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Development of the Information System "Drug Inventory Management"

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Abstract

Modern pharmacies always have a need to control the inventory of medicines. As the global coronavirus pandemic of 2019-nCoV has shown, an insufficient and slow response to medical problems among the population can lead to a collapse of the global economy on a par with the Great Depression of the 1930s, the consequences of which people will feel over the next few years.

The article is devoted to the development of a web application for managing drug stocks. A model of the drug inventory management system consisting of 2 subsystems is proposed. The requirements for the drug inventory management system are defined and a user-friendly interface to the drug inventory management system is developed.

Keywords

Information system, drug inventory management, web applications.

1. Introduction

Every human being must eat, drink, sleep, and breathe during his or her life. Also, every human being is bound to get sick. That is why humanity is constantly improving the means and methods of fighting diseases. For this purpose, new medicines are constantly being produced, treatment methods are being developed, and disease prevention is being improved.

The development of communication technologies and the high level of Internet access among the population makes it possible to design a medicines inventory management system that will be able to interact with the outside world, providing the ability not only to adjust and manage the availability of medicines in the pharmacy warehouse, but also to ensure that clinic patients have access to view the availability of medicines in the most convinient pharmacy department. The issue of the availability of medicines in the stocks of at least one pharmacy in a city or district is solved by creating a web-based application for managing medicines stocks with Internet access and the ability to open the status of warehouse fulfillment for all users of the web network. The introduction of a warehouse inventory management system for pharmacies in Ukraine is only gaining momentum. The pharmacy inventory management system is a specialized way to manage the warehouse of medicines and a means of providing patients with information about the availability of medicines in the pharmacy department.

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2. Designing “Drug inventory management” web service

«Drug inventory management» web service is a combination of two concepts:

- Inventory management system;
- Drug search system.

First of all, it is a system for managing medicines stocks. Such a program is created for entrepreneurs, owners and employees of pharmacy departments, who in today's realities must abandon the maintenance of paper journals and trust electronic information systems for inventory management.

For a commercial enterprise, it is very important to ensure the consistency of the existing range of goods in order to maintain a high-level customer service. If the company is incapable of providing the client with the required items with required quantity, it may lose its customer base. To solve that problem, businesses need inventory management systems to provide uninterrupted customer service at the highest possible level when shortages or overstocks are impossible at the logistics level.

The inventory management system should help to respond in a timely manner to user actions on the warehouse. This means that whenever users perform any actions on the system, it needs to track these actions and dynamically evaluate the new state of the warehouse, taking into consideration the latest data on changes in the system. For example, when a certain number of items are sold (removed) from the warehouse, the system must respond immediately and automatically create and send an order for the required amount of new goods to refill the storage.

Using an inventory management system requires a certain amount of experience with information technology and the ability to manage the actual delivery of goods to the warehouse. Therefore, the personnel using such a system should be able to foresee:

- possible random fluctuations of demand for goods over the period between deliveries. For example, during the first outbreak of the coronavirus pandemic, some pharmacies experienced a large shortage of cold remedies and vitamin-D preparations but this could have been avoided with good inventory control and proper staff training;
- geographical remoteness of the branch or warehouse from the supplier, which does not allow to obtain the necessary funds at the time and in the amount required;
- seasonality of sales or production of goods, which may change the quantity of deliveries or the need of necessary materials in certain periods of the year and negatively affect the reputation of the sales outlet among consumers;
- the risk of changes in market prices for final products.

Therefore, the main task of the inventory management and inventory analysis system is to be able to predict when it is better to order goods and what the order size should be.

The following parameters of the management system should be identified:

- order point, which is the critical level of product inventory, at which it becomes necessary to initiate a new order;
- the insurance level of stocks, which is a sufficient level of goods in the warehouse of the enterprise, branch or warehouse;
- frequency of purchases, which is determined by the frequency of necessary stocks of products renewal or the duration of the interval between two possible purchases;
- replenishable quantity of products, which determines not only the quantity of goods, but also achieving the minimum cost of storing stocks in accordance with the specified replenishment costs.

The system should provide the ability to perform inventory rationing operations, which means controlling the volume of current and insurance stocks at economically reasonable levels. Such values should be managed using special software that makes it possible to analyse the remaining goods at the beginning and end of the month, compare them and help the employer, the user of the system, draw conclusions for regulating warehouse resources, maintaining them at the required level based on customer demand and delivery periods of new stocks, preventing excess or shortage of stocks.

