



# SCIENTIFIC RESEARCH OF THE SCO COUNTRIES: SYNERGY AND INTEGRATION

上合组织国家的科学研究：协同和一体化

Proceedings of the  
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参与者的英文报告

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Part 1: Participants' reports in English

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这些会议文结合了会议的材料 – 研究论文和科学工作者的论文报告。它考察了职业化人格的技术和社会学问题。一些文章涉及人格职业化研究问题的理论和方法论方法和原则。

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## Foreword

*We thank all participants of our conference "Scientific research of the SCO countries: synergy and integration" for the interest shown, for your speeches and reports. Such a wide range of participants, representing all the countries that are members of the Shanghai Cooperation Organization, speaks about the necessity and importance of this event. The reports of the participants cover a wide range of topical scientific problems and our joint interaction will contribute to the further development of both theoretical and applied modern scientific research by scientists from different countries. The result of the conference was the participation of 72 authors from 7 countries (China, Russia, Uzbekistan, Kazakhstan, Azerbaijan, Tajikistan, Kyrgyzstan).*

*This conference was a result of the serious interest of the world academic community, the state authorities of China and the Chinese Communist Party to preserve and strengthen international cooperation in the field of science. We also thank our Russian partner Infinity Publishing House for assistance in organizing the conference, preparing and publishing the conference proceedings in Chinese Part and English Part.*

*I hope that the collection of this conference will be useful to a wide range of readers. It will help to consider issues, that would interest the public, under a new point of view. It will also allow to find contacts among scientists of common interests.*

**Fan Fukuan,**

*Chairman of the organizing committee of the conference*

*"Scientific research of the SCO countries: synergy and integration"*

*Full Professor, Doctor of Economic Sciences*



## 前言

我们感谢所有参加本次会议的“上海合作组织国家的科学研究：协同作用和整合”，感谢您的演讲和报告。代表所有上海合作组织成员国的广泛参与者都谈到此次活动的必要性和重要性。参与者的报告涵盖了广泛的主题性科学问题，我们的联合互动将有助于不同国家的科学家进一步发展理论和应用的现代科学研究。会议结果是来自7个国家（中国，俄罗斯，乌兹别克斯坦，哈萨克斯坦，阿塞拜疆，塔吉克斯坦，吉尔吉斯斯坦）的83位作者的参与。

这次会议的召开，是学术界，中国国家权力机关和中国共产党对维护和加强科学领域国际合作的高度重视的结果。我们还要感谢我们的俄罗斯合作伙伴无限出版社协助组织会议，准备和发布中英文会议文集。

我希望会议的收集对广大读者有用，将有助于在新的观点下为读者提供有趣的问题，并且还将允许在共同利益的科学家中寻找联系。

范福宽，  
教授，经济科学博士，中国科学院院士，会议组委会主席“上合组织国家科学研究：协同与融合”

对可持续森林管理体制方面的国际分析  
**INTERNATIONAL ANALYSIS OF INSTITUTIONAL ASPECTS OF  
SUSTAINABLE FOREST MANAGEMENT**

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抽象。 本文介绍了国际实践和可持续森林管理方法的分析结果，在此基础上，得出了关于在俄罗斯联邦实施可持续发展政策过程中其应用的一些结论。

关键字： 可持续森林管理， 可持续发展， 国际森林管理经验， 森林认证

**Abstract.** *The article presents the results of the analysis of international practice and approaches to sustainable forest management, on the basis of which a number of conclusions have been drawn about their application in the process of implementing the sustainable development policy in the Russian Federation.*

**Keywords:** *Sustainable forest management, sustainable development, international forest management experience, forest certification*

The organizational and legal foundations of forest management often create numerous barriers to sustainable management, which leads to the declarative nature of sustainable development goals in the absence of specific effective mechanisms for their implementation. One of the common misconceptions is the attitude to the forest only as a source of timber, which makes any business speculative and makes it impossible to use other types of forest ecosystems.

Overcoming this problem in a particular region requires studying the best practices of forest planning and forest management not only in Russia, but also abroad. In this sense, the experience of the EU can be useful, which has been demonstrating an increase in the area of forests and the productivity of forest ecosystems for 60 years, despite the global trend of their decline in most countries.

The EU supranational policy on integrated forest management is based on three main principles, set forth in the document “The New EU Forestry Strategy: For Forests and the Forest Sector” (Forest Strategy 2013) [1]:

1) the principle of sustainable management and use of forests. This rule is based on the balance of the use of natural resources of the forest while maintaining

its regenerative potential, biodiversity and viability [2];

2) the principle of resource efficiency implies the development of rural areas, optimization of economic development through the creation of new jobs;

3) the principle of global responsibility: the core condition for the implementation of this rule is inexhaustible forest management, in which there are three areas:

- support for achieving social goals in forest management;
- improving the quality of accounting information on forest management;
- improvement of forest management policy.

The first direction implies the development of a set of measures for the protection of forests, the production of competitive products based on the processing of forest resources, the development of bioenergy, the involvement of the urban and rural population in these processes. The second is associated with system monitoring and the development of a database on forests, which contributes to fixing deviations in changes in their state, conducting scientific research and introducing innovations into forest management processes. The third is aimed at the development of coordination and cooperation ties, both at the national and international levels, to balance the processes of forest policy implementation, exclude the use of contradictory measures to maintain global forest potential. Each direction is divided into stages, the achievement of which is controlled using intermediate criteria. In accordance with the Forest Strategy, 5.4 billion euros should be spent by the end of 2020 [3].

In the EU countries (Finland, Sweden), part of the forest is privately owned. At the same time, the key condition for private forest use remains the so-called principle of “everyone's right” to access the forest, which ensures freedom of movement in the forest, regardless of whose property it is. This is literally an unwritten rule, since there is no special rule describing it in any law. But this privilege “works” in legal proceedings and applies to everyone, regardless of citizenship and nationality. It assumes any non-motorized way of moving through the forest and a ban on starting a fire. At the same time, the possibility of setting up a camp, picking mushrooms, herbs, flowers and berries, with the exception of specially protected ones, is allowed. Comparative analysis data on the organization of effective forest management in individual EU countries are presented in Table 1.

*Table 1 - Comparative analysis of the basics of forest management in the EU countries*

Country	Forest amount	Legislative acts regulating forest use	Directions of integrated forest management	Forest ownership structure	Presence of certification
Finland	26.3 million hectares - 71.6% of the country's territory	1886 - the first forest law; 1990 - inclusion of the principles of political and social sustainability in forestry policy 2010 - cardinal update of the legal framework for forest management, implementation of innovations	- Preservation of the diversity and sustainability of forests; - hunting, trades; - ecological tourism; - forest bioenergy; - preparation of peat; - preservation of memorial sites of military operations; - observation of animals	The state owns 34%, industry - 8% and other organizations - 5% of forest lands. 53% of forests are owned by private owners	FFSC FSC
Sweden	28 million hectares - 68% of the country's territory	1903 - First enactment of the Swedish Forest Law (regulates forest use), updated in 1979 and 1994. 1999 - Environmental Code of Sweden, which regulates the protection of forest areas	- Recreation; - sport fishing, - reindeer husbandry; - timber harvesting; - model forests; - development of rural areas, hydropower, the use of wind energy; - preservation of cultural heritage; - nature protection, production of environmentally friendly products from berries and mushrooms; - tourism and hunting	19% of forests are owned by state-owned companies, 81% are owned by private forest owners, the average size of a private forest owner's plot is 45 ha	PEFC (Pan-European Forest Certification System) FSC
Germany	11.4 million hectares, which is about a third of the country's area	Federal Forestry Law (1975) Federal Law on Nature Conservation (2002)	- Hunting (roe deer, red deer, fallow deer, wild boar); - timber and woodworking industry: paper production and printing industries; - recreation	48% to private owners, 29% - to lands, 19 % -companies 4% to the state	FSC PEFC

Country	Forest amount	Legislative acts regulating forest use	Directions of integrated forest management	Forest ownership structure	Presence of certification
Spain	14.4 million hectares - 29% of the total territory of the country	1999 - Spain Forestry Strategy	75% of forests are used commercially - forest plantations to prevent the occurrence of soil erosion; - recreation; - tourism; - collection of non-wood products (nuts, herbs, mushrooms, etc.)	75% of forests are available for commercial use and 1/4 of forests are designated for biodiversity conservation; 1/7 - forest plantations	Spanish Forest Certification (CEF) PEFC
Italy	More than 11 million hectares	Integrated environmental management at the municipal level. Forestry is carried out on the basis of Forest Plans, developed and approved every 10 years by the municipalities. The initiative for management decisions comes from the management of the commune	- Harvesting wood; - collection of white truffles; - preparation of oak cork; - collection of black pine resin (Pinus nigra), chestnut fruits, edible mushrooms, medicinal herbs; - recreation; - tourism	90% of certified forests are state	FSC, PEFC
Norway	12 million hectares - 41% of the entire country	1988 - adoption of 23 basic standards for sustainable forest management in Norway (Living Forest Standards for Sustainable Forest Management in Norway) Forests are also managed through small-scale forestry	All citizens are allowed open access to all forests and fields, which has been enshrined in legislation since 1957. - recreation; - collection of non-wood products; - hunting Fishing; - extraction of forest raw materials for energy and building materials	About 80% of the forests are owned by family co-owners - farmers (the average area of one such plot is about 50 hectares)	PEFC Norway, "Living Forests" Standard

Country	Forest amount	Legislative acts regulating forest use	Directions of integrated forest management	Forest ownership structure	Presence of certification
Austria	3.92 million hectares	1852 - the first adoption of the Forest Law; 1975 - Forest Law, updated 1987 The forest is under strict protection, it is forbidden to use forest land for agricultural purposes.	64% of forests are used for operational purposes, in the rest of the forests there is limited economic activity - commercial activity; - protective activity; - recreation	18% owned by the state, 82% private, collective or church property	FSC Standard ISO 14001
Netherlands	276 thousand hectares	1997 - adoption of the document "Certification and sustainable forest management (minimum requirements)"	- Recreation (there are 20 protected areas in the country with a total area of 120 thousand hectares) - Agriculture	58% of forests are privately owned, 42% public; 50% of public forests are state-owned	FSC
France	13 thousand hectares	1827 - Forest Code; 1964 - creation of the National Forest Fund 1963 - Creation of the Directorate of Forests, the goal is to control and manage state-owned forests	- Forestry works; - recreation and tourism; - commercial activity	36% - public forests (of which 14% - state property, 22% - municipal), 64% - private forest owners	FSC OPP certification system (ORR - Organization, Regulation, Results)

Source: compiled by the author based on [4].

According to Table 1, it can be concluded that the majority of European countries, when creating laws regulating the use of forests, as well as certification of forest use, are guided by the principles of sustainable development or sustainable management.

There are two aspects to the problem of forest certification - firstly, it is certification of forest management itself, and secondly, it is market-oriented certification. Market certification is most widely used, for example in Austria, due to the high level of imports of forest products and logging. This type of certification is carried out according to the ISO 14001 standard.

Taking into account a number of existing documents (FSC, PEFC, ISO, EMAS), the Norwegian government in 1988 legalized 23 basic standards for sus-

tainable forest management (Living Forest Standards for Sustainable Forest Management in Norway). These teaching materials covered a wide range of different aspects in areas such as economics, ecology and sociology. In the course of the work, the most problematic aspects of forest management in the country were also considered - for example, road construction, limiting the use of herbicides, changing tree species in existing forests, as well as creating new ones.

In 1998, three countries - Germany, France and Finland - agreed to manage and oversee the Pan-European Forest Certification System (PEFC). However, this initiative did not take root, as there were no national standards that would suit all parties. At the same time, Germany internationally adopted its own personal certification standard based on FSC principles. This standard has specified some of the conditions and criteria for standardization that are unique to Germany.

France's forest certification OPP (ORR - Organization, Regulation, Results) was established in 1996 by the National Working Group. It is based on the principles of PEFC and the country's legislation. In the developed standard, special attention was paid to forest management issues in terms of conservation of biological and water diversity that could be used by private owners. These associations are responsible for developing forest management plans in accordance with the structure of private ownership. The implementation of these plans is monitored by state forestry organizations.

Of all the countries in the European region, the United Kingdom has the least forest resources, and therefore it is the largest importer. The market of this country is aimed at ecological products, therefore, much attention is paid to the issues of their certification. The UK is one of the countries focusing on the market application of its Woodmark certification system. This is the highest product label, which indicates that 90% of the raw materials, both primary and secondary, were of English origin, and that the wood used in the production of this product comes from sustainably and legally managed forests.

The policy on the use of sustainable forest products has been implemented in the Netherlands at the national level since 1995. In 1997, the results of this policy and its best practice were consolidated in the document "Certification and sustainable forest management (minimum requirements)". The basic rules were combined into four groups of requirements: preservation of the ecological function of forests; efficiency of forest management; compulsory certification and independence of its bodies; the need for certification of the entire production chain for the product. Already at that time the main certification system for forest products in the country was the FSC system.

In today's market for forest certification and forest products, there are many different national, local and regional product labels. Many of these labels and systems overlap each other, confirming that a product meets the same environmen-

tal or social requirements. As a result, most certification systems remain on the market for no more than a year, after which they are either completely eliminated or merged with another system. For the European market, the most effective and well-known are three international systems: PEFS, FSC and ISO.

This analysis uses information on forest management in the EU countries, but it is important to mention also the participation in this issue of African and South American countries, such as Brazil, Algeria, Morocco, as well as countries of the Asian region - Indonesia, China, Japan, Malaysia. According to global reports, more than 50 national forest certification systems exist and are being finalized in the world at the same time.

Thus, summarizing all of the above, it becomes possible to draw several conclusions about the most promising areas in which to develop multipurpose forest management in Russia.

Firstly, it is extremely important to draw a clear distinction at the state level of forestry legislation between the personal rights of the forest owner and the rights of the public with regard to all possible types of forest use. The recreational use of the forest, as well as its use for the collection of non-timber resources, must be legally established as free use of forests. Forests should remain completely open to the public, as it is counterproductive to control the collection of non-timber resources by enterprises and the public (unless such actions lead to negative consequences for the volume of existing resources, and also prevents the forest from performing its other functions). At the same time, the forest owner must strictly monitor the collection of rare species.

Secondly, multipurpose forest management is effective if it is subject to competent strategic forest management planning. In this respect, forest management is a key tool. Demonopolizing forest management and adding existing forest management guidelines to support mechanisms for multipurpose forestry (collecting data, promoting forest and non-timber forest products and services that the forest can provide, etc.) will allow it to reach a new level of quality.

Thirdly, when setting forest management objectives, the goal of felling should not be set as the main one; it should be considered in combination with other forest management goals. In most cases, it is harvested wood that provides the greatest income, but setting this goal as the main one hinders the development of other areas of forest use. The social and recreational area of forest management is difficult to assess in a financial format. Therefore, in the long-term planning of forest use in a particular zone, it is necessary to establish, taking into account the interests of all stakeholders, which socially important forest functions should be developed. The most convenient and strategically advantageous is the additional zoning of the forest zone, taking into account the principles of sustainable development. Logging in such an area may be completely prohibited or limited by a set of rules.



It is also important not to forget about the ability to distribute afforestation areas in accordance with how these areas are planned to be used.

Fourthly, it is extremely important to base multipurpose forest management on transparent, open to a wide range of people decisions made on the basis of analysis of discussions and meetings with stakeholders. The result of these meetings should be a result that satisfies all parties, the discussion should not be formal and should aim at legitimizing the interests of large companies. On the basis of the discussions, not only the economic efficiency should be assessed, but also the cultural and social aspect of planning multipurpose forest use.

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全球危机后影响俄罗斯不良贷款动态的宏观经济因素

**MACROECONOMIC FACTORS AFFECTING THE DYNAMICS OF  
NON-PERFORMING LOANS IN RUSSIA AFTER THE GLOBAL CRISIS**

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*Doctor of Technical Sciences, Professor, Chief Researcher*

*Financial University under the Government of the Russian Federation*

抽象。 基于已开发的回归模型的结果，本文分析了行业和宏观经济因素以及决定因素对2008年至2018年俄罗斯银行业不良贷款动态的影响的重要性。该研究结果将有助于更深入地了解影响俄罗斯和其他发展中国家逾期贷款和不良贷款变化动态的主要原因，这将使监管机构和个人银行能够采取平衡的措施和针对性的行动，以保持俄罗斯联邦的竞争力。整个银行业。

关键词：不良贷款，宏观经济因素，GDP，通货膨胀，失业，回归方程

**Abstract.** *Based on the results of the developed regression model, the article analyzes the significance of the impact of industry and macroeconomic factors and determinants on the dynamics of Non-Performing Loans in the Russian banking sector, from 2008 to 2018. The results of the study will contribute to a deeper understanding of the main reasons affecting the dynamics of changes in overdue loans and non-performing loans in Russia and other developing countries, which will allow both supervisory authorities and individual banks to take balanced measures and targeted actions to maintain the competitiveness of the entire banking industry.*

**Keywords:** *Non-Performing Loans, macroeconomic factors, GDP, Inflation, Unemployment, regression equation*

JEL code: G24, E5.

Non-Performing Loans, NPL pose a threat to sustainable development of both developed (see, for example, the eurozone [6,8,15]) and developing countries (see, for example, the BRICS countries [19]) and are considered the main indicator of financial the stability of the banking sector in these countries. In developing countries, banks usually take more risks in order to increase their market share. With an increase in the probability of obtaining a higher profit, risks also grow, which ultimately leads to an increase in NPL [16]. Recently, the growth of NPL has become a matter of concern for monetary regulators and supervisors of all

countries of the world, which resulted in the understanding that in order to restore the active functioning of financial markets, it is necessary to pay close attention to NPL (problem loans) and their determinants [10]. Actual (ex-post) credit risk as an important element of non-performing loans is one of the key features of the banking system and economic downturn [17]. Banks at risk of bankruptcy have a significant proportion of NPL in their loan portfolios before collapse or financial difficulties [2].

Banks actively interact with each other (in particular, in the interbank credit market), including competing with each other in the financial market, so poor performance of even one bank can affect the performance of the entire banking sector and cause fear of a systemic crisis. Poor credit quality poses threats of systemic risk, creates fear that depletes deposits, discourages financial intermediation, and finally slows down economic growth and development. Non-performing, overdue loans, NPL, play a decisive role in the poor performance of banks, in addition, banks are limited in their important intermediary role in the real economy and economic growth, the presence of problem loans [22]. In some studies, NPL have been called “financial pollution” for their negative impact on the economy [1].

Therefore, in every country in the world, for regulators implementing monetary policy, it is important to know and understand the effects of the influence of the underlying factors on the dynamics of changes in non-performing loans.

This paper examines the macroeconomic determinants and components of NPL in the Russian economy for the post-crisis period from 2008 to 2018. The study used macroeconomic data and data from the entire banking sector in Russia using a set of time series data with an annual frequency. To analyze the influence of the selected data, a regression model is used in the work.

An analysis of the available research results in the public literature allows us to conclude that the main factors influencing the NPL dynamics can be divided into two main sources - macroeconomic factors: GDP growth and inflation [7], unemployment [12] and real interest rates [14], - and sectoral factors (specific to the banking industry), these are - management efficiency [13] and the size of the bank [11], which can affect the bank's ability to repay loans.

As a result of the research, a direct link was found between macroeconomic determinants and the quality of the loan portfolio, which is the most important criterion for the health of the banking sector. Research results show that bad loans decrease as the economy grows when borrowers have enough income to repay their loans on time. It was found that during economic growth, loans are most likely to be issued regardless of the creditworthiness of customers, while during an economic downturn, overdue loans tend to grow and increase.

Work [5] found the relationship of NPL with economic progress, risk aversion and interest rates and showed that NPL tended to increase when there was a down-

ward trend in economic growth and increased risk aversion and interest rates. When studying the determinants that stimulate NPL growth, work [15] found that macroeconomic variables such as gross domestic product, interest rates, unemployment, and government debt can influence the growth of non-performing loans and overdue loans. In [18] it was established that the main sources of NPL growth are economic (GDP) recession, lack of employment, and inflation.

In a comparative study of the economies of France and Germany, it was established how macroeconomic variables affect the growth of NPL [3] and it was found that the French economy is more vulnerable to banking factors than the German economy. In addition, it was shown that economic expansion and a decrease in unemployment are positively associated with a reduction in problem loans. Macroeconomic variables, including unemployment and economic development, significantly affect the dynamics of changes in NPL, while sectoral variables, such as management skills and preference in risk perception, influence future changes in NPL [4]. In addition, work [21] found a stable and long-term relationship between NPL, macroeconomic variables, and bank-specific factors. It was found that inflation and unemployment are positively and significantly associated with NPL.

The purpose of this study was to identify the significance of sectoral and macroeconomic determinants of NPL (Non-Performing Loans) in the Russian banking sector for the period from 2008 to 2018, based on the results of the developed regression model.

The results of the study will help to understand the main reasons driving the growth of NPL in Russia and other developing countries and will help individual banks to take better measures to maintain a competitive industry.

**Methodology.** This article assumes that problem overdue loans in the Russian economy, *NPL*, depend on both macroeconomic, *ME* and industry determinants, *IS*., Causing changes in NPL

Let's discuss the functional relationships of determinants.

Based on the above analysis of the published results of similar studies, in the work, as independent determinants of the dependent variable of the model - NPL, they considered both specific, specific determinants characteristic of the banking industry, and macroeconomic determinants.

Factors used as control determinants capable of stimulating NPL changes included the following:

- Macroeconomic determinants: annual GDP growth rate (**rGDP**); annual inflation rate (**INF**); annual unemployment rate (**UNR**); exchange rate, official (**EXCH**); export solvency to pay for imports (**EXPCAP**);

- Determinants of the bank's activities: the share of bank loans to the private sector in the total share of loans (**BankCred**); bank interest rate on loans (**LendRate**).

*Source of data and characteristics of the sample.* In this study, we used dynamic data characterizing the macroeconomic and banking industry-specific indicators of the Russian economy. Data are presented with annual periodicity for 2008–2018.

The data used in the empirical analysis was obtained from the main source - the World Bank Database [20]:

**NPL: Nonperforming Loans, Bank nonperforming loans to total gross loans (%)**, 2008 – 2018;

**GDP: Real Gross Domestic Product growth rate**, Annual percentage growth rate of GDP at market prices, 2008 – 2018;

**UNR: Unemployment rate, total**, (% of total labor force), 2008 - 2018

**INF: Inflation rate**, annual inflation rate, as measured by the consumer price index, CPI, 2008 – 2018;

**EXCH: Official exchange rate**, the official exchange rate of the dollar against the ruble Official exchange rate refers to the exchange rate determined by national authorities or to the rate determined in the legally sanctioned exchange market. It is calculated as an annual average based on monthly averages (local currency units relative to the U.S.dollar), 2008 – 2018;

**EXPCAP: Exports as a capacity to import** (constant LCU), export as ability to import is equal to the current value of export of goods and services, deflated by the import price index. Data in constant local currency. 2008 – 2018;

**BankCred: Domestic credit to private sector by banks** - the share of bank loans to the private sector in the total share of loans, 2008 – 2018;

**LendRate: Lending rate**. interest rate on loans, Lending rate is the bank rate that usually meets the short - and medium - term financing needs of the private sector, 2008 – 2018.

**Collinearity test.** To avoid the latent problem of multi-collinearity that can arise from the correlated model explanatory variables, it is necessary to check how correlated the selected model explanatory variables are. For convenience, let's rename the model variables in accordance with the following correspondences: **X1-rGDP; X2 – INF; X3 -EXCH; X4 – UNR; X5 – EXPCAP; Z1 –BankCred; Z2 –LendRate; Y – NPL.**

The paper considers two models: without taking into account the **EXPCAP** variable - model 1 and taking into account the **EXPCAP** variable - model 2.

