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MEDICATION MARKET PERFORMANCE ANALYSIS WITH HELP OF ANALYTIC HIERARCHY PROCESSING

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Abstract. This study proposes the concept of Analytic Hierarchy Processing (AHP) on the market of active substances used in treatment of HIV and checks the control factors and criteria interconnection and implements Random Forest forecasting model. The new method must help to improve the management decision-making process in the fields of healthcare government budget planning. It has become a prime concern for understanding and comparing of publicly available information with internal market data and the consequences of companies` and government`s actions in choosing the best approach for correct construction of to reduce HIV incidence in Russia. The paper develops the forecasting model of one of the parameters, which has a substantial role in decision-making process. The medication market data in this study represents the cumulative daily concluded contracts, used in treatment of HIV in Russia, the level of HIV incidence (yearly) and federal budget on healthcare (yearly). The proposed approach have more than 82% average accuracy at predicting the sum of medication contract prices at the 3-year time period. The received figures are effective in predicting the factors` behavior in future. It can be used for improved modulation of AHP and consequently, the overall accuracy of the model structure.

Keywords: medical contract prices analysis; multy criteria decision making; machine learning approach; innovations; healthcare management; HIV; Russia

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JEL Classification: D40, I11, I18

1. Introduction

Medication market sustainability is a permanent concern of any society as it is a crucial part of its wellbeing. The changes in the development of this market is influenced by political, economic, social, technological, legal and environmental factors and can have drastic outcomes in the short and long run.

The main objective of the government and society as a whole is proposedly a reduction in new HIV cases in the country, increasing market activity and accessibility of medical treatment. Obviously, it is very hard to achieve all of the above by one drastic policy change. Following the theory of Multi Criteria Decision Making (MCDM) and Analytical Hierarchy Processing (AHP) in particular, the main groups of actors in achieving this goal are:

society – actor, which goal is less infected people;
government – actor, which goal is increasing business activity and reducing prices;
private companies (suppliers/vendors) – actors, which goal is to increase profits.

The composition of control factors is the same as one of the data: the federal budget spending on healthcare, HIV incidence and concluded contract prices for 32 selected INNs.

The dynamics of HIV spread rate should be reflected by the government spending, subsequently affecting the number of concluded contracts in the related medical supply.

This paper not only proposes the concept of AHP on the market of active substances used in treatment of HIV, but also checks the control factors and criteria interconnection and implements Random Forest forecasting model for one of them, enabling the ability for preemptive actions at regulating and achieving one or several objective parameters, mentioned earlier.

2. Literature review

The problem of exploiting powerful multiple criteria decision making approaches is indispensable for healthcare organizations while evaluating different alternatives in the presence of varying types of criteria like many researchers wrote for industry and for banking sector (Kucukaltan, 2016; Akyıldız, 2015, Onar, 2019; Gul, 2018).

Some of the existing papers, regarding government spending, are focused on the hospital performance metrics (Kumar et al., 2019; Chang et al., 2015; Lee et al., 2019) or regional statistics (Belton and Stewart, 2002; Edmonds et al., 2019; Kruger et al., 2019) which partially influenced our study. Most of the authors were focused on predicting mortality rates compared with government spending, improving healthcare benefits and patient treatment, inequality of services or other related concerns, using advanced statistic technics and neural networks.

The topic of HIV was broadly discussed in multiple studies, including government spending (Beyrer et al., 2017; Haakenstad et al. 2019). It was also reported that Russian Federation has the largest HIV epidemic in Europe (Stuikyte et al., 2019). The current strategy of Russian government is well described in paper (Nyangarika et al., 2018).

The virus itself, its spread rate, health and economic impact was discussed numerous times by many researchers. Some of their works were used by authors to understand the threat and regional situation (Lebedev et al., 2019; Vetrova et al., 2018; King et al., 2019; Pape, 2018). We also looked at the potential active substances used in the treatment of HIV in Russia (Tremblay et al., 2018).

The paper used solutions from several reliable studies of MCDM application for different sectors and cases (Sabaei et al., 2015). There were also researches, concentrated on the evaluation of different methods of MCDM, which guided this study to the strategy applied (Asadabadi et al., 2019). To create a general understanding of the MCDM in healthcare and hospital sector we analyzed the existing literature related to the AHP (Schmidt et al., 2015). Subsequently, we used methods and proposals in application of AHP in the selected sector (Padilla-

Garrido et al., 2014). One of the researches was also considering the local government spending the country, but it covered the healthcare infrastructure (Kharisma et al., 2019; Mitsek, 2015). Despite that, some of the AHP methods from that paper were partially applied in this study.

In our study, we use Random Forest algorithm as one the most recent decision tree classifiers and regression models, which can be used for various tasks (Browne, 2000; Mikhaylov et al, 2018). Its functionality is used to forecast future values of sum of contract prices (Nyangarika et al., 2019b; Nyangarika et al., 2019a).

