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IMPROVING THE EFFICIENCY OF DRUG SUPPLY MANAGEMENT OF A MEDICAL ORGANIZATION THROUGH THE USE OF A BUSINESS INTELLIGENCE SYSTEM

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Abstract. This paper considers the process of drug management in a medical organization providing medical care under the MHI, on a fee-for-service basis, as well as high-tech medical care. The provision of medicines is one of the most complex multilevel tasks that medical organizations have to deal with. In the course of the study the potential importance of improving the manageability of medicines based on data for the medical institution and the healthcare industry as a whole was determined, the existing shortcomings of the medicines management process were identified and the BI-application model that solves the various problems that arise during the management of medicines was created. Practical significance of the work is due to the results of the performance evaluation: the use of the model will allow to visualize complex medical data, contributing to improving the quality of services, transparency of quantitative and financial costs of medicines and obtaining important statistical data for healthcare.

Keywords: medication management, Smart Hospital, BI applications, Data Driven, business modeling

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ПОВЫШЕНИЕ ЭФФЕКТИВНОСТИ УПРАВЛНЕНИЯ ЛЕКАРСТВЕННЫМ ОБЕСПЕЧЕНИЕМ МЕДИЦИНСКОЙ ОРГАНИЗАЦИИ В ХОДЕ ПРИМЕНЕНИЯ СИСТЕМЫ БИЗНЕС-АНАЛИТИКИ

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Аннотация. В данной статье рассматривается процесс управления лекарственным обеспечением в медицинской организации, оказывающей медицинскую помощь в рамках ДМС на платной основе, а также высокотехнологичную медицинскую помощь. Лекарственное обеспечение является одной из наиболее сложных многоуровневых задач, стоящих перед медицинскими организациями. В ходе исследования была определена потенциальная значимость повышения управляемости лекарственным обеспечением на основе данных для медицинского учреждения и отрасли здравоохранения в целом, выявлены существующие недостатки процесса управления лекарственным обеспечением и создана модель BI-приложения, решающая различные проблемы, возникающие при управлении лекарственным обеспечением. Практическая значимость работы обусловлена результатами оценки эффективности: использование модели позволит визуализировать сложные медицинские данные, способствуя повышению качества обслуживания, прозрачности количественных и финансовых затрат на лекарственные средства и получению важных для здравоохранения статистических данных.

Ключевые слова: управление лекарственными средствами, Smart Hospital, BI-приложения, Data Driven, бизнес-моделирование

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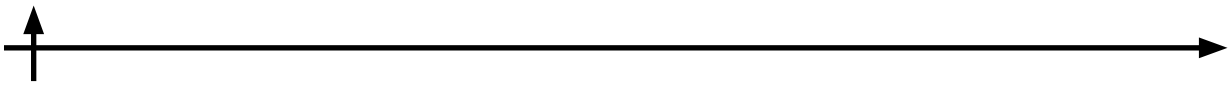
Introduction

The proliferation of increasingly sophisticated technologies makes human life more comfortable in many different areas. Smart solutions are spreading everywhere: neural networks, Internet of Things, tracking of various indicators, for example, driving style. Similar "smart" technologies are also present in medicine, directly influencing not only convenience but also people's lives through the use of modern digital equipment and an innovative approach to treatment.

The innovative approach to treatment should also include the process of medication management. The provision of medicines is one of the most complex multi-level challenges that healthcare organisations have to face. The solution of this task is presented by various methods, but it is extremely difficult to develop a single organisation of this process due to the different focus, level of development, workload and organisation of work of medical organisations in general and clinics in particular (Melnikova, 2019).

The object of the study is the process of managing the drug supply of a medical organisation, the subject is to improve the efficiency of this process in the application of business intelligence



system (Ilyashenko, 2020).

The aim of the work is to create a model of BI-application capable of giving doctors and analysts access to important non-obvious information obtained during the application of medicinal treatment of patients (Anufrieva, 2022). The objectives of the work are to:

1. to determine the potential value of improving data-driven medication management for both the healthcare provider and the healthcare industry as a whole;

2. to dentify the existing deficiencies in the medication management process;

3. to create a valid BI application model demonstrating the potential effectiveness of the solution.