Tables 1 and 2 show the cross-correlation matrix of variables for models 1 and 2.

**Table 1 – Cross-correlation matrix of variables of model 1**

	<i>X1</i>	<i>X2</i>	<i>X3</i>	<i>X4</i>	<i>Z1</i>	<i>Z2</i>	<i>Y</i>
<i>X1</i>	1.	-0.343172	-0.242228	-0.37308	-0.392135	-0.747536	-0.51171
<i>X2</i>	-0.343172	1.	-0.223958	0.405078	-0.064048	0.758078	-0.366504
<i>X3</i>	-0.242228	-0.223958	1.	-0.531816	0.805447	0.205296	0.726956
<i>X4</i>	-0.37308	0.405078	-0.531816	1.	-0.592417	0.403169	0.026928
<i>Z1</i>	-0.392135	-0.064048	0.805447	-0.592417	1.	0.317789	0.50381
<i>Z2</i>	-0.747536	0.758078	0.205296	0.403169	0.317789	1.	0.220987
<i>Y</i>	-0.511719	-0.366504	0.726956	0.0269289	0.50381	0.220987	1.

Source: author's calculations

**Table 2 - Cross-correlation matrix of variables of model 2**

	<i>X1</i>	<i>X2</i>	<i>X3</i>	<i>X4</i>	<i>X5</i>	<i>Z1</i>	<i>Z2</i>	<i>Y</i>
<i>X1</i>	1.	-0.343172	-0.242228	-0.37308	0.688048	-0.392135	-0.747536	-0.511719
<i>X2</i>	-0.343172	1.	-0.22395	0.405078	-0.271365	-0.064248	0.758078	-0.366504
<i>X3</i>	-0.242228	-0.223958	1.	-0.531816	-0.426137	0.805447	0.205296	0.726956
<i>X4</i>	-0.37308	0.405078	-0.53181	1.	-0.472542	-0.592417	0.403169	0.0269289
<i>X5</i>	0.688048	-0.271365	-0.426137	-0.472542	1.	-0.27143	-0.759677	-0.6623
<i>Z1</i>	-0.392135	-0.064028	0.80544	-0.592417	-0.27143	1.	0.317789	0.50381
<i>Z2</i>	-0.747536	0.758078	0.205296	0.403169	-0.759677	0.317789	1.	0.220987
<i>Y</i>	-0.511719	-0.366504	0.726956	0.0269289	-0.6623	0.50381	0.220987	1.

Source: author's calculations

According to the econometrics manual (Kennedy) [9], multi-collinearity is a problem when the correlation is above 0.80, which is practically not (apart from the correlation of the series *Z1* and *X3* at 0.80) in Tables 1 and 2. The correlation between the five variables is broadly consistent with economic theory: *NPL* were negatively associated with GDP growth and changes in the credit-to-GDP ratio, and were positively correlated with changes in unemployment. Inflation was positively correlated with changes in lending and GDP growth and negatively correlated with unemployment.

From the analysis of the properties of the matrix, it follows that, in general, the correlation between other determinants was not strong, which suggests that the problem of multicollinearity is either not serious within the framework of these models, or does not exist at all (table 2).

**Basic regression equation**

Consider the basic equation relating changes in the dependent variable, *NPL*, to changes in the independent variables of the models.

**Model 1.** In a linear approximation, the basic regression equation relating changes in the dependent variable, *NPL*, to changes in the model's independent variables: *rGDP*, *INF*, *UNR*, *EXCH*, *BankCred*, *LendRate*, is as follows:

$$NPL = \alpha_0 + \beta_1*rGDP + \beta_2*UNR + \beta_3*INF + \beta_4* EXCH + \gamma_1*BankCred + \gamma_2*LendRate + \varepsilon$$

where:  $\alpha_0; \beta_1; \beta_2; \beta_3; \beta_4; \gamma_1; \gamma_2$  – unknown parameters of regression model 1;  $\varepsilon$  – stochastic remainder of model 1.

Table 3 shows the numerical values of the parameters of the regression equation of Model 1, without taking into account the influence of the variable, EXP-COP, export, as a container for import.

**Table 3 - Numerical values of the parameters of the regression model 1**

	<i>Estimate</i>	<i>Standard Error</i>	<i>t-Statistic</i>	<i>p-Value</i>	<b>R<sup>2</sup>-"RSquared"</b>
1	-6.97207	5.8146	-1.19906	0.296677	0.971
GDP	-0.105945	0.0960274	-1.10328	0.331816	
INF	-0.19888	0.105915	-1.87773	0.133631	
EXCH	0.1076	0.0215485	4.99338	0.007526	
UNR	1.54221	0.434336	3.55073	0.023783	
BankCred	0.094505	0.0924515	1.02221	0.36447	
LendRate	-0.16572	0.253826	-0.65291	0.549441	

Source: author's calculations

Taking into account the numerical values of the parameters, the regression equation of model 1 will have the following form:

$$NPL = -6.972 + 0.0945*BankCred + 0.108*EXCH - 0.10595*GDP - 0.1988*INF - 0.166*LendRate + 1.542*UNR$$

**Model 2.** In a linear approximation, the basic regression equation relating changes in the dependent variable, NPL, to changes in the independent variables of the model: rGDP, INF, UNR, EXCH, EXPCAP, BankCred, LendRate, is as follows:

$$NPL = \alpha_0 + \beta_1*rGDP + \beta_2*UNR + \beta_3*INF + \beta_4* EXCH + \beta_5*EXPCAP + \gamma_1*BankCred + \gamma_2*LendRate + \varepsilon$$

where:  $\alpha_0; \beta_1; \beta_2; \beta_3; \beta_4; \beta_5; \gamma_1; \gamma_2$  – unknown parameters of regression model 2;  $\varepsilon$  – stochastic remainder of model 2.

Table 4 shows the numerical values of the parameters of the regression equation of model 2, taking into account the influence of the variable, EXPCOP, export, as a capacity for import, on the dynamics of changes in non-performing loans, NPL.

**Table 4 - Numerical values of the parameters of the regression model 2**

	Estimate	Standard Error	t-Statistic	P-Value	R <sup>2</sup> "RSquared"
1	-21.8937	12.1241	-1.8058	0.168697	0.982
GDP	-0.0541963	0.0949274	-0.570924	0.608016	
INF	-0.334871	0.138275	-2.42179	0.0940185	
EXCH	0.142656	0.0322421	4.42453	0.0214417	
UNR	2.17154	0.605865	3.5842	0.0371756	
EXPCAP	2.29447	1.6789	1.36665	0.265146	
BankCred	0.0847468	0.0841107	1.00756	0.387887	
LendRate	0.240596	0.375947	0.639974	0.567713	

Source: author's calculations

Taking into account the numerical values of the parameters, the regression equation of model 2 will have the following form:

$$NPL = -21.89367 + 0.0847 * BankCred + 0.14266 * EXCH + 2.2945 * EXPCAP - 0.0542 * GDP - 0.3349 * INF + 0.2406 * LendRate + 2.172 * UNR$$

It should be noted that in regression model 2:  $R^2 = 0.982$ , and in model 1:  $R^2 = 0.971$ , which means that in model 2, which takes into account the influence of the EXPCOP variable, exports as a container for imports on the dynamics of non-performing loans, NPL, changes in the dependent variable, NPL, are 98.2% associated with changes in the independent variables of model 2, which indicates a greater predictive ability of model 2 compared to model 1.

Another important result of the work is the fact that in model 2, along with the macroeconomic factor that takes into account the influence of the inflation rate on the growth of non-performing loans, UNR, a similar effect is exerted by the factor that takes into account exports as a capacity for imports, EXPCAP.

**Conclusions.** Using the estimates of the parameters of the regression equation with data for the post-crisis period of 2008–2014, the article analyzes the influence of macroeconomic and banking industry-specific determinants on the dynamics of changes in problem, overdue loans in the Russian banking system.

The results of the work are largely consistent with similar results available in the literature for developed and developing countries. Namely, the work found that among the macroeconomic determinants in the considered basic regression model, GDP growth, unemployment rate, inflation and domestic bank credit to the private sector have a significant impact on problem, bad or overdue loans. In addition, it was also found that, along with the macroeconomic factor that takes into account the effect of the inflation rate on the growth of non-performing loans, the factor that takes into account exports as a capacity for imports has a similar effect.



The results of the work indicate that NPL respond to macroeconomic factors such as GDP growth and unemployment, but it can also be easily assumed that there is a feedback effect from NPL that affects the performance of the real economy, since the growth of NPL has a significant impact on private loans (as a share of GDP), GDP growth, inflation and unemployment, thus confirming the thesis that healthy and sustainable economic growth cannot be achieved without a reliable and stable banking system.

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职业技术教育学生的专业能力发展  
**DEVELOPMENT OF PROFESSIONAL COMPETENCE OF TVET  
STUDENTS**

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抽象。 本文探讨了职业技术教育与培训学生专业能力形成的相关性。 揭示了未来教师“专业能力”概念的实质。 在专业能力下，我们考虑基础知识的专业知识，方法和教义以及教学交流文化的和谐结合。

关键字：能力，专业能力，未来的老师，发展，自我发展，自我完善等。

**Abstract.** *The article examines the relevance of the formation of professional competence of TVET students. The essence of the concept of "professional competence" of a future teacher is revealed. Under professional competence, we consider the harmonious combination of professional knowledge, methodology and didactics of primary education, as well as the culture of pedagogical communication.*

**Keywords:** *competence, professional competence, future teacher, development, self-development, self-improvement, etc.*

The formation of the professional competence of future specialists is an urgent problem of modern professional education. In the professional training of teaching staff, a gap is formed between the normative content within the boundaries of existing state standards and the practical specific needs of a modern teacher who requires competitiveness from a specialist.

"The teacher is a key figure in the reform of vocational education. In a rapidly changing open world, the main professional quality is the knowledgeable preparation of students. The teacher must constantly demonstrate them to his students...".

The requirements of the "Professional standard of a teacher" [2] orients us towards the preparation of a future teacher. The main condition for the quality training of a primary school teacher is the formation of his professional competence. The changes taking place in the educational world indicate the need to form not only a philosophical and pedagogical position in him, but also methodological, didactic, communicative, methodological competencies, etc. Working according to the new generation FSES, a teacher needs to develop, improve, enrich himself with professional knowledge, in order to be competitive in the labor market.

Today, one of the basic principles of building the educational process at school is the development of the student's personality, his mastering of new ways of action that will allow him to successfully study further, to realize his cognitive requests and needs. This can be achieved by training highly qualified specialists who meet the needs of society and impose not only knowledge, skills and abilities, but also a set of competencies. The study and development of pedagogical disciplines by future teachers, enriches them with the necessary theoretical and practical knowledge, purposefully prepares them for productive and high-quality pedagogical activity. In our opinion, the content of the disciplines studied by future teachers such as "Theoretical and methodological foundations of the class teacher's activities", "Theoretical foundations of the organization of training in primary grades", "Methods of teaching productive activities with a workshop", "Fundamentals of the organization of extracurricular work in social activities", "Involvement of junior schoolchildren in research activities", "Working with gifted children", "Project activities of younger students using information technology" and others help to form the professional competence of the future teacher. Industrial practice in professional modules helps students to consolidate the acquired knowledge.

The professional competence of a teacher is considered to be an important component of professionalism and pedagogical excellence. In the scientific lexicon, the concept of "competence" appeared at the end of the 50s of the XX century. From the very beginning, both domestic and foreign researchers in the scientific discussion interpreted this term in different ways. Foreign researchers in the content of this concept put, initially, practical content, the presence of abilities that are necessary for the effective performance of a particular action in a particular subject area (R. White, J. Raven, P. Bourdieu, D. Himes, P. Weil, F. Danver, F. Mern and others). The representative of domestic researchers V.D. Shadrikov gives the following definition: "Competence is a range of issues in which someone is well informed, someone's range of authority, rights. Thus, we see that competence does not refer to the subject of activity, but to a range of issues related to the activity. In other words, competencies are functional tasks associated with an activity that someone can successfully solve. Competence refers to the subject of the activity. This is the acquisition of personality, thanks to which a person can solve specific

problems ..." [6, p. 17]. The professional development of the personality of the future teacher is aimed at comprehending professional priorities and at revealing their personal potential.

The term "professional competence" has long been used by domestic and foreign pedagogues and psychologists, but, unfortunately, there is still not a single generally accepted interpretation of this term, which fully reveals the essence of this concept.

Kodzhaspirova G.M. in the pedagogical dictionary gives such a definition of the teacher's professional competence - it is "the teacher's possession of the necessary amount of knowledge, skills and abilities that determine the formation of his pedagogical activity, pedagogical communication and the teacher's personality as a bearer of certain values, ideals and pedagogical consciousness" [4, p. 52]. Based on this interpretation, we can say that a teacher can be considered professionally competent if he not only carries out pedagogical activities and pedagogical communication at a sufficiently high level, but also achieves consistently high results in teaching and educating students.

Thus, today vocational education is a purposeful approach to the education and training of students in the interests of society and the person himself. The training of students is now becoming one of the most important factors in the training of a competitive specialist who meets the requirements for the personality of a future teacher. He must be responsible in preparing students and adequately bear his mission - a teacher. On a personal level, professional education and qualifications are not just characteristics of a particular specialist, but also become a condition for his competitiveness. "The teacher is the organizer of the pedagogical process, is constantly in interaction with children, parents, colleagues and other people, all this imposes a huge responsibility on him and makes great demands on him" [5, p. 575]. Therefore, the vocational education system is faced with the tasks of systematic training of qualified specialists who meet the requirements of scientific and technological progress and have broad professional knowledge.

Higher school is an educational multicultural space, where we have created conditions for the formation of a personality, namely, higher school is the driving force in the development of the future teacher's worldview, his professional growth, mobility, and the formation of professional competence. Competencies of a future teacher are internal intellectual resources that will manifest themselves in organizing professional activities to achieve the set goal of teaching, upbringing, and development of students in the educational process. In the process of forming the professional competence of the future teacher, we have created optimal conditions in the teaching and educational process, we apply active teaching methods, a system of didactic principles, and the technology of personal development. The problem of the professional development of the personality of a future teacher

today is also of particular importance, since vocational training is a driving force in the development of human resources and lays the foundation for teaching. The essence of the formation of professional competence in a future teacher and practice-oriented professionalization is to turn him into a professional capable of self-development and self-improvement.

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互联网技术和资源是大学英语学习和教学过程中的动力来源  
**INTERNET TECHNOLOGIES AND RESOURCES AS THE SOURCE OF  
MOTIVATION IN THE PROCESS OF STUDYING AND TEACHING  
ENGLISH AT THE UNIVERSITY**

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抽象。 本文考虑了现代互联网资源和技术在高等教育英语培训组织中的有效性。 互联网技术使学生和教师可以使用真实的教育材料和资源：音频文本和视频，平台课程，TED演讲和TED Ed的讲座，有关研究主题的其他材料。 本文介绍了工作方法以及使用这些材料的可能性，以及教师在应用中应考虑的因素。 结论是，相关性，新颖性和广泛的主题有助于增加学生的学习动机，并使学习更具吸引力，更有趣和更有效。

关键词：真实材料，互联网资源，信息技术，TED演讲，在线课程，教学过程，动机。

**Abstract.** *The paper considers the validity of the use of modern Internet resources and technologies in the organization of the English language training in higher education. Internet technologies provide students and teachers with access to authentic educational materials and resources: audio texts and videos, platform courses, lectures from the TED talks and TED Ed, additional materials on the topics studied. The article describes the methods of work and the possibility of using these materials, the factors that teachers should consider in their application. It is concluded that the relevance, novelty, a wide range of topics contribute to increasing the motivation of students and make learning attractive, more interesting and effective.*

**Keywords:** *authentic material, Internet resources, information technologies, TED talks, online courses, the process of teaching, motivation.*

The 21-st century is the age of technology, in which progress outstrips life, so the problem of integrating information technologies is becoming more and more urgent. This factor indicates the need to introduce Internet technologies in the educational environment. The most common among telecommunications technologies is the World Wide Internet. The Internet is a global network that unites users from various organizations, public institutions and private firms, as well as private users [3, p. 2]. Teachers and undergraduate students, learners have access to resources with educational and authentic information in a foreign language, presented in a variety of formats (podcasts, TED talks videos, educational platforms, thematic online courses, etc.) in accordance with the needs and interests of the audience, available for review and study at a convenient time in unlimited access. The use of Internet resources allows you to create the necessary conditions for optimizing the process of learning English both in the classroom at the University and during extracurricular work of students, the process becomes more exciting and interesting in discovering a new world of the foreign language and its culture. The integration of Internet technologies into the educational process and their application is very relevant, since the use of these resources as teaching tools corresponds to the tasks and goals of training and education. This technology also creates an individual space, taking into account the students' abilities, level of knowledge and interests, and helps them realize the real significance of the language they study. The system of teaching foreign language communication at the university is effective if it meets all modern methodological approaches. Modern Internet provides a foreign language teacher with unlimited opportunities to use information resources, as well as a completely new technical potential, which helps to significantly increase the level of foreign language teaching. A characteristic feature of these technologies is authenticity, relevance, informativeness, multi-media, etc. [7]. Thanks to the Internet resource, the teacher can effectively solve a specific educational task in a minimum amount of time with minimal effort.

In our work, **the object** of research is FutureLearn online courses and Ted talks videos, and **the subject** is their direct implementation in the process of teaching English at the University. The purpose of the article is to describe these Internet resources, as well as methods and techniques of their use in the process of teaching English to undergraduate students. MOOCs (Massive Open Online Courses) are of great value for learning English as an additional authentic material. This article will focus on the MOOC resource, an educational University platform FutureLearn [12], which offers various thematic courses lasting from two to ten weeks. In order to get started, the student must register, choose a course, and start performing the proposed tasks. Another great advantage of this resource is that participants are provided with an online space for constructive interaction. Through MOOCs, learners can share information about



relevant resources, provide feedback to each other to support learning, and develop cross-cultural understanding. There are several ways to use MOOCS. In the traditional format, participants complete all the necessary tasks, exercises, tests, watch videos, share their opinions with other participants, read additional material, and can receive a certificate of successful completion of the course, following the recommended requirements. The resource can also be used in various forms, depending on individual learning and teaching needs. For example, you can perform tasks selectively, in accordance with the task set by the teacher or the personal interest of the student, performing mutual verification of tasks between students, as an independent development of the material, or under the supervision of the teacher.

An important aspect in selecting a suitable course for studying is the appropriate language level of students. The following courses are suitable for working with junior students: "Basic English 2: Pre-Intermediate", "English for Healthcare" [12], etc. In the "Exploring English: Language and Culture" course, intermediate level students are introduced to British life and culture, and can also improve their knowledge and skills of the English language. They find answers to the following questions: Why is English so widely used? How does technology help you learn? What does British music mean to you? [12]. There is a wide range of topics and links to sites that can be included as additional authentic sources when mastering the main material in the disciplines "Practical English course", "The culture of speech communication", "Practical foreign language course": English literature, Shakespeare and the globe theater, Music and society, English countryside, etc. Grammar material is also presented, examples, structures are given. It is important to have the motivation and self-learning skills of students to do the tasks. A higher result can be achieved in the classroom by the teacher offering tasks, making questions and a plan for discussing videos viewed or articles read as additional sources on the topic under study.

The use of Internet technologies is more relevant at the senior or advanced stage of training. At this stage, students tend to independently search for information through a foreign language, expanding their vocabulary and knowledge on the basis of new educational environments: Google Classroom, Toolkit, Coursera, Moodle, ATutor, MOOC, Ilias, EDMODO, Diskurs, MyBigCampus, Skyeng, Schoology, Eliademy, etc. Special attention should be paid to the independent work of students with Internet resources, awareness and processing of the information received. The teacher here should act as an organizer of this activity, as an assistant. Therefore, we can say that Internet technologies are part of the information culture of both teachers and students. According to the definition of P.V. Sysoev and M.N. Evstigneev, educational Internet technologies are text, audio and video materials with various topics that contribute to the formation of foreign language communicative competence and the development of students' com-

municative and cognitive skills to search, select, classify, analyze and generalize information [9, p. 370].

Videos from the TED talks website are also important for learning English. TED Talks – an American media organization that posts talks online for free distribution under the slogan "ideas worth spreading". TED's early emphasis was on technology and design, consistent with its Silicon Valley origins. It has since broadened its perspective to include talks on many scientific, cultural, political, and academic topics [13]. These videos are widely used for educational purposes all over the world, as an additional source of authentic material in English classes and for independent work, homework in order to expand the horizons, form and develop students' communicative competence. According to the researcher I. N. Kosheleva, "TED talks lectures are a powerful tool in raising awareness of the young generation about global issues and involve students in a global discussion on burning questions" [5, p.17].

Taking into account the availability of video conferences, their thematic diversity, and the relevance of the proposed materials, we consider it possible and necessary to use them in the process of bachelor's education at the University. When selecting videos, you should take into account their duration, the language level of students, the purpose of training, and the use of materials in English classes, as homework preparation, or for independent work. In contrast to the senior or advanced students, it is preferable for junior ones, to select video materials on topics that they have already passed, in order to facilitate the perception of new information or adapt the material to the language level of students. You can also refer to the open educational resource TED Ed [14], which offers thematic sections ("Playing With Language", "Our Changing Climate", "You Are What You Eat", etc.) with ready-made lessons that consist of several parts, allow students to work on different language skills, and require preliminary critical consideration by the teacher for their most effective application. The work is carried out according to the following plan:

1. Watch – watch a short video in class or as a preliminary homework assignment.
2. Think – a mini-test is performed to verify the information received.
3. Dig Dipper – offers a selection of additional materials on the topic on the site or search in the form of independent work of students (presentation, essay, etc.).
4. Discussion – discussion of the video after viewing (independent construction of questions or answers to the questions proposed by the teacher).

For senior or advanced students, it is possible to conduct classroom and independent work with the thematic materials of the TED talks video hosting, which complement the textbooks used in the University. You can work with your favorite videos in three stages: pre-demonstration, demo, and post-demonstration with

accompanying tasks and exercises that contribute to the development of listening, reading, critical thinking, foreign language communication skills, creativity, cognitive interest and general erudition of students [5, p. 16-17], [11, p. 293].

Useful materials for preparing for classes in English at the University for independent work of bachelors are presented in the textbooks "Watch and Discuss" [6], "Dive into English with "TED" [2]. Texts in the TED conference format are accompanied by exercises, additional lexical and grammatical tasks, and questions for discussion. There may be changes in the sequence of exercises and tasks in accordance with the methodological guidelines of the teacher or certain conditions of training in groups. In the course of independent preparation for the presentation and discussion of videos on the topic, students can work out the text component of Transcript in detail, using reference literature, dictionaries, additional Internet sources; prepare a list of words, collocations, idiomatic expressions, terms, abbreviations, etc.; highlight grammatical structures; emphasize phrasal verbs. Questions for discussion can relate to the content of the video itself, as well as the features of the presentation of the material, the speaker's presentation skills used in the video lecture [10, p. 230]. Moreover, they can make interactive presentations on the platforms: Prezi, MyCollages, Kizoa, PowToon, AdobeSpark.

Students have the opportunity to become more involved in the process of activity using Internet technologies in the educational process. Common features of Internet resources at the senior and advanced stage at the institute include:

- unlimited access to libraries, online dictionaries, and encyclopedias;
- getting a variety of modern and authentic information about the country and culture of the language under study;
- sending various types of messages (text, visual and audio);
- lack of boundaries in space and time in the process of searching for information and communication;
- improving information culture as a necessary component of modern personality;
- the ability to interact with experts in various fields of science through the interactive nature of a significant part of virtual educational and information services;
- the ability to get further education enrolling in the distance learning courses [1].