There are numerous works, which describe multiple approaches at treating the time-series data using neural networks and, in particular, Random Forest algorithm (Pavlyshenko, 2019; Dingli and Fournier, 2017). But those are mostly concentrated on the publicly available data of trading stock prices or sales, rather than prices of contracts.

The Random Forest or boosting algorithm weren't that popular, but still has some respectful and significant works, which included time-series forecasting and data mining (Lohrmann and Luukka, 2018; Singh Maini and Govinda, 2017; An et al., 2019a; An et al., 2019b; An et al., 2019c; An et al., 2020a).

The authors of this study see AHP techniques and statistical data as an opportunity to accurately predict and advise the future government healthcare spending in regards of HIV treatment.

3. Methods

Data sources

This study is based on the public data provided by Russian Federal State Statistic Service (Rosstat), Ministry of Finance of the Russian Federation and World Health Organization (WHO) via open source. The statistics, related to the internal market situation is granted by Cursor Marketing Ltd. (www.cursor-is.ru). Official government reports of Rosstat and Ministry of Healthcare of the Russian Federation has recently boosted the media activity, regarding increasing HIV incidence in Russia (Holt, 2019; Beyrer et al., 2017; Stuikyte et al., 2019).

In 2018 the federal budget expenditure on healthcare was equal to 537,3 billion RUB (www.minfin.ru) or 7,73 billion USD, as of exchange rate on 30 Dec 2018 (www.cbr.ru). The government spending on healthcare has increased since 2008, but it is still not the highest in reported years. These statistics are ought to represent the active measurements, taken by the Russian government, to prevent or at least slow down the spread of HIV infection in the country.

We included recent statistic concerning overall HIV infected people, Federal budget healthcare spending and the daily contract prices in Russia since Oct 2008 till Feb 2019. This time span was chosen as maximum available for internal market information, thus limiting the number of observations to this period. For the purpose of this study, we use the data only till 31 Dec 2018 in the general analysis and the rest is implemented into the model`s train and test sets (Mikhaylov, 2018a; Mikhaylov, 2018b; Mikhaylov et al., 2020; An et al, 2020b).

Data structure and statistical analysis

The Federal budget spending is presented in yearly format, as is HIV incidences statistics. We used this data for brief overview and comparison of market and government data.

The medical treatment of HIV is a complex task (Lebedev et al., 2019; Vetrova et al., 2018; Tremblay et al., 2018; Mikhaylov, 2019), thus we gathered the information, referencing to the 32 INNs and their supplements, which were mentioned as the part of the supply order in the documentation of the concluded contracts. These can be found in the list below:

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1.	Abacavirum	17.	Maravirocum
2.	Amprenavirum	18.	Natriinucleospermas
3.	Atazanavirum	19.	Nelfinavirum
4.	Darunavirum	20.	Nevirapinum
5.	Didanosinum	21.	Phosphazidum
6.	Dolutegravirum	22.	Raltegravirum
7.	Doravirine	23.	Rilpivirinum
8.	Efavirenzum	24.	Ritonavirum
9.	Elsulfavirinum	25.	Saquinavirum
10.	Emtricitabinum	26.	Stavudinum
11.	Enfuvirtidum	27.	Tenofovirum
12.	Etravirinum	28.	Tipranavirum
13.	Fosamprenavirum	29.	Treonil
14.	Indinavirum	30.	Valgancyclovirum
15.	Lamivudinum	31.	Zalcitabinum
16.	Lopinavirum	32.	Zidovudinum

Furthermore, the study concentrates on the current and historical market situation, related to the INNs mentioned above. This includes region, client, vendor, provider, INN and price of the contract analysis, either overall for the chosen period or top 10 positions yearly.

The paper uses the base method of AHP, proposed by (Saaty, 1987) to establish base connections between goal and factors and come up with possible solutions to the established objective. See figure 1.

