
ОРГАНІЗАЦІЯ ТА ЕКОНОМІКА ФАРМАЦІЇ

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SCIENTIFIC SUBSTANTIATION OF THE BASIC TRENDS OF PRESCRIPTION AND NON-PRESCRIPTION MEDICINES SALES IN UKRAINE

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Key words: prescription medicines; over-the-counter medicines; sale of medicines; methods of mathematical statistics

There is violation in a clear procedure of prescribing by doctors and dispensing of drugs from pharmacies in Ukraine. It has been noted that determination of the main trends in sales of prescription and non-prescription medicines from domestic pharmacies is one of today's topical areas of medicine and pharmacy. According to the results of the pharmaceutical market analysis it has been found that today the methods for determination of trends of drug sales using the methods of mathematical statistics are practically absent. The method of determination of the main trends in sales of prescription and OTC medicines in Ukraine and regions has been suggested; based on its results it has been found that in Ukraine on the whole and in most of the regions there is a tendency of decreasing the level of drug sales. At the same time for OTC medicines the increase of the level of sales is observed in the Dnipropetrovsk, Donetsk, Zhitomir, Zaporozhia, Kievan, Kirovohrad, Odessa and Kharkov regions. For prescription medicines the increase of the level of sales takes place in the Donetsk and Zhitomir regions. The models of regression proposed can be effectively used for solving tasks of prognostication and analysis of indexes of drug sales. The results of the correlation analysis indicate a significant positive relationship between the number of outpatient visits and the income level, between bed occupancy and the level of sales of prescription medicines, as well as between the income level and the number of sales of prescription medicines.

Efficiency of pharmaceutical provision of the population is primarily related to the social issues: the organization of dispensing of prescription and non-prescription medicines, free and preferential dispensing of drugs, etc. [2, 5]. Dispensing of prescription medicines is a normative constituent of the regulatory authority of drug circulation in every socially developed country, it ensures efficiency, safety and rational pharmacotherapy and promotes reduction of self-medication and polypharmacy. However, over the years of independence a clear procedure of prescribing by doctors and dispensing of drugs from pharmacies has been almost completely destroyed in Ukraine [4].

Ukraine has chosen the way to reform the health care system, so determination of the main trends in sales of prescription and non-prescription medicines from pharmacies is one of today's topical areas of medicine and pharmacy.

Experimental Part

The pharmaceutical market analysis has shown that currently the methods for determination of trends of drug sales using the methods of mathematical statistics are practically absent [3-10]. In this regard, the aim of the research was to substantiate approaches to determination of the main trends of indicators in sales of pre-

scription and non-prescription medicines in Ukraine, as well as their dependence on a combination of factors that affect them.

The object of the study was methodological approaches to identification and assessment of trends in sales of drugs (prescription and OTC) in Ukraine and its regions in 2005-2013. To analyze the sample was formed by monthly observations divided into two combinations: sales (by number) of drugs by prescription and sales of nonprescription medicines.

Results and Discussion

As a result of research we have proposed the method of determination of trends in sales of prescription and non-prescription medicines in Ukraine and its regions that includes the following stages:

At *the first stage* averaging of the input data for each population and all regions was carried out; based on it the average sales and variance were calculated [1].

At *the second stage* homogeneity of variances was carried out by Fisher criterion; as a result it was found that the variance estimates of drug sales were not uniform [1].

At *the third stage* of the method proposed the plots of dependence of the average level of drug sales from

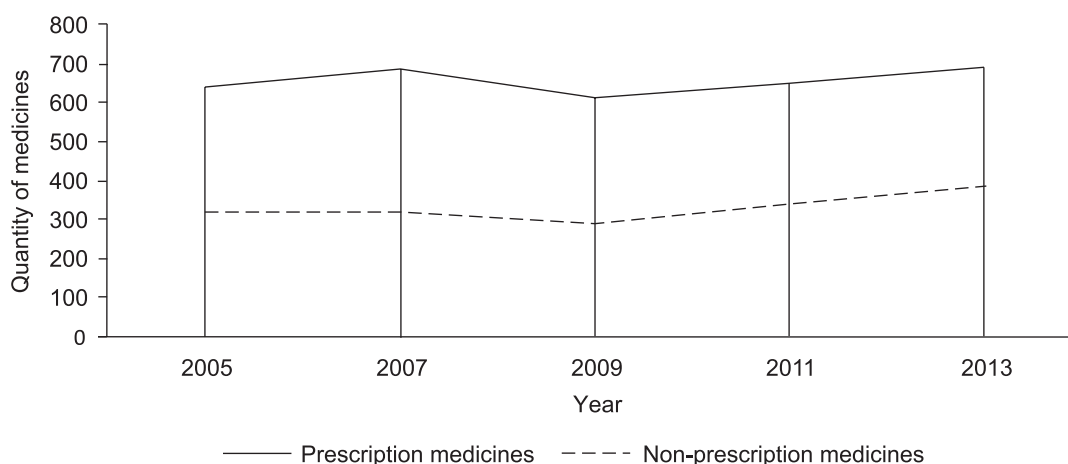


Figure. Dynamics of sales of prescription and non-prescription medicines for 2005-2013 in Ukraine.

the time dimension were built using the data obtained on the two previous stages.