The naturalness of the lexical stock and grammatical forms, the situational adequacy of the language tools used, are the main characteristics of authentic materials. They give learners the opportunity to see examples of a foreign language usage in real communication, repeat examples of verbal and non-verbal means of the partner's speech. Students also have the opportunity to get new, sometimes unusual solutions to problems during their discussions (topical, round table or final) in the classroom under the guidance of a teacher [8, p. 205].

Thus, MOOC FutureLearn, video lectures TED talks, TED Ed, other educational Internet resources can be productively used as additional sources of modern authentic material, resources for classroom and extracurricular work, and increase students' motivation. The above-mentioned Internet resources and types of work with them provide undergraduate students with the opportunity to improve their listening skills, written and oral presentation of information, its critical comprehension, subsequent discussion, formation and development of communicative competence. Using Internet resources in the process of teaching foreign languages, learners are given the opportunity to get specific country-study knowledge, such as geographical location, main attractions, knowledge of background and non-equivalent vocabulary, idioms and lexical units, knowledge of speech etiquette. It should be noted that the use of Internet technologies and multimedia tools in the educational process of teaching foreign languages helps teachers to improve the management of learning, increase the efficiency and objectivity of the educational process, reduce time spent and increase the motivation of students in the educational process to acquire knowledge, increase interest in learning a foreign language, develop a desire for self-control and self-improvement, this has a positive impact on learning outcomes [4, p. 396]. The introduction of Internet technologies and web resources significantly simplifies the process of communication between students and native speakers, as students have the opportunity to communicate both in writing using email, social networks and other Internet resources, and orally using video conferences and social networks. At the same time, the discussion can be not only about university subject topics, but also about everyday things that are as close as possible to communication in real conditions, because the global Internet network is an immense database, the information of which is constantly updated. This high-quality educational content can be used for self-education and self-development, as well as for intellectual pleasure.

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孔子学院是俄罗斯语言文化普及的工具  
**THE CONFUCIUS INSTITUTE AS AN INSTRUMENT OF  
POPULARIZATION OF CHINESE LANGUAGE AND CULTURE IN  
RUSSIA**

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抽象。近年来，越来越多的俄罗斯人开始学习汉语和中国文化。特别是2013年的“丝绸之路经济带”倡议加快了汉语人才的培训，使他们能够更好地满足俄罗斯人民的汉语学习需求。因此，如今，学校和大学在培养中国人才，在俄罗斯传播学习汉语和文化方面发挥着至关重要的作用。目前，大约有17,000名俄罗斯学生在学校学习中文，其中3000名是高中学生。在2019年，学生们第一次有机会通过汉语考试。在文化和教育领域的现代俄中关系正在蓬勃发展。发起了前所未有的联合项目，特别是近年来，在俄罗斯开设了18个孔子学院。该研究提出了一项关于在巴什基尔国立大学进行汉语和文化教学研究的调查结果，以及在巴什基尔国立大学的基础上开设孔子学院以普及汉语和文化的需要。

关键词：孔子学院，中国语言文化，汉语教学。

**Abstract.** *In recent years, more and more people in Russia have started learning Chinese language and culture. In particular, the initiative of “Silk Road Economic Belt” in 2013 has accelerated the training of Chinese language talents so that they can better meet the needs of Russian people’s for Chinese language learning. Therefore, nowadays schools and universities play a vital role in the training of Chinese talents, spreading learning Chinese language and culture in Russia. At present, about 17 thousand Russian students are studying the Chinese language at school, among which 3 thousand are high school students. In 2019 students for the first time had the opportunity to pass an examination of Chinese language. The modern Russian-Chinese relations in the field of culture and education are developing dynamically. An unprecedented number of joint projects were initiated, in particular, 18 Confucius Institutes were opened in Russia in recent years. The research presents the results of a survey concerning Chinese language and culture teaching and learning at Bashkir State University and the need of opening the Confucius Institute on the basis of Bashkir State University to*

*popularize Chinese language and culture.*

**Keywords:** *the Confucius Institute, Chinese language and culture, Chinese Language Teaching.*

### **Introduction**

In recent years, the number of Chinese-Russian cultural exchanges has become much greater. 2007 was marked in Russia as a "Year of China", 2009 year in China - "Russian year", 2010 in Russia - "Chinese year", 2012 year in China - "Russian Tourism Year", 2013 year in Russia - "China Tourism Year" and 2014 year was marked as "Chinese-Russian youth friendship year". In July 2017 Russia in order to deepen the comprehensive strategic partnership implemented the "Chinese-Russian Cultural Cooperation Plan". Thus, many scientists began to pay more attention to the development of exchange and cooperation between China and Russia from different angles (Hu Fenghua, 2006; Tao li, 2009; Chen Xiaoxue, Li Shuang, 2012; Shu Mi, 2013).

During this period, experts and scientists are studying the ways of the Chinese-Russian exchange from different sides. Chinese and Russian scholars studied intercultural communication between China and Russia (Zheng Lixin, 2014; Mr. Yang, 2014; Sha Yuchao, 2014).

Confucius Institute (Confucius Institute Global Network) is a network of international cultural and educational centers established by the National Office for the promoting of Chinese language to foreigners (Hanban). The main task of Confucius Institute is to promote the understanding of China and Chinese culture in countries around the world, developing friendly relations between China and other countries. The training of Confucius Institutes is focused on the specifics of cooperation with the Chinese side.

Confucius Institute is committed to Chinese language international education and Chinese-foreign cultural exchange, has become an important force to promote economic and cultural exchanges between countries. Confucius Institute's Chinese teaching includes both Chinese speaking teaching and Chinese Written Language Teaching. The purpose of setting standards and norms is to serve the interests of learners (Zhang Hongqian, 2017).

The current motivation to learn Chinese in Russia is due to significant factors. First of all, this is the economic prospects for the development of mutually beneficial relations between the two powers. China's influence on the world market is increasing, so the Chinese language is no less than English. Knowing it provides the conditions for creating a successful business. Secondly, the prevalence of Chinese, which is stated by more than 13 million people. Third, the professional needs of Chinese language experts. Due to the complexity of the Chinese language, there are not many people who speak Chinese in Russia. The ability to communicate in

Chinese language significantly increases the potential of self-realization in modern society. Fourth, additional opportunities for moral and spiritual development. China's philosophy and culture carries a rich heritage. Studying Chinese language helps to learn the wisdom and culture of the Chinese people. Thus, at present, knowledge of Chinese language becomes an important condition for the realization of the needs of various representatives of the Russian society.

At present, about 17 thousand Russian students are studying the Chinese language at school, among which 3 thousand are high school students. In 2019 students for the first time had the opportunity to pass an examination of Chinese language. The People's Republic of China is positively looking at the Russian decision to introduce the exam of this language.

Since the study of Chinese language and culture in Russia has increased, there is an increasing need to study this issue. The role of the Russian Confucius Institute in the spread and popularization of Chinese language and culture is very important. In addition, it is necessary to consider the prospects of learning Chinese and Chinese culture in Russia in more details.

The purpose of this study is to analyze the current situation of Chinese language teaching at Bashkir State University and to determine the prospects of the need of opening the Confucius Institute on the popularization of the Chinese language and culture in Russia.

In order to do this, an Internet survey was conducted among residents of Bashkir Republic and, in particular, Ufa. The survey was attended mostly by students and everyone, regardless of whether they study Chinese or not. For the clarity of the study, our aim is to increase the number of respondents to 300, for now 89 questionnaires have been received. In this regard, the following results of the analysis are preliminary, but we still can draw conclusions and make proposals regarding the Confucius institution as a key cultural and educational project of China abroad.

Conducting the survey has the following tasks:

- Study of the reasons for interest in Chinese language, Chinese culture and history;
- Study of the image of China in the mass consciousness of young people;
- Study the plans of young people associated with the study of Chinese language and culture;
- Study young people's suggestions on using new means and methods for promotion of Chinese language and culture;
- Study the need of opening Confucius Institute on the basis of Bashkir State University and its role of s in the popularization of Chinese language and culture.



## 1 Questionnaire survey: review

Questionnaire survey is one of the key techniques in the study of public opinion, besides allowing study an independent assessment, which is important for scientific research. It should be emphasized that Russian researchers have repeatedly addressed in their works the problems of mutual perception of the inhabitants of Russia and China, the cultural component of their lives. From a number of works first of all it is necessary to pay attention to monographs (Kuznetsov, 2013; Larin, 2011), articles (Alaguiva, 2007; Larina 2016), which reveals the state of public opinion in Russia and China, and attention is focused mainly on the views inherent in Russian citizens living in the Far East.

From Chinese studies it is necessary to mention the work of Shanghai Professor Dai Rong "Confucius Institute: Chinese language and cultural diplomacy" (Dai Rong, 2013). In the first part of his work, the author gives a theoretical basis for his research, appealing to such concepts as cultural and linguistic diplomacy. The second part of the work is practical and more informative. In it, in addition to the history of the creation, the opening of the Confucius Institute in the world's educational institutions, the advantages of the Confucius Institute over other similar network institutions, as well as the results of the analysis of a sufficiently large volume of materials, pointed to the shortcomings and sometimes threats in the work of the Confucius Institute.

An interesting research was conducted by Professor of the Shanghai University of foreign languages Wu Ying. In the monograph "Confucius Institute and the spread of the Chinese language abroad" (Wu Ying, 2013) the author gives the results of a survey of 565 respondents — students Of Confucius institutes in different countries (USA, Russia, Japan, Thailand). The survey was conducted in 2008-2011 in 16 Confucius Institutes. The questions of the questionnaire cover such aspects as the quality of teaching and knowledge of Chinese culture in the process of learning in IC. The results of the study are presented in the aggregate and separately for each country. The survey data give the author the opportunity to suggest that, despite the large material and personnel investments in the development Of Confucius institutions, their effectiveness is not so high and their greater integration into educational structures abroad and a better understanding of the mentality and culture of foreign countries is necessary.

### 1.1 Structural characteristics of the survey

The survey "Confucius Institute: Chinese language and culture" was compiled on the basis of a free platform Survio.com. The results of 89 questionnaires were analyzed.

Age of respondents: 16-40 years, the majority of respondents aged 19-25 years.

Geography of the survey: Central part of Russia, Volga Federal district, Ural.

Gender profile: 79% of women and 21% of men answered the questions.

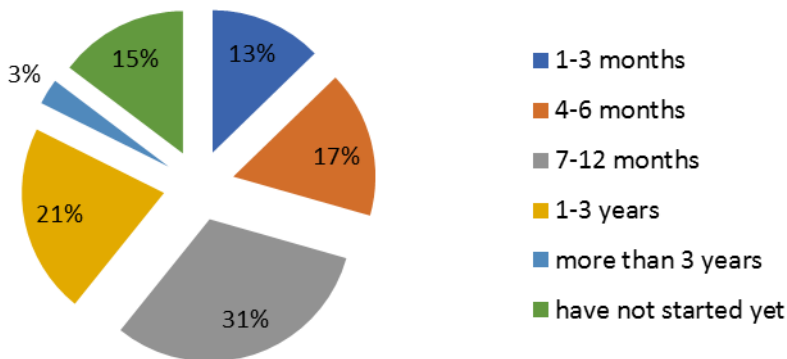
## 2 Main research findings

The questionnaire consists of 15 questions divided into 3 modules: the impact of the Chinese language on the lives of respondents, Chinese culture popularization and the Confucius Institute work efficiency. In this study, we present as the main problem the results of a survey on the work of the Confucius Institute in the popularization of the Chinese language and culture.

### 2.1 “Chinese language studying” module

Most of our interviewees (68%) are not aware of the existence of the Confucius Institute at all, including its role and the activities within this project, while respondents 32% heard about it and want to study there and participate in its culture activities, 85% of our respondents are interested in the activities of the Institute in order to learn more about China, Chinese language and culture.

#### How long have you studied Chinese language?



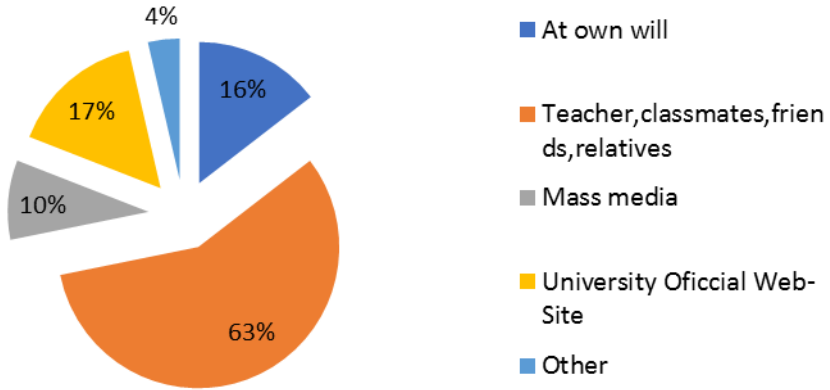
*Fig. 1 How long have you studied Chinese language?*

According to Fig. 1, more than 60% of respondents have been studying Chinese for more than one year on a regular basis and know it at a sufficient level to give a reliable description of the Chinese language and culture.

Moreover, young people are ready to use a variety of interactive methods, primarily those of a cultural, mass and informational nature, in order to better and more effectively study Chinese language.

Answers to the question of what prompted you to learn Chinese language and culture can be seen in figure 2.

## What prompted you to learn Chinese language and culture?



*Fig. 2 What prompted you to learn Chinese language and culture?*

### 2.2 “Chinese culture” module

The results of the survey on Chinese culture are also of interest. For example, the question "Whom of the following famous Chinese do you know?" received the following results: almost all know Confucius and Mao Zedong, least of all know the iconic Chinese Director Zhang Yimou and the Last Qing Emperor Pu Yi. We should also note that respondents know the actor Jackie Chan more than the current President of China Xi Jin-ping. All these indicate a weak awareness of the outstanding personalities of China. In this case, we can talk about the lack of study of the cultural component so that Confucius Institute could fill this gaps, being currently one of the key organizations promoting Chinese culture to the young generation.

As for the culture of China, the results are as follows: in the question "What traditional holidays do you know?" the majority answered "Chinese new year" (99%) and "Lantern Festival" (77%). Only 30% know other holidays. In Russia the Chinese New year is popular due to the Chinese horoscope and the ratio of years to a certain animal. In this case, it can be argued that the results of the study affected the weak coverage of traditional Chinese holidays in the Federal Media. Most of the information about Chinese culture appears in specialized magazines, Newspapers and TV channels designed for those interested in China or studying Chinese language and culture, but not for a wide range of readers.

Among respondents, Chinese tea (78%), Chinese calligraphy (70%) and Chinese cuisine (70%) are the most favorite Chinese categories; Chinese Opera (38%) and Chinese poetry (27%) were the most unpopular answer, probably due to their

inaccessibility, as well as the complexity of understanding and perception. It is not necessary to go to China in order to taste Chinese tea or cuisine, to admire examples of calligraphy: these elements of Chinese culture are widely represented in Russia. But understanding Chinese Opera, and especially poetry, requires a deep knowledge of the Chinese language and culture.

### 2.3 “Confucius Institute work” module

Considering the results of the on the questions Confucius Institute, the answers to two questions about the activities of the Confucius Institute are quite informative. To the question "Is it necessary to open the Confucius Institute in your city?" we received the following answers: "Yes, it is necessary" (41%) "no, this is not necessary" — 34%, "no answer" — 35%.

Most respondents say, the obvious advantage, for example, is that there is no need to go to other cities of the country to pass international exam in Chinese language HSK. Most of them believe that it is necessary to focus on the advertising work of the Confucius Institute. Young people have an interest in the culture and history of China. The Confucius Institute, in view of this fact, should be more active in promoting and publicizing its activities.

Among the young people there are those who are determined to study Chinese seriously enough (preparation for the exam; reading Chinese literature; listening: Chinese TV programs). This should be taken into account when developing training programs at the Confucius Institute, that is, to focus not only on the average listener of language courses, but also to offer, including individual language programs, taking into account the needs and goals of students.

If we look at the statistics on the quality and methodology of teaching Chinese, 64% of respondents want to study Chinese language in Russian and Chinese at the same time, only in Chinese 28% and only 7% want to learn Chinese with explanations only in Russian. These data coincide with the results of the level and timing of language learning. So, those who have just started to learn Chinese language, prefer a Russian-speaking teacher, and, conversely, students with a high level of proficiency — only in Chinese.

Further, given the relatively high percentage of those wishing to attend a basic Chinese course and a comprehensive course (short-term language courses + Chinese Culture + trips to China), it would be important to expand the offer of comprehensive courses in order to attract more students.

Most of the respondents associated the prospects of studying Chinese language and culture with a positive image of China (let us cite several answers of the respondents: "the growing role of China in the world"; "China is an interesting country to travel"; "China is a country with interesting culture"; "China - the birthplace of martial arts", etc.) and the desire to build their career ("go to China to study"; "to do business with China").

### Conclusion

Conducting this sociological survey is an effective tool for obtaining feedback in order to study the views of young people in Russia about the language, culture and history of China. The results of sociological research will serve as a good informative basis for optimizing the activities of the Confucius Institute and prospects of Chinese language and culture studying.

Thus, having studied the key results of the survey, it is necessary to offer some recommendations for the further work of Confucius Institute and its effective work in promoting the Chinese language and culture.

1. Involve both Chinese and Russian teachers of Chinese language and culture. The purpose of this recommendation is to improve the quality of teaching, for example, at the beginning level, Russian students prefer Russian-speaking teachers in order to more effectively master the Chinese language.

2. Increase the number and quality of activities related to Chinese culture and language. For example, every year the Confucius Institute form plans and programs, but there is very little information about them.

3. To improve the advertising and information work of the Confucius Institute, as young people have an interest in learning Chinese language and culture, but due to the lack of information about activities and training programs, most young people do not consider further language learning.

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远程学习中的RFL课程中的游戏技术: 传统与创新

**GAME TECHNOLOGIES IN RFL CLASSES IN DISTANCE LEARNING:  
TRADITIONS AND INNOVATIONS**

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抽象。 本文强调了俄语作为外语在课堂上使用游戏技术的有效性, 并指出了其极高的激励潜力。 使用特定示例分析了在远程学习中证明自己的游戏类型。 要特别注意使用游戏技术为学生准备TORFL考试的必要性。

关键字: 俄语作为外语, 游戏方法, 远程学习, 语言能力测试, 互动性, TORFL

**Abstract.** *This article emphasizes the effectiveness of the use of gaming technologies in the classroom in Russian as a foreign language, notes their high motivational potential. The types of games that have proven themselves in distance learning are analyzed using specific examples. Particular attention is paid to the need to use gaming technologies in preparing students for the TORFL exam.*

**Keywords:** *Russian as a foreign language, game methods, distance learning, language proficiency testing, interactivity, TORFL*

Taking part in the process of teaching Russian language to foreign students for several decades, it can be stated that the attitude towards the use of gaming technologies and methods in the classroom in Russian as a foreign language (hereinafter - RFL) has changed from active enthusiasm for them to complete denial of the need to use them.

Meanwhile, playing in class is not only a way to help students overcome difficulties in learning the vocabulary and grammar of the language, but also the opportunity to organize the presentation of complex material in an engaging and

accessible form. Teachers involved in the State Test of Russian as a Foreign Language (hereinafter - TORFL) note the fact that the game is even a component of this exam in the "Writing" and "Speaking" subtests.

Motivation and active involvement of students in the learning process is the dream of every teacher. Games have a number of characteristics that make it possible not only to increase the motivation for learning a language, but also to involve all students in the group in the learning process. In addition, they have a certain interactivity, i.e. instant feedback, which allows you to evaluate the learning outcome here and now.

In modern methodological literature, play methods are usually referred to as active and interactive learning methods. A number of researchers put an equal sign between them [2], some highlight fundamental differences [1, 4]. In our opinion, active learning methods include, first of all, game tasks (for example, crosswords, rebuses, board games using various equipment, etc.). Interactive teaching methods should be understood as communicative tasks that are focused primarily on the interaction of students (for example, role-playing, imitation, business games, projects, etc.).

If we work with a children's audience, then the use of games in the classroom is a necessary element of the learning process. Children live in the game, they perceive game techniques easily and quickly. For children, you can combine play with exercise. For example, stand up, pronounce a phrase, depict actions with hand movements. Motor skills help well to memorize texts. Thus, while learning the song "The blue ball is spinning, spinning", the teacher can accompany each phrase with a set of gestures that help to memorize the text: "spinning, spinning" - rotational movement of the hands; "Blue ball" - a ball is depicted, indicates a blue object; "Turns, turns over the head" - rotational movements over the head; "Turns, turns, wants to fall" - movement with hands down; "The gentleman wants to steal the young lady" - an indication of a young man and a girl in a group, grasping movement with his hands, etc.

If we have an adult audience, then often the use of games can cause a negative reaction. The important thing here is to introduce games in a casual way, as if it were a spontaneous decision. It is better to apply them not at the end of the lesson, but in the middle, so that the students do not have the feeling that they were only playing in the lesson. In addition, the rules of the game should be easy and simple to explain. Any game should have a purpose and should match the level of language proficiency of the students.

With an adult audience, the method of G.A. Kitaygorodskaya "activation of the capabilities of the individual and the team", which is based on personality-oriented communication and the principle of the game/role-based organization of educational material and the educational process [3]. Following this method, from

the first meeting, each student receives a specific role, with which he passes the entire course of study. This role is a chance for a student to become the person he could never be in real life, i.e. live the life of another person. Kitaigorodskaya's method helps to remove the psychological barrier, levels the contradiction between the existing life situation and the lesson. This method works productively in short-term language courses, but its elements undoubtedly need to be applied in traditional teaching as well.

A wide variety of games are used in teaching RFL. To date, a lot of educational and methodological manuals have been published on games in the classroom. Among the most popular are the reissued textbook by a group of authors, edited by A.A. Akishina "Russian language in games", a textbook by D.V. Kolesova and A.A. Kharitonov "Wordplay", textbook by A.L. Leontyeva "50 games in the lessons of the Russian language", etc.

At the moment, the situation is such that universities have to switch to distance learning. This challenge of the times gives impetus to the search and development of new teaching methods.

Let's consider those gaming technologies that can be actively used in the RFL distance learning situation.

Game "**Snowball**", where each student must repeat a chain of words spoken by previous students, has been surprisingly effective in online learning. It makes students listen carefully to each other and stay in focus of the camera. This game can be used at any stage of learning, starting from the first lesson.

Game "**Alias**" (other versions are "**Hat**" or "**Understand me**"), the purpose of which is to teach students to interpret words, to explain their meaning. A stopwatch can be used to enhance the thinking activity of students. This game also works well for online learning.

TV games such as "**Who Wants to Be a Millionaire**" or "**One Hundred to One**", the rules of which are already well known to everyone, also give a positive result in distance learning. For example, you can ask the question "What do you think Russians buy in stores in case of quarantine?" The answers can be very detailed. You can ask to compare the range of purchases of Russians and people of the country in which the student is located.

"**Wimmelbuchs**" (picture books, in which there are many small details, plot lines, but no text and students must independently describe the drawing). Wimmelbuchs is a unique exercise that can be used at different stages of training. For example, at level A-1, you can give a task to describe what is shown in the picture. And at level B-1, using the same picture, give the task to compose a story based on the plot shown in the picture. One Wimmelbuch can be used to compose countless stories.

"**Crosswords**" and "**Chainwords**" are games that need no introduction. But if



a teacher gives homework to students, using programs on the Internet, independently composing a crossword puzzle and offering it to other students to solve, this game method takes on a new sound.