Materials and Methods

Therefore, it is essential not only to manage medicines, but also to use modern smart solutions in this process to achieve qualitatively new results in various fields, in particular, in medicine. Medical organisations that use the Smart Hospital concept in their development and aspire to become an institution that can rightfully be called a Smart Hospital, naturally seek to use innovations in their processes to improve their efficiency. These efforts often result in cost savings, staff relief, fewer errors, and critical data that can be used to create predictive analytics that monitor and forecast processes (Bouvy, 2021), thereby improving the accuracy of results for all processes being evaluated, gaining new insights through in-depth analyses of seemingly unrelated facts and events, and increasing process transparency, which reduces misconduct by increasing the number of errors and errors in processes. All of the above can not only provide localised improvements, but, in the case of the medical sphere, it has a positive effect on the quality of treatment as a whole, which, in turn, is one of the main objectives of healthcare.

The described effects are largely based on data and the correct construction of work with them. Special attention should be paid to BI-systems - tools that use advanced methods to collect, analyse and present data, including in large volumes, to extract meaningful information for the purpose of making management decisions. In healthcare, BI systems can help hospitals and clinics make data-driven decisions that improve patient outcomes, reduce costs and increase operational efficiency. One of the key benefits of BI systems is their ability to combine data from multiple sources, including electronic medical records, pharmacy and accounting systems, into a single centralised repository, process it quickly and efficiently, and present this information in an easy-to-understand way that simplifies decision-making (Popova, 2020).

In the context of medication management, BI systems can help healthcare organisations optimise medication use and reduce medication errors. By analysing prescribing patterns and patient data, BI systems can identify potential drug interactions, dosage discrepancies and other issues that could compromise patient safety. They can also provide real-time data on medication use, allowing healthcare providers to quickly adjust dosages, change medications or take other actions as needed. In addition, BI systems can help healthcare organisations track drug stock levels and usage patterns, ensuring that medicines are available when needed and that waste is minimised.

Another benefit of BI systems is that they can help identify trends and forecast the need for medicines, allowing for optimised procurement and distribution (Litvinenko, 2021). It can also be useful for epidemic control, for example, when disease outbreaks occur, BI systems can help identify them quickly and take action to prevent and treat them. As the healthcare industry continues to become more data-driven (Rukina, 2022), BI systems can significantly improve the efficiency of medication management and improve the quality of patient care in healthcare facilities.

The organisation whose processes were used to analyse and create the BI application is the

Almazov National Medical Centre, which is a large scientific and medical institution in the Russian Federation and St. Petersburg that provides medical care under the MHI, on a fee-for-service basis, as well as high-tech medical care (Bansal, 2013; Ilin et al., 2019).

The uniqueness of the Centre lies in the harmonious combination of fundamental and applied research in various fields with the provision of multidisciplinary specialised, including high-tech medical care to the population and continuous interdisciplinary training of scientific and medical personnel.

The medical research centre has built a comprehensive system for planning the procurement of medicines and medical consumables and for monitoring their use at all levels of circulation. Attempts are being made to organise records of medicines and medical consumables by source of funding for procurement, as well as product records (by series and by batch) to monitor expiry dates and purchase prices. The Centre's management hopes to obtain full information in real time on the availability and consumption of medicines at any level, both in the warehouses and in the wards. For high-cost medicines and medical consumables, write-off information, within an idealised situation, should be detailed to the individual patient.

Let us consider the process of medicines management in the current state. Since the medical organisation is focused on the provision of high-tech care, it is expected to pay much attention to the optimization of processes taking into account modern approaches (Domracheva, 2017). The process of medicines management, which is supported by the Medical Information System (MIS) and the system of planning and accounting of medicines based on the industry solution "1C: Medicine. Hospital Pharmacy".

