

УДК 616.32/.345-006.6-018-097:577.152.34

<https://doi.org/10.20538/1682-0363-2018-3-88-95>

For citation: Lazarenko V.A., Antonov A.E., Markapuram V.K., Awad K. Experience of neuronet diagnosis and prediction of peptic ulcer disease by results of risk factors' analysis. *Bulletin of Siberian Medicine*. 2018; 17 (3): 88–95.

Experience of neuronet diagnosis and prediction of peptic ulcer disease by results of risk factor analysis

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ABSTRACT

Aim. To develop and verify a method for diagnosis of peptic ulcer based on neural network analysis of patient risk factors data.

Materials and methods. This article presents the results of a study based on materials on the risk factors of 488 patients. The data was analyzed using internally developed the artificial neural network (Certificate of State Registration of Program for Computers (RU) no. 2017613090).

The results of the study. The proposed approach demonstrated levels of sensitivity of 74.4%, $m = 4.3$ and specificity of 93.3%, $m = 2.46$ during clinical testing.

The prediction of the age of probable hospitalization ensured the generation of an array of data for which the Mean Absolute Error (MAE) of the prognosis was 1.8 years, $m = 0.11$ in the training set and 1.9 years, $m = 0.15$ in the clinical testing set. The maximum of absolute prognosis error in the clinical testing set did not exceed 2.2 at $p = 0.95$ and 2.3 years at $p = 0.99$.

Conclusion. A new method is proposed for diagnosis of peptic ulcer based on a neural network analysis of data on patients' risk factors. During clinical testing of the model, this approach demonstrated Area Under the Curve (AUC) levels reaching 0.943. The use of the artificial neural network also made it possible to predict the age of probable hospitalization. The use of the neural network demonstrated additional advantages including: non-invasiveness, the lack of need to prepare the patient for the study and the possibility to obtain results immediately after the onset of the disease without a time delay for sample processing.

Keywords: artificial neural network; neuronet; multilayer perceptron; diagnosis; diagnostics; peptic ulcer disease; artificial intelligence; prognosis.

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INTRODUCTION

The problem of peptic ulcer remains relevant due to the high incidence, reaching 6–16% of the population, as well as the risk of development of dangerous complications [1]. A common approach to the diagnosis of peptic ulcer is based on assessment of the clinical, laboratory and instrumental data obtained during the examination of the patient. Such a strategy is belated for the purpose of the primary personalized preventive strategy development [2, 3] since it deals with a disease that has already developed and therefore does not meet modern requirements for making competent management decisions [4–6].

At the same time, the risk factors for peptic ulcer are well known. Their list includes sex and age [7–10], heredity [11, 12], social and professional hazards [13, 14], unhealthy diet [7, 14, 15], stresses [8] and also factors associated with unhealthy habits [16] and the intake of ulcerogenic drugs [17]. All these elements act simultaneously before the onset of the disease and can in principle be detected in advance. However, their spectrum is a set of data difficult to structure. They act together and demonstrate implicit interrelations and signs of cobweb causality [18]. Data of such a kind is complex in processing and requires involvement of a wide range of IT and automated control systems [19, 20].

The series of attempts to develop specialized information systems allowing the assessment of risk factors using conventional biostatistical methods had been developed. However, they demonstrated inability to fully solve the problem of developing a personalized preventive strategy because of their inherent fundamental mathematical limitations [21–23]. On the contrary, artificial neural networks (ANNs) have demonstrated opportunities for analyzing difficult data [24, 25], but their potential in this area of medicine is still to be studied.

For the reasons mentioned above, the objective of this study was to develop and verify a method for diagnosis of peptic ulcer based on neural network analysis of data on patients' risk factors.