"Comics", especially those created on their own using the site [www. toonytool.com](http://www.toonytool.com), allow the student to show all their imagination and build a monologue on behalf of another person. Having tried on someone else's role, the student, as a rule, builds a story easily and naturally.

Many sites and online resources have appeared to help the teacher, which make it possible to build classes interactively, achieving a good feedback from students. For example, you can use the resource <https://quizlet.com/ru> to practice vocabulary. For creating quizzes and various questionnaires, the resource <https://kahoot.com/> has proven itself well. You can design tests and polls of different formats using <https://www.plickers.com>. Stories in texts and pictures can be created with the help of <https://www.adme.ru>. Russian songs can be found at <https://www.videos-in-russian.php>. Russian television can be viewed at <http://russia.tv/video/>.

It has already been mentioned that the game is a component of the exam at all TORFL levels in the Writing and Speaking tests. The task of the teacher is to prepare their students in advance for such tasks, where the focus is shifted from a real person to an abstract character. Going to the exam, students should already have experience in playing the role of another person, abstracting from their own "I". The higher the level of testing, the more tasks of this kind are included in the examination materials and the more difficult it is to formulate tasks.

For example, when testing for level A-2 in the "Letter" subtest there is the following task: "You leave home and stay at work until 20.00, but you need to pick up your child from kindergarten at 18.00-19.00. Write a note about this to your husband/wife/nanny/grandmother and ask them to pick up the child from kindergarten". Often, untrained test-takers try to explain to the teacher that they do not have a child, or that their child does not go to kindergarten, i.e. try on the task for themselves, cannot go out of context.

At higher TORFL levels, the test taker should try on more roles. For example, at the level C-1 in the "Speaking" subtest there is a task, in which the test taker must build a dialogue on behalf of the director of a large company. It is very difficult for a young person to imagine himself in this role and conduct an interview with a candidate for the position. Perhaps that is why TORFL C-1 and C-2 levels are not recommended for young people.

Thus, speaking of the fact that play is an important element of human activity, we must understand the need to use gaming technologies in the RFL learning process, since games give an incentive to the development of students' speech, adapt them to Russian-speaking communication. The advantage of gaming technologies is that they contribute to the development of students' creative abilities, ensure the

inclusion of students in real communicative situations. And, of course, it is important to remember that the speech skills formed in students when mastering gaming technologies are tested and evaluated at all levels of our main exam - TORFL.

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英语的躯体短语单元，其语义基于手势  
**SOMATIC PHRASEOLOGICAL UNITS OF THE ENGLISH  
LANGUAGE, THE SEMANTICS OF WHICH ARE BASED ON  
GESTURES**

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抽象。该科学论文提出了混合到主题组中的不同躯体短语单元。这些主题组中的每个主题组都包含几个语义字段，这些语义字段由不同数量的主题短语单元表示。作者强调，比较英语和俄语的措辞单元的语义后，他们发现了主题组中未包含的某些措辞单元，并且还提供了一些措辞单元的示例。

关键词：词组，比较，英语，语义组。

**Abstract.** *The scientific paper presents different somatic phraseological units mixed into thematic groups. Each of these thematic groups include several semantic fields, represented by a different number of somatic phraseological units. The authors underline that comparing the semantics of phraseological units of the English and Russian languages they have found some phraseological units that are not included in the thematic groups, also they present some examples of phraseological units.*

**Keywords:** *phraseological units, comparison, the English language, semantic group.*

Considering the problem of language and culture through the prism of their interaction, cultural linguistics often chooses language units that have acquired symbolic, standard, figurative-metaphorical meaning in culture and which generalize the results of the activity of human consciousness. The goal of linguistic and cultural studies is to study the ways in which language embodies in its units, stores and translates culture.

Culture codes are universal in nature and inherent in humans. However, their manifestation, the share of each of them in a particular culture, as well as the metaphors in which they are implemented, are always nationally determined and conditioned by a particular culture [1, p. 380].

The somatic code of culture is an extremely interesting and original linguistic layer, reveals the specifics of the worldview of native speakers of the language and culture. The existence of this code is universal. However, the somatic codes of different linguocultures, striving to preserve the universal features, are distinguished by their national identity. Parts of the body, playing a symbolic role in the mythopoetic picture of the world, act as standard carriers of certain human qualities, reflect the experience of the people speaking the given language.

Gestures have an ancient origin and are found in representatives of different cultures. Sign language is considered by many scientists to be one of the oldest forms of communication. "Each of the attributes of the body, be it shape, size, position or height, under certain conditions expresses or conveys some meaning. Age, occupation, life joys and hardships, feelings and thoughts - everything leaves traces on the human body and is reflected in the non-verbal behavior of a person" [3, p. 128]. There is a certain similarity between sign and natural languages, which is possible due to the fact that "the deep, primarily biological, processes underlying non-verbal and verbal activity are essentially similar." That is why in sign phraseological units with somatisms in different languages one can find greater semantic similarity than in phraseological units with components of other thematic groups [2].

The imagery of the somatic phraseology of the next thematic group is based on various gestures that serve as a common human form of emotional manifestation of mental states. Basically, these are phraseological units with the structure of verb-substantive phrases: a verb that communicates a gesture, body movement and a somatic component that names a part of the body that produces a particular gesture. For example:

To shrug one's shoulders means shrugging - showing disinterest or ignorance

To stand shoulder to shoulder - Stand shoulder to shoulder

To shake one's head - Shake the head (a sign of disagreement)

To hold one's head up - Keeping the head up - show determination, show confidence

To join hands - Join hands (unite)

To raise a hand - Raise a hand

To put your hand on your heart - Put the hand on the other heart (chest) - speak the truth, speak from the bottom of the heart

To go down on one's knees - Fall on your knees, bow down

To look down one's nose at - Look with your nose up - look with contempt

to stick one's nose up in the air - Turn up your nose - be arrogant

To give a hand - Give a hand - provide help

To shake hands (with someone) - Shake hands in agreement

To open mouth - Open your mouth - say something

To have one's hands tied behind one - Be arrested

To scratch one's head - Be at a loss, be at a loss [5].

Such phraseological units usually develop on the basis of “phraseological combinations” that carry a semantic load both in the literal and figurative sense. Not all phrases that have a symbolic meaning, gestures are subject to phraseologization, some of them remain in the position of “phraseological alignments” - potential phraseological concatenations: raise your hands, shrug your shoulders, shake your head, etc. [4].

Due to some discrepancy between socially significant body movements and emotional gestures among their carriers, individual somatic phraseological units of this type are represented in the Russian language by formations that have no parallels in English and vice versa. For example:

English version: to keep one's fingers crossed (keep fingers crossed) - wish good luck to someone;

English version: to run one's fingers through one's hair (run your fingers through your hair) - fix your hair;

English version: to hold / put a gun to somebody's head (keep a gun at the head) - to threaten;

English version: to show one's hand (show hands) - show cards.

Russian version: to spread hands - to expand business;

Russian version: tilt your neck to one side - to doubt;

Russian version: keep belly - hold on to belly laughing;

Thus, gestures and facial movements are one of the sources of the formation of somatic phraseological units. However, sign phraseological units do not always have parallels in Russian and English, due to the mismatch of socially significant gestures among their carriers.

The interest of researchers in somatic vocabulary, from an extralinguistic point of view, is determined by the fact that the process of realizing oneself among the surrounding reality and defining oneself as a person began with sensations arising directly through the senses and parts of one's own body. Thus, since somatic vocabulary is one of the oldest lexical universals, therefore, somatic phraseology is also one of the most ancient and significant categories of phraseological units, which directly (through the correlation of the associative figurative base with standards, symbols, stereotypes of national culture) correspond to the cultural information about the world, society.

Due to the lack of a clear and uniform interpretation of the concept of "phra-

seological unit" in the works of national and foreign linguists, summarizing the considered points of view, we can conclude that phraseological units are a complex linguistic phenomenon, highly informative language units, the features of signs and structures of which distinguish them against the background other structural units.

Phraseological units with a somatic component are a highly productive part of the phraseological composition. They arise spontaneously, independently of each other in different periods and in different languages, since they have a common basis in the observation by a person of himself, parts of his body, in the general physical and mental characteristics of a person, in general conditions of development, in the observation of the life and behavior of animals, in the study of human actions and emotions.

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学龄儿童烧伤中烧伤毒血症对呼吸系统昼夜节律的影响，取决于呼吸频率的昼夜节律和氧饱和度

**INFLUENCE OF BURN TOXEMIA ON THE RESPIRATORY SYSTEM ACCORDING TO CIRCADIAN RHYTHMS OF RESPIRATORY RATE AND OXYGEN SATURATION IN BURN DISEASE IN SCHOOL-AGE CHILDREN**

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抽象。在严重烧伤后的第一天，呼吸频率最明显的升高通常是第3组儿童的皮肤烧伤表面积为2-3A度 $25.8 \pm 11.4\%$ ，3B度 $22.5 \pm 6.6\%$ ，IF $-95.8 \pm 19.1$ 单位燃烧程度越严重，每天的氧饱和度指数差异就越明显。在第1组的整个毒血症期间（24小时），呼吸频率通过增加频率来补偿氧需求的增加，并将氧饱和度保持在 $97.9 \pm 0.2\%$ 。在第2组中，在22:00检测到呼吸增加的代偿性。在第3组中，在RR的昼夜节律的中位数与氧饱和度指标之间未发现显著相关性。

关键词：呼吸频率的昼夜节律，血氧饱和度，毒血症，烧伤，学龄儿童

**Abstract.** *On the 1st day after a severe burn injury, the most pronounced increase in respiratory rate is typical for children of group 3 with a burn surface area of the skin of 2-3A degree  $25.8 \pm 11.4\%$ , 3B degree  $22.5 \pm 6.6\%$ , IF -  $95.8 \pm 19.1$  units The more severe the degree of the burn, the more pronounced are the differences in the oxygen saturation index per day. Throughout the entire period of toxemia in group 1 for 11 hours (out of 24 hours), the respiratory rate compensated for the increased oxygen demand by increasing the frequency, maintaining the oxygen saturation index at  $97.9 \pm 0.2\%$ . In group 2, the compensatory nature of increased respiration was detected at 22:00. In group 3, no significant correlation was found between the mesor of the circadian rhythms of the RR and the oxygen saturation indicator.*

**Keywords:** *circadian rhythm of respiratory rate, oxygen saturation, toxemia, burns, school-age children*

**Relevance.** The oxygen saturation level reflects the degree of saturation of hemoglobin and the body as a whole. By its value, one can judge the effectiveness of the respiratory process. Oxygen saturation in the blood, the rate tends to 100%. In severe burns, respiratory complications can occur even in the absence of direct lung injury. For example, an increase in vascular permeability of the microvasculature that occurs in severe burns is associated with a high risk of pulmonary edema and ARDS. Circular chest burns compress the chest, obstructing ventilation. In addition, it is known that the healing of burns is accompanied by an increase in basal metabolism. This hypermetabolic state is manifested by increased oxygen consumption and CO<sub>2</sub> production. During this period, the authors consider it necessary to increase alveolar ventilation and appoint oxygen inhalation.

In connection with the above, the assessment of the dynamics of the circadian rhythm of the oxygen saturation indicator seems relevant, since it allows early identification of some pathogenetic mechanisms involved in the development of oxygen starvation and makes it possible to timely drug correction in order to prevent irreversible disorders in oxygen-sensitive organs and systems in the acute period. severe burn injury.

**Purpose of the work.** Study and assess the effect of burn toxemia on the respiratory system according to the circadian rhythms of the respiratory rate and oxygen saturation in burn disease in school-age children.

**Material and research methods.** The clinical material is presented by the data of hourly monitoring of the respiratory rate (RR) and oxygen saturation index (OS) by pulse oximetry in children admitted to the Republican Scientific Center for Emergency Medical Aid (RSCEMA) in connection with thermal burns. A phase analysis of the structure of the circadian rhythm of the studied parameters was carried out in 26 children aged 7.1-18 years with severe burns during the period of toxemia. The main feature that determined the division into groups was the duration of intensive care in the conditions of the intensive care unit (ICU), due to the severity of the burn disease. In group 1, the monitoring data of the studied parameters were considered in 12 children (up to 10 days on average  $7.3 \pm 1.1$ ), in group 2 in 7 (11-20 days on average  $12.7 \pm 1.2$ ), 3 - in 7 children (more than 21 days  $28.8 \pm 4.8$ ).



**Table 1**  
*Patient characteristics*

	Age in years	boys	girls	Days at the ICU	Burn area and depth		IF, units
					2-3A degree,%	3B degree,%	
<b>Group 1</b>	11,4±3,2	10	2	7,3±1,1	41±11	6,6±6	57±11
<b>Group 2</b>	15±2	6	1	12,7±1,1*	55,1±14,4	4,8±3,5	86,3±15,7*
<b>Group 3</b>	9,7±1,5 <sup>≈</sup>	4	3	28,8±4,8* <sup>≈</sup>	25,8±11,4 <sup>≈</sup>	22,5±6,6* <sup>≈</sup>	95,8±19,1*

\*- difference is reliable relative to the research data in group 1

<sup>≈</sup>- difference is reliable relative to the research data in group 2

As presented in tab. 1, the average age of children in group 3 was  $9.7 \pm 1.5$  years, it turned out to be significantly less than in group 2 by 6 years ( $15 \pm 2$ ) and in group 1 by 2 years ( $11.4 \pm 3.2$ ).

**Results and discussion.** On the day of admission of patients to the clinic, the mesor of the circadian rhythm RR was  $21.3 \pm 0.8$  in group 1,  $20.7 \pm 0.6$  in group 2, and  $25 \pm 3.8$  breaths per minute in group 3 (tab. 2).

**Table 2**  
*Dynamics of the mesor of the circadian rhythm of the respiratory rate during the period of toxemia in children over seven years old.*

Days	Group 1	Group 2	Group 3
1	21,3±0,8	20,7±0,6	25,0±3,8
2	21,2±0,3	21,3±0,4	22,4±0,4
3	21,1±0,2	20,7±0,3	22,8±0,3
4	22,1±0,4	20,8±0,3	23,3±0,4
5	22,3±0,3	21,1±0,4	23,2±0,4
6	22,3±0,2	21,1±0,5	23,0±0,3
7	23,0±0,7*	21,0±0,4	23,6±0,3
8	22,1±0,9	21,3±0,6	23,9±0,4
9	23,8±0,7*	22,4±0,5*	23,0±0,5
10		21,8±0,5	23,2±0,3
11		22,3±0,5*	23,2±0,6
12		22,1±0,7	22,4±0,3
13			24,4±0,4
14			24,0±0,5
15			24,2±0,4
16			24,9±0,5

Days	Group 1	Group 2	Group 3
17			24,0±0,5
18			24,1±0,5
19			23,9±0,7
20			24,3±0,4
21			24,6±0,5
22			24,8±0,5
23			24,3±0,9
24			22,8±0,6
25			22,8±0,9

\*- reliably relative to the indicator in 1 day

On the first day, no significant deviations from the age norm were found, although an increase in the mesor of the circadian rhythm RR to  $25 \pm 3.8$  per minute was noted in group 3. An increase in the mesor of the circadian rhythm RR was detected in group 1 on days 7.9 by 8% ( $p < 0.05$ , respectively), in group 2 on days 9 and 11 by 8% ( $p < 0.05$ ), which indicated a trend to the development of acute respiratory failure in the second week of the toxemia period in the first and second groups of children (tab. 2).

Dynamics of the mesor of the circadian rhythm of the respiratory rate during the period of toxemia in children over 7 years old



Fig.1

As shown in fig. 1, the fluctuations of the mesor of the circadian rhythm RR were an irregular undulating broken curve with a period of oscillations of three eight-day sinusoids, in which one can see five to four-day phases. The average level of mesor for the entire period of toxemia was the highest in patients of group 3 -  $23.7 \pm 0.7$  breaths per minute, in group 2 -  $21.4 \pm 0.5$  and in group 1 -  $22.1 \pm 0.6$  per minute. The amplitude of daily changes in RR throughout the observation also changed in waves with a maximum value of 1 day - 4 breaths per minute in children of group 3, 2.3 per minute in group 2, 1.3 per minute in group 1 (fig. 2).

Amplitude of daily fluctuations of BR depending on the severity of the condition



Fig.2

On the first day of treatment, the average daily level of the mesor of the circadian rhythm of oxygen saturation fit into the normative data within 97.6% in group 1 to 98.3% in the second group, the average indicator for the entire period of toxemia in all groups was  $97.9 \pm 0.2\%$ . Changes in the average daily level of the circadian rhythm of oxygen saturation also occurred in a wave-like manner (fig. 3), representing a more monotonic curve than the dynamics of the mesor of the circadian rhythm RR for 25 days (group 3), 12 days (group 2), 9 days (group 1).

Dynamics of the mesor of the circadian rhythm of oxygen saturation during toxemia in children over 7 years old

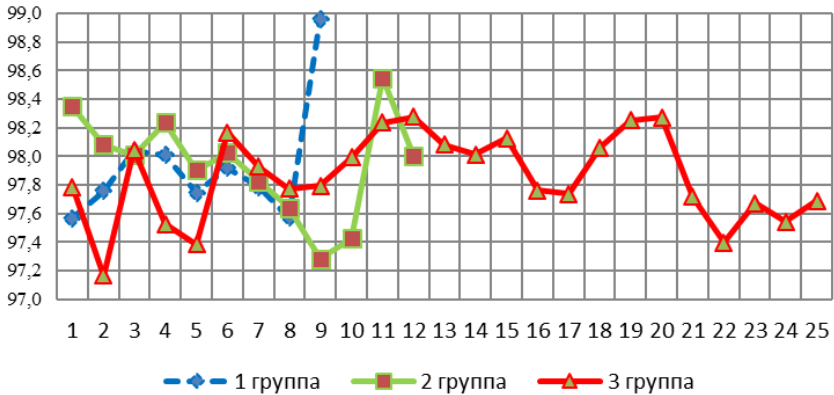


Fig.3.

Amplitude of daily fluctuations in the oxygen saturation index depending on the severity of the condition

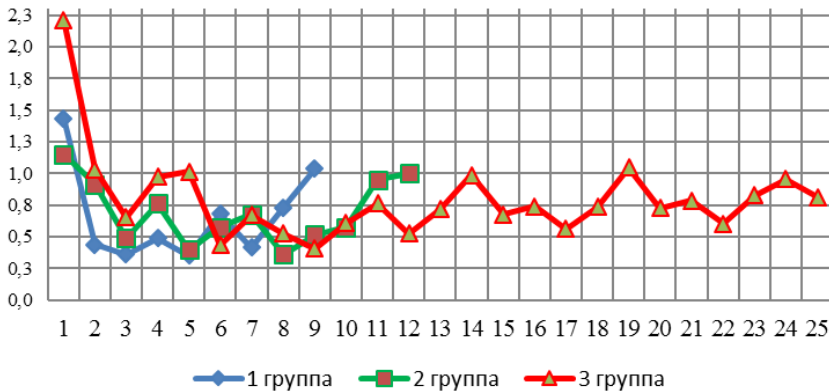


Fig.4

Oxygen saturation fluctuations were most pronounced on the first day, so in group 3, the amplitude of oxygen saturation fluctuations was the highest, 2.3%, in group 2 - 1.2%, in 1 - 1.4%. It turned out that the more severe the degree of the burn, the more pronounced the changes in the oxygen saturation index per day (fig. 4).

The severity and duration of shifts in the acrophase of the circadian rhythm of BR in children over 7 years old

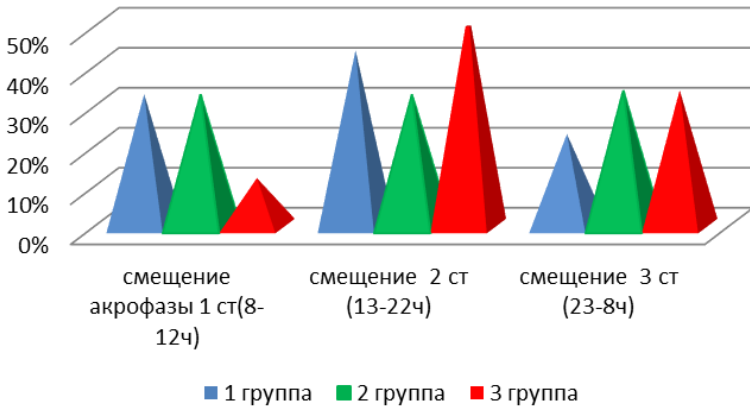


Fig.5

As shown in fig. 5, it was in group 3, during the longest duration of intensive therapy, that a shift in the acrophase of the circadian rhythm RR of degrees 2 and 3 was observed, accounting for 54% and 34% of the duration of intensive therapy. While in group 2, the RR acrophase shift of varying severity took the same part of the toxemia period. In group 1, time prevailed (44%) with a moderate shift of acrophase (within daytime).

The severity and duration of shifts in the acrophase of the circadian rhythm of oxygen saturation in children over 7 years old

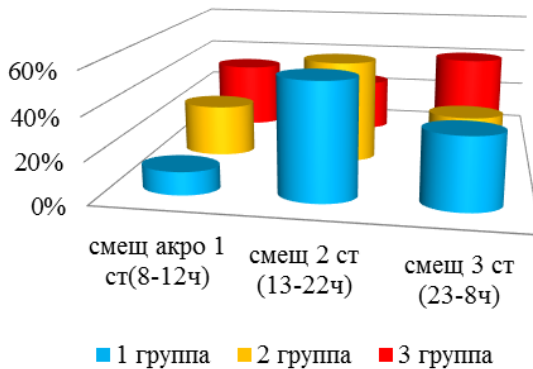


Fig.6

The shift in the acrophase peaks of the oxygen saturation index within the day-time hours (grade 2) prevailed in groups 1 and 2 (55% and 50%, respectively). The longest time inversion of the circadian rhythm of the oxygen saturation indicator was found in children of group 3 - 41% (fig. 6).

Hourly correlations of saturic acid and BR in children over 7 years old

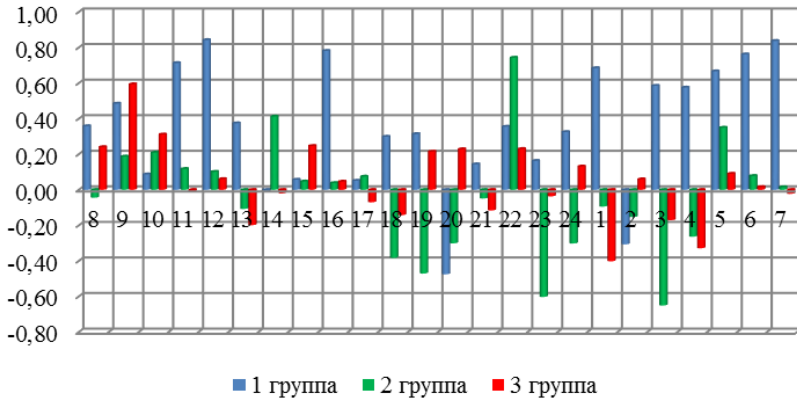


Fig.7

Figure 7 shows the data of correlations between the oxygen saturation index and the respiratory rate. The direct correlation dependence of the oxygen saturation indicator on the respiratory rate prevailed in children of the 1st group at 11.12.16 o'clock in the afternoon and at night (at 1,3,4,5,6,7 o'clock). That is, throughout the entire period of toxemia in group 1 for 11 hours (out of 24 hours), the respiratory rate compensated for the increased oxygen demand by increasing respiration rate, maintaining the oxygen saturation indicator at a high level. In group 2, the compensatory nature of increased respiration was revealed only at 22:00. In the evening night hours, an inverse correlation appeared more pronounced at 23:00 (-0.6), at 3:00 in the morning (-0.68). That is, increased respiration at this time of day in group 2 was not accompanied by a natural increase in oxygen saturation, that is, it turned out to be insufficient and corresponded to respiratory hypoxia, although an increase in respiration rate by 8% was detected only on the 9th and 11th days. In group 3, the compensatory significance of increased respiration decreased significantly, correlations between RR mesors and oxygen saturation index were insignificant. This confirms the idea that the more severe the burn, the more pronounced the failure/insufficient ventilation of the lungs in the correction of more

severe and complex disorders of homeostasis systems with thermal damage of more than 50% of the skin surface with a depth of 3B degree more than 20%.