However, at this stage there is no IT support for medication management at the patient level, there is no tight mutual integration between the existing systems, and there are various problems of application utilisation by the staff (SHmonin, 2017). In particular, due to high workloads, staff do not have time to complete patient prescribing information, as this step of the application is not optimised for the needs of facility staff. For example, some data is extremely difficult to edit, so it is easier for staff to enter information into the system after a certain stage of treatment has been completed. Also, due to the complexities of working with the system itself, some data are recorded in paper spreadsheets, which is a consequence and supports the thesis about the complexity of interaction between systems and staff.

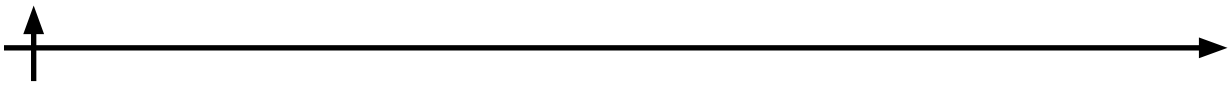
Thus, medication management is not fully supported, resulting in the following consequences:

1. the lack of a unified medication record at the level of the whole clinic and not always correct distribution of medication between departments and, eventually, patients;

2. complication of both current and predictive analytics in terms of finance (including determination of the level of costs per patient) and direct consumption;

3. the inability to collect meaningful medical statistics that can not only support the process, but also take into account the interrelationship of symptoms and predict the course of diseases, which in the long term could help to optimise treatment as well as improve the whole process of care.

As follows from the above, an important aspect of working with data is the process of data processing and analysis. BI-systems contribute significantly to solving this issue. Business Intelligence (business analytics, business "intelligence") has many interpretations that differ from each other to a greater or lesser extent (Ilin, 2021). This was due to the multifaceted nature of the word "Intelligence", containing such facets as the ability to be ready to understand, knowledge imparted or acquired in various ways, the process of knowing in terms of action or state and working with data in the field of their "exploration", study, research.A BI system technology that can have a significant effect on the process under consideration is the introduction of



dashboards, which serve as a visualisation system for operational management and comprehensive coverage of drug management. Visualisation is the representation of data using graphics such as charts, tables, graphs, graphs, infographics, animations, conveying complex data relationships in a way that is easier to understand. Dashboard is an interactive dashboard that visually presents, visualises, explains and analyses data.

Based on the existing difference in the medication management process between the current state and the optimised model, a way to modernise the process by implementing a BI class solution is being considered. Through such a step, tasks such as:

1. creating a single medication record at the clinic-wide level;

2. current and predictive analytics, taking into account the aspects of financing and consumption;

3. collection of full-fledged medical statistics serving as a basis for analysing costs and prospects of various methods of treatment of patients.

Thus, the following effects can be achieved:

– Ensuring control over the movement of medicines at all levels;

– Improving the efficiency of planning and implementation of drug procurement;

– Reducing the cost of procurement of medicines by increasing the accuracy of the formation of needs;

– Improved quality of customer service through accurate distribution of medicines between departments and patients;

– Reducing errors in the administration and recording of medication administration;

– Improvement of company image;

– Improved quality of service.

Expected damages (problems) should also be emphasised:

– Unpreparedness of personnel to change;

– Change in the technology of working with information;

– Temporary increase in the workload of the company's employees at some stages of the implementation project;

– System maintenance.

Consequently, the BI-system can be used to display the costs of medicines in quantitative and cost terms up to the costs per patient, the consumption of specific medicines at different levels of consumption in different time periods, as well as to display the methods by which symptoms were treated with which medicines. Accordingly, the analytical dashboards created in the BI system will be able to answer the following questions based on the selected data:

1. "how much in quantitative and financial terms were medications spent on a particular patient?";

2. "which medications are used in relation to symptoms and diagnoses?";

3. "in what dosages is the medication used?" and many others.

Based on the available test dataset, further analyses will be built on information about 64 patients belonging to 24 wards, 6 posts and 2 departments of the clinic. Consideration of drug provision would then cover all levels of the clinic: patient, wards, posts, departments and the clinic as a whole. However, it should be borne in mind that the data in the test model is incomplete, and therefore not all the benefits of using BI systems can be demonstrated. Thus, on the basis of the generated data, the QlickView programme was used to create a dashboard model, with the help of which the possible analytical dashboards that facilitate decision-making in the management of medicines are visually displayed.