There are two popular classical inventory management systems that help to achieve the purpose of continuous supply of material resources to the customer in situations where there are no deviations

from the timely planned indicators and the inventory is always consumed evenly, named the fixed order quantity system and the fixed-order interval warehouse management system.

In addition to these two systems, there are also modifications of them, such as a system with a predefined frequency of replenishment to a specified level and a "minimum-maximum" system.

To build a new warehouse management system, it is required to choose one of these modifications or create a new one by combining several systems into one.

A fixed-order system is a model of inventory management in which a clearly fixed constant is set for the optimal order size, after which it never changes. The optimal order size in such a system is calculated taking into account the minimization of the total cost of storage and reordering.

The reserve insurance stock size is set to anticipate inventory shortages due to logistical reasons, such as the delay between ordering and receiving delivery of inventory.

The inventory threshold level specifies when the inventory level is as critical as possible for the next order to be created. The threshold level is calculated so that the order is received by the department or warehouse when the current stock of trade materials is reduced to the reserve level.

The maximum desirable stock is the sum of the reserve stock and the new delivery stock, which is determined taking into account the specifics of the product itself, demanding for it, and available space in the company's warehouse.

In such a system, an order for a new batch of products is placed when the current inventory reaches a minimum critical level, which is set by the "order point". Delivery intervals depend on the intensity of inventory sales to customers, meaning that the demand for the product among customers, the optimal order size, and the interval between sending an order and receiving the goods due to the order are the managing parameters for this system.

In some such systems, the order point is not fixed beforehand. Instead, the moment the order submission is made is either based on the supplier's fulfilment of the exact delivery obligations or on the fluctuations in consumer demand on inventory sales. In this case, the order point is "floating".

Such system is often abbreviated as a "two-bin system", as the inventory is stored as if in two storages, one of which is consumed from the moment of receiving the next batch of inventory until the critical order point is reached, and the other - in the period between the interval of order submission and the fulfilment of the supplier's obligations.

The fixed order inventory management system is recommended for use when there are:

- potential commercial failures in case of absence of stocks;;
- significant cost of storing large amounts of inventory;
- unacceptable excesses of the replenished order quantity due to the high cost of products from the supplier;
- unknown level of demand;
- price reductions for bulk orders;
- the supplier's batch has a minimum order threshold.

The main disadvantage of such systems is the high entry requirement for an employee of the resource management system, due to the need of being able to correctly select the minimum order point. Incorrect selection of the order point in these systems may lead to significant business losses.

Another system is an inventory management system with a fixed time interval between orders, or a periodic ordering system, where the frequency of purchases is clearly defined, but the size of purchases may vary. According to this system, warehouse owners must check the inventory balances and create orders based on the observation of the sales of warehouse stocks every time in a specific period, for example, every week or month.

The order size in each period between deliveries may vary. Therefore, this model of the system is acceptable for use only if the supplier can provide logistics transportation with different stock sizes per shipment. This practice will be unacceptable if the warehouse is large and deliveries are made by the number of containers or railcars. The supplier may often ask for a higher order fee in exchange of flexible changes in the size of the goods. In such cases, the use of a periodic ordering system is also impossible.

Additionally, it is worth noting that such a system may lead to stock shortages. The demand on goods may increase unexpectedly in the interval between orders, which will provoke a shortage of goods.

This model is recommended for implementation when:

- stock shipping allows to change the batch size;
- fees among suppliers for transportation and order placement are not too excessive;
- shortage of consumer goods is not problematic for the enterprise.

The periodic ordering system can be considered relatively simple because it is amended only once between deliveries. But the problem of stock-outs is critical for pharmacies.

A system with a given frequency of replenishment to a specified level is a combination of the two systems listed above. Such a system is best suited for implementation in enterprises with frequent and significant fluctuations of consumer stocks.

In such system, orders are divided into planned ones, which must be registered at the end of each specified period, where the size of the next order is calculated based on the predicted sales level until the next delivery of the new batch is completed, and additional orders which are registered when the warehouse stock reaches the critical point of the order.

In the minimum-maximum system, orders are created only if the minimum or lower inventory level is reached in the warehouse or enterprise, and the size of the order for new inventory should always be such that it immediately replenishes the resource level to the maximum. But this creates a high risk of inventory shortages.

Such an ordering model is acceptable only if there are significant costs for storing and replenishing stocks, when it is necessary to quickly sell the goods at any price, even at the cost of creating a shortage.

Therefore there are a sufficient number of models for managing stocks in a warehouse, but the most suitable for pharmacies will be a system with a given frequency of replenishment to a specified level due to the prediction of a possible shortage of medicines and preparations for seasonal changes in demand for medicines.