**Conclusion.** On day 1, the most pronounced increase in breathing rate is characteristic of children of group 3 with an area of the burned skin surface of 2-3A degree  $25.8 \pm 11.4\%$ , 3B degree  $22.5 \pm 6.6\%$ , IF -  $95.8 \pm 19.1$  units. The more severe the degree of the burn, the more pronounced are the differences in the oxygen saturation index per day. Throughout the entire period of toxemia in group 1 for 11 hours (out of 24 hours), the respiratory rate compensated for the increased oxygen demand by increasing the frequency, maintaining the oxygen saturation index at  $97.9 \pm 0.2\%$ . In group 2, the compensatory nature of increased respiration was detected at 22:00. In group 3, there was no significant correlation between the mesor of circadian rhythms RR and the oxygen saturation index.

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眼科医生眼中的结核病问题

**PROBLEMS OF TUBERCULOSIS THROUGH THE EYES OF AN  
OPHTHALMOLOGIST**

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抽象。

这项研究的目的。 对高危人群和肺结核人群的眼科病理结构进行临床和统计分析。

材料与amp;方法。 该分析是在1853年患有非肺部疾病的眼科结核病诊治所的患者中进行的。

结果与amp;讨论。 成年肺结核患者的眼部病理表现为：各种视网膜病变的48.6%，屈光和调节障碍的27.4%，晶状体病理的8.4%。 对较年轻年龄组的分析显示，儿童和青少年的视网膜疾病患病率分别为63.8%和64.8%。

结论。 有必要为眼科病房提供适当的诊断电生理设备和现代成像设备，以便将研究结果存档。

关键词：肺外结核；视网膜疾病；眼损伤

**Abstract.**

**Purpose of the study.** Conduct a clinical and statistical analysis of the structure of ophthalmic pathology in people at risk and people with pulmonary tuberculosis.



**Material and methods.** *The analysis was carried out in 1853 patients of the office of the ophthalmological tuberculosis dispensary of patients with non-pulmonary form of the disease.*

**Results and discussion.** *Eye pathology in adult patients with pulmonary tuberculosis is represented by: 48.6% of various retinal lesions, 27.4% of refraction and accommodation disorders, 8.4% of lens pathology. The analysis of younger age groups showed the prevalence of retinal diseases in both children and adolescents - 63.8% and 64.8%, respectively.*

**Conclusions.** *It is necessary to provide the ophthalmological reception room with appropriate diagnostic electrophysiological devices and modern imaging devices with the possibility of archiving the research results.*

**Keywords:** *extrapulmonary tuberculosis, retinal diseases, eye damage*

### **Relevance**

Eye damage refers to the extrapulmonary form of tuberculosis and after the pulmonary and osteoarticular forms it takes the third place in the number of cases [1,2,3]. Tuberculosis requires long-term treatment, despite the development of the modern pharmacological industry, due to which there is an increase in the life expectancy of patients with cardiovascular pathology, rheumatic diseases [4], neoplastic processes [5], HIV infection [6]. As a rule, visual function is restored in the treatment of early manifestations of ocular tuberculosis, and in the treatment of later stages of the disease remains reduced, up to disability [7]. At the same time, long-term treatment of pulmonary and osteoarticular forms of tuberculosis with specific therapy (ethambutol) leads to toxic damage to the lens and optic nerve. At the tuberculosis dispensary (Oblast, city, interdistrict) there is an office for ophthalmological reception of patients with eye tuberculosis, before prescribing a course of specific treatment, or when ophthalmological changes appear against the background of therapy of a risk group (institution employees). The doctor of this office needs not only fundamental knowledge of the problems of tuberculosis, the peculiarities of changes in the organ of vision in other systemic diseases [4,5], and possible complications of medical interventions [8].

### **The purpose of this study**

Conduct a clinical and statistical analysis of the structure of ophthalmic pathology in people at risk and people with pulmonary tuberculosis in three age groups: children (people 0-14 years old), adolescents (people 15-17 years old) and adults (patients over 18 years old), observed in SBHCI TO "Oblast anti-tuberculosis dispensary" in Tyumen to determine the main trends in these patient groups.

### **Material and methods**

The report of an ophthalmologist SBHCI TO "Oblast anti-tuberculosis dispensary" (hereinafter dispensary) on the structure of registered diseases for 2019 was

chosen as the main source of information of interest. The main method was the retrospective clinical and statistical analysis of the data obtained by the ophthalmologist of the dispensary. During the analyzed period, 1,853 patients turned to the ophthalmological office, among which 47 cases were children 0-14 years old, and 37 cases were adolescents 15-17 years old. The rest of the patients belong to the adult age group.

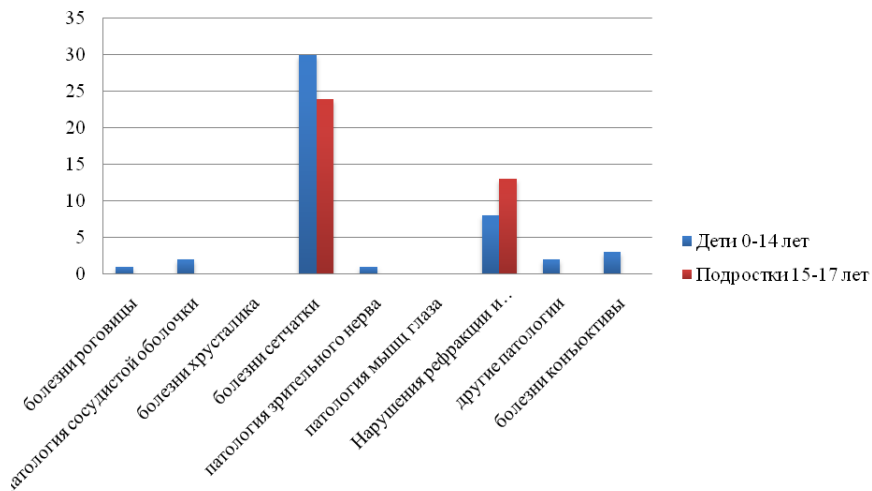
### **Results and discussion**

In the course of the work, it was found that the absolute majority (847 cases, or 48.6%) of eye pathologies in adult patients with pulmonary tuberculosis are represented by various retinal lesions (fig. 1). At the same time, more often than others, a change in the shape and ratio of retinal vessels was observed, caused, as a rule, by the presence of a concomitant premorbid background - such diseases as ischemic heart disease, arterial hypertension, diabetes mellitus, atherosclerosis and the manifestation of the toxic effect of anti-tuberculosis drugs. The complete absence of age-related macular degeneration in the structure of retinal pathology was also revealed. Disorders of refraction and accommodation, represented mainly by myopic processes of varying severity, became the second most common in the adult age group (478 cases, or 27.4%) in the structure of referrals. The number of patients with myopia was 361, or 75.5% of all cases of refractive error and accommodation. The proportion of lens pathology in adults was 8.4% and was found in 146 cases. The internal structure of the pathology is mainly represented by age-related cataract (131 cases or 92.5%), however, postoperative conditions also took place (3 cases of aphakia and 5 cases of pseudophakia). The proportion of surgical conditions in the structure of the lens pathology in the group under consideration was 5.6%. The rest of the pathologies (less than 2% of the total number of lens diseases) is represented by complicated cataract that arose while taking ethambutol.



*Fig 1. The structure of ophthalmological manifestations in the adult age group*

The incidence of optic nerve (ON) pathology was 97 cases or 5.6% of the total sample among adults. The spectrum of nosologies is represented by ON inflammation (neuritis), congestive disk ON, partial atrophy of the optic nerve (associated with ethambutol intake). It should be noted that the predictor of the development of neuritis, as a rule, was the phenomenon of meningitis, which often accompany the course of pulmonary tuberculosis in patients with a history of HIV infection. Rare nosologies in adults: conjunctival diseases - 18 cases or 1% of the total sample; corneal pathology (chronic and degenerative conditions) - 12 cases or 0.7%; choroidal diseases - 11 cases or 0.6% of the sample; other conditions of the eyes and adnexa - 36 cases or 2% of the total sample.



**Fig 2.** The structure of ophthalmological manifestations in children and adolescents age groups

The analysis of younger age groups showed the prevalence of retinal diseases in both children and adolescents - 63.8% and 64.8%, respectively (fig. 2). The most likely predictor of the development of this spectrum of pathology is the use of specific pharmacological therapy. Disorders of refraction and accommodation were somewhat less common - the proportion of violations was 27.7% and 35.2%, respectively. In addition, in the children's age group, 3 cases of conjunctivitis (6.4%), 2 cases of iridocyclitis (4.3%), one case of corneal and optic nerve pathology (4.2%) were also diagnosed.

### Conclusions.

1) Most often (48.6%) in the adult age group there is a spectrum of various retinal disorders. Disorders of refraction and accommodation are somewhat less common (27.4%).

2) General patterns of distribution of pathologies in all age groups were found: retinal pathology prevails in the overwhelming majority of cases, regardless of age category, and refractive and accommodation disorders rank second in prevalence in the analyzed groups. Further distribution of pathologies in frequency of occurrence did not reveal any obvious patterns.

3) In view of the detection of the described tendencies, it is necessary to provide the ophthalmological reception room with the appropriate equipment: electrophysiological, modern visualization devices - a retinal (or fundus) camera, optical coherence tomography with the ability to archive and observe the dynamics of changes, computer perimetry.

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计算机断层扫描在视觉器官成像中的可能性

## POSSIBILITIES OF COMPUTER TOMOGRAPHY IN IMAGING OF THE ORGAN OF VISION

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抽象。 以一名67岁的P. 患者的临床病例为例，显示了现代计算机断层扫描成像方法的有效性，该方法包括在具有眼部病理的颅脑外伤患者的护理标准中。

关键词：眼外伤，可视化，计算机断层扫描。

**Abstract.** *On the example of a clinical case of patient P., 67 years old, the effectiveness of the modern method of imaging computed tomography, which is included in the standard of care for patients with traumatic brain injury, with eye pathology, is shown.*

**Keywords:** *eye trauma, visualization, computed tomography.*

### Introduction

At the end of the 20th century, many special diagnostic methods appeared with a very high degree of detailing of the structures under study [1]. The obtained results of medical imaging are necessary for the diagnosis of diseases, treatment and

monitoring of patients [2]. Modern methods of radiation diagnostics include plain radiography, X-ray computed tomography (CT), magnetic resonance imaging, ultrasound (US) A - and B-scanning, spatial ultrasound scanning with color Doppler mapping [3]. These methods in ophthalmology are intended for visualization of the orbit, mainly of the structures of the posterior segment of the eyeball and are of great importance, in case of a serious condition of the patient, the impossibility of other optical methods of visualization of the eyeball [4,5]. CT is a mandatory method for examining patients with traumatic brain injury (TBI) [6,3]. A multi-disciplinary approach to the examination and treatment of a patient by specialists of different profiles almost always occurs in polytrauma, neoplasms of the skull and brain [4,5]. Diagnostic imaging techniques are extremely important in head trauma with damage to the eyeball and periocular tissues [2,3].

**The purpose of our study was** the analysis of a clinical case of the effectiveness of the modern CT imaging method in monitoring a patient with combined neurosurgical and ophthalmic trauma on the background of somatic polymorbidity.

#### **Materials and methods**

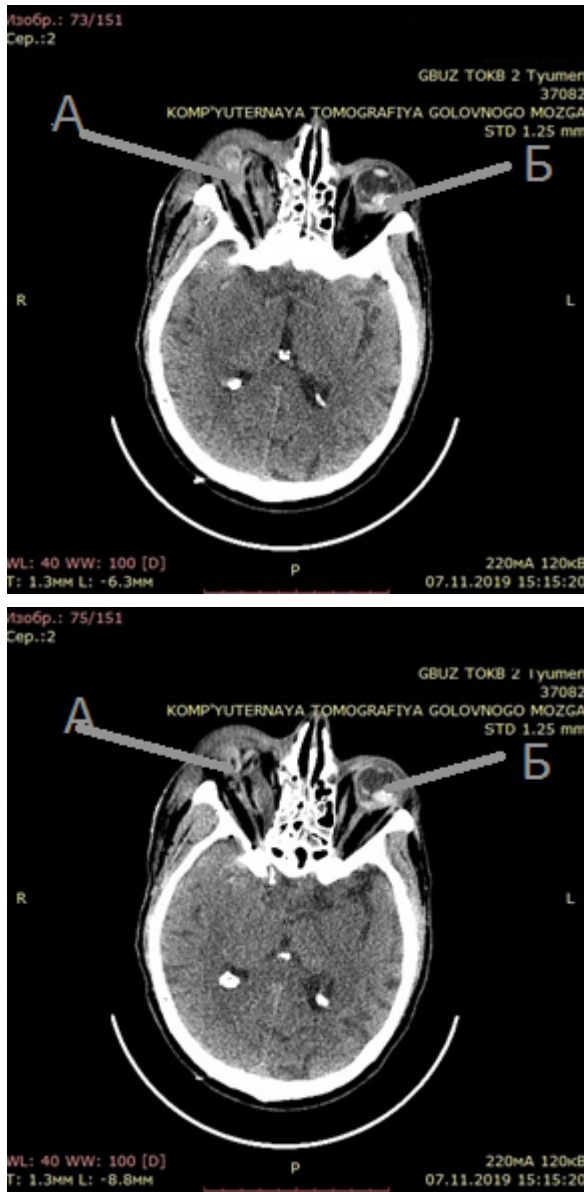
A clinical analysis of the characteristics of the nature of the trauma, monitoring of the results of diagnostics and tactics of types of treatment in patient P., 67 years old, with an improvised firearm delivered on 07.11 is presented. 2019 to the surgical department №3 SBHCI TO "OCH №2" by the ambulance team in serious condition.

#### **Results and discussion**

Patient P., 67 years old, was admitted with a diagnosis of gunshot wound. Open TBI. Severe contusion of the brain. Intracerebral hematoma in the right parietotemporal lobe of the brain. Fracture of the right parietal bone. Multiple foreign objects of the brain. Suicidal attempt. (S06.31). Associated diagnoses: Other injuries of the eye and orbit. Gunshot wound. Destruction of the right eyeball. Penetrating wound of the left orbit, foreign body (pellet?) of the left orbit. Severe contusion, hyphema, hemophthalmus of the left eyeball. Fracture of the walls of both orbits, hematoma of the eyelids of both eyes (S05.8). The diagnosis is made as a result of examination of the patient by a neurosurgeon, ophthalmologist, CT of the brain and orbits. Neurological status: consciousness - medication sedation; criticality - violated; orientation in place and time - violated; cerebral symptoms - in the form of impaired consciousness; pupillary reaction to light - absent; eyeball movements - setting the gaze forward; violation of sensitivity on the face - not known; face - asymmetric due to traumatic edema of the soft tissues of the face; tongue - along the middle line; muscle strength in the arms and legs - reduced; muscle tone in the arms and legs - reduced; reflexes from hands and feet are reduced; coordination tests, superficial sensitivity, paresthesias, aphatic disorders – can't be evaluated;

epileptic seizures - none; control over the function of the pelvic organs - violated; meningeal symptoms - none. The patient was examined by an ophthalmologist in the intensive care room. When examining the ophthalmological status, it is impossible to determine visual acuity, due to the severity of the patient's condition. OD - eyelid hematoma, the palpebral fissure is closed. The eyeball is collapsed, has no shape and tone. An extensive scleral wound is visible, its boundaries are not determined, in the conjunctival cavity there is a conglomerate of undifferentiated inner membranes and contents of the eyeball that have fallen out of the wound. OS - eyelid hematoma, the palpebral fissure is closed, the position of the eyeball in the orbit is correct, the range of motion cannot be assessed, pronounced chemosis of the conjunctiva, the anterior chamber of normal depth, a suspension of blood in moisture, the pupil is medium wide, there is no reaction to light and fundus reflex. The tone of the eyeball by palpation (TP) is normal. During hospitalization, changes in blood tests were revealed: relative neutrophilic (82.2%) leukocytosis ( $18.27 \times 10^9/l$ ) with a shift to the left to stab (8%), normochromic (CP 0.92) normocytic (MCV 81 fl) anemia (hemoglobin 107 g/l, erythrocytes  $3.66 \times 10^9/l$ ), hyperglycemia (10.8 mmol/l), hyperuricemia (9.1 mmol/l). CT (07.11.2019): intracerebral hematoma in the right parietotemporal lobe of the brain, multiple artifacts of metallic density. CT signs of intracerebral hematoma. Pneumocephalus. Foreign bodies in the substance of the brain. Comminuted fractures of the bones of the vault and facial parts of the skull. Damage to orbital structures. Hemosinus. On CT of the orbits - signs of destruction of the right eyeball, multiple fractures of the walls of both orbits. On the border of the frontal sinus and the left orbit, foreign bodies of metallic density (pellet?) are determined, in the left eyeball the contents are close to the density of blood.





**Fig. 2.** Computer tomograms of the orbits - A) signs of destruction of the right eyeball; B) contents close to the density of blood in the posterior pole of the left eyeball

The patient was prescribed systemic antibacterial, vascular and infusion therapy, surgical treatment. According to urgent indications in a hybrid operating room, decompressive trepanation was performed (decompressive bifrontal craniotomy, removal of a multi-fragmented fracture of the frontal bone, foreign bodies of the brain matter, intracerebral hematoma of the left frontal lobe, sanitation of the subdural space) and enucleation of the right eyeball.

In the early postoperative period (11.8.19), neutrophilic (91.6%) leukocytosis ( $10.9 \times 10^9/l$ ), hyperglycemia (8.6 mmol/l), hyperuricemia (9.1 mmol/l) persist, and hypoproteinemia was also revealed. due to a decrease in the fraction of albumin (33 g/l) and an increase in the level of creatinine (160  $\mu\text{mol/l}$ ). These indicators persist for a week (until 11.16.19), then there is a tendency to a decrease in the level of leukocytes ( $9.6 \times 10^9/l$ ), an increase in the level of platelets ( $453 \times 10^9/l$ ) and their normalization, while anemia remains (erythrocytes  $3.27 \times 10^9/l$ , hemoglobin 90 g/l).

The patient consulted by a therapist, noted: stable hemodynamics, blood pressure on the right hand: 160/100 mmHg, heart rate - 88 bpm, sinus heart rhythm, heart sounds - muffled, rhythmic; pulsation in the peripheral arteries is determined. Electrocardiography (ECG): Sinus tachycardia 100 per minute. Signs of left ventricular hypertrophy with systolic overload. Signs of subepicardial apex ischemia. Diagnosed with Ischemic heart disease (IHD). Atherosclerotic cardiovascular sclerosis. Arterial hypertension stage 3, grade 3, risk 4. CHF I, without specifying f.c. Recommended: diet 10, lisinopril 10 mg in the morning, bisoprolol 10 mg in the morning, hypothiazide 25 mg in the morning, acetylsalicylic acid 0.5 1/4 in the evening, atorvastatin 20 mg in the evening, anticoagulants.

In the postoperative period, additional topical therapy was prescribed: in the right conjunctival cavity - solution of levomycetin 0.25%, solution of ciprofloxacin 0.3%, 1 drop 4 times a day; in the left eye - solution of levofloxacin 0.5%, solution of dexamethasone 0.1%, 1 drop 4 times a day, parabolbar solution of heparin 500 IU + solution of dexamethasone 0.5 ml daily.

CT control of the brain (11.08.2019): in comparison with the CT-study of 11.07.2019, the state after surgery is determined, the defect of the frontal region is approximately 12.0x9.4 cm. In the area of surgical intervention, bone fragments and foreign bodies are determined. Intracranial foreign bodies are noted. In the frontal areas, hemorrhagic areas surrounded by a zone of low density are determined, with a total size of 7.2x4.0 cm on the right, 2.4x2.2 cm on the left. SAH is noted in the parietal regions, along the interhemispheric fissure and the cerebellar tentorium. A small amount of blood is detected in the lateral ventricle.



*Fig. 3. Computer tomograms of the orbits - A) lack of visualization of the right eyeball; B) contents close to the density of blood in the posterior pole of the left eyeball*

In dynamics, when examining the ophthalmological status, hematoma of the eyelids of both eyes remains, the palpebral fissure on the right and left is closed. OD - anophthalmos, the conjunctival cavity is clean. OS - the position of the eyeball is correct, Maklakov's tone is 19 mmHg, subconjunctival hemorrhages, the pupil is drug-induced mydriasis (tropicamide 1%), a blood clot is organized in the pupil area, the fundus reflex is not detected. Additionally, OS treatment was prescribed - parabolbarbo solution of heparin 500 IU + solution of dexamethasone 0.5 ml daily.

CT of the brain in dynamics (11.14.19): in comparison with the CT-study of 11.08.2019, the appearance of a parenchymal hematoma in the left frontal region is noted, measuring 2.1x2.5x4.0 cm, with an approximate volume of 10 ml. Intracranially, air bubbles are not detected. The rest of the CT picture is the same.





*Fig. 3. CT orbits - A) lack of visualization of the right eyeball; B) fragments of the frontal bone in the orbit; C) contents close to the density of lysed blood in the posterior pole of the left eyeball*

When viewed by an ophthalmologist 27.11.19, positive dynamics was revealed - the eyelid hematoma resolved, the palpebral fissure was closed on the right and left, OD - anophthalmos, the conjunctival cavity is clean, OS - the position of the eyeball is correct, the Maklakov tone is 18 mmHg, the pupil is round, regular, drug-induced mydriasis (tropicamide 1%), retroental heme, eye reflex gray-pink, fundus details are not visualized.

To determine the tactics of managing the patient, CT of the orbits was prescribed. CT (11.27.19) in dynamics recorded the absence of blood in the left eyeball, the shape of the eyeball is not changed.



*Fig. 3. Computer tomograms of the orbits - a) lack of visualization of the right eyeball; b) fragments of the frontal bone in the orbit; c) the structure and shape of the left eyeball is preserved*

Thus, if it is impossible to inspect the structures of the posterior segment of the eyeball using standard methods (direct ophthalmoscopy), CT of the orbits is an additional effective method of visualization with the possibility of dynamic monitoring of the state of the structures of the eyeball.

#### Conclusion

The presented clinical example clearly demonstrates the need for a multidisciplinary approach in the management of patients with craniocerebral trauma: the need for diagnostic manipulations in the state of providing the patient with intensive care, surgical interventions in a hybrid operating room (neurosurgeon and ophthalmologist), the effectiveness of a modern imaging method (CT of the brain and orbits) in the dynamics of observation of structural ophthalmic changes in the eyes.