Dynamics of prescription and OTC medicines for 2005-2013 in Ukraine is shown in Figure.

Analysis of the plots obtained allowed to conclude about the possibility of approximation of these dependences with quadratic polynomials [1], namely:

$$y(x) = a_0 + a_1x + a_2x^2.$$

Table 1

The values of regression equations parameters for the regions of Ukraine

| Regions | a_0 | a_1 | a_2 |
|--------------------|--------|--------|--------|
| Vinnitsya | 11.419 | -1.608 | 0.182 |
| Volhynia | 11.588 | -1.396 | 0.121 |
| Dnipropetrovsk | 26.655 | -0.991 | 0.159 |
| Donetsk | 25.308 | 2.805 | -0.088 |
| Zhytomyr | 7.246 | 0.292 | 0.013 |
| Zakarpattia | 8.902 | -1.169 | 0.1 |
| Zaporozhia | 13.878 | 0.03 | 0.017 |
| Ivano-Frankivsk | 8.428 | -1.003 | 0.135 |
| Kyivan | 10.748 | -0.61 | 0.083 |
| Kyiv city | 27.164 | -1.637 | 0.197 |
| Kirovohrad | 8.009 | -0.186 | 0.013 |
| Lugansk | 18.407 | -0.06 | 1.628 |
| Lviv | 28.08 | -3.954 | 0.317 |
| Mykolaiv | 7.355 | -0.364 | 0.057 |
| Odesa | 14.427 | -0.65 | 0.124 |
| Poltava | 10.296 | -0.659 | 0.173 |
| Rivne | 9.975 | -1.134 | 0.107 |
| Sumska | 8.686 | -1.22 | 0.134 |
| Ternopil | 8.481 | -1.258 | 0.104 |
| Kharkiv | 21.578 | -0.167 | 0.011 |
| Kherson | 9.546 | -0.978 | 0.124 |
| Khmel'nitska | 13.85 | -2.023 | 0.181 |
| Tcherkasy | 10.685 | -0.803 | 0.093 |
| Tchernivtsi | 6.73 | -0.666 | 0.079 |
| Tchernihiv | 11.243 | -1.541 | 0.154 |
| Republic of Crimea | 29.099 | -2.984 | 0.23 |

The fourth stage of the method provided for the calculation of regression equations parameters, the results of which for sales of prescription medicines are given in Tab. 1.

Next, at *the fifth stage* the test of significance of regression equations parameters was carried out. Assessment of significance was carried out according to Student's test by calculating confidence intervals (15) for each coefficient of each equation. However, some of the coefficients were insignificant, for example, for Luhansk region, therefore, the corresponding regression equations were recalculated.

At *the sixth stage* the adequacy test was carried. After elimination of insignificant coefficients the regression equations obtained were tested for adequacy by Fisher criterion [1]. All equations were adequate.

Thus, the analysis of the results obtained by calculation leads to the following conclusion: in Ukraine as a whole and in most regions of the country there is a tendency of decreasing the level of drug sales. At the same time for OTC medicines the increase of the level of sales is observed in the Dnipropetrovsk, Donetsk, Zhitomir, Zaporozhia, Kievan, Kirovohrad, Odessa and Kharkov regions. For prescription medicines the increase of the level of sales takes place in the Donetsk and Zhitomir regions.

Using the research results obtained we have formed a matrix of values of the factors that are likely to affect the sales of prescription and OTC medicines. In all cases, the numerical values of the factors are determined by the rate per capita. Besides, because the ranges of variation in the numerical values of the various factors are significantly different from each other, normalization of these factors to their maximum value has been conducted (Tab. 2).

According to the results of calculations a matrix is formed where

F_1 – is the number of ambulatory visits per capita;

F_2 – is the number of hospital beds per capita;

F_3 – is the average bed occupancy;

F_4 – is the income of the population per capita.

We introduce the value Y – sales of medicines per capita that are average normalized by the maximal value.