MATERIALS AND METHODS

The study included 488 patients with pathologies of the hepatopancreatoduodenal zone (including 117 men and 59 women with peptic ul-

cer) undergoing inpatient treatment in the city of Kursk. The mean age of patients with peptic ulcer was 48.1 ($m = 1.23$) years. In the course of the study, we internally developed the "System for the Intellectual Analysis and Diagnosis of Diseases", based on the principle of a multilayer perceptron with hyperbolic tangent used as an activation function [26].

Patients were divided into two groups: those who received treatment before 01 January, 2011 ($n_1 = 385$) and after this date ($n_2 = 103$). The first subgroup comprised 133 patients with peptic ulcer and 252 patients in whom this diagnosis was excluded. The first subgroup was used to train the perceptron. This process was carried out with two types of outputs – qualitative and quantitative. The qualitative one was associated with the presence or absence of the diagnosis (as well as a possible vague outcome) and quantitative represented the age of hospitalization of patients for hepatopancreatoduodenal diseases. The second subgroup comprised 43 people with peptic ulcer and 60 patients with other pathologies (pancreatitis, cholecystitis). It was used to test "System" in practical healthcare field.

The following input parameters were selected as input parameters of perceptron: the age and sex of patients, the risk factors they had: the form and the extent of bad habits, the presence or absence of stress, employment, eating habits and the diet regime [27]. The following perceptron settings were used: the number of hidden layers – 3 and the number of neurons in the hidden layer – 10.

The evaluation of the ANN work quality was carried out using the methods of descriptive and inductive statistics, calculation of sensitivity, specificity, prognosis errors, and Receiver Operating Characteristic (ROC) analysis.

RESULTS AND DISCUSSION

Differences in sets of risk factors in patients with peptic ulcer on the one hand and cholecystitis and pancreatitis on the other allowed to successfully train the network for the recognition of data vectors. The result of the ROC analysis is shown in Fig. 1. The threshold value y_B , defining the interval $(-y_B; y_B)$, within which the output (unadapted) value of the network was interpreted as undefined (vague), was assumed to be 0. That is, all output values of the network were treated as true or false – the presence or absence of peptic ulcer [28].

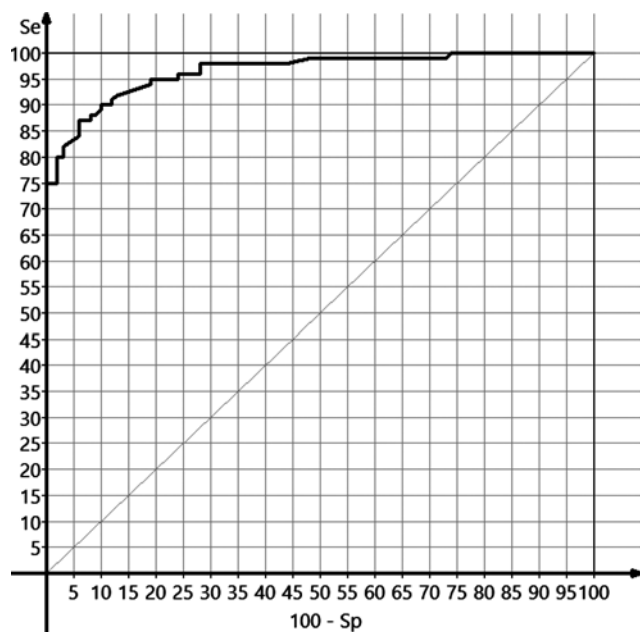


Fig. 1. Results of ROC-analysis for training set at border value $y_b = 0$.

The value of the AUC of the presented graph for the training set equaled to 0.966. For the clinical testing group, the result of ROC analysis is shown in Fig. 2. The AUC for this group was 0.943. Decrease in the AUC can be explained by the variations of risk factors' influence on the development of peptic ulcer and proves the necessity to dynamically update the information on risk factors. Nevertheless, the quality of the mathematical model for recognizing the data vectors in the training set and in the clinical testing group remains high.