3. Requirements for “Drug inventory management” web service

The application should be a web service running on a remote server and accessing a cloud database. Such an architecture will protect user data from intruders and will not cause a load on users' devices. The transfer of data from the server to the client should be fast and dosed, preventing too much data from appearing in the client's browser at one time and on one page. Filters and the ability to view data lists through page selection should be present.

Analysing the seasonal fluctuations in demand for medical products, the inventory management system in a pharmacy should have a model that will not allow shortages under any circumstances. Such a model is a system with a given frequency of replenishment of stocks to a specified level. With such a model, the responsible person will see recommendations for replenishment at the end of each restocking period and, in case of high demand for the product, when the critical point of the inventory level is reached, a purchase order for a new batch of stock will be automatically generated. The best solution would be to give the user the opportunity to choose the model of the management system for each product separately.

In addition, there should be a system for sending requests for replenishment and a system for receiving orders that will allow replenishing the stock at the branch. The system should be rich for medicinal products already included in the reference book, which are registered in the State Register of Medical Products of Ukraine and to have an ability to add new products to the reference book when placing an order. To replenish the warehouse, it is necessary to first create an request for a new batch, and then confirm the arrival of the batch from this request to the company's warehouse.

It is also necessary to provide sales management system which allows to build a system for selling stocks from the warehouse. Such system will be a cash desk where the pharmacist of each department will be able to sell medicines from the stock by units. In addition, it is necessary to add a system for removing medicines from the warehouse and a separate page with a list of medicines that have expired or will soon expire.

The software implementation of the system should be based on a client-server architecture to avoid overloading the user's device. No calculations should be performed on the client application side. The

browser itself should only display the data that comes in response to requests from the server. Databases must be able to store huge amounts of data. A single pharmacy department may receive dozens of orders per day, and the system must be ready to be used by an unlimited number of departments, so theoretically, the software implementation of the system will work with a huge amount of stored data. The programming language for building the computing server should be versatile enough to implement a massive-load ready system.

4. Designing "Drug inventory management" web service

The development of the system in the client-server architecture will make it easier to support the project during its lifetime by dividing the program into logical parts, including:

- a client used for data input and output;
- a server that calculates applied functions which are programmed to suit the needs of the research area;
- a storage that implements data saving.

The following pages have been developed for the client representative part of the application:

- departments registered in system search page;
- medicines searching page;
- page of department with the selection of medicines inside it;
- a request for registration of an organization and a profile of the director of the company creation page;
- a request for registration of departments creation page;
- department's employees management page;
- a page for creating a request to technical support of the system, for example, with a request to add a new drug to the drug reference book;
- page for viewing statistics on the organization and the whole system;
- a page for viewing user technical support requests;
- warehouse management page with the ability to customize the inventory replenishment model, creating order request to the supplier, confirming disposals of expired stocks.

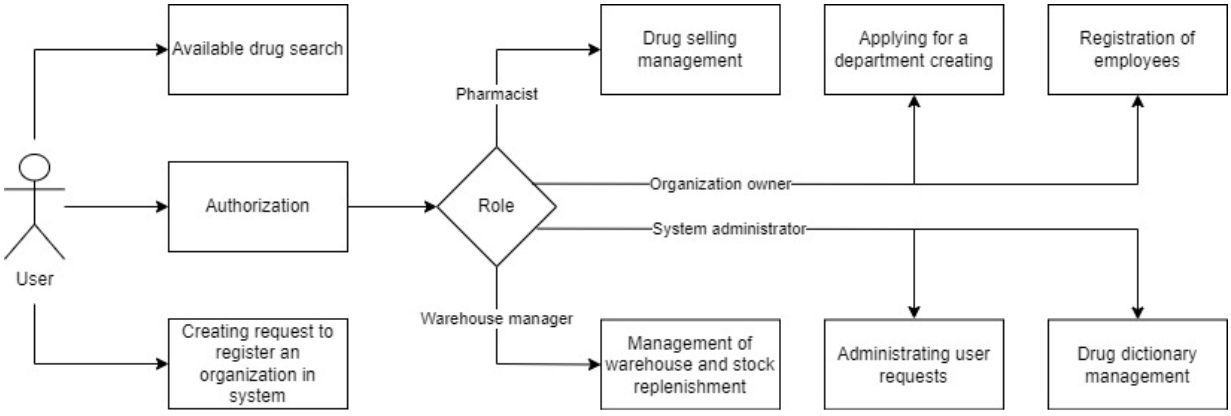

Figure 1: User interaction with the web application

Figure 1 shows a short UML diagram of user interaction with a web application according to the requirements for designing the structure of web pages.