Let's take a closer look at the task of determining the financial costs of medicines per patient. Based on the question posed, it can be seen that objects reflecting financial costs, medicines and

patients are needed. To realise this task, first of all, we created a Simple table, which contains ID-patients, their surnames, first names and patronymics to increase the clarity of orientation during use. The ability to apply sorting to this table makes it easier to find the desired patient. In addition, the "Search" field directly allows you to find a specific patient by patient ID, last name, first name or middle name.

The next step is to create a pie chart, where the patient ID and Medication Name are used as dimensions. The order in which the measurements are specified is important because it affects the way the data is displayed. The parameter "Cost of treatment in conventional units" is selected as an expression. The described analytical panel is shown in Figure 1.

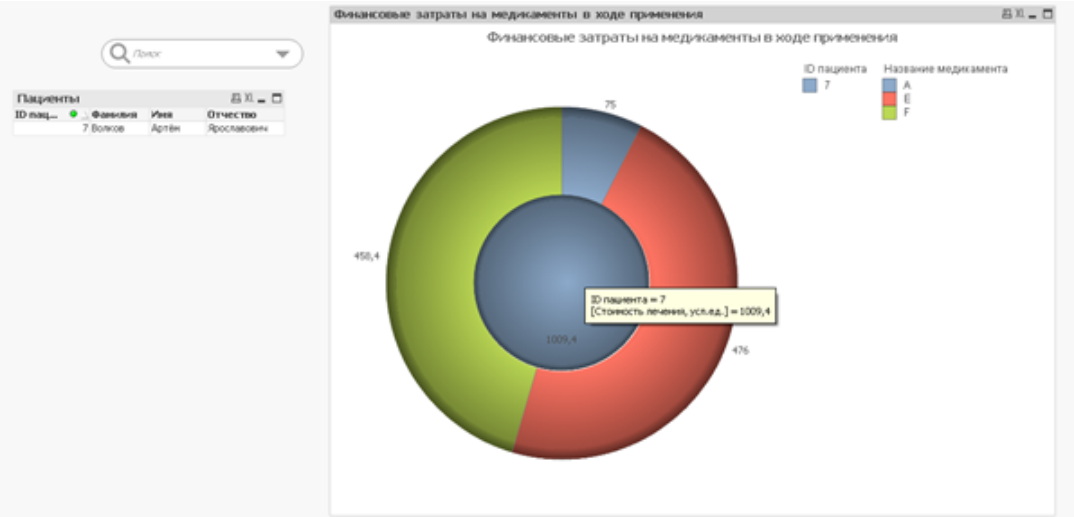


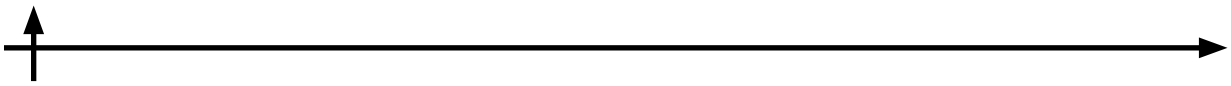
Fig. 1. How much financial resources were spent on medicines per patient

Thanks to the features of BI tools, it is possible to obtain specific illustrative values among a large amount of data. For example, if you move the cursor over the inner circle, you can see that the values represent the patient ID and the cost of treatment. The sector borders define the medications that were used during the treatment, and the triangle will indicate the selected ID in the list on the chart. If you select a patient ID from the list in the diagram, the sector related to it will be highlighted.

If you put the cursor over the outer circle of the diagram, the name of the medicament, the ID of the patient to which the sector with the medicament belongs, the cost of treatment with a specific medicament for a specific patient, as well as other sectors with the application of the medicament are displayed. The triangle in the side list displays the selected medication, and if you move the cursor over a medication from the list, the associated sectors in the diagram will be displayed.