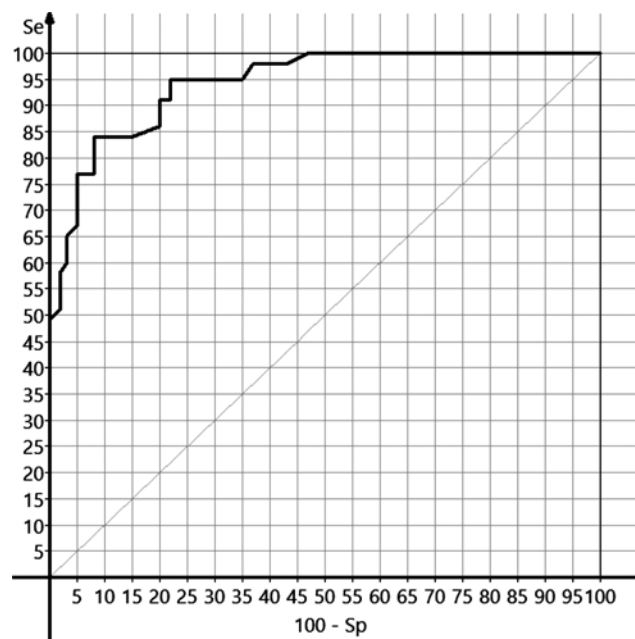


Fig. 2. Results of ROC-analysis for clinical approximation set at border value $y_b = 0$.

As can be seen from data presented in Table 1, the network successfully coped with the task of distinguishing the disease based on an analysis of risk factors' spectrum. The sensitivity and specificity indicators were at the level of conventional diagnostic methods. In general, the results of clinical testing are expectedly slightly inferior to the results shown by the data from the training set. This can also be explained by the dynamics of risk factors over time. The results show no signs of network's overtraining.

Table 1

The results of training and clinical testing of the "System of Intellectual Analysis and Diagnosis of Diseases" in the diagnosis of peptic ulcer.		
Characteristic	Training set, $n = 385$	Clinical testing, $n = 103$
Sensitivity (+/+)	88,0 (1,66)	74,4 (4,30)
False negative rate (-/+)	10,5 (1,56)	23,3(4,16)
Specificity (-/-)	90,1 (1,52)	93,3 (2,46)
False positive rate (+/-)	7,9 (1,38)	5,0 (2,15)
Total: confirmed peptic ulcer ($n = 176$), cases	133	43
excluded peptic ulcer ($n = 312$), cases	252	60

The results for quality assessment of predicting the age of probable hospitalization are presented in Table 2. The MAE of the predicted age was calculated as the absolute of the difference between the estimated and empiric values. This indicator did not exceed 1.9 years for the clinical testing group. For the training set it was lower.

The percentiles p_{95} and p_{99} were determined for the maximum prediction error. Just like for diagnostic model, the forecast of the quantitative indicator was more accurate for the training set. Nevertheless, during the clinical test, the ANN demonstrated the absolute error of the hospitalization age not exceeding 2.3 at probability level of $p = 0.99$.

Table 2

The results of training and clinical testing of the multilayer perceptron in predicting the age of probable hospitalization

Characteristic	Training set ($n = 133$)	Clinical approbation ($n = 43$)
Mean of the empiric age (M_y), years	47.3	50.7
Its Standard Error (m_y), years	1.41	2.51
Mean of the estimated age (M_t), years	47.5	49.2
Its Standard Error (m_t), years	1.41	2.42
Mean Error (ME), years	-0.2	1.5
Mean Squared Error (MSE), years ²	4.6	4.6
Mean Absolute Error (MAE), years	1.8	1.9
Its Standard Error (m_{MAE}), years	0.11	0.15
The error of the prognosis will exceed (percentile p_{95}), years	1.95	2.15
The error of the prognosis will exceed (percentile p_{99}), years	2.02	2.25
Mean Percentage Absolute Error (MPAE), %	4.3	4.1
Mean Percentage Error (MPE), %	-0.6	2.4

In addition, it should be noted that the neural network could be executed on non-specialized, personal computers. The application has low hardware requirements at the stage of practical application. The use of the "System of Intellectual Analysis and Diagnosis of Diseases" could be performed by a health care provider having no special additional training. The use of ANN also demonstrated additional advantages: no need to prepare the patient for the study, the possibility of obtaining results immediately after the onset of the disease (and in principle before the moment) and the absence of time delay for processing the material. The investigation was non-invasive.