Table 2

The matrix of the normalized factors of influence on drug sales in regions

| Regions | F_1 | F_2 | F_3 | F_4 |
|--------------------|-------|-------|-------|-------|
| Vinnitsya | 0.837 | 0.752 | 0.910 | 0.443 |
| Volhynia | 0.845 | 0.730 | 1.000 | 0.490 |
| Dnepropetrovsk | 0.914 | 0.860 | 0.974 | 0.573 |
| Donetsk | 1.000 | 0.735 | 0.973 | 0.586 |
| Zhytomyr | 0.909 | 0.678 | 0.980 | 0.438 |
| Zakarpattya | 0.764 | 0.707 | 0.910 | 0.356 |
| Zaporozhia | 0.818 | 0.793 | 0.943 | 0.390 |
| Ivano-Frankivsk | 0.773 | 0.800 | 0.890 | 0.417 |
| Kyiv, city | 0.990 | 0.691 | 0.930 | 1.000 |
| Kyivan | 0.783 | 0.772 | 0.890 | 0.450 |
| Kirovohrad | 0.742 | 0.835 | 0.950 | 0.520 |
| Lugansk | 0.891 | 0.875 | 0.978 | 0.580 |
| Lviv | 0.840 | 0.823 | 0.964 | 0.510 |
| Mykolaiv | 0.970 | 0.728 | 0.910 | 0.550 |
| Odesa | 0.784 | 0.758 | 0.937 | 0.450 |
| Poltava | 0.875 | 0.754 | 0.940 | 0.503 |
| Republic of Crimea | 0.788 | 0.783 | 0.941 | 0.650 |
| Rivne | 0.844 | 0.771 | 0.982 | 0.413 |
| Sumska | 0.740 | 0.819 | 0.931 | 0.360 |
| Ternopil | 0.948 | 0.805 | 0.978 | 0.386 |
| Kharkiv | 0.956 | 0.717 | 0.942 | 0.350 |
| Kherson | 0.824 | 0.766 | 0.966 | 0.580 |
| Khmel'nit'ska | 0.836 | 0.775 | 0.956 | 0.530 |
| Tcherkasy | 0.830 | 0.780 | 0.958 | 0.433 |
| Tchernihiv | 0.806 | 0.777 | 0.988 | 0.590 |
| Tchernivtsi | 0.813 | 1.000 | 0.956 | 0.456 |

We also introduce the model of dependence of the level of sales on main factors:

$$y(x) = a_1F_1 + a_2F_2 + a_3F_3 + a_4F_4$$

The calculation of dispersion of homogeneity gives us the possibility for calculating vector A. According to the results of calculation the vector has the form of:

$$A = (0.261; -0.109; 0.462; 0.574).$$

The model for standardized variables obtained is adequate by Fisher criterion. Regression models are efficiently used to solve the problems of predicting the endogenous variable depending on the values of the factors that affect. However, the numerical values of the coefficients of the multiple regression equation do not give a correct representation of the relationship between

the levels of various factors since they depend on the scale of their measurement that can be chosen arbitrarily. In this sense, the matrix of correlation coefficients between the values of the factors and the resulting index, which is independent of the scale is much more informative.

The cross-correlation matrix looks like:

| | | | | |
|--------|--------|--------|--------|--------|
| 1 | -0.311 | 0.2687 | 0.3902 | 0.2061 |
| -0.311 | 1 | 0.1516 | -0.127 | -0.208 |
| 0.2687 | 0.1516 | 1 | 0.1005 | 0.402 |
| 0.3902 | -0.127 | 0.1005 | 1 | 0.6292 |
| 0.2061 | -0.208 | 0.402 | 0.6292 | 1 |

The significance of the correlation coefficients is checked by Student's test as follows: statistics $t = r\sqrt{(n-2)/(1-r^2)}$ is calculated with Student's distribution of $k = n - 2$ degrees of freedom, where r – is the coefficient of correlation, n – is the number of experiments. To test the null hypothesis at the significance level α and the number of degrees of freedom k by the tables of Student's distribution (t -distribution) the critical value $t_{\alpha,k}$ that satisfies the condition, $P(|t| \geq t_{\alpha,k}) = \alpha$ is found. If $|t| \geq t_{\alpha,k}$, then the null hypothesis about the absence of correlation between the variables must be rejected [1].

In the analysis $n = 26$, and $t = 4.0 \frac{r}{\sqrt{1-r^2}}$.