If you click on a medicine from the list indicated in the diagram, a dip will occur, reflecting on which patients this medicine was spent on. At the same time, the content of the table showing the patient's name will change. The same process happens with all the data of the analytics application: only those that are relevant to the selected parameter are displayed.

The outer circle in this selection carries less visual analytical information, while hovering the cursor over one of the inner sectors reflects how much money was spent on the application of the selected medication for a particular patient. By selecting through search, filtering, ID, last name, first name, middle name or by clicking on the desired ID in the chart, the displayed data will change its appearance. By such selection and moving the cursor over the inner circle of the diagram, the answer to the initially posed question "How much money was spent on medicines



for one patient?" will be displayed: patient 7, cost 1009.4.

If you move the cursor over the outer circle, it will be displayed what costs for which medication were spent on a particular patient. It is also possible to sample a group of patients by selecting several patients in the list, which may be necessary for a clear comparative analysis. For example, if you move the cursor over the inner circle, you can see which medicines apply to the patient, the ratio of medicines to each other, and how much money was spent on the patient. If you move the cursor over the outer circle, you can see which patients in the group the medicine applies to, the name of the medicine and the cost of treatment with this medicine for the selected patient.

Results and Discussion

From the data presented, it is possible to draw conclusions about the financial costs that will be incurred in treating a patient with a particular data set. This makes it possible to predict the costs that may be incurred by both the clinic and the patient, and to determine what financial actions need to be taken and considered in order to achieve a positive effect from the treatment being carried out.

At the stage of solving the considered problem, it can be noticed that analytical dashboards are able to display the same data from different points of view, giving more possibilities for visualising the information when making management decisions. Thus, the use of even one dashboard can potentially provide an answer to a whole group of interrelated questions, which confirms the effectiveness of using BI-system as a tool for solving complex multifaceted problems (Koshechkin, 2018). This feature is also characteristic of the subsequent presented analytical dashboards.

Other tasks, the solution of which is possible with the help of BI-application, have been identified earlier and are presented further in a general way. For example, analysing how much medication was spent on a particular patient in quantitative terms. Such diagrams can help in analysing in what doses medicines are used at what characteristics of the patient, which can have a positive impact on treatment forecasting.

It is also important to analyse the use of medication in relation to symptoms and diagnoses. Using a BI application, an analytical dashboard has been created to show which medications and in what quantity were used when selecting a single symptom. When a particular medication is selected, the symptoms to which it applies and the frequency of use are reflected. In the case of this model, the display cannot be called capable of providing new analytical information, but it should be taken into account that in real data, medicines are often used against several different symptoms, which can make this display more statistically correct and weighty in analysing the use of medicines in treatment. When several medicines or symptoms are displayed, the chart shows how many times the medicines were used and against which symptoms, and in the second, which specific symptoms were used for which medicines and how many times they were used.

Based on these analyses, it is not only possible to determine the relationship between medicines and symptoms, but also to determine the frequency of use of medicines and to adjust procurement plans, leading to optimised drug costs. Similarly, analytics reflecting the association of medicines with diagnoses are presented in a similar way. By selecting one diagnosis, it is possible to obtain the entire list of medicines used during treatment, their names, their association with the diagnosis and the number of uses. When selecting several diagnoses in the form of columns of different colours, each of which characterises a diagnosis, the total number of uses and the specific relationship to the diagnosis will be available for each medicine used to treat the selected diagnoses. It is also possible to select a single medicine and obtain a single

column showing all diagnoses associated with the medicine and the frequency of use of the medicine for treatment. A similar display is possible when multiple medications are selected in relation to each medication. By applying this dashboard to analytics, it is possible to visualise the relationship between diagnoses and medications, which can have a positive impact on predicting the course of treatment when a patient is admitted and the cost of medications when dealing with a particular diagnosis.

The BI application also facilitates the display of the frequency of use of a medication. Thus, if a single medication is selected, it is displayed in which dosages it is used and with what frequency the dosage is used. When selecting multiple medicines, the display is similar: all dosages applicable to the medicines and the frequency of their use in the indicated dosages are shown. Making a selection by dosage displays which medicines have been used in the indicated dosages. Thus, this dashboard characterises the dosage of medication use, allowing the collection and evaluation of statistical data and, at the same time, predictive medication management in the clinic.