CONCLUSIONS

1. A new method for diagnosing peptic ulcer is suggested. It is based on a neural network analysis of data on patients' risk factors. During the clinical testing, this approach demonstrated

sensitivity levels of 74.4%, $m = 4.3$ and specificity 93.3%, $m = 2.46$. The AUC indicator reached .943.

2. The prediction of the age of probable hospitalization of patients with peptic ulcer using the neural network analysis demonstrated the MAE of the forecast equal to 1.8 years, $m = 0.11$ for the training set and 1.9 years, $m = 0.15$ for the clinical testing group. The absolute error of the forecast in the clinical testing group would or did not exceed 2.2 at $p = 0.95$ and 2.3 years at $p = 0.99$, respectively.

CONFLICT OF INTEREST

The authors declare the absence of obvious and potential conflicts of interest related to the publication of this article.

SOURCE OF FINANCING

The authors state that there is no funding.

COMPLIANCE WITH THE PRINCIPLES OF ETHICS

The research corresponds to ethical standards developed in accordance with the World Medical Association Declaration

of Helsinki "Ethical Principles for Medical Research Involving Human Subjects" as amended in 2000 and the "Rules of Clinical Practice in the Russian Federation" approved by the Order of the Ministry of Health of the Russian Federation on June 19, 2003. no. 266. Informed consent was obtained from the persons participating in the study.