The system uses two databases: MongoDB for storing user authorization information and PostgreSQL for storing data about items, orders, order batches, historical data, and statistics.

MongoDB acts as a data warehouse for organizations, their departments and users. The database schema is shown in Figure 2. The links in the figure are added purely for a better understanding the interaction of documents.

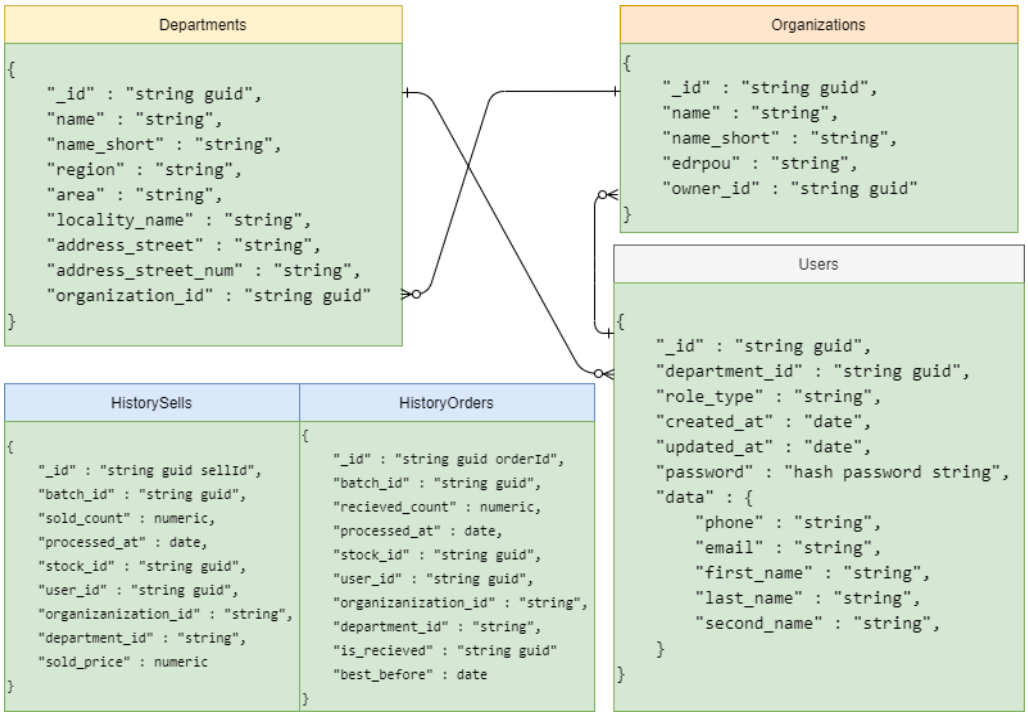

Figure 2: MongoDB database schema

The documents in the Organization collection contain brief but extremely important data about the organization in the system - its Unified State Register of Enterprises and Organizations of Ukraine (USREOU) code, name and director's ID.

The departments collection contains information about the branches' relationship with organizations, its name, addresses of departments, which are divided into regions, districts, settlements, addresses and address numbers.

The Users collection contains documents describing registered users. Such documents contain information about the department identifier (which is optional, since the system administrator may not have an organization), user role, password, and personal data such as first name, last name, second name, e-mail, and phone number.

Historical data is stored in the HistorySells table, which records are added when a pharmacist makes an action on selling a product and HistoryOrders which stores the moments of batches processing when requests for their delivery are created and when the arrival is recorded.

Figure 3 shows a diagram of the database store of PostgreSQL.