In addition to the previously mentioned tasks, the developed system makes it possible to obtain answers to such questions as: determination of the average duration of administration of different medicines, as well as financial and quantitative expenditure of medicines per department, post and ward. Thus, it becomes possible to compare drugs among themselves and determine the frequency of prescription of a particular term of administration, which can help to make a more correct prognosis of treatment with a particular drug. In turn, determining the distribution of medicines at different levels of the clinic down to the patient is useful both in terms of collecting statistics on the use of medicines and in tracking costs to avoid inappropriate write-offs, both in terms of financial and quantitative costs.

In addition to the above answers to these questions, the BI system can also be used to provide a comprehensive description of interrelated data on all parameters based on the choices made. Thanks to this feature, it becomes possible to obtain information that is not obvious at the first consideration, and at the same time - to draw new conclusions and even gain new knowledge.

In this application, not every dashboard reflects a lot of characteristics useful for analysis in the course of making a particular choice, however, based on all the above-mentioned features of the created analytics dashboards, we can conclude that the interconnection of dashboards created with the use of a single data model makes it possible to obtain indicative reliable information through simple actions, which is important for users who are not aware of the subtleties of such applications, but need their capabilities.

Conclusion

Based on the model work presented, the BI system collects data that is disparate and displayed in various tables, creating a clear, simple, and easy-to-use representation of the data. The ability to search, create lists of data and dive into different levels of information allows you to quickly gather information that answers a question in varying degrees of depth. The BI application's connectivity is worth mentioning: thanks to it, selecting a parameter on one panel changes the data displayed on the others, which makes the analysis more complete and in-depth. Thus, it becomes possible to quickly track changes in indicators, and, no less importantly, facilitates the process of detecting their connection even when it is not obvious. Thanks to this, the forecasting of drug costs, the impact of drugs, their applicability in certain cases and many other issues receive qualitative support based on data, which can improve the quality of medical services through the correct allocation of finances, resources (Chemeris, 2021), as well as the preliminary consideration of many indicators (Chemeris, 2022), which can suggest

a model of the most effective treatment.

In the course of applying the above model to real data, taking into account their supplementation with a wider set of interrelated tables, it should be expected that there will be an opportunity for rapid and high-quality analytics of processes related to medicines, which will have a significant positive impact on the entire process of medication management. The use of dashboards will make it possible to achieve an increase in the economic efficiency of the medical organisation through qualitative changes in its work. Thus, thanks to the use of analytical dashboards it is possible to:

1. more accurate forecasting of patients' treatment terms by taking into account the use of medicines depending on the patient's characteristics, which has a positive impact on the assessment of the state of the bed stock and planning of patient admissions;

2. Improving the accuracy of cost planning for the provision of medicines to the medical organisation and all its components up to the patient through the use of analytics of quantitative and financial use of drugs;

3. Increase transparency of medication use by tracking related indicators such as medication costs per department, post, ward and patient, which will allow to identify and exclude misuse and/or write-off of medications;

4. Obtaining data on medication use in relation to symptoms, diagnoses, timing of administration and patient characteristics that are important for overall health development, which will allow global patterns in population health to be noted and taken into account both in current planning and in the event of epidemics, emergencies, mass accidents and other factors affecting population health;

5. Increased patient satisfaction through the use of previously obtained analytical data in the course of treatment, which helps to predict the most appropriate method of drug administration (drugs, dosages, timing of administration) for a particular organism, taking into account its similarity with already studied cases;

6. Establishment of new standards of health care delivery to the population and development of innovations based on analysis and consideration of both explicit and implicit patterns of medication use and drug supply of the organisation.

It is expected that qualitative changes will also affect the quantitative indicators, having a direct impact on the flow of patients, namely by reducing the recovery time, due to which the total number of patients admitted per year will increase. This, in turn, will have a positive impact on the overall health of the community, which directly correlates with the goals of healthcare in general and the object of the study in particular, increasing the sustainability of the medical organisation.

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