REFERENCES

- Антонов А.Е., Лазаренко В.А., Новомлинец Ю.П. Хирургические аспекты условно-радикального лечения осложненной язвенной болезни. *Вестник новых медицинских технологий*. 2006; 13 (3):150-152 [Antonov A.E., Lazarenko V.A., Novomlinites Yu.P. Khirurgicheskie aspekty uslovno-radikal'nogo lecheniya oslozhnennoy yazvennoy bolezni. *Vestnik novykh meditsinskikh tekhnologiy* – *Journal of New Medical Technologies*. 2006; 13 (3):150-152 (in Russ.)].
- Лопухова В.А., Тарасенко И.В., Кореневская Е.В. Исследование демографических процессов: преждевременная смертность и потерянные годы потенциальной жизни населения г. Курчатова. *Современные проблемы науки и образования*. 2017; (2):113. [Lopukhova V.A., Tarasenko I.V., Korenevskaya E.V. Research of demographic processes: premature mortality and potential years of life lost of the population Kurchatov-city. *Sovremennye problemy nauki i obrazovaniya* – *Modern problems of science and education*. 2017; (2):113. (in Russ.)].
- Кайланич Г.А., Лопухова В.А., Кайланич Е.А., Тарасенко И.В. Оценка качества стационарной медицинской помощи на основании формализованного интервью населения города Орла. *Современные проблемы науки и образования*. 2017; (2):5. [Kaylanich G.A., Lopukhova V.A., Kaylanich E.A., Tarasenko I.V. Quality assessment of hospital care based on the formalized interview of the population Orel-city. *Sovremennye problemy nauki i obrazovaniya* – *Modern problems of science and education*. 2017; (2):5. (in Russ.)].
- Светый Л.И., Лопухова В.А., Тарасенко И.В., Климин А.С. Применение системы оценки технологий здравоохранения в принятии эффективных управленческих решений. *Журнал научных статей Здоровье и образование в XXI веке*. 2013; 15(1-4): 234-235. [Svetyu L.I., Lopukhova V.A., Tarasenko I.V., Klimkin A.S. The use of health technology assessment in making effective management decisions. *Zhurnal nauchnykh statej Zdorov'e i obrazovanie v XXI veke* – *The journal of scientific articles Health and Education Millenium*. 2013; 15 (1-4): 234-235. (In Russ.)].
- Лопухова В.А., Тарасенко И.В., Кайланич Г.А., Кайланич Е.А. Изучение качества внебольничной медицинской помощи в медицинских организациях города Орла. *Современные проблемы науки и образования*. 2016; (5). <http://www.science-education.ru/ru/article/view?id=25383>. (Дата обращения: 28.11.2016). [Lopukhova V.A., Tarasenko I.V., Kaylanich G.A., Kaylanich E.A. The study of outpatient care quality in medical institutions of the Orel-city. *Sovremennye problemy nauki i obrazovaniya* – *Modern problems of science and education*. 2016; (5). <http://www.science-education.ru/ru/article/view?id=25383>. (access date 28.11.2016. (In Russ.)].
- Симонян Р.З., Кайланич Г.А., Лопухова В.А., Тарасенко И.В. Изучение качества медицинской помощи при оценке технологий здравоохранения. *Международный журнал прикладных и фундаментальных исследований*. 2016; (8): 185-187. [Simonyan R.Z., Kailanich G.A., Lopukhova V.A., Tarasenko I.V. The study of medical care quality in the health technology assessment. *Mezhdunarodnyj zhurnal prikladnyh i fundamental'nyh issledovaniy*. 2016; (8): 185-187. (in Russ.)].
- Курамшина О.А., Кофанова Ю.А., Габбасова Л.В., Крюкова А.Я. Факторы риска развития гастродуоденальной патологии, роль образовательных программ в терапевтической коррекции у лиц молодого возраста. *Медицинский вестник Башкортостана*. 2011; 6 (3): 19–23. [Kuramshina O.A., Kofanova Yu.A., Gabbasova L.V., Kryukova A.Ya. Risk factors of gastroduodenal pathology development. educational programmes in therapeutic strategies applied to youth. *Meditsinskiy vestnik Bashkortostana* – *Bashkortostan Medical Journal*. 2011; 6 (3): 19–23. (in Russ.)].
- Сошина А.А., Сергеева В.В., Зиняева Т.В. Особенности клинической картины и прогноз у пациентов, освидетельствованных в бюро медико-социальной экспертизы в связи с язвенной болезнью желудка и двенадцатиперстной кишки. *Казанский медицинский журнал*. 2013; 94(1):124–127. [Soshina A.A., Sergeeva V.V., Zinyayeva T.V. Clinical features and prognosis in patients examined in medical and social expertise bureaus due to peptic ulcer disease. *Kazanskiy meditsinskiy zhurnal* – *Kazan Medical Journal*. 2013; 94(1):124–127. (in Russ.)].
- Малышенко О.С., Белобородова Э.И., Вавилов А.М. Влияние возраста и типа поведения на течение язвенной болезни. *Терапевтический архив*. 2005; (2):28–31. [Malyshenko O.S., Beloborodova E.I., Vavilov A.M. Impact of age and type of behavior on the course of ulcer disease. *Terapevticheskiy arkhiv* – *Therapeutic Archive*. 2005; (2):28–31. (in Russ.)].
- Вахрушев Я.М., Ефремова Л.И., Белова Е.В. Сравнительная характеристика течения язвенной болезни в различные возрастные периоды. *Терапевтический архив*. 2004; (4):15–18. [Vakhrushev Ya.M., Efremova L.I., Belova E.V. Age-related comparative characteristics of ulcer disease course. *Terapevticheskiy arkhiv* – *Therapeutic Archive*. 2004; (4):15–18. (in Russ.)].
- Гребенев А.А., Шептулин А.А. Язвенная болезнь. М.: Медицина, 1995:187 [Grebenev A.L., Sheptulin A.A. Ulcer Disease. Moscow.: Meditsina, 1995:187 (in Russ.)].
- Лопатина В.В. Факторы риска в развитии язвенной болезни. *Здоровье населения и среда обитания*. 2011; (12):16–18. [Lopatina V.V. Risk factors in the