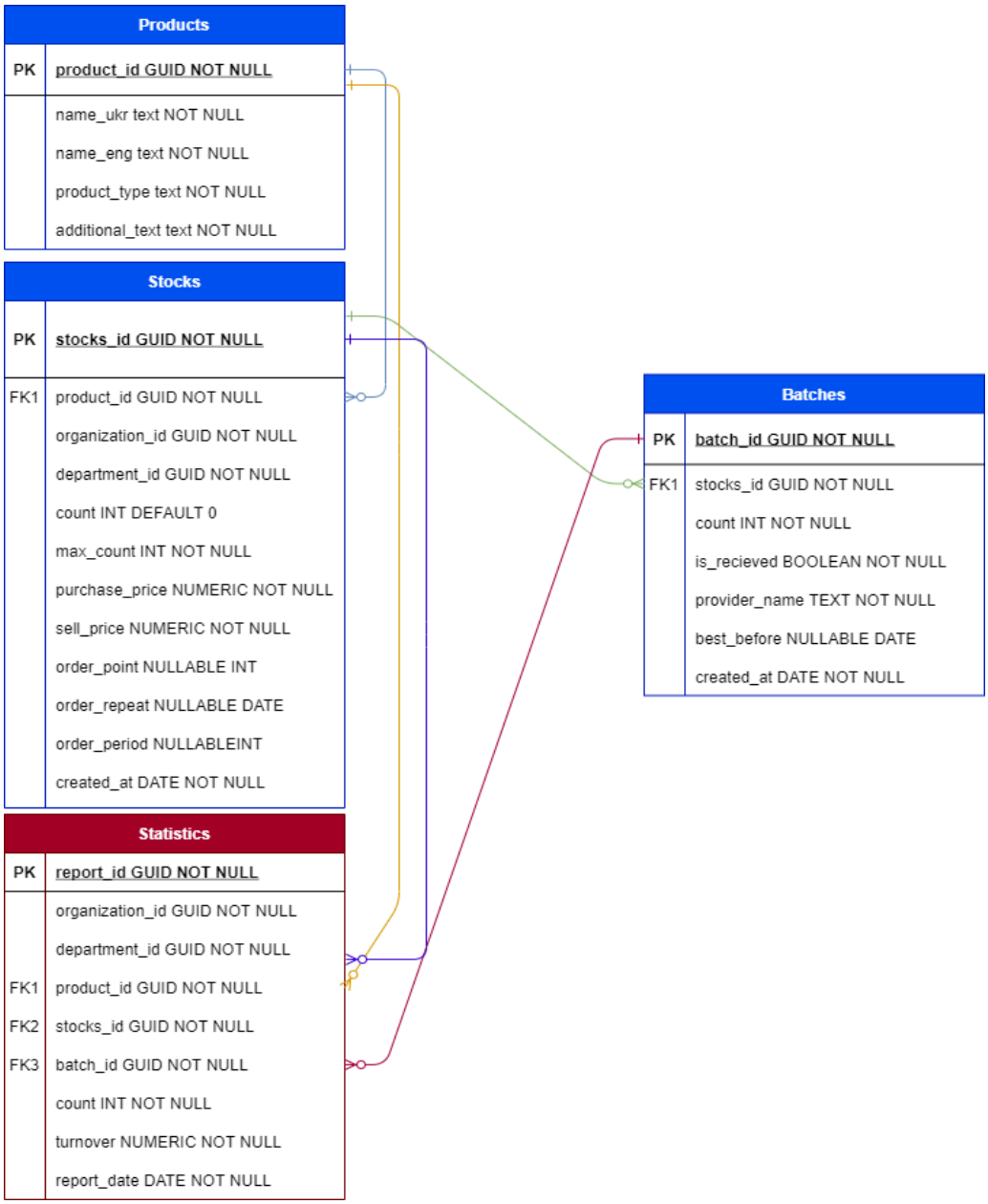

Figure 3: PostgreSQL database schema

The core of inventory management is implemented using three tables: the Product table, the Stocks table, and the Batches table. The Product table contains the basic data of medicines and other goods that may be available in the warehouse of the pharmacy department. This data includes the name in Ukrainian and English, the type of product to define the category, and additional information that serves purely to describe the product to an unregistered user who can use the drug search service.

Stocks is a storage of inventory of a particular product for each branch. It calculates the count of stocks from the Batches table, indicates the price of the purchase and sales of items by the piece. To manage the creation of orders, this table has fields for the "order point", the order period in days, and the date of the next order. There are also organization and department fields that are stored in another database.

Batches - a collection of all batches of products linked to the table with the warehouse storage. Each batch has its own quantity, a note on its arrival, and an optional field with the expiration date.

The Statistics table shows the quantity of goods that was in the department at the time the statistics were saved, shows the cash turnover for the day, and contains links to all other tables required for inventory management.

5. Development of “Drug inventory management” web service

Access to the web application is not restricted. This means that any Internet user can visit this website. This allows the platform to be promoted as a website for finding medicines.

The user can find the department they need in the system using special address filters. The filter allows to find a pharmacy by region, district, settlement, address and house number.

If the user needs to clarify the availability of a particular medicine, they can additionally enter its name in the search bar of the main page or check its availability on the pages of the found departments. An example of the results of searching for a department by filter is shown in Figure 4.