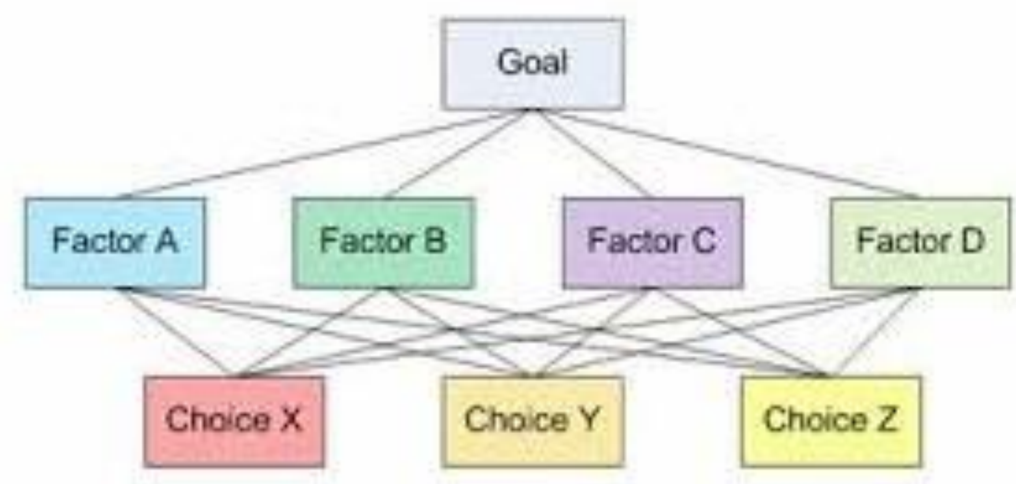

Figure 1. Structure of AHP method

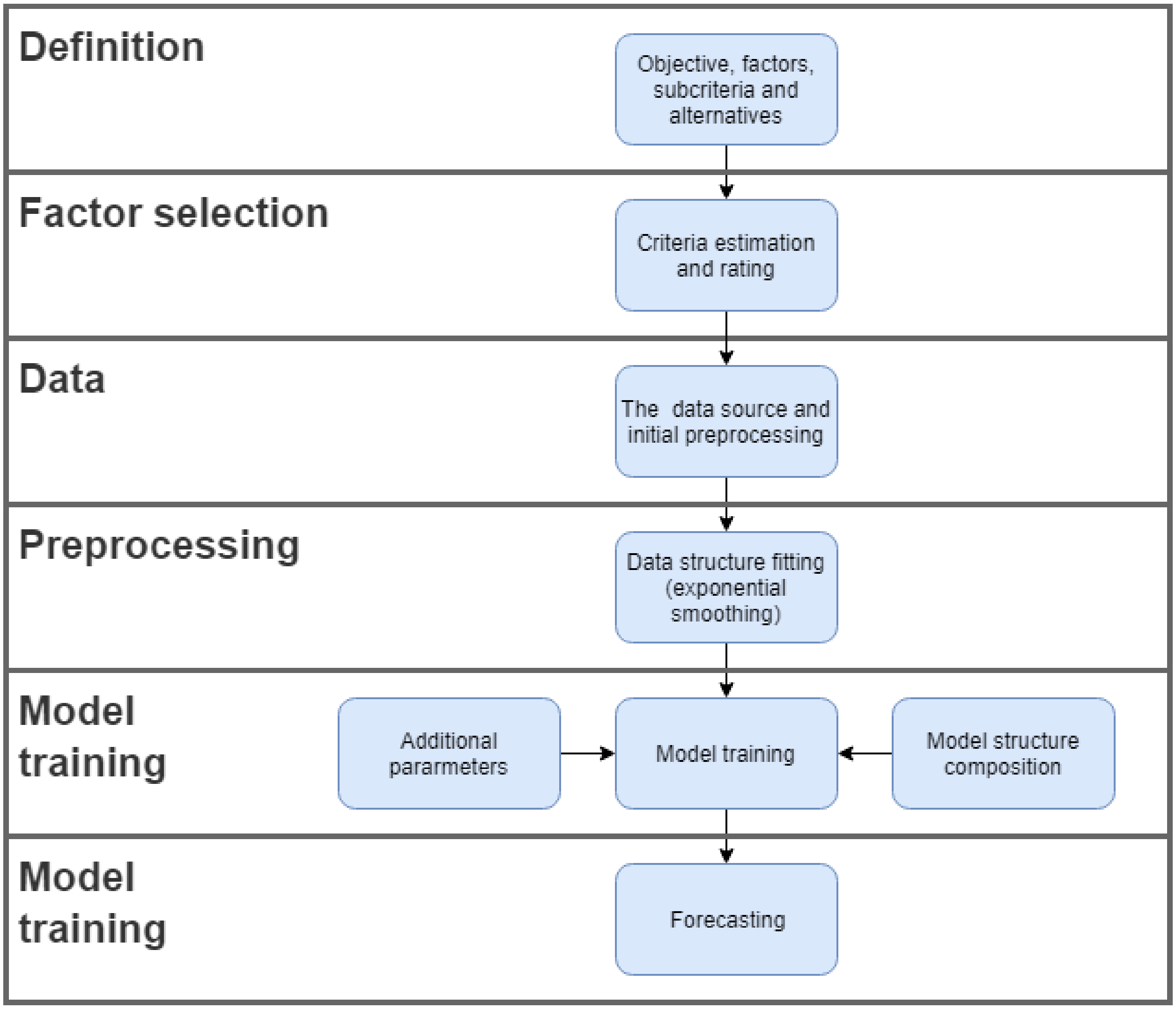

Figure 2. Proposed preprocessing methodology

These methods help to evaluate the factors, which is necessary for reaching the final goal of improving the healthcare procedures and financial planning of government spending, concerning HIV incidence in Russia. By using the AHP, we analyze the significance of each factor and propose the best strategy of resolving the issue, based on the statistics and graphics acquired. See fifure 2.