- development of ulcer disease. *Zdorov'e naseleniya i sreda obitaniya*. 2011; (12):16–18. (in Russ.).]
13. Бойцов С.А., Самородская И.В., Третьяков В.В. Градиент смертности населения в возрасте 40–59 лет в субъектах Российской Федерации. *Вестник Российской академии медицинских наук*. 2014; (7):106–111. [Boytsov S.A., Samorodskaya I.V., Tret'yakov V.V. Gradient of mortality of persons aged 40–59 in regions of the Russian Federation. *Vestnik Rossiyskoy akademii meditsinskikh nauk – Annals of the Russian Academy of Medical Sciences*. 2014; (7):106–111. (in Russ.).]
 14. Galea S., Tracy M., Hoggatt K.J., DiMaggio C., Karpati A. Estimated Deaths Attributable to Social Factors in the United States. *Am. J. of Publ. Health*. 2011;101 (8):1456–1465.
 15. Карамнова Н.С., Шальнова С.А., Деев А.Д., Бойцов С.А. Привычки питания, характеризующие уровень сердечно-сосудистого здоровья в российской популяции. Результаты эпидемиологического исследования эссе-РФ. *CardioСоматика*. 2015; (S1):47. [Karamnova N.S., Shal'nova S.A., Deev A.D., Boytsov S.A. Habits of nutrition, characterizing the level of cardiovascular health in the Russian population. The results of the epidemiological study essay-RF. *CardioSomatika*. 2015; (S1):47. (in Russ.).]
 16. Rosenstock S., Jorgensen T., Bonnevie O., Andersen L. Risk factors for peptic ulcer disease: a population based prospective cohort study comprising 2416 Danish adults. *Gut*. 2003; (52):186–93.
 17. Соловьева С.В. НПВП-гастропатии – проблема пожилых. *Академический журнал Западной Сибири*. 2012;(3):28. [Solov'eva S.V. NSAID-gastropathies - the problem of elderly. *Akademicheskij zhurnal Zapadnoy Sibiri – Academic Journal of West Siberia*. 2012;(3):28. (in Russ.).]
 18. Константинова Е.Д., Вараксин А.Н., Жовнер И.В. Определение основных факторов риска развития неинфекционных заболеваний: метод деревьев классификации. *Гигиена и санитария*. 2013; (5): 69–72. [Konstantinova E.D., Varaksin A.N., Zhovner I.V. Identification of the main risk factors for non infectious diseases: method of classification trees. *Gigiena i sanitariya*. 2013; (5): 69–72. (In Russ.).]
 19. Безруков Н.С., Еремин Е.А. Построение и моделирование адаптивной нейро-нечеткой системы в задаче медицинской диагностики. *Информатика и системы управления*. 2005;2 (10):36–46. [Bezrukov N.S., Eremin E.L. Construction and modeling of the adaptive neuro-fuzzy system in the problem of medical diagnostics. *Informatika i sistemy upravleniya – Information Science and Control Systems*. 2005;2 (10):36–46. (in Russ.).]
 20. Скворцова В.И. Семь принципов модернизации здравоохранения. *Вопросы экономики и управления для руководителей здравоохранения*. 2010; (5): 7–14. [Skvortsova V.I. Seven principles of organization of healthcare. *Voprosy jekonomiki i upravleniya dlja rukovoditelej zdavoohranenija*. 2010; (5): 7–14. (In Russ.).]
 21. Лазаренко В.А., Антонов А.Е., Новомлинец Ю.П. Визуальная среда непараметрического корреляционного анализа факторов риска у больных с хирургической патологией. *Журнал научных статей Здоровье и образование в XXI веке*. 2017; 19(4): 34–37. [Lazarenko V.A., Antonov A.E., Novomlinec Ju.P. Visual environment for nonparametric correlation analysis of risk factors in patients with surgical diseases *Zhurnal nauchnykh statej Zdorov'e i obrazovanie v XXI veke – The journal of scientific articles Health and Education Millenium*. 2017; 19 (4): 34–37 (In Russ.).]
 22. Лазаренко В.А., Антонов А.Е., Прасолов А.В., Чурилин М.И. Проблема оптимизации регрессионного анализа в оценке факторов риска, влияющих на развитие хирургических заболеваний гепатопанкреатодуоденальной зоны. *Журнал научных статей Здоровье и образование в XXI веке*. 2017; 19 (5): 24–27. [Lazarenko V.A., Antonov A.E., Prasolov A.V., Churilin M.I. The problem of regression analysis optimization in evaluation of risk factors influencing the development of surgical diseases of hepatopancreatoduodenal zone. *Zhurnal nauchnykh statej Zdorov'e i obrazovanie v XXI veke – The journal of scientific articles Health and Education Millenium*. 2017; 19 (5): 24–27. (In Russ.).]
 23. Лазаренко В.А., Антонов А.Е. Роль социальных факторов риска в развитии язвенной болезни в курской области. *Курский научно-практический вестник «Человек и его здоровье»*. 2016; 2: 35–39. DOI: 10.21626/vestnik/2016-2/06. [Lazarenko V.A., Antonov A.E. The Role of Social Risk Factors in Peptic Ulcer Development in Kursk Region. *Kurskij nauchno-prakticheskij vestnik "Chelovek i ego zdorov'e" – Kursk Scientific and Practical Bulletin "Man and His Health"*. 2016; 2: 35–39. (in Russ.).]
 24. Щепин В.О., Расторгуева Т.И., Проклова Т.Н. К вопросу о перспективных направлениях развития здравоохранения Российской Федерации. *Бюллетень Национального научно-исследовательского института общественного здоровья имени Н.А. Семашко*. 2012; (1): 147–152. [Shhepin V.O., Rastorgueva T.I., Proklova T.N. Towards prospective directions of healthcare development in the Russian Federation. *Bjulleten' Nacional'nogo nauchno-issledovatel'skogo instituta obsbhestvennogo zdorov'ja imeni N.A. Semashko*. 2012; (1): 147–152. (In Russ.).]
 25. Мустафаев А.Г. Применение искусственных нейронных сетей для ранней диагностики заболевания сахарным диабетом. *Кибернетика и программирование*. 2016; (2): 1–7 DOI: 10.7256/2306-4196.2016.2.17904. [Mustafaev A.G. Use of artificial neural networks in early diagnosis of diabetes mellitus disease. *Kibernetika i programmirovanie – Cybernetics and Programming*. 2016; (2): 1–7. (in Russ.).]
 26. Лазаренко В.А., Антонов А.Е. Система интеллектуального анализа и диагностики заболеваний. Свидет-