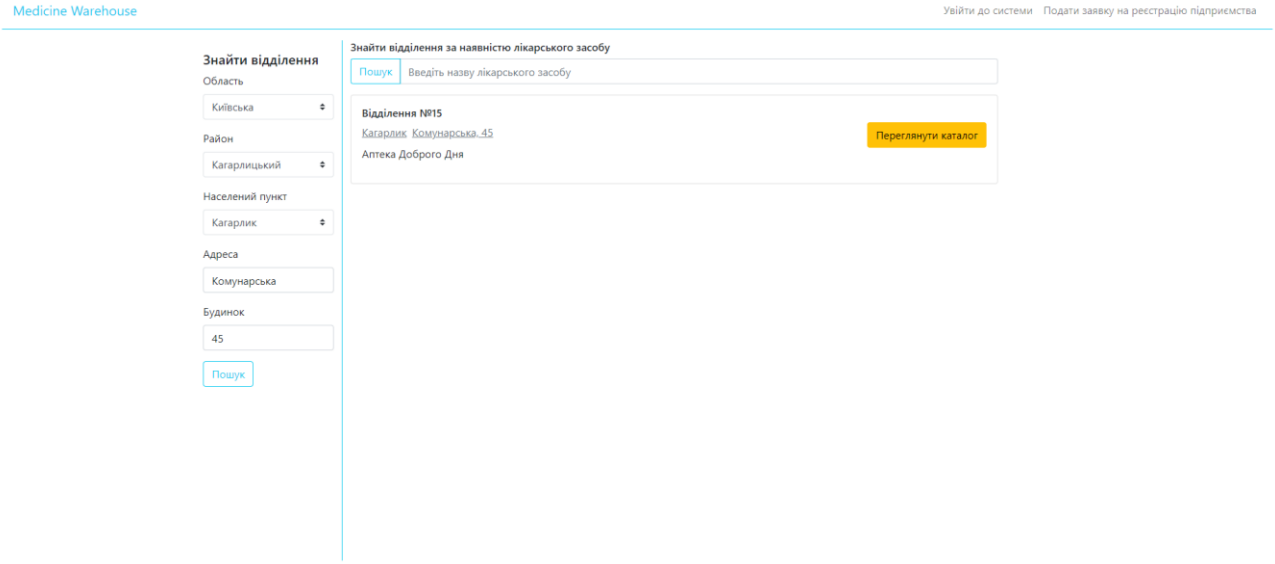

Figure 4: Home page of the web application

If the user clicks the "View catalogue" button, system will redirect browser to the individual page of the selected department. On this page, user can see a list of all the medicines available in the pharmacy's inventory. If the list seems too long, the user can use the search field to find the required drug.

Information about the drug includes its name in Ukrainian and English, prices for the drug in the department, and its description. The department catalogue is shown at Figure 5.