For this purpose, we also implemented Random Forest regression model for forecasting of concluded contract prices. The source data consisted of final contract price and sum of positions in the particular tender. We used sum of positions as the base of calculations for each INN in contract if possible. Otherwise, the duplicated final price for each INN of the contract was divided by its amount and price of supplied medicine, according to the info, provided in the document. The data also contained some duplicated companies, excluding subsidiaries. Those were replaced by the original full name of the legal entity as of 01 Sep 2019.

Finally, we sorted and combined the data for each year into one table. But the initial figures were incomplete, regarding every day observation, thus creating inconsistency with zero or non-existent values and preventing algorithm from processing it properly. It was decided to use a widely accepted method of simple exponential

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smoothing to deal with highly convoluted data (Ostertagová et al., 2012). The data preparation for the Random Forest model was as follows. In order to achieve confident results, we added Moving average, Exponential Moving Average and the raw data values. This decision was based on the experimental results of this study and others (Gao et al, 2018), concerning predicting future values of the time series.

$$\text{Moving Average} = \frac{A_1+A_2+\cdots+A_n}{n} \quad (1)$$

where:
A_n – average
n = 30

$$\text{Exponential Moving Average}_t = \alpha \times P_t + (1-\alpha) \times EMA_{t-1} \quad (2)$$

where:
α – weight coefficient (from 0 to 1)
EMA_{t-1} – value of EMA mean for the time period (t-1)
t = 30

$$\text{Pearson`s correlation coefficient} = \frac{N\sum xy-(\sum x)(\sum y)}{\sqrt{[N\sum x^2-(\sum x)^2][N\sum y^2-(\sum y)^2]}} \quad (3)$$

where:
N = number of pairs of scopes
$\sum xy$ = sum of the products of scores
$\sum x$ = sum of x scores
$\sum y$ = sum of y scores
$\sum x^2$ = sum of x scores
$\sum y^2$ = sum of y scores

Data preparation and handling is entirely conducted in Microsoft Office Excel (Microsoft Corp.), Python 3.6 (Python Software Foundation), with the following packages: numpy (Zavadskas et al., 2014), matplotlib (Liberatore, 2008) and pandas (Kinney, 2010). We make use of Scikit-learn (Lee and He, 2019) for the random forest regression model.

Prediction algorithm

Random Forest algorithm is a combination of tree predictors such that each tree depends on the values of a random vector sampled independently and with the same distribution for all trees in the forest. We make use of the method presented in the paper (Khaidem, 2016).

Considering numerical part of the experiment, we followed the (Krauss et al. 2017), whose method guarantees the generalization and accuracy of the prediction model. For the proper model setting we create two sets of data: training and test. First consist of 80% of historical data, the second – the 20%. The overall amount of days is 3793 and all of them are used in predicting the future parameters.

As mentioned above, we make use of Random forest regression model with bootstrap aggregation. By using the training data, it performs the following procedure (Khaidem, 2016):

1. Selects each group of subsamples in N training set.
2. Creates a random-forest tree R_n to the bootstrapped data until the minimum node size is reached, repeating the following steps:
   a. Selects u variables at random from the U set of all variables.
   b. Chooses the best variable from u.
   c. Splits the node into to new nodes.
3. Output the ensemble of Rn
4. In order to make a prediction of the given test data at each point in the future it averages the output:

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$$F` = \frac{1}{B}\sum_{i=1}^{B} Fi(x) \quad (4)$$

For the measurements of the model validity, we utilize train and test accuracy score, Oob-score and cross-validation score, provided by base metrics of scikit-learn. Subsequently, the first one gives an approximation of how well the model is trained, whether it is overfitting or not and its forecasting accuracy. The Oob-score is specific to the Random Forest algorithm. The main base of the random forest is a bootstrap aggregation, which helps to improve the stability and accuracy of the machine learning technics. It also helps to avoid or reduce overfitting and works especially well with decision trees. In this paper for regression, we simply fit the same regression tree many times to bootstrap sampled versions of the training data, thus creating a large amount of end points and average the result (Carayannis, 2018; Dayong et al., 2020; Denisova et al., 2019; Dooyum et al., 2020).

Finally, k-fold cross-validation is a resampling procedure used to evaluate machine learning models on a limited data sample (Browne, 2000; Mikhaylov, 2015). This study uses base 3-fold random data shuffle, in order to evaluate the model.