- тельство о гос. регистрации программы для ЭВМ (RU) № 2017613090. Заявитель ФГБОУ ВО «Курский государственный медицинский университет» Минздрава России № 2016664120; 22.12.2016; опублик. 10.03.2017. [Lazarenko V.A., Antonov A.E. System for Intellectual Analysis and Diagnosis of Diseases. Certificate for State Registration of Programs for Computers (RU) no. 2017613090. Applicant FSBEI HE "Kursk State Medical University" MOH Russia no. 2016664120 on 22.12.2016; published on 10.03.2017.]
27. Лазаренко В.А., Антонов А.Е. Опыт разработки программного комплекса для нейросетевой диагностики и прогнозирования заболеваний гепатопанкреатодуоденальной зоны. *Врач и информационные технологии*. 2017; (4): 132–140. [Lazarenko V.A., Antonov A.E. Experience of the Development of the Software Package for Neural Network Diagnosis and Prediction of Diseases of Hepatopancreatoduodenal Zone. *Physicians and IT*. 2017; (4): 132–140. (in Russ.)].
28. Лазаренко В.А., Антонов А.Е. Оценка качества функционирования искусственных нейронных сетей с логическими выходами в диагностике заболеваний гепатопанкреатодуоденальной зоны. *Казанский медицинский журнал*. 2017; 98 (6): 928–932. DOI: 10.17750/KMJ2017-928. [Lazarenko V.A., Antonov A.E. Evaluation of the Quality of Functioning of Artificial Neural Network with Logic Outputs in the Diagnosis of Diseases of Hepatopancreatoduodenal Zone. *Kazan Medical Journal*. 2017; 98 (6): 928–932. (in Russ.)].