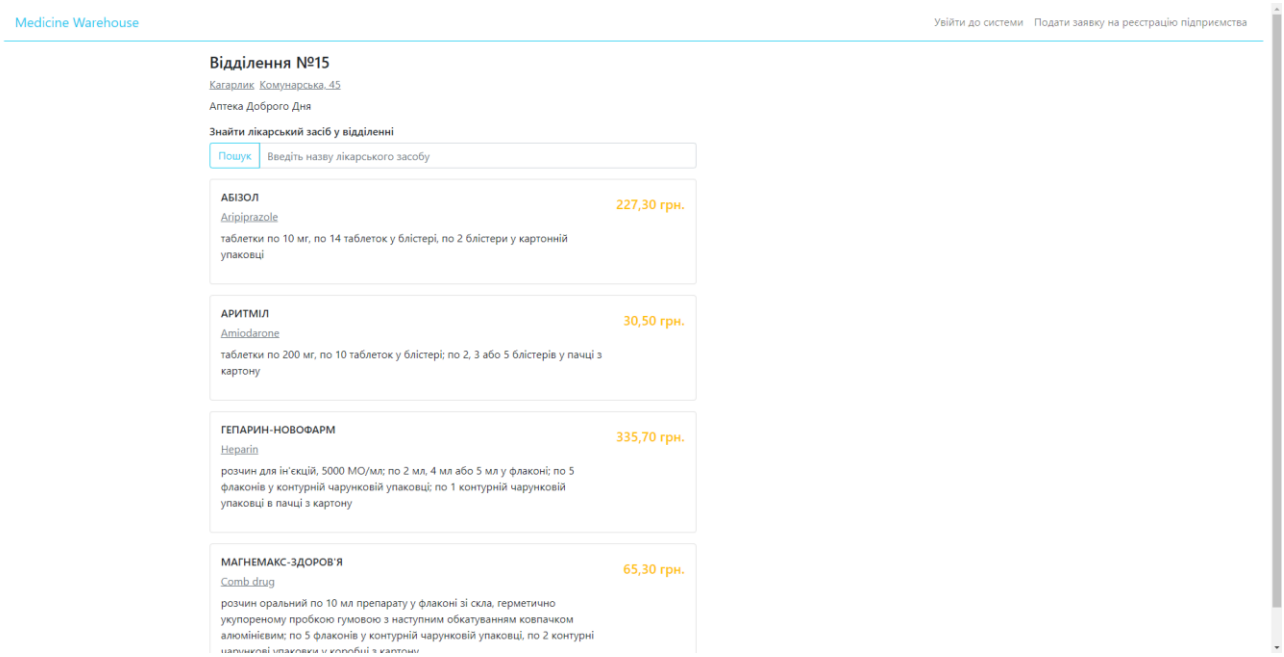

Figure 5: Catalog of the department's medicines

Therefore, the user can find medicines in the most convenient pharmacy locations, as well as find the location with the most convenient price.

The system has special preconditions for inventory management:

- If the drug is not present in the State Register of Medicines, the system administrator must add the appropriate type of medicine to the drug dictionary manually;
- Registered organization. The owner of organization must apply request for registration of the company. After that the administrator in the case of successful verification of the legal entity confirms registration and grants access;
- Department creation. After logging in to the personal account, the head must create a request for creating a department of pharmacy, which administrator will review similarly to the request for creating an organization.
- Creating a user with the role of organization manager and linking it to the department. A user with the role of organization owner performs it.

After all the preconditions completion, the pharmacy employee with the created account must log in to the system using his personal login and password.

Upon successful login, the inventory manager sees the inventory table. The first time inventory manager logs in, the table will be empty.

To fill it in, click the "Create a stock entity" button above the table. The menu of adding a new stock entity to the branch will open. The user must fill in all the fields and select which model the order management system should be selected for this medicine. The interface for adding a stock item is shown in Figure 6.

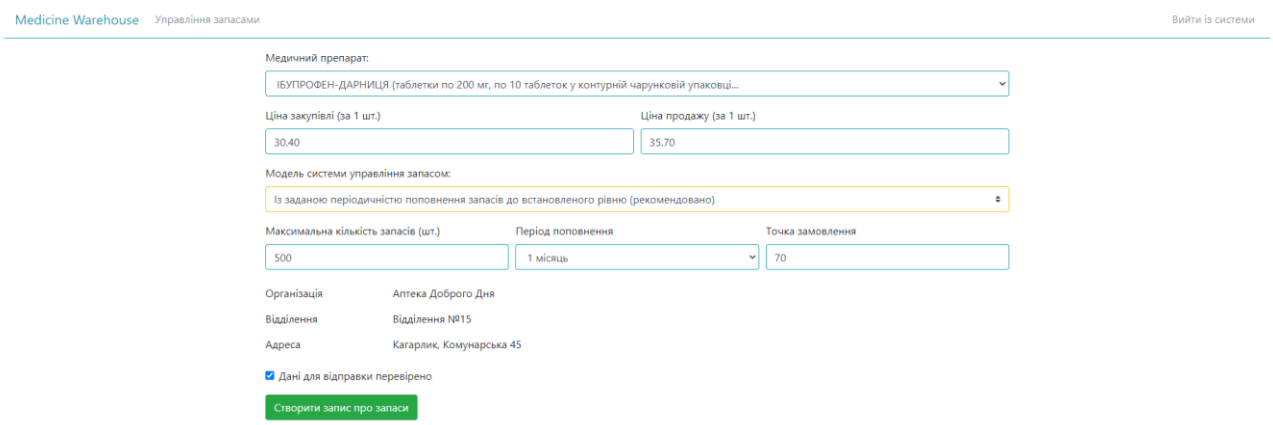

Figure 6: Adding a stock entity to a department page

The newly created inventory entity places at the inventory management page. This entity is assigned by status "Requires order". This situation is shown on Figure 7.