Tabulated value $t_{kp} = 2.07$. Therefore, in the resulting matrix the following factors are significantly different from zero:

$r_{1,4} = \langle F_1, F_4 \rangle = 0.39$ ($t = 2.075$) – is the correlation between the number of outpatient visits and the income level;

$r_{3,5} = \langle F_3, Y \rangle = 0.402$ ($t = 2.151$) – is the correlation between bed occupancy and the level of sales of prescription medicines;

$r_{4,5} = \langle F_4, Y \rangle = 0.629$ ($t = 3.964$) – is the correlation between the income level and the number of sales of prescription medicines.

Thus, the regression models proposed can be effectively used for solving tasks of prognostication and analysis of indexes of drug sales.

CONCLUSIONS

The method of determination of trends in sales of prescription and OTC medicines in Ukraine has allowed to reveal that in most regions of the country there is a tendency of decreasing the level of drug sales.

The results of the correlation analysis indicate a significant positive relationship between the number of outpatient visits and the income level, between bed occupancy and the level of sales of prescription medicines, as well as between the income level and the number of sales of prescription medicines.

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НАУКОВЕ ОБҐРУНТУВАННЯ ОСНОВНИХ ТЕНДЕНЦІЙ (ТРЕНДІВ) РЕАЛІЗАЦІЇ РЕЦЕПТУРНИХ ТА БЕЗРЕЦЕПТУРНИХ ЛІКІВ В УКРАЇНІ

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Ключові слова: рецептурний відпуск; безрецептурний відпуск; реалізація ліків; математико-статистичні методи

Вказано на порушення чіткого порядку виписування рецептів лікарями та рецептурного відпуску ліків з аптек в Україні. Наголошено, що встановлення основних тенденцій продажів рецептурних і безрецептурних ліків з вітчизняних аптечних закладів є одним з актуальних напрямків медицини та фармації. За результатами аналізу фармацевтичного ринку встановлено, що наразі практично відсутні методики визначення тенденцій реалізації ліків з використанням математико-статистичних методів. Запропонована методика встановлення трендів реалізації рецептурних та безрецептурних ліків в Україні і регіонах, за результатами застосування якої з'ясовано, що в Україні в цілому і по більшості регіонів країни має місце тенденція до зниження рівня реалізації ліків. Разом з тим для безрецептурних препаратів підвищення рівня продажів спостерігається в Дніпропетровській, Донецькій, Житомирській, Запорізькій, Київській, Кіровоградській, Одеській та Харківській областях. Стосовно рецептурних препаратів підвищення рівня продажів спостерігається в Донецькій і Житомирській областях. Запропоновані моделі регресії можуть ефективно використовуватися для вирішення задач прогнозування та аналізу показників реалізації ліків. Результати кореляційного аналізу свідчать про наявність значної позитивної залежності між числом амбулаторних відвідувань і рівнем доходу, між зайнятістю ліжок і рівнем продажів рецептурних препаратів, а також між рівнем доходу і числом продажів препаратів за рецептом.

НАУЧНОЕ ОБОСНОВАНИЕ ОСНОВНЫХ ТЕНДЕНЦИЙ (ТРЕНДОВ) РЕАЛИЗАЦИИ РЕЦЕПТУРНЫХ И БЕЗРЕЦЕПТУРНЫХ ЛЕКАРСТВ В УКРАИНЕ

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Ключевые слова: рецептурный отпуск; безрецептурный отпуск; реализация лекарств; методы математической статистики

Указано на нарушение четкого порядка выписывания рецептов врачами и рецептурного отпуска лекарств из аптек в Украине. Отмечено, что установление основных тенденций продаж рецептурных и безрецептурных лекарств из отечественных аптечных учреждений является одним из актуальных направлений современной медицины и фармации. За результатами анализа фармацевтического рынка установлено, что сегодня практически отсутствуют методики определения тенденций реализации лекарств с использованием методов математической статистики. Предложена методика установления трендов реализации рецептурных и безрецептурных лекарств в Украине и регионах, по результатам применения которой установлено, что в Украине в целом в большинстве регионов страны наблюдается тенденция к снижению уровня реализации лекарств. Вместе с тем для безрецептурных препаратов повышение уровня продаж наблюдается в Днепропетровской, Донецкой, Житомирской, Запорожской, Киевской, Кіровоградской, Одесской и Харьковской областях. Для рецептурных препаратов повышение уровня продаж имеет место в Донецкой и Житомирской областях. Предложенные модели регрессии могут эффективно использоваться для решения задач прогнозирования и анализа показателей реализации лекарств. Результаты корреляционного анализа свидетельствуют о наличии значительной позитивной зависимости между числом амбулаторных посещений и уровнем дохода, между занятостью коек и уровнем продаж рецептурных препаратов, а также между уровнем дохода и числом продаж препаратов по рецептам.