4. Results

Federal budget analysis and HIV incidence in Russia

The overall spending (Table 1) has increased through the time period of the study in rubles, but its peak was in 2012. Since then, the figure below demonstrates the stable downwards trend, with last specific increase in 2018. Unfortunately, publicly available data does not represent the division by sectors of medical supply, thus unable to provide more than general apprehension.

Table 1. Federal budget spending on healthcare for the studying time period in RUB and USD based on the exchange rates of 01 Jan 2008.

Healthcare budget spending	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Billions/RUB	278,2	352,3	347,4	499,6	613,8	502,0	535,5	516,0	506,3	439,8	537,3
Billions/USD	11,3	14,4	14,2	20,4	25,0	20,5	21,8	21,0	20,6	17,9	21,9

Source: Russian Federal State Statistic Service (Rosstat) https://www.gks.ru/

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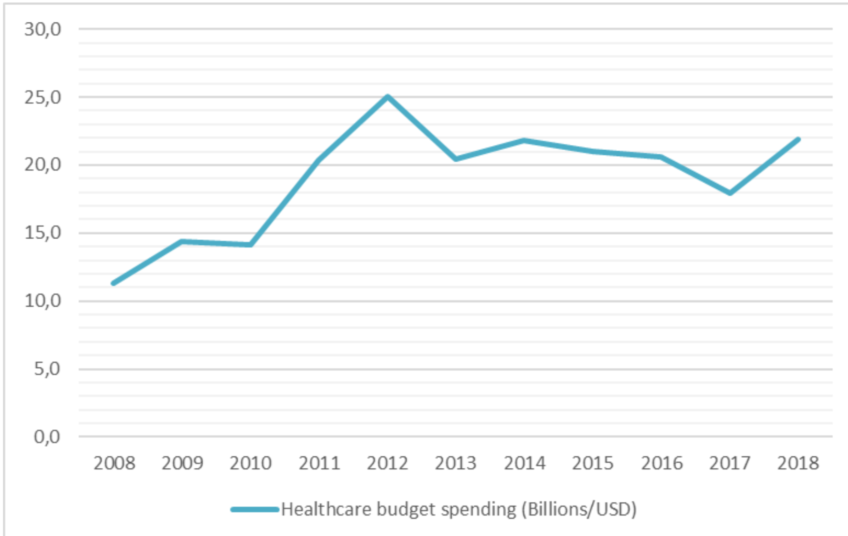

Figure 3. Federal budget spending on healthcare for the studying time period in USD, based on the exchange rates of 01 Jan 2008. Graphical representation.

These tendencies are most possibly due to the current long-term economic recession in Russian Federation caused by multiple factors (Eberhardt et al., 2015; Viktorov and Abramov, 2019) alongside with government budget policy (Stepanovich, 2018; An et al., 2019; Nyangarika et al., 2019). See figure 2.

To better understand the situation with HIV incidences in Russia we gathered the publicly available statistics, including worldwide. The overall amount of infected people in the world is steadily increasing with each year. Nevertheless, this rate is still lower than the one in Russia, as shows Figure 4 and Table 2.

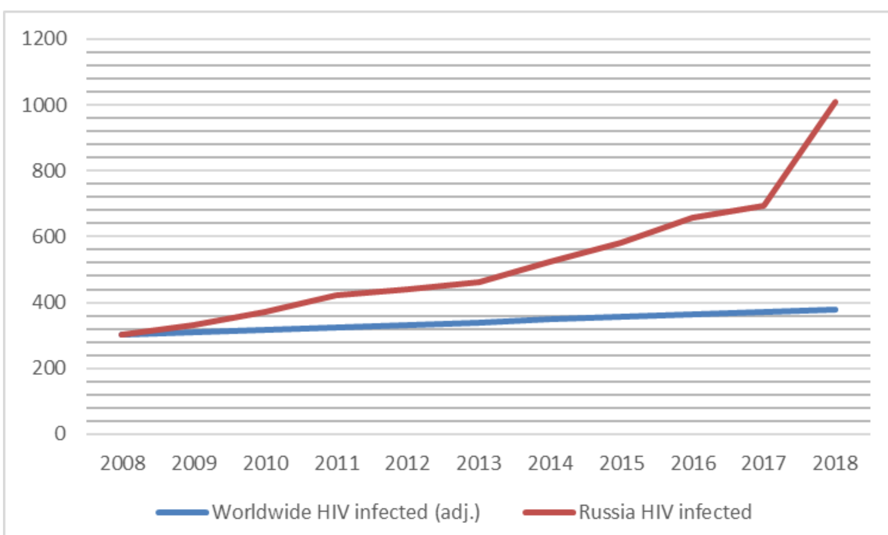

Figure 4. Overall number of HIV infected people among all age groups

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Table 2. Overall number of HIV infected people among all age groups, including newly infected.