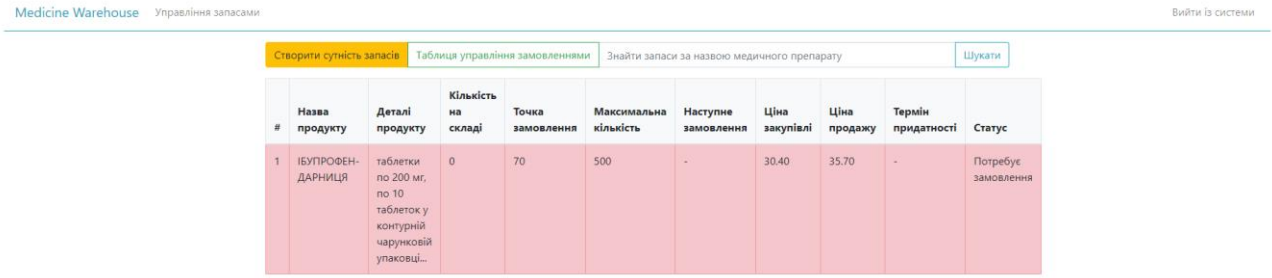

Figure 7: Inventory management page

The first batch of goods must always be ordered manually. This is necessary so that the next automatic order, when the critical point is reached, can read the name of supplier's organization and create the next order for it.

In order to request a batch of items, it is necessary to go to the order management page by clicking on the "Order management table" button. On this page, clicking the "Place order" button, select the required stock category from the list, enter the name of the supplier and enter the quantity of goods to be ordered. Please note that the system will automatically calculate the quantity of goods to be ordered based on the data entered in the stock entity. After filling in the order data, click the "Confirm order delivery" button..

The order will next appear in the table of the order management page, as shown in Figure 8. New orders are always highlighted in green. To confirm receiving the order, click the "Confirm receiving" button in the line with the ordered item in the "Status and management" column. Clicking this button will take the user to the page for entering data about the received order. There user has to enter the date of receiving the order, which will be used to generate the date for the next order, according to the replenishment period specified in the inventory settings.

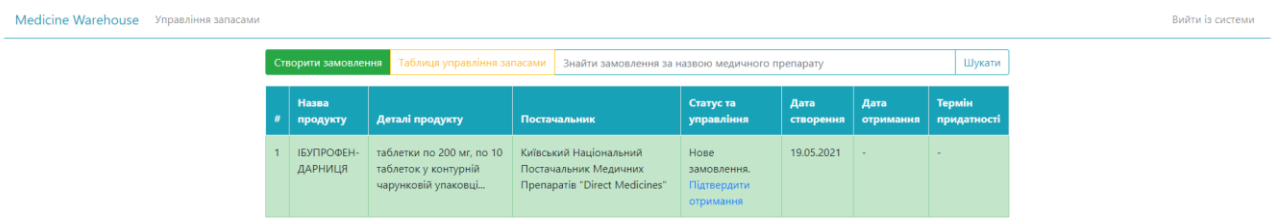

Figure 8: Managing batch orders page

After confirmation, the order status will change to "Received", and the inventory line on the page will be updated according to the received data and will not be highlighted in red. The updated inventory management page is shown in Figure 9. If everything was done correctly and the stock level is not close to the order point, the status will change to OK.

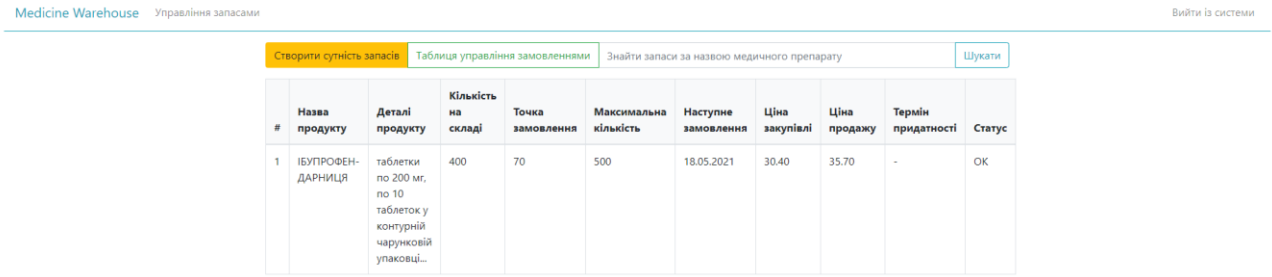

Figure 9: Successfully added stock entity

6. Conclusions

As a result of research on models of inventory management systems at enterprises, analysis of the relevance of the solution, a review of existing warehouse and inventory management systems and a review of modern technologies for the development of high-speed web applications, the "Drug inventory management" system which allows to search and manage medicines was developed, which includes methods for creating and recording the receiving of orders for a batch of medicines, starting with a list of prerequisites, such as registration of the organization, creation of branches and user profiles, adding a medicine to the directory, choosing a method of management.

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