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高危儿童早产儿视网膜病变的发展因素

**FACTORS OF THE DEVELOPMENT OF RETINOPATHY OF  
PREMATURITY IN CHILDREN OF THE RISK GROUP**

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这项研究的目的。为了确定有风险的儿童中RP的发生率，母亲的产科史，胎龄和出生体重的特征。

材料和方法。对638名早产儿在三年期间的门诊记录进行了分析，其中309名女孩（48.44%）和329名男孩（51.56%），平均妊娠期为32周，平均出生体重为1631克。

结果与讨论。在100%的病例中发现了母亲的产科病理，其中一名患者出现了多种加重性疾病（1.32），胎盘病理占了主导地位（40.12%-胎盘功能低下和胎盘早剥）。早产儿视网膜病变（RP）发生在104名（16.30%）患者中，RP发生风险组-534名（83.69%）患者。按疾病分期的RP结构以1期RP（60人）为主，第二位是3期RP（23人），第三位是2期RP（20例患者），在4-5岁时诊断为RP 1名患者。

结论：RP发生和发展的危险因素是母亲的体细胞病理学存在，导致胎儿缺氧的发生。RP的发展与早产时婴儿和眼睛组织的深度不成熟有关。出生体重较轻且胎龄较短的儿童发生RP及其严重形式的风险最高。



关键词：早产儿视网膜病变，母体产科史，胎龄。

**Purpose of the study.** *To identify the incidence of RP among children at risk, the characteristics of the mother's obstetric history, gestational age and birth weight.*

**Materials and methods.** *The analysis of outpatient records of 638 premature babies over a three-year period was carried out, of which 309 girls (48.44%) and 329 boys (51.56%), with an average gestation period of 32 weeks, an average birth weight of 1631 grams.*

**Results and discussion.** *Obstetric pathology of mothers was detected in 100% of cases, there was a combination of several aggravating nosologies in one patient (1,32), placental pathologies took the leading place (40.12% - placental dysfunction and low placentation). Retinopathy of prematurity (RP) developed in 104 (16.30%) patients, the risk group for the development of RP - 534 (83.69%) patients. The structure of RP by stages of the disease is dominated by stage 1 RP (60 people), second place is stage 3 RP (23 people), third place is stage 2 RP (20 patients), stage 4-5 RP was diagnosed in 1 patient.*

**Conclusions:** *Risk factors for the development and progression of RP are the presence of somatic pathology in the mother, contributing to the occurrence of fetal hypoxia. The development of RP is associated with a deep immaturity of the infant and eye tissues at the time of premature birth; children with less birth weight and shorter gestational age have the highest risk of developing RP and its severe forms.*

**Keywords:** *retinopathy of prematurity, maternal obstetric history, gestational age.*

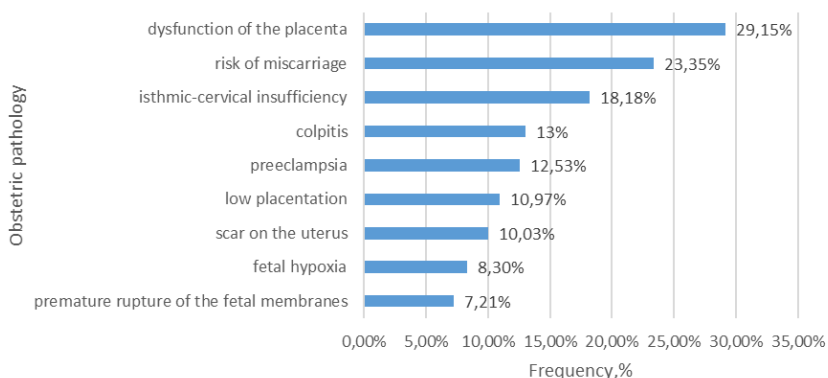
**Relevance:** Retinopathy of prematurity (RP) is a vitreoretinal vascular-proliferative lesion of the eyes of preterm infants in the first months of life, in severe cases leading to low vision and blindness [1]. From January 1, 2012, the health care of the Russian Federation switched to international standards for nursing newborn babies (body weight from 500 grams, gestational age from 22 weeks) [2]. RP attracts increased attention of ophthalmologists and neonatologists due to an increase in the incidence of the disease, a progressive decrease in the mortality rate of premature infants and an increase in disability [1,2]. The decrease in the mortality rate is due, inter alia, to the development of legal, psychological, medical, social assistance to women during pregnancy and the success of modern perinatology [3]. The challenge for doctors is to save the life of such a child and reduce the fatal complications of RP (retinal detachment). Ophthalmological care is as close as possible to the child, diagnostic and therapeutic laser rooms are located on the basis of perinatal centers [1]. Despite this, an unfavorable outcome of RP (development of stages IV-V) is observed in 3.3% of cases [2]. The underdevelopment of many organs and systems in a premature baby contributes to the emergence of various pathological conditions, therefore, the study of the somatic status remains

relevant [4,5]. Currently, RP occupies one of the leading places among diseases leading to visual disability in children [6]. Organization of effective ophthalmic care, including surgical, is one of the main tasks [5].

**Purpose:** Identify the frequency of RP development among children at risk, the characteristics of the mother's obstetric history, gestational age and birth weight.

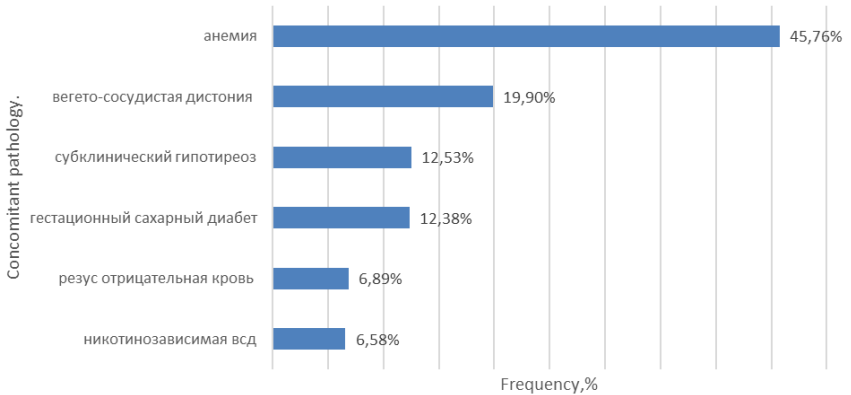
**Materials and methods:** The study was carried out on the basis of the SBHCI TO "OKH № 2" ophthalmological department of the Children's Hospital in the consultative and diagnostic room for the detection and observation of children with RP, which was organized according to the order of the Tyumen Region Health Department № 508 dated July 4, 2017 On the organization of medical care for children profile "Ophthalmology". According to the order, an examination by an ophthalmologist was carried out for all premature babies born at a gestational age of up to 35 weeks and weighing less than 2000 grams, who are being treated in the neonatal pathology department and the neonatal intensive care unit. The observation continued after discharge from inpatient conditions with the established frequency until the age of three years. Ophthalmological examination included an external examination of the anterior segment of the eyeballs, examination with a RetCam Clarity Medical Systems digital wide-angle retinal camera under conditions of drug mydriasis, skiascopy, and ultrasound examination was carried out according to indications. During the period from August 2017 to May 2019, 638 patients were examined in the office, of which 309 girls (48.44%) and 329 boys (51.56%). The average gestational age was 32 weeks, the average birth weight was 1631 grams.

**Research results:** We have assessed maternal risk factors for the birth of premature babies. Obstetric pathology of mothers was detected in 100% of cases (fig. 1), while a combination of several aggravating nosologies in one patient was often noted (1,32), placental pathologies occupied the leading place (40.12% - placental dysfunction and low placentation).



**Fig. 1.** Frequency of obstetric pathology in mothers of newborns (%)

Of the concomitant somatic pathology in mothers (fig. 2), the most frequent cases were: anemia - 292 cases, endocrine pathology - 159 cases (subclinical hypothyroidism and gestational diabetes mellitus), vegetative-vascular dystonia - 127 cases, Rh negative blood - 44 cases. In addition, attention is drawn to the presence of nicotine addiction in 42 (6.58%) cases of observations.

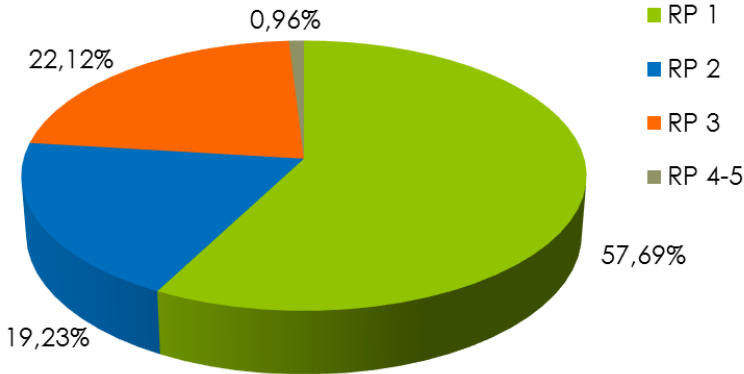


**Fig. 2.** The structure of concomitant somatic pathology of mothers of newborns (%)

According to our data, prematurity is often observed in multiple pregnancies. So 145 (22.72%) children were born from twins, and 19 (2.97%) from triplets.

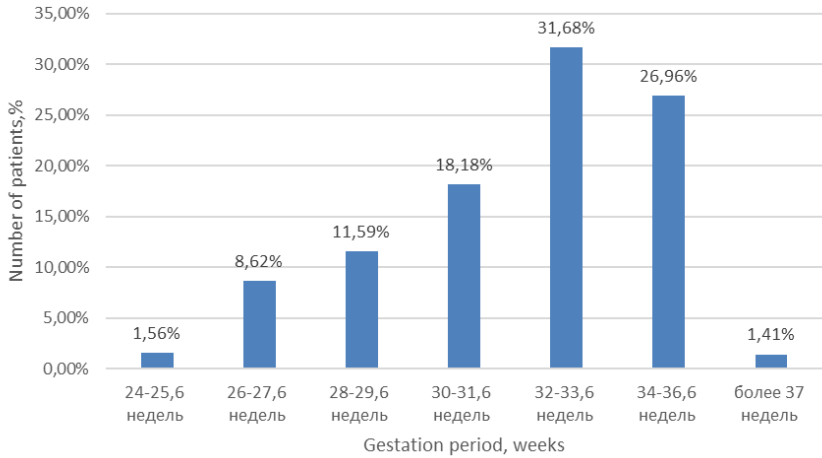
Among premature babies, pregnancy occurred through IVF in 76 (11.91%) cases, as a result of which twins were born in 49 (64.47%) cases and triplets in 12 (15.78%) cases.

Of the surveyed, RP developed in 104 (16.30%) patients, the main part is the risk group for the development of RP - 534 (83.69%) patients. The structure of RP by stages of the disease is shown in Figure 3, the leading position is taken by RP 1 stage (60 people), the second place is RP 3 stage (23 people), the third place is RP 2 stage (20 patients), RP 4-5 stages was diagnosed in 1 patient.



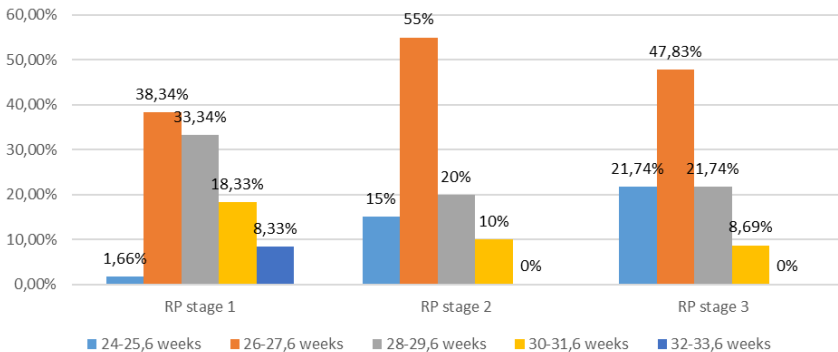
*Fig. 3. RP structure by stages*

General characteristics of patients with RP by stages: RP 1 (60 people): average gestational age - 29 weeks, average birth weight - 1171 g, Apgar score 5.67/6.63 points. Stage 2 RP was detected in 20 patients (19.23%), the mean gestational age was 28 weeks, the mean birth weight was 985 g, the Apgar score was 4.8/6.6 points. All patients with PH1 and PH2 showed spontaneous regression of the disease. RP stage 3 was detected in 23 patients (22.12%) with an average gestational age of 27 weeks, an average birth weight of 958 g, an Apgar score of 6/6.8 points. Of the patients with RP 3, retinal laser coagulation was performed in 18 patients, which is 78.26%, 4 patients were diagnosed with subthreshold stage of RP (17.39%). One child (4.3%) did not undergo RLC due to contraindications for general condition (severe hydrocephalus, condition after bypass surgery), retinal detachment developed, the child died at the age of 1 year. RP stage 4-5 was detected in 1 patient, the boy was born at 28 weeks, weighing 1130 grams. A detailed analysis of RP development was carried out depending on the gestational age. Among children at risk of developing RP (fig. 4), the first place is taken by patients born at 32-33.6 weeks, the second - 34-36.6 weeks, the third - 30-31.6 weeks. One in five of the risk group was born before 30 weeks of gestation.



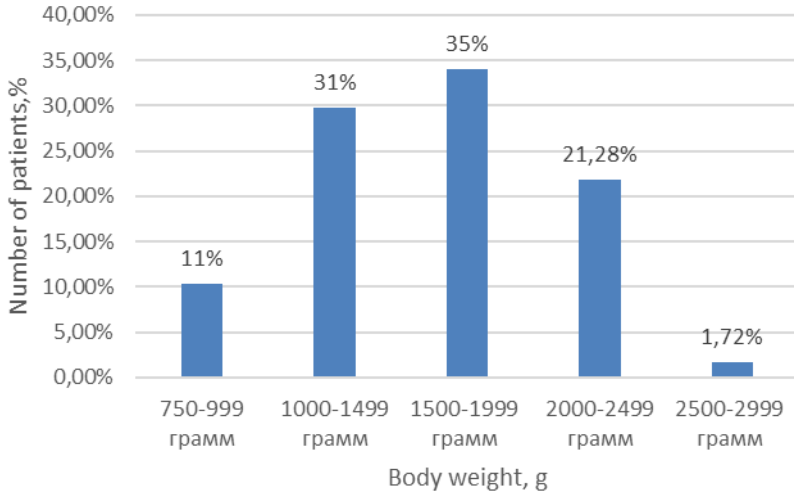
**Fig. 4.** The structure of patients at risk for the development of RP by gestational age

An analysis of the gestational age of patients with stage 1-3 RP (fig. 5) showed that RP develops most often in children born at an earlier date: the first place is taken by patients at 26-27.6 weeks, the second is 28-29.6 weeks. However, patients born at 24-26 weeks develop more severe stages of RP.



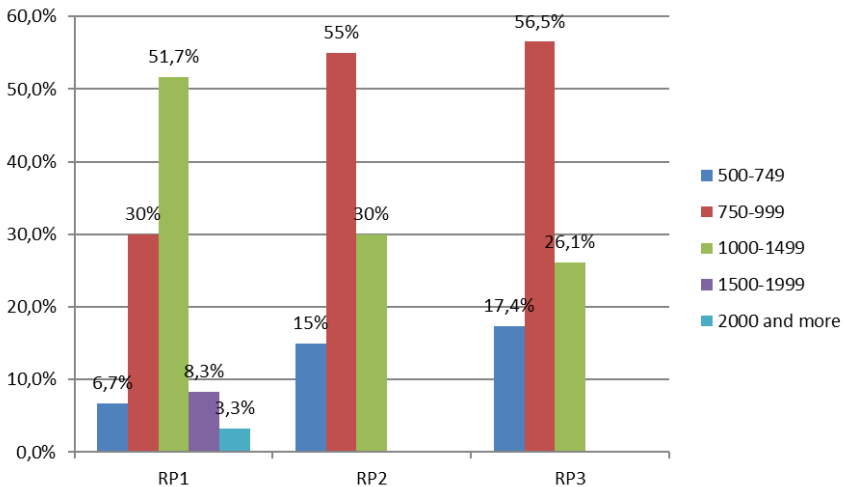
**Fig. 5.** Dates of gestation depending on the stages of RP

Analysis of birth weight in patients at risk for the development of RP (fig. 6) showed that most children were born with a weight of more than 1500 (58%), a third - from 1000 to 1500 grams, 11% - with an extremely low body weight (less than 1000 ).



**Fig. 6.** The structure of patients at risk for the development of RP by body weight

A detailed analysis of birth weight in patients showed that RP develops most often in children with extremely low body weight (from 500 to 1000 grams), while the frequency of more severe forms of RP increases with decreasing body weight. (fig. 7).



**Fig. 7.** Distribution of patients with RP by stages depending on body weight

Conclusion, findings:

1. The development of RP, and especially its severe forms, is primarily associated with the deep immaturity of the infant and eye tissues at the time of premature birth. Children with lower birth weights and shorter gestational age are at greatest risk of developing RP and severe RP.
2. Important risk factors for the development and progression of RP are maternal conditions (somatic and obstetric) that contribute to the occurrence of fetal hypoxia: anemia, endocrine disorders, smoking, placental pathology, chronic diseases of the female genital organs,
3. Children who have undergone RP require close supervision by an ophthalmologist throughout the entire period of growth and formation of visual functions.

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医疗保健中的沉浸式虚拟现实系统

IMMERSIVE VIRTUAL REALITY SYSTEMS IN MEDICAL CARE

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注解。 本文讨论了虚拟现实（VR）系统的主要特征及其在医疗保健中的应用领域（外科手术，神经病学，心理学/精神病学，疼痛治疗）。 分析其优势。 VR系统代表了强大的诊断平台，为专业人士开辟了新的可能性。 使用该技术，可以降低康复过程和患者护理的成本，并适当地管理资源。 它是连接物理和虚拟现实的有力工具，医生和外科医生可以借助这些工具提高患者对医生和治疗方法的信心。

关键字：VR，虚拟现实，VR技术，生物医学，沉浸式虚拟现实，IVR，医疗，培训，诊断，治疗

**Annotation.** *The article discusses the main characteristics of virtual reality (VR) systems and their areas of application in medical care (surgery, neurology, psychology/psychiatry, pain therapy). Analysis of their advantages. VR systems represent a powerful diagnostic platform that opens up new possibilities for professionals. Using this technology, it is possible to reduce the cost of rehabilitation process and patient care, and manage resources properly. It is a powerful tool for connecting the physical and virtual realities, with which doctors and surgeons can increase the patient's level of confidence in the doctor and the therapy.*

**Keywords:** *VR, virtual reality, VR technologies, Biomedicine, Immersive virtual reality, IVR, Medical, Training, Diagnosis, Treatment*

At the moment virtual reality (VR) systems are getting famous due to its vast sphere of applications. They provide a better 3D visualization experience during the teaching process. Moreover, it provides an innovative way to interact with the patient's soft tissue.

Virtual reality (VR) is one of the progressive digital tools used in health care. VR systems immerse the user in a virtual environment, while replacing sensory sensations with a digital three-dimensional (3D) alternative [1]. This aspect is relevant for use in medicine, since it allows you to evoke and analyze emotional

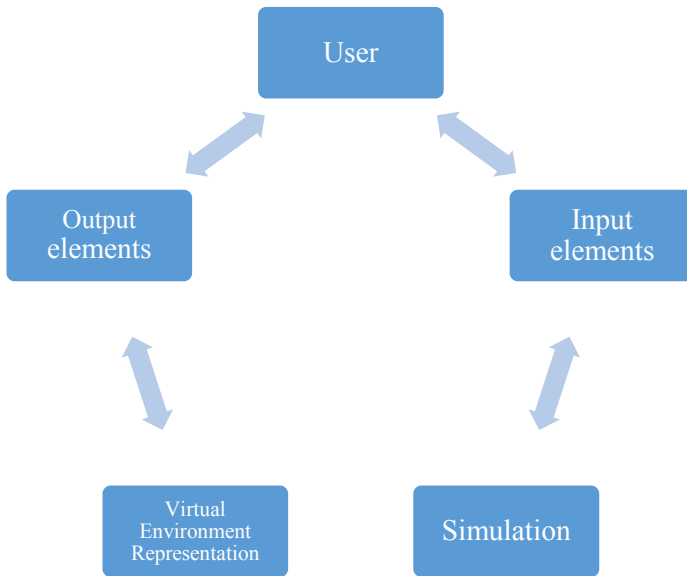


reactions. [1,2].

VR systems consist of output elements, which mean auditory, visual, tactile transmitters, energy transmitters, input devices – mouse, chaser, gloves, as well as a system for modeling a graphical environment – a helmet or glasses [2]. In a virtual environment, all the features of activity (duration, severity, type of feedback) can be adopted based on the type of treatment and individuals' ability [3,4]. In addition, individuals can see their motor results and correct them if necessary.

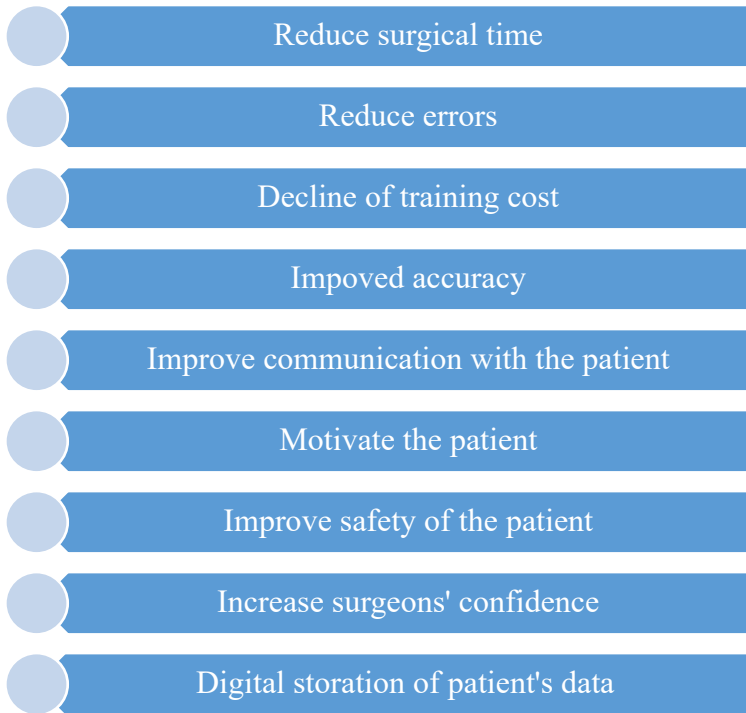
The structure of typical VR system is shown in figure 1.

VR technologies can provide stimulation (visual, sound, sensory) in two ways: 1) passive – viewing video content; 2) active – in this case, the user controls objects inside the simulation. Moreover, in both ways of stimulations, there is a response from the computer, which processes the results of user's actions [5].



**Figure 1** – Functional diagram of virtual reality systems

At the moment, the introduction of VR technology in the field of medicine is associated with the convenience of obtaining new knowledge in safe simulation. It helps future doctors and nurses to study anatomy and sections of epidemiology, to practice the skills required for operations. The new possibility of training operations in virtual reality cause no harm to the patient [6], and also forms the doctor's confidence to carry out complex operations (figure 2).



**Figure 2** – *Virtual reality advantages in the health care*

In the treatment of psychological diseases, VR tools allow the patient to interact with the virtual character, which promotes the development of social skills and provides affordable treatment with less risk to life [7].

This technology can also be used to treat limb pain: the patient is immersed in a simulation where a virtual limb is created. Performing the recommended exercises will help in analyzing the patient's condition and overcome pain.

In patients with neurological diseases, as well as in patients with severe injuries of the musculoskeletal system, VR technologies allow continuing the course of rehabilitation at home. At the same time, doctors can conduct remote monitoring and correction of training in virtual reality.

Despite the listed advantages, technology also has a number of disadvantages. The main problem with the widespread use of VR in medicine is its cost. In addition, the rehabilitation process takes a long time, and the equipment itself needs

powerful hardware and software. It is also currently impossible to use VR technology to diagnose new diseases since its functionality is limited to identifying specific cases [8].