Received 30.03.2018

Accepted 15.05.2018

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УДК 616.33/.34-002.44-07:004.89

[https://doi.org/ 10.20538/1682-0363-2018-3-88-95](https://doi.org/10.20538/1682-0363-2018-3-88-95)

Для цитирования: Лазаренко В.А., Антонов А.Е., Markapuram V.K., Awad K. Опыт нейросетевой диагностики и прогнозирования язвенной болезни по результатам анализа факторов риска. *Бюллетень сибирской медицины*. 2018; 17 (3): 88–95.

Опыт нейросетевой диагностики и прогнозирования язвенной болезни по результатам анализа факторов риска

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РЕЗЮМЕ

Цель. Разработать и верифицировать способ диагностики язвенной болезни, основывающийся на нейросетевом анализе данных о факторах риска больного.

Материалы и методы. В статье приводятся результаты исследования, проведенного по материалам 488 больных, посвященного изучению возможности диагностики и прогнозирования язвенной болезни, основывающейся на нейросетевом анализе данных о факторах риска с применением искусственной нейронной сети собственной разработки (свидетельство № 2017613090).

Результаты. В ходе клинической апробации данный подход продемонстрировал уровни чувствительности 74,4%, $m = 4,3$ и специфичности – 93,3%, $m = 2,46$.

Прогнозирование возраста вероятной госпитализации обеспечило генерацию массива данных, показатель средней абсолютной ошибки (mean absolute error, MAE) прогноза которого составил 1,8 года, $m = 0,11$ для обучающей группы и 1,9 года, $m = 0,15$ для группы клинической апробации. Модуль ошибки прогноза в группе клинической апробации не превысит 2,2 ($p = 0,95$) и 2,3 года ($p = 0,99$) соответственно.

Заключение. Предложен новый способ диагностики язвенной болезни, основывающийся на нейросетевом анализе данных о факторах риска больного. В ходе клинической апробации данный подход продемонстрировал уровни AUC, достигающие 0,943. Применение искусственной нейронной сети позволило также прогнозировать возраст вероятной госпитализации. Применение нейросети также обладало дополнительными преимуществами, в том числе неинвазивностью, отсутствием необходимости подготовки больного к исследованию, возможностью получения результатов сразу после возникновения заболевания, отсутствием временной задержки на обработку материала.

Ключевые слова: искусственная нейронная сеть, многослойный персептрон, диагностика, язвенная болезнь, искусственный интеллект, прогнозирование.

КОНФЛИКТ ИНТЕРЕСОВ

Авторы декларируют отсутствие явных и потенциальных конфликтов интересов, связанных с публикацией настоящей статьи.

ИСТОЧНИК ФИНАНСИРОВАНИЯ

Авторы заявляют об отсутствии финансирования.

**СООТВЕТСТВИЕ
ПРИНЦИПАМ ЭТИКИ**

Исследование одобрено региональным этическим комитетом ФГБОУ ВО КГМУ Минздрава России (протокол № 4 от 9.03.2018 г.).

Поступила в редакцию 30.03.2018

Подписана в печать 15.05.2018

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