielęgniarskiego we wszystkich zbadanych procesach.

Słowa kluczowe: analiza procesowa, dystrybucja leków, obciążenie personelu farmaceutycznego.