Prameter/Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Worldwide infected (th. People)	30200	30900	31700	32400	33200	34000	34800	35600	36400	37200	37900
Worldwide newly infected (th. People)	2200	2100	2100	2000	2000	1900	1900	1900	1800	1800	1700
HIV infected in Russia (th. People)	301,3	332,9	372,9	422,3	438,4	463,3	522,6	581,7	658,1	693,1	1007,36
Newly HIV infected in Russia (th. People)	44,1	50,7	57,2	59,6	59,7	63,6	73,5	87,3	86,9	85,8	101,34

Source: Russian Federal State Statistic Service (Rosstat) https://www.gks.ru/

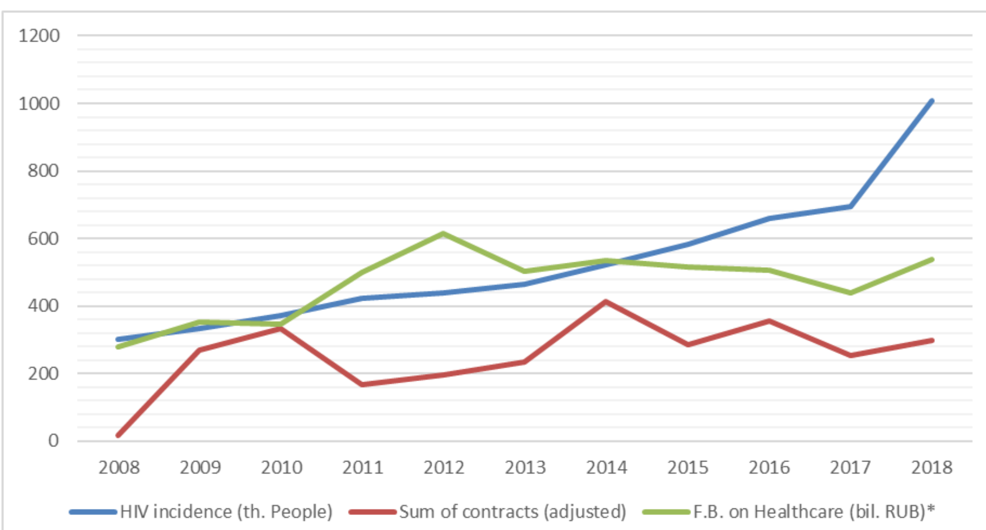
Unfortunately, this study does not aim at finding the causation of such drastic changes in figures. But this trend might affect the demand for the selected INNs and medical treatment, increasing government spending and thus inflating the number of concluded contracts and their prices per year (Gura et al., 2020).

Market overview: leading positions

This section of the study will cover the internal market data considering prices of concluded contracts between private or government owned suppliers and state clients and medical facilities, concerning 32 INN. It is worth noting, that the factor divisions, presented in this section, might play a role in the overall AHP for the established goal, mentioned earlier.

The sum of contract prices shows the clear increase since 2008 and especially in 2014 – 2018. This may indicate the general concern and subsequent response of the government officials on the rise of HIV incidence. Although on the figure 5, we can see that peaks in federal budget spending are different from the ones of contract prices. This is most possibly due to the fact that healthcare government spending has its own division of spending budgets per each subsequent region, medical organization and group of medical supplies.

Figure 5. The sum of contract prices of selected INNs for the time period of the study.



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The government spending on selected INNs is better visualized by the comparison of adjusted contract prices and amount of HIV infected people in figure 6. Nevertheless, the figures also indicate slight decrease in sum of contract prices after 2014. This phenomenon might be caused by several factors, including economic crisis, change in internal government policy or any other.

Via this graph we also can see that there is no definitive effect of unadjusted sum of contract prices on the dynamic of HIV spread. It is also may be confirmed by low correlation between these two dataset: Pearson correlation coefficient (PCC) = 0,4152. Taking this into consideration, we can say that current number of concluded contracts on selected set of HIV related medication does not represent the trend of HIV incidence in Russia, assuming data completeness and fairness of tender auctions. But it almost fits the dynamics of federal budget spending on healthcare overall.

Furthermore, the correlation coefficient of official government spending and sum of concluded contracts is 0,3847. Finally, the PCC of HIV incidence and federal budget on healthcare is 0,495. The results conclude that there is a lack of strong positive connection between these three control criteria. Nevertheless, the 2018 data point visually shows that government has started to react on the issue. We propose further increase in the government spending on these INNs and possible price reduction of tenders, lowering the market barriers for new participants. This should play an important role in increasing of accessibility of the medical care, but would possibly decrease profits of big private companies, as will be described further (Table 3).

Table 3. The comparison of HIV incidence, adjusted sum of contract prices and federal budget spending on healthcare in Russia. *F.B.S. – short for Federal Budget Spending.

Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
HIV incidence (th. People)	301,3	332,9	372,9	422,3	438,4	463,3	522,6	581,7	658,1	693,1	1007,37
Sum of contracts (bil. RUB)	1688,15	26955,6	33314,1	16589,3	19614,9	23549,9	41281,2	28683,8	35739,5	25498,3	29797,9
F.B.S.* on Healthcare (bil. RUB)	278,2	352,3	347,4	499,551	613,823	501,979	535,535	515,985	506,337	439,846	537,312

Source: Russian Federal State Statistic Service (Rosstat) https://www.gks.ru/

This study does not concentrate on the effects of INNs on the medical treatment of HIV, but we analyzed the total proportion of each active substance in terms of total contract prices for the whole observed time period.

These INNs might be widely used or have a high buying price or both. This effect might also indicate the popularity of the medical treatment strategies, which include these types of active substances. Unfortunately, our observations lack sufficient amount of timely data to make better, more definitive conclusions about this particular detail of the market.

Nevertheless, we also analyzed the suppliers, which won and, subsequently, completed the contract with one or multiple medical institutions and government agencies. According to the collected data, the R-Pharm group holds a leading position as a main winner of government tenders and supplier of medical substances in Russia for the duration of studying period. Yet, even in top 10 suppliers we can see in Table 4 some companies stopping their operations on the Russian market in the field of HIV medical treatment, during the same time frame. JSC Empire-Pharma has declared bankruptcy in 2015, also being brought into multiple juridical suits (www.dp.ru).

Table 4. The statistics of contract winners for selected INNs in Russia (th. RUB).

Year/Company	R-Pharm Group	Pharmstandard	Multiple winners	Cosmopharm Ltd	Empire-Pharma	Pharmimex	Biotech Ltd	Irvin 2 Ltd	Rosta
2009	3186264	-	-	6555	3120023	-	1332964	1797456	1930895
2010	3030451	11289	-	6270	4710235	-	240036	2151872	1251674
2011	5919673	1764625	-	12693	0	-	109055	22524	345356
2012	7960662	2633948	-	-	1861	915945	-	-	-
2013	8733644	2290311	0	1643645	3	1897211	-	61783	1284
2014	9362010	2181228	3792204	1711123	11254	1448387	-	225383	1410346
2015	9414030	1382173	4151813	1728363	-	1467914	0	146518	128786
2016	10262806	2000997	5835953	2022340	-	866766	1013741	18903	-
2017	13747741	3548231	515135	2119840	-	751043	2064063	506833	-
2018	13226211	4501009	917360	612893	-	26860	1025436	335604	-
Total	84843492	20313811	15212464	9863722	7843375	7374126	5785296	5266876	5152605

Source: Russian Federal State Statistic Service (Rosstat) https://www.gks.ru/

If we look closely at the government contractors, who act on the side of the client – the biggest share possesses the Ministry of Healthcare of Russian Federation, closely followed by the Ministry of Healthcare of Moscow region and multiple customers. This definition may combine from several to hundreds of government and partially government controlled organizations. It is used in the official contract documentation, thus unable being avoided. Consequently, we can observe the trend of increasing dominance of the Ministry of Healthcare in the recent years, but a period of 2013 – 2015 is confirming the statement, mentioned above, about the short term change of the governmental policy to diversify some of the spending from big market players in this particular time period.

We also can say that the local healthcare institutions statistics is similar to the high level of reported HIV incidence in the region, especially in Rostov, Sverdlovskiy, Chelyabinsk and Krasnodar region (Beyrer et al., 2017).

For example, we can assume that the companies, which operate in the region with the highest incidence are receiving bigger portion of federal budget, thus able to spend more than other government institutions in other regions. The Table 6 clearly indicates a trend of the government response on the current situation. In addition to that, the spending of the central regions, such as Moscow is increased, because there are concentrated many health organizations, hospitals and AIDS hospices, working country-wise (Nie et al., 2020).

Finally, for this section we shall look at the vendors of the study selected INNs and give a small inquiry about the market situation. To our regret, the publicly available information, relating to the structure of import and export of medical supplies in Russia is mostly unavailable for the observed companies. But the existing data shows that one of the biggest pharmaceutical corporations in the world are playing a very important role on the medication market, concerning HIV treatment in Russia.

The findings in this paper are highly related to the field of MCDM and AHP. The study describes an empirical research, concerning the application of AHP in the sphere of medication market using the HIV incidence related statistics and demonstrates the improvement of AHP concept by applying the Random Forest regression model for forecasting of one of the factors. Thus showing the positive results for potential adaptation of such tool in future studies (Lopatin, 2020; Lopatin, 2019).

The paper developed the concepts of exploiting powerful multiple criteria decision-making approaches (Kucukaltan, 2016; Akyıldız, 2015, Onar, 2019; Gul, 2018; Mutalimov et al., 2020). It evaluate different alternatives in the presence of varying types of criteria such as: HIV spread rate, government spending, and the number of concluded contracts.