Conclusions. Virtual reality systems are effective for use in clinical practice. They represent a powerful diagnostic platform that opens up new possibilities for applications in various fields of medicine. Expected that using such technologies will be increased since with their help in digital format, it is possible to perform a more thorough analysis of the patient's condition. However, due to several shortcomings, they need further improvement and research.

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DOI 10.34660/INF.2020.85.52.014

纵断面患者垂直方向面部美学障碍的定量评估  
**QUANTITATIVE ASSESSMENT OF FACIAL AESTHETICS  
DISORDERS IN THE VERTICAL DIRECTION IN PATIENTS WITH  
MESIAL OCCLUSION**

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抽象。 这篇文章提出了根据轮廓远射线照相图对具有各种形式的齿系近牙比率的患者在垂直方向上违反面部美学的定量分析结果。 在具有骨骼形式异常的患者中观察到最明显的变化。

关键词：中颌上颌，放射线照相分析，牙颌面异常的定量评估。

**Abstract.** *The article presents the results of a quantitative analysis of violations of facial aesthetics in the vertical direction in patients with various forms of mesial ratio of dentition according to profile teleroentgenograms. The most pronounced changes were observed in patients with skeletal forms of the anomaly.*

**Keywords:** *mesial occlusion, analysis of teleradiograms, quantitative assessment of dento-maxillofacial anomalies.*

The prevalence of dentoalveolar anomalies both among children and among adults, according to various data, ranges from 75% to 95.3%. The mesial ratio of the dentition accounts for 8% to 16.9% [1,2,5]. There are several forms of this pathology:

- skeletal anomalies, characterized by a change in the size of the jaws and their location in the skull;
- tooth-alveolar anomalies, characterized by a change in the ratio of the dentition of the upper and lower jaws;

- combined forms of anomalies [1,4,6,7,8].

A group of functional anomalies is distinguished separately, characterized by the habitual displacement of the lower jaw forward and the formation of a class III anomaly. We attribute these violations to skeletal anomalies, in particular, to the lower prognathia with the possibility of forward displacement of the lower jaw.

According to various studies, the main reason for the formation of class III anomalies is a hereditary predisposition. Already in the early stages of formation, this pathology is accompanied by significant morphological, functional and aesthetic disorders [1,2,3]. Underdevelopment or overdevelopment of the upper and lower jaws, their asymmetry, as well as a change in position, cause deformations of the contours of the middle and lower parts of the face, a change in profile, which significantly affects the aesthetics of the patient's face. However, soft tissue compensation must always be considered. In patients with a mesial ratio of the dentition, a straight or concave profile type is noted, the lower part of the face can be shortened or enlarged, depending on the type of growth of the facial part of the skull and the ratio in the incisor area (reverse overlap), chin protrusion. When pathology is combined with a functional forward displacement of the lower jaw, the facial signs of anomaly are more pronounced. In some clinical cases, malocclusion can be combined with significant changes in facial aesthetics, in others - against the background of significant malocclusion changes in facial aesthetics are insignificant [5].

Differentiation of the forms of mesial ratio of dentition, analysis of the type of growth of the facial part of the skull and changes in facial aesthetics consists in a clinical examination of the patient, analysis of photographs of the face and dentition, calculation of diagnostic models, X-ray cephalometric examination and CBCT analysis.

**Purpose of the study:** quantitatively assess the disturbances in facial aesthetics in the vertical direction in a group of patients with mesial dentition.

**Objectives of the study:**

1. Conduct an analysis of the prevalence of various forms of mesial ratio of dentition.
2. Conduct a quantitative assessment of violations of facial aesthetics in the vertical direction in patients with various forms of mesial ratio of the dentition.

**Materials and research methods**

We analyzed the profile teleroentgenograms of 113 patients - 46 men and 67 women aged 20 to 60 years with a mesial ratio of dentition who applied to dental clinics in St. Petersburg (Russia) for the purpose of orthodontic treatment. The average age of the surveyed was  $33.5 \pm 7.5$  years. The lateral teleroentgenograms were calculated using a modified technique [9].

Based on the revealed values of the inter-apical angle - ss-n-spm and the Wits

parameter, the forms of the mesial ratio of the dentition were differentiated into skeletal, tooth-alveolar and forms with a skeletal component.

A quantitative assessment of the violation of facial aesthetics in the vertical direction was carried out according to the data of the ratio of the front upper face height  $gl'-sn'$  to the front lower height  $sn'-Kme'$  according to the method of R.A. Fadeeva and A.N. Isravnikova [5].

**Results of the study:**

As a result of the studies, it was revealed that the frequency of occurrence of skeletal forms of mesial ratio of dentition is 83.2%, forms with a skeletal component - 14.2%, and dentoalveolar forms - only 2.6%.

The skeletal component group was divided into two subgroups:

I – the value of the angle  $ss-n-spm$  is within normal limits, decrease in the values of the Wits parameter;

II– decrease in the value of the angle  $ss-n-spm$ , the value of the Wits parameter is normal (tab. 1).

*Table 1. Analysis of  $ss-n-spm$  angle values and Wits parameter values.*

The shape of the mesial ratio of the dentition		Indicator name	M±m		p	
			men	women	men	women
Skeletal forms		ss-n-spm	-1,85±2,19°		p<0,0001	
		Wits	- 6,98±4,97mm	- 6,02±3,33mm	p<0,01	p<0,0001
Skeletal component	I subgroup (ss-n-spm within normal limits, decreasing Wits values)	ss-n-spm	2,05±0,71°		p>0,05	
		Wits	- 3,05±1,51mm	- 2,83±1,47mm	p<0,05	p<0,01
	II subgroup (decrease in the angle $ss-n-spm$ , Wits values are normal)	ss-n-spm	-0,06±0,91		p<0,001	
		Wits	0,74±1,56mm	-0,22mm	p>0,05	p>0,05
Tooth-alveolar forms		ss-n-spm	2,2±1,08°		p>0,05	
		Wits	- 0,35±0,95mm	2,09mm	p>0,05	

Table 1 shows that the average value of the angle ss-n-spm in the group with skeletal forms of mesial ratio of dentition is  $-1.85 \pm 2.19^\circ$  ( $p < 0.0001$ ), the value of the Wits parameter is  $6.98 \pm 4.97$  mm ( $p < 0.01$ ) for men and  $-6.02 \pm 3.33$  mm for women ( $p < 0.0001$ ). The mean value of the ss-n-spm angle in the I subgroup of patients with a skeletal component is  $2.05 \pm 0.71^\circ$  ( $p > 0.05$ ), the value of the Wits parameter is  $-3.05 \pm 1.51$  mm ( $p > 0.05$ ) for men and  $-2.3 \pm 1.42$  mm for women ( $p < 0.01$ ). In subgroup II, the mean value of the angle ss-n-spm was  $-0.06 \pm 0.91^\circ$  ( $p < 0.001$ ), the value of the Wits parameter was  $0.74 \pm 1.56$  mm for men ( $p > 0.05$ ) and  $-0.22$  mm for women ( $p > 0.05$ ). In the group with dentoalveolar forms, the mean value of the ss-n-spm angle was  $2.2 \pm 1.08^\circ$  ( $p > 0.05$ ), the value of the Wits parameter was  $-0.35 \pm 0.95$  mm ( $p > 0.05$ ) for men and  $2.09$  mm ( $p > 0.05$ ) for women. Statistically significant differences were found in the group with skeletal forms of mesial ratio of the dentition, in subgroup I of patients with a skeletal component when analyzing the values of the Wits parameter in men and women, in subgroup II of patients with a skeletal component when analyzing the values of the angle ss-n-spm.

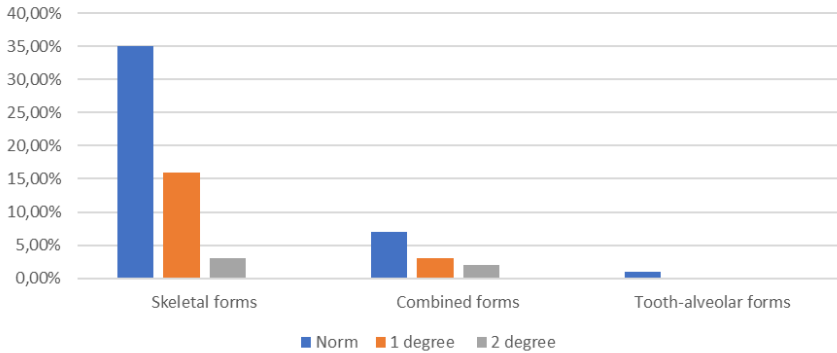
It was found that most of the dentition rows studied with a skeletal component of the mesial ratio have a reduced value of the Wits parameter at normal values of the ss-n-spm angle - 75%. The subgroup of patients with a reduced ss-n-spm angle and Wits values within the normal range is 25%.

In the future, in order to simplify the processing and presentation of the obtained material, we combined the subgroups with the skeletal component into one group, calling it a group with combined forms of anomalies: skeletal and tooth-alveolar. In patients of this group, both skeletal manifestations of pathology were noted, as evidenced by changes in the studied parameters (the ss-n-spm angle or the Wits parameter), and tooth-alveolar (disturbances in the ratio of the dentition, characteristic of the mesial occlusion).

A quantitative assessment of facial aesthetics disorders in the vertical direction in patients with a *decrease in the lower/increase in the upper facial height* according to the ratio of the anterior upper facial height gl'-sn' to the anterior lower height sn'-Kme' revealed: no disturbance in aesthetics in 35% of patients with skeletal forms of mesial ratio of dentition, I degree of violation of facial aesthetics - in 16% of the examined, II degree - in 3%. In patients with combined forms of the mesial ratio of the dentition, the absence of aesthetics impairment was noted in 7% of cases, grade I impairment - in 3% of patients, grade II - in 2%. In patients with dento-alveolar forms of the mesial ratio of the dentition, the absence of aesthetics disturbance was noted in 1% of patients (fig. 1, tab. 2).



Quantitative assessment of facial aesthetics disorders in the vertical direction in patients with mesial ratio of dentition with a decrease in the lower/increase in the upper facial height



**Fig. 1** Quantification of vertical facial aesthetics disturbances in patients with mesial dentition with a decrease in the lower/increase in the upper facial height.

**Table 2.** A quantitative assessment of violations of facial aesthetics in the vertical direction in patients with a decrease in the lower/increase in the upper face height.

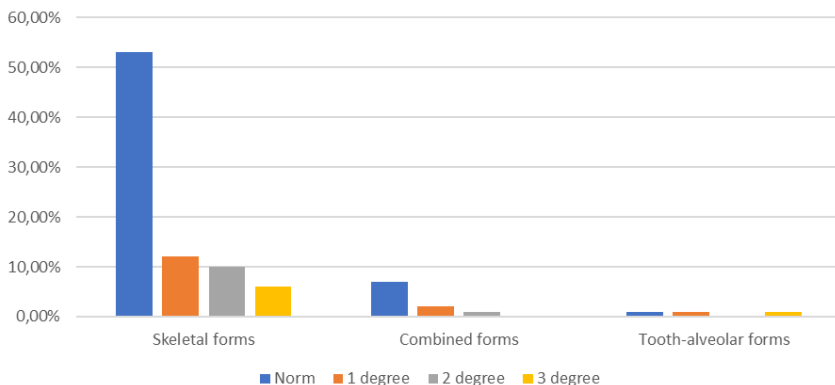
	Skeletal forms	p	Combined forms	p
Norm	1,00±0,04	p<0,0001	0,99±0,03	p<0,01
1st degree	1,09±0,03	p<0,0001	1,08±0,02	p<0,05
2nd degree	1,22±0,04	p<0,0001	1,2±0,04	p<0,0001
3rd degree	-	-	-	-

From tab. 2, it can be seen that in the group of patients with a skeletal form of mesial ratio of the dentition, the average value of normal indicators of facial aesthetics in the vertical direction in patients with a *decrease in the lower/increase in the upper facial height* is  $1 \pm 0.04$  ( $p < 0.0001$ ). With the I degree of aesthetics impairment, the average value of the indicator is  $1.09 \pm 0.03$  ( $p < 0.0001$ ), with the II degree -  $1.22 \pm 0.04$  ( $p < 0.0001$ ). In the group of patients with combined forms of mesial ratio of the dentition, the average value of normal indicators of facial aesthetics in the vertical direction in patients with a *decrease in the lower/increase in the upper face height* is  $0.99 \pm 0.03$  ( $p < 0.01$ ). With the I degree of aesthetics

disturbance, the average value of the indicator is  $1.08 \pm 0.02$  ( $p < 0.05$ ), with the II degree -  $1.2 \pm 0.04$  ( $p < 0.0001$ ). Statistically significant differences were found in all groups of the surveyed.

A quantitative assessment of facial aesthetics disorders in the vertical direction in patients with an *increase in the lower/decrease in the upper face height* according to the ratio of the gl'-sn' front upper face height to the sn'-Kme' front lower height revealed: absence of aesthetics disturbance in 35% of patients with skeletal forms of mesial ratio of dentition, I degree of facial aesthetics impairment - in 12% of patients, II degree of facial aesthetics impairment - in 10%, III degree of impairment - in 6% of patients. In patients with combined forms of mesial ratio of the dentition, the absence of aesthetics impairment was noted in 7% of cases, grade I impairment - in 2% of patients, grade II - in 1%. In patients with dento-alveolar forms of the mesial ratio of the dentition, the absence of aesthetics disturbance was noted in 1% of patients, the I degree of impairment in 1%, and the III degree of impairment in facial aesthetics was also noted in 1% of the subjects (fig. 2, tab. 3).

Quantitative assessment of facial aesthetics disorders in the vertical direction in patients with mesial ratio of dentition with an increase in the lower/decrease in the upper face height



**Fig. 2** Quantification of vertical facial aesthetics disorders in patients with mesial ratio of dentition with an increase in the lower/decrease in the upper face height.

**Table 3.** *Quantitative assessment of violations of facial aesthetics in the vertical direction in patients with an increase in the lower/decrease in the upper face height.*

	<b>Skeletal forms</b>	<b>p</b>	<b>Combined forms</b>	<b>p</b>	<b>Tooth-alveolar forms</b>	<b>p</b>
<b>Norm</b>	<b>1±0,04</b>	<b>p&lt;0,0001</b>	<b>0,99±0,03</b>	<b>p&lt;0,01</b>	<b>1</b>	<b>p&gt;0,05</b>
1st degree	0,92±0,01	p<0,0001	0,91±0,01	p<0,05	0,93	p>0,05
2nd degree	0,87±0,02	p<0,0001	0,85	p>0,05	-	-
3rd degree	0,8±0,03	p<0,0001	-	-	0,79	p>0,05

From tab. 3, it can be seen that in the group of patients with a skeletal form of mesial ratio of the dentition, the average value of normal indicators of facial aesthetics in the vertical direction in patients with an *increase in the lower/decrease in the upper face height* is  $1 \pm 0.04$  ( $p < 0.0001$ ). With I degree of aesthetics impairment, the average value of the indicator is  $0.92 \pm 0.01$  ( $p < 0.0001$ ), with II degree -  $0.87 \pm 0.02$  ( $p < 0.0001$ ), with III degree -  $0.8 \pm 0.03$  ( $p < 0.0001$ ). In the group of patients with combined forms of mesial ratio of the dentition, the average value of normal indicators of facial aesthetics in the vertical direction in patients with an *increase in the lower/decrease in the upper face height* is  $0.99 \pm 0.03$  ( $p < 0.01$ ). With the I degree of aesthetics impairment, the average value of the indicator is  $0.91 \pm 0.01$  ( $p < 0.05$ ), with the II degree -  $0.85$  ( $p > 0.05$ ). In the group of patients with dento-alveolar forms of the mesial ratio of the dentition, the average value of normal indicators of facial aesthetics in the vertical direction in patients with an *increase in the lower/decrease in the upper face height* is  $1$  ( $p > 0.05$ ). With the I degree of aesthetics impairment, the average value of the indicator is  $0.93$  ( $p > 0.05$ ), with the III degree -  $0.79$  ( $p > 0.05$ ). Statistically significant differences were found in the group of patients with skeletal forms of the mesial ratio of the dentition, in the group with combined forms with normal values of facial aesthetics and in violation of the first degree.

### Conclusions:

1) The most common forms of mesial ratio of dentition in adult patients are skeletal forms - 83.2%. Forms with skeletal components are found in 14.2% of cases. Tooth-alveolar forms account for only 2.6%.

2) In the group of patients with a mesial ratio of dentition with a skeletal component (combined forms), most of the anomalies are with a decrease in the value of the Wits parameter - 75%. Anomalies with a decrease in the n-s-gn angle were found in 25% of the examined.

3) Violation of the aesthetics of the face in the vertical direction in patients with a *decrease in the lower/increase in the upper face height* in most cases was revealed in skeletal forms of the mesial ratio of the dentition: I degree in 16%, II degree in 3% of cases. Violation of facial aesthetics in the vertical direction in patients with an *increase in the lower/decrease in the upper face height* in most cases was also found in skeletal forms of the mesial ratio of the dentition: I degree - in 12%, II - in 10%, III - in 6% of the examined.

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群众医疗的满意度

## THE SATISFACTION OF THE POPULATION WITH MEDICAL CARE

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抽象。 为了改善人民的健康状况，有必要不断使医疗保健现代化，开发医疗技术，优化行业管理和结构，并提高从事医疗保健工作的专业人员的专业水平。 所有这些领域的目的都是为了提高医疗质量，其中一项内容就是民众对医疗的满意度。 本文考察了评估成年人对医疗质量的满意度的方法论方面，并以萨马拉州为例，确定了影响成年人对医疗质量的因素。

关键词：医疗，满意度，患者取向，用于衡量满意度的问卷，护理质量

**Abstract.** *To improve the health status of the population, it is necessary to constantly modernize health care, develop medical technologies, optimize the management and structure of the industry, and improve the professional level of specialists working in health care. All these areas are aimed at improving the quality of medical care, one of the components of which is the satisfaction of the population with medical care. The article examines the methodological aspects of assessing the satisfaction of the adult population with the quality of medical care and identifies the factors influencing the satisfaction of the population with medical care using the example of the Samara Oblast.*

**Keywords:** *medical care, satisfaction, patient orientation, questionnaires to measure the level of satisfaction, quality of care*

The most important component of the quality of medical care is the level of satisfaction of patients and the population with the provision of medical care. The indicator of patient satisfaction with the quality of medical care reflects the degree of implementation of a patient-centered approach in the provision of medical services associated with better treatment outcomes and a favorable financial condition of a medical organization [1].

The urgent task of the healthcare sector is to increase satisfaction with medical care of the population and patients at all levels of medical services. The satisfaction of the population with the quality of medical care closely correlates with the quality of its provision. The interpretation of the concept of quality of medical care depends largely on the level of economic development of the country, its cultural, scientific and social aspects, the general level of education of the population [2].

In the Russian Federation, action plans (roadmaps) are being implemented to improve the efficiency of the health care system, including restructuring organizations that provide medical care, routing patient flows, and increasing wages for medical workers. All these activities, to one degree or another, contribute to improving the quality of medical care [3, 4].

An important aspect of studying the satisfaction of the population with medical care is the methodology for assessing the satisfaction of the adult population with the quality of medical care, which helps to determine the factors affecting the organization of medical care.

Patient satisfaction with health care has been measured since 1970, when a scale of patient satisfaction with primary health care was developed. Further, in the 1970s and 1980s, various questionnaires on patient and client satisfaction were created to assess the overall satisfaction of patients with medical services [7, 9].

Since the 2000s, the United States began to analyze patient satisfaction with medical services at the state level, when a methodology for assessing medical care by inpatients was developed [11].

In the European Region, the satisfaction of the population with medical care is also widely studied, questionnaires are used to ensure the quality control of medical care. At the same time, most of the developed questionnaires contain sections on the assessment of factors that influence satisfaction, for example, the interaction of the patient with the staff (ethical components), time characteristics (waiting time for an appointment, duration of an appointment with a doctor) and environmental issues (physical comfort, logistics of medical organizations). The dynamics of satisfaction among the population as a whole is analyzed, since maintaining satisfaction within a certain threshold is an indicator of adequate managerial decisions in health care [8, 10].

The Ministry of Health of the Russian Federation is also developing questionnaires for assessing satisfaction with medical care; in the country, satisfaction with medical care is gradually increasing, over ten years the satisfaction rate has increased from 30 to 40.4% [5].

At the same time, in each region of the country, the study of the level of satisfaction is carried out using different methods. Scientific works on measuring the level of patient satisfaction with the quality of medical care, as a rule, involve their own methodological tools, which makes it difficult to compare the results obtained

by different researchers [6].

In Samara Oblast over the past years, under the auspices of the Government, a project has been carried out to increase the satisfaction of the region's residents with health services. The long-term goal of the project is to increase the satisfaction of the population with the provision of medical care from the current 30-40% to 70%.

The project includes several stages, including team building, training in flexible project management technologies, questioning the population, developing directions to improve satisfaction with medical care, identifying the main problems in areas, work in areas, including identifying the causes of problems, solving them and developing a road cards.

In the course of the study, 30 people were interviewed experts in the field of healthcare organization and 505 people from Samara Oblast aged 18 and older. The main directions for increasing the satisfaction of the population of Samara Oblast were six positions, including cultural issues in the provision of medical care, management, personnel problems, the availability of medical care, informatization of medical organizations and their sanitary and technical condition.

The following points were attributed to the reasons for the identified problems:

1. Lack of clear goals, criteria for effective assessment and analysis of population satisfaction with medical care.
2. Low motivation for a patient-centered approach among employees and managers of medical organizations.
3. Lack of a list of required standards in medical organizations.
4. Lack of training on management issues for heads of medical organizations.
5. Emotional burnout of employees.
6. Lack of work with the population (improving medical literacy, managing patient expectations).
7. Decentralization of the IT-sphere, lack of resources and priorities for informatization.

Improving the ethical and social culture of medical workers in Samara Oblast should be implemented by updating the Code of Professional Ethics, training staff on ethical aspects of behavior, sharing best practices on population satisfaction, and psychological support for employees.

Management in medical organizations and management of the health care system involves a number of activities aimed at:

- identification of problems in a specific medical organization;
- optimization of lean manufacturing learning processes;
- development of a list of standards for a manager's work ("manager's book");
- work with the personnel reserve of health managers;
- assessment of the population's satisfaction with medical care.

Personnel issues on the satisfaction of the population with medical care should cover such areas as:

1. Interaction of employers with students.
2. Involvement of freelance specialists of the Ministry of Health of Samara Oblast in solving current problems of medical care.
3. Creation of favorable conditions by local governments for the work of medical specialists.
4. Improving the effectiveness of the institution of mentoring.
5. Improving the professionalism of medical workers.

The availability of medical care is realized by:

- reducing the waiting time for medical care;
- optimization of the activity of the registry in polyclinics;
- self-admission of patients by nursing staff;
- rational navigation and implementation of the principles of "lean production" in the hospital;

Informatization of healthcare is an important factor in its improvement, which should be aimed at implementing the following aspects:

1. The use of information technology in organizational processes in the provision of medical care.
2. Continuation of equipping medical organizations with automated workstations.
3. Creation of a single information space in the field of healthcare.
4. Creation of a system of electronic interaction of the health service with other departments.

The sanitary-technical condition implies the provision of the following main points:

- solution of sanitary and hygienic problems of medical organizations;
- Carrying out current and major repairs of healthcare institutions;
- organization of an accessible environment for patients with limited mobility.