The paper also check the applicability of MCDM for Russian health care sector like foreign researchers (Sabaei et al., 2015). The paper did not develop the study about the applied strategy (Asadabadi et al., 2019; Schmidt et al., 2015). However, It used methods in application of AHP in the healthcare sector like Padilla-Garrido et al. (2014). We covered the healthcare infrastructure of Russian economy like the one It was done for Java region in Indonesia (Kharisma et al., 2019) and regions of Russia (Mitsek, 2015).

In addition, the paper developed the recent decision tree classifiers and regression models (Browne, 2000), which can be used for forecast future values of sum of contract prices (Litvishko and Litvishko, 2019; Litvishko et al., 2019a; Litvishko et al., 2019b).

The paper use new data sources and transforms the traditional approach focused on the hospital performance metrics (Kumar et al., 2019; Chang et al., 2015; Lee et al., 2019; Mikhaylov and Sokolinskaya, 2019; Mikhaylov et al., 2019; Mikhaylov, 2020) or regional statistics (Belton and Stewart, 2002; Edmonds et al., 2019; Kruger et al., 2019).

The research proved the ideas about the government spending (Beyrer et al., 2017; Haakenstad et al. 2019) and support position Stuikyte et al. (2019) about dangerous HIV situation in Russia and largest HIV epidemic in Europe (Alwaelya et al., 2020; Yumashev and Mikhaylov, 2020).

In the future research we recommend to understand the threat and regional situation and develop the direction of international researchers (Lebedev et al., 2019; Vetrova et al., 2018; King et al., 2019; Pape, 2018). We also contributed the analysis of the treatment of HIV in Russia by Tremblay et al. (2018).

5. Conclusion

The current spread of HIV incidence in Russia is increasing (Holt, 2019). The cause of the problem may lie in the field of economic problems and low rate of economic growth (Eberhardt, and Menkiszak, 2015). The recent years saw the decline in government budget spending on healthcare, thus affecting the situation in negative way. The identification of the specific factors, their influence and future trends, might help to develop new management decision making strategies, regarding the issue.

To evaluate these economic factors, we used the methods of MCDM model (AHP), graphical and regression analysis in the form of Random Forest models and correlation coefficients. We identified the possible alternative decision strategies for improving the healthcare budget spending, which should help to potentially bring to a halt or even reduce the HIV incidence in Russia. Furthermore, we made a prediction model to forecast future real market values for concluded contracts of the selected medication, used in the treatment of HIV.

The current studies show the potential for MCDM techniques in local regions, using public data (Schmidt et al., 2015). This paper proposes the same methods, bur at much bigger scale with additional tools, like Random Forest regression.

If we look at the data representing actual regional HIV incidence in Russia, it is clear that there is a partial similarity of affected regions between our results and conclusions of other authors (Beyrer et al., 2017;

Haakenstad et al. 2019). It was also discovered that there is no strong positive correlation between market data, federal budget spending and HIV spread rate, which, to our knowledge, was not reported in previous studies.

Methods of predicting factors for AHP models with wider data points could potentially lead to improved results in managerial decision making process and thus increase efficiency of government budget spending on healthcare.

Assuming data completeness and fairness of tender auctions, we can say that current number of concluded contracts on selected set of HIV related medication does not represent the trend of HIV incidence in Russia, as are other criteria, thus rendering them to be independent. The proposed concept, regarding AHP with existing data, has shown its effectiveness in developing of strategy for the potential improvement of HIV incidence dynamics, business activity and accessibility of medical care in Russian Federation (Shedenov et al, 2019; Veynberg and Titov, 2017; Veynberg and Popov, 2016; Veynberg et al., 2015; Mikhaylov and Tarakanov, 2020).

Overall situation indicates an increase in government expenses on the supply of the selected INNs in 2017-2018, boosting the activity of market participants in the field of medical tenders. The study concludes that it would be highly efficient to prolong this trend and diversify the amount of participants in the market of government tenders for the selected active substances (Yumashev et al., 2020).

The proposed approach and unique initial data has shown a substantial result of more than 82% average accuracy at predicting the sum of contract prices for the selected INNs at the 3-year time period. The received figures are effective in predicting the factors` behavior in future. It can be used for improved modulation of AHP and consequently, the overall accuracy of the model structure.

The Random Forest model was approved as an efficient tool at forecasting the sum of contract prices in the long-term time scales. This model may be used as a guideline for the suppliers, vendors, society decision makers and government companies, for forecasting of future business activities and reduction of HIV incidence relating to the market of INNs used in its medical treatment or any other group of active substances.

Further studies will concentrate on incorporating other factors into the similar models and development of new approaches of MCDM and Random Forest model combination at the medication market prediction.

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