At present, based on the data of the study, the Roadmap "Increasing the satisfaction of residents of the region with health services" has been developed, which specifies the content of activities, deadlines, executors, funding requirements and criteria for assessing the effectiveness of activities.

Thus, according to the data of the analysis, the patient-oriented approach is the basis of modern healthcare in many countries and its availability, assessed by the level of patient satisfaction, serves as an indicator of the quality of medical services provided. At the same time, the result is the stability of the level of satisfaction, which is regarded as a positive trend.

There are a large number of questionnaires for measuring the level of satisfaction with the quality of medical care, but the results obtained with their help are



incomparable with each other, which does not allow tracking the dynamics of the level of satisfaction, as well as learning from experience to improve it.

Currently, it is important to conduct a large study to examine the factors of satisfaction, which will allow interpreting the results of measuring the level of satisfaction with the quality of medical care.

The satisfaction of the population with medical care is one of the criteria for the quality of medical care, it requires the creation of a methodology adaptive to the regional health care system, requires continuous monitoring for modern adjustments of measures. Increasing the satisfaction of the population with medical care is a continuous and long-term process that requires scientific and practical support.

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细胞技术对其切除后肝脏体积变化的影响  
**INFLUENCE OF CELL TECHNOLOGIES ON CHANGES IN LIVER  
VOLUME AFTER ITS RESECTION**

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抽象。研究了主要 ( $n = 20$ ) 和对照组 ( $n = 20$ ) 组肝切除后肝脏体积的变化。在主要组中，细胞治疗以术中通过空心脐带静脉注射自体间充质干细胞 ( $25 \times 10^6$  单位) 的形式使用。对照组不使用细胞技术，术后进行肝细胞治疗。发现在主要组中，在使用细胞疗法的背景下，患者肝组织的体积显示出更快的增加，这表明刺激了修复性再生过程。

关键词：肝再生刺激，肝切除，细胞治疗，自体间充质干细胞，肝脏体积。

**Abstract.** *The study of changes in the volume of the liver after its resection in the main ( $n=20$ ) and control ( $n=20$ ) groups was carried out. In the main group, cell therapy was used in the form of intraoperative injection of autologous mesenchymal stem cells ( $25 \times 10^6$  units) through the cannulated umbilical vein. In the control group, cell technologies were not used and hepatotropic therapy was carried out in the postoperative period. It was found that in the main group, against the background of the use of cell therapy, patients showed a more rapid increase in the volume of hepatic tissue, which indicates the stimulation of reparative regeneration processes.*

**Keywords:** *stimulation of liver regeneration, liver resection, cell therapy, autologous mesenchymal stem cells, liver volume.*

### Introduction

Liver surgery has a fairly long history. Despite the fact that surgical interventions on the liver began to be performed back in the 19th century [1], there are still many questions about how to prevent possible postoperative complications. A rather formidable complication after liver resection is the development of hepatocellular failure [2,3], which may occur due to an imbalance between the functional capabilities of the liver and the needs of the patient's body itself [4]. One of the

ways to prevent this complication is to stimulate the reparative regeneration of the liver tissue [5]. It is possible to evaluate the regenerative processes in the liver after its resection using computed tomography of the abdominal organs [6]. To stimulate the reparative regeneration of the liver tissue in the postoperative period, we propose to use cell therapy, the effectiveness of which is presented in experimental studies [7].

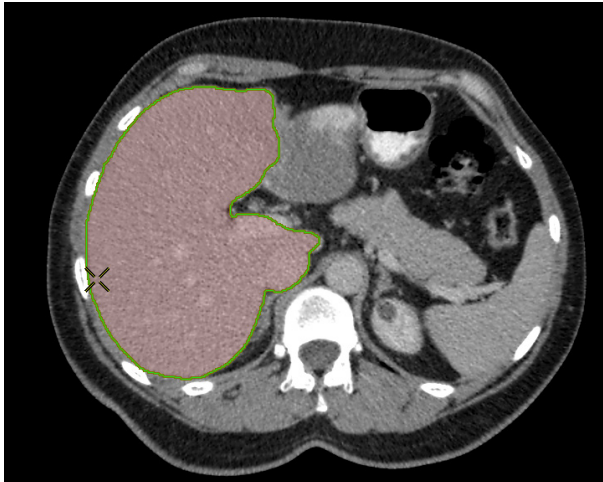
**Purpose** – evaluate the effect of cell therapy on changes in liver volume in the postoperative period when performing liver resection.

#### **Materials and methods**

The control and the main group included 20 patients with benign liver neoplasms (parasitic cysts, liver hemangiomas), who required 40-45% of liver resection. Before the operation, as well as in the postoperative period (on the 1.7 and 30 days after the operation), the analysis of changes in the volume of the liver was carried out. Patients of the main group, after receiving liver resection, intraoperatively, through the recanalized umbilical vein, were injected with autologous mesenchymal stem cells in an amount of  $25 \times 10^6$  units. To obtain autologous mesenchymal stem cells at the preoperative stage, patients underwent sampling of the patient's adipose tissue from the inner thigh. Patients in the control group did not receive cell technologies treatment; in the postoperative period, this group of patients underwent hepatotropic therapy (L-ornithine-L-aspartate 20g per day intravenously, 10 days).

#### **Results**

To assess the change in the volume of the liver after its resection, patients in the control and main groups underwent computed tomography of the abdominal organs before the operation, as well as on days 1, 7 and 30 after the surgery. The volume of the liver and the volume of the neoplasm were determined using computed tomography before surgery (fig. 1).



*Fig. 1. Determination of liver volume using computed tomography of the abdominal organs*

Table 1 shows the parameters of the liver volume in patients of the control and main groups before surgery, as well as in dynamics in the postoperative period.

**Table 1**  
*Dynamics of changes in liver volume (cm<sup>3</sup>) in patients of control and study groups*

<b>Indicator</b>	<b>Control group</b>	<b>Main group</b>
Liver volume before surgery	1534,5±59,8	1555,2±72,9
The volume of the pathological neoplasm	233,7±10,2	214,9± 13,9
The volume of normal liver tissue before surgery	1300,8±64,0	1340,3± 74,6
Liver volume 1 day after surgery	1003,7±69,3	1011,2±70,5
Liver volume on day 7 after surgery	1050,7±8,8	1130,5±12,0
Liver volume 30 days after surgery	1085,0±7,0	1284,7±7,2

When performing computed tomography before surgery, there were no significant differences between patients in the control and study groups, both in the volume of the liver and in the volume of liver neoplasms ( $p=0.331$  and  $p=0.079$ ). On the 1st day after surgery, in patients of both the control and the main group, the decrease in liver volume corresponded to the volume of surgery, without statistically significant differences ( $p=0.732$ ). When analyzing the dynamics of liver volume on the 7th day after the operation, it was revealed that in the group in which cell therapy was used, there was an increase in the volume of hepatic tissue by 11.8%,

while in the control group the increase in liver volume was 4.7% ( $p=0.0001$ ). On the 30th day after the operation, it was noted that the volume of the liver increased both in the control and in the main group. However, in patients who underwent intraoperative administration of autologous mesenchymal stem cells, the volume of the liver increased by 27.1%, and in patients of the control group, only by 8.1% ( $p=0.0001$ ). In addition, statistically significant differences were found between groups in the rate of increase in liver volume in the postoperative period ( $p=0.0001$ ).

### Conclusion

Based on the analysis of changes in the volume of the liver after its resection in patients with and without cell therapy, it was revealed that intraoperative injection of autologous mesenchymal stem cells directly into the vascular bed of the liver contributes to a faster increase in liver tissue in the postoperative period. A similar situation can be associated both with the direct stimulating effect of the introduced cellular structures on the proliferative activity of hepatocytes, and with their indirect influence through the stimulation of the synthesis of biologically active substances. It should also be noted that the use of cell therapy did not cause any side effects in patients in the postoperative period, which confirms the safety of the method.

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研究中度慢性牙周炎止血系统的状态

**STUDYING THE STATE OF THE HEMOSTASIS SYSTEM IN  
CHRONIC PERIODONTITIS OF MODERATE SEVERITY**

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抽象。 前瞻性研究了48位年龄在35至45岁，病程为3至10年的中度慢性牙周炎患者。 为了评估中度严重的慢性全身性牙周炎患者的凝血过程，使用了血栓弹力描记法，该方法可以通过血块形成的物理特征评估全血的凝血和纤溶活性。 记录到严重程度中等的慢性全身性牙周炎中血液的凝血潜能增加。 使用标准医疗措施对血液的凝结和纤溶活性没有明显的积极作用。

关键词：慢性全身性牙周炎，止血，凝血指标，血凝块形成时间，弹性模量，溶出度计算值。

**Abstract.** *A prospective study of 48 patients with chronic periodontitis of moderate severity at the age of 35 to 45 years with a disease duration of 3 to 10 years was carried out. To assess the processes of blood coagulation in patients with chronic generalized periodontitis of moderate severity, the thromboelastography method was used, which makes it possible to assess the coagulation and fibrinolytic activity of whole blood by the physical characteristics of the forming clot. An increase in the coagulation potential of blood in chronic generalized periodontitis of moderate severity was registered. The use of standard medical measures does not have a significant positive effect on the coagulation and fibrinolytic activity of the blood.*

**Keywords:** *chronic generalized periodontitis, hemostasis, coagulation index, time of clot formation, modulus of elasticity, calculated percentage of lysis.*

Inflammatory periodontal diseases are one of the frequently discussed problems of modern dentistry. According to the WHO, they are observed in 90-95% of the adult population [1]. At the same time, chronic generalized periodontitis is undoubtedly considered the most common and severe periodontal pathology. A long course of the disease with periods of remission and exacerbations contributes to the formation of dysfunction of the dentition due to destruction of bone tissue and, as a result, tooth loss [1,2]. It should be noted that such a difficult situation is observed not only in Russia, but also in many foreign countries, yielding leadership only to caries [1,2,3,4,5,6,7,8].

The inflammatory process in the periodontium leads to a decrease in the reactivity of the body and can lead to a weakening of the ligamentous apparatus of the tooth, destruction of tissues, which is accompanied by loss of the tooth [7,8]. Prevention, early diagnosis and treatment of periodontal diseases are one of the topical social, economic and medical problems [6,8].

To understand the pathogenetic aspects of chronic periodontitis, including in relation to lesions of other organs and systems of the body in order to further develop new treatment and prevention regimens, it is necessary to study in detail the processes occurring in the periodontal tissues, including the study of the hemostatic system in chronic periodontitis.

**The purpose of the study** was the study of the state of the hemostasis system in patients with chronic generalized periodontitis of moderate severity.

### **Material and methods**

A prospective study of 48 patients with chronic periodontitis of moderate severity aged 35 to 45 years with a disease duration of 3 to 10 years, who were treated at the Dental Clinic of the FSBI HE "Ogarev MSU", was carried out. The patients underwent a comprehensive examination upon admission, on the sixth day of treatment, and on the twelfth day after the end of therapy. Also examined were 20 volunteers (10 men and 10 women, aged from 30 to 50 years) - conditionally healthy individuals without signs of periodontal tissue disorders, subject to the standard requirements of medical ethics of the Russian Federation.

All patients received traditional anti-inflammatory therapy according to clinical guidelines (treatment protocols) approved by the Decision of the Council of the Association of Public Associations "Dental Association of Russia" on April 23, 2013 with amendments and additions based on Resolution № 18 of the Council of the Association of Public Associations "Dental Association of Russia" dated September 30 2014 year. After professional hygiene (after instrumental removal of dental deposits and leveling of the tooth root surface using Scaling & RootPlaning technology using ultrasonic scalers, the following therapeutic manipulations were



performed: oral baths with dioxidine or Dimexide, rotocon solution, chlorophyllipt and other medicinal preparations; therapeutic applications with maraslavin solutions, polyminerol; medical dressings with anti-inflammatory ointments (metrogil denta, holisal) were applied; therapeutic dressings with ointments that improve microcirculation (troxorutinic, butadionic, heparin). A suspension of chlorhexidine with metronidaz was put into the pathological periodontal pockets.

To assess the processes of blood coagulation in patients with chronic generalized periodontitis of moderate severity, the thromboelastography method was used, which makes it possible to assess the coagulation and fibrinolytic activity of whole blood by the physical characteristics of the forming clot, which is undoubtedly an advantage over other methods for assessing these parameters.

### Results of the study

It was found that at the time of patients' referral to the clinic, the parameter R (reactive time) - the value that determines the period of blood coagulation and characterizes the first phase of coagulation (prothrombinase constant) - was shortened and was 22.51% ( $p < 0.05$ ) less than normal (tab. 1). The parameter K (the time of clot formation (thrombin constant) in patients before treatment was also lower than normal by 19.80% ( $p < 0.05$ ), which indicated a more rapid formation of thrombin. The parameter MA (maximum amplitude - reflects the maximum clot density, depends on the amount of fibrinogen, platelets and their properties) at this time of observation was higher than normal by 14.82% ( $p < 0.05$ ).

**Table 1.**  
*Thromboelastography indices in chronic periodontitis of moderate severity (M±m)*

Indicator	Norm	When contacting	Terms of treatment	
			6 days	12 days
R (reaction time), min	3,02 ±0,09	2,37±0,10*	2,43±0,11	2,50±0,13*
K (clot formation time), min	0,99 ±0,05	0,82±0,04*	0,82±0,05*	0,84±0,05*
MA (maximum amplitude),%	59,17 ±1,19	70,11±3,08*	72,13±3,21*	71,20±2,89*
G (clot strength as modulus of elasticity), d/sc	7,93 ±0,22	9,12±0,52*	8,75±0,41*	8,45±0,51
EPL (calculated percentage of lysis), %	1,20 ±0,05	0,91±0,03*	0,92±0,04*	0,96±0,04*
CI (coagulation index), %	0,11 ±0,005	0,21±0,010*	0,18±0,011*	0,15±0,02

Note: \* - significance level at  $p < 0.05$ .

The parameter G (total clot strength (modulus of elasticity), obtained as a result of coagulation interactions, calculated from the amplitude (A),  $G = (5000 \times A) / (100 \times A)$ ) was also 12.86% higher than the norm ( $p < 0.05$ ).

The EPL parameter (characterizes fibrinolytic activity) was below normal by 21.93% ( $p < 0.05$ ). The coagulation index CI increased by 75.00% ( $p < 0.05$ ).

During treatment in patients with chronic moderate periodontitis, there was a change in the coagulation and fibrinolytic activity of the blood. On the sixth day of therapy, the maximum amplitude indicator was 21.9% higher than normal ( $p < 0.05$ ). The indicator of clot formation time (K) on the sixth day remained below the norm by 16.2% ( $p < 0.05$ ). Clot strength indices as modulus of elasticity (G) and coagulation index (CI) slightly decreased, still remaining above normal, and amounted to 10.3% ( $p < 0.05$ ) and 72.7% ( $p < 0.05$ ) respectively. The calculated percentage of lysis also slightly increased while remaining below the norm by 22.5% ( $p < 0.05$ ).

On the 12th day of therapy, an increase in the reaction time (R) was recorded and amounted to 84% ( $p < 0.05$ ) of the norm. The indicator of clot formation time (K) slightly increased, remaining below the norm by 15% ( $p < 0.05$ ). There was a slight decrease in the maximum amplitude, which remained above the norm by 20% ( $p < 0.05$ ). There was an increase in the estimated percentage of lysis (EPL), although the indicator remained below normal by 19.2% ( $p < 0.05$ ).

### Conclusions

Thus, the data of thromboelastography demonstrated an increase in the coagulation potential of the blood in chronic generalized periodontitis of moderate severity, which corresponds to the classical concepts of changes in the hemostatic system during inflammation. The use of standard medical measures does not have a significant positive effect on the coagulation and fibrinolytic activity of the blood.

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使用胶体纳米颗粒构建固相测试系统, 用于快速诊断危险感染  
**CONSTRUCTION OF SOLID-PHASE TEST SYSTEMS USING  
COLLOIDAL NANOPARTICLES FOR EXPRESS DIAGNOSTICS OF  
DANGEROUS INFECTIONS**

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抽象。考虑到ELISA中使用的酶标记的缺点, 本文讨论了使用新的替代标记-无机物质的催化活性纳米粒子的前景。为此, 在免疫前测定中测试了金和银的纳米颗粒, 作为特异性抗体和抗原的标记物, 用于检测布鲁氏菌, 鼠疫, 图拉血病和假结核病微生物的体液和可溶性抗原及其抗体。活性炭颗粒还用作布鲁氏菌抗原的标记, 用于检测实验兔血清中的特异性抗体。

结果表明, 使用金和银纳米颗粒作为免疫试剂标记的斑点免疫测定的灵敏度是 $\geq 2.5 \times 10^4$  CFU/ml血红细胞和 $\geq 5$ ng/ml的鼠疫, 布鲁氏菌病, Tularemia和假结核病病原体可溶性抗原。在患病或接种疫苗的人的血液血清中, 以及滴度 $\geq 1:400$ 的实验动物和家畜的血液血清中, 检测到了含有胶体金属和碳的斑点免疫测定中的特异性抗体。

使用金和银纳米颗粒的诊断试剂在性能上并不逊色于ELISA中使用的酶结合物, 但与此同时它们具有许多优势: 它们更便宜, 更容易制备, 在储存过程中更稳定, 能够提供可靠的结果视觉记录, 体现在对人体健康无害的指标体系中。

使用无机微粒标记物的点免疫测定可在任何实验室中用于紧急情况下的信号测试, 甚至是装备不完善的实验室。它的特点是敏感性高, 专一性强, 示范性结果, 信息内容, 表达性, 经济技术可及性。

关键词: 点免疫法金纳米颗粒银纳米颗粒碳颗粒布鲁氏菌弗朗西斯菌鼠疫耶尔森菌

**Abstract.** *Taking into account the drawbacks of the enzyme label used in ELISA, the article discusses the prospects for using new alternative markers - catalytically*

*active nanoparticles of inorganic substances. For this purpose, nanoparticles of gold and silver were tested in dot-immunoassay as markers of specific antibodies and antigens for the detection of corpuscular and soluble antigens of brucella, plague, tularemia, and pseudotuberculosis microbes and antibodies to them. Particles of activated carbon were also used as a marker of Brucella antigens for the detection of specific antibodies in experimental rabbit sera.*

*It was shown that the sensitivity of dot-immunoassay using gold and silver nanoparticles as markers of immune reagents was  $\geq 2.5 \times 10^4$  CFU/ml corpuscular and  $\geq 5$  ng/ml soluble antigens of the causative agents of plague, brucellosis, tularemia and pseudotuberculosis. Specific antibodies in the dot-immunoassay with colloidal metals and carbon were detected in the blood sera of sick or vaccinated people, as well as in the blood sera of experimental and domestic animals in titers  $\geq 1:400$ .*

*Diagnosticums using gold and silver nanoparticles in their performance characteristics are not inferior to the enzyme conjugates used in ELISA, but at the same time they have a number of advantages over them: they are much cheaper and easier to prepare, more stable during storage, are able to provide reliable visual recording of results, are manifested in indicator systems harmless to human health.*

*Dot immunoassay using inorganic corpuscular markers can be used in any laboratories, even poorly equipped ones, in the field, in emergency conditions as a signal test. It is characterized by high sensitivity and specificity, demonstrative results, information content, expressiveness, economic and technological accessibility.*

**Keywords:** *dot immunoassay, gold nanoparticles, silver nanoparticles, carbon particles, Brucella spp., Francisella tularensis, Yersinia pestis*

Recently, in the development of solid-phase methods for express diagnostics of infectious diseases, approaches have been developed in parallel aimed at creating both multiparametric tests that allow in one device (microchip) to simultaneously identify the range of agents of interest and are intended for use in large, well-equipped laboratories, and monotest systems - simple-to-implement single tests for identifying a biological object, which could be implemented in poorly equipped laboratories, in the field, in a doctor's office or for self-diagnosis at home. Monotest systems are technically represented by a wide variety of immunochromatographic, immunofiltration and so-called "dot-blot" methods, in which membrane substrates serve as a solid phase, and various fluorescent substances, enzymes, nanoparticles of heavy metals, dispersed dyes are used as markers. The development of methods in both versions is associated with the solution of a number of practical problems, first of all - an increase in the specificity and sensitivity of the determination, a reduction in the analysis time, a decrease in the cost of test systems, etc.

Dot immunoassay (DIA) is one of the most common express methods for the detection of pathogenic microorganisms and the diagnosis of diseases caused by them. Sufficiently high specificity and sensitivity, ease of installation, miniaturization (sample volume 1–3 µl), rapidity, no need for readers and other expensive devices make DIA promising for the indication of pathogens of especially dangerous infections, especially in emergency situations.

The most attractive is the use in DIA as markers of immune reagents not enzymes, but nanoparticles of gold, silver, etc.

It is known that enzyme markers suffer from a number of significant drawbacks, including a complex procedure for the isolation and purification of the enzyme, a significant loss of enzyme and ligand activity during the preparation of the conjugate, the need to store the enzyme itself and preparations based on it at low temperatures or in a preservative, susceptibility to analysis results. the influence in the studied sample of impurities that can inactivate the enzyme or provoke a spontaneous reaction, and finally, the toxicity of individual components of the developing system (Hosseini S. et al., 2018).

The noted shortcomings served as the basis for the deployment of work on the search for inorganic chromogenic markers for use in immunoassay. As a result, a number of domestic and foreign firms have obtained and tested immunodiagnostics for DIA based on highly dispersed nanoparticles of platinum, gold, silver, copper, etc.; non-metals - selenium, tellurium, sulfur, silicon, etc., as well as their compounds (Liu L. et al., 2019). Such diagnostics are capable, upon accumulation on the surface of the matrix, to create a color distinguishable visually or recorded spectrophotometrically.

Inorganic markers based on gold and silver nanoparticles have noticeable advantages over enzymes, since the preparation of colloidal particles is extremely simple, the binding of a marker with an immunoreagent is performed in a gentle sorption method, while inorganic markers are stable over a relatively wide range of physicochemical conditions, which results in long shelf life immunosols.

The active use of gold nanoparticles (GNPs) in different areas of biology is evidenced by the appearance of works devoted to the use of GNPs conjugates with various substrates in the studies of biochemists, microbiologists, immunologists, cytologists and many other specialists (Liu L. et al., 2019).

Studies by a number of authors have shown that DIA using GNPs conjugates is superior to ELISA in sensitivity (Dykman, L. A. et al., 2018).

The use of GNPs in solid phase immunoassay methods is based on the intense red color of this marker, which allows visual determination of the reaction results. Moreover, the sensitivity of the assay can be increased using the technique of enhancing the staining of gold adsorbed on the membrane with silver (Dykman, L. A. et al., 2018; Win, S. H. et al., 2019).

In search of more accessible and cheaper catalytically active metals than gold, capable of being detected by a "physical manifestation" with a sensitivity similar to gold, another noble metal, silver, attracted attention (Zhao, L. J. et al., 2017).

Colloidal silver is an active catalyst and is capable of initiating a large number of indicator catalytic reactions suitable for detecting trace amounts of sol. Their essence lies in the formation of a metal layer as a result of a chemical reaction taking place on a surface sensitized with silver, and characterized by a very high sensitivity (Kurdekar A. D. et al., 2017).

An even more practical and cheap label than silver is a carbon marker - activated carbon, which has universal sorption properties for a variety of biomacromolecules (Posthuma-Trumpie, G. A. et al., 2012).

We tested nanoparticles of metals - gold and silver, as well as carbon as markers of specific immune reagents for the detection of corpuscular and soluble antigens (Ag) of brucella, plague, tularemia, pseudotuberculosis microbes and antibodies (Ab) to them in DIA.

Gold nanoparticles were prepared by boiling a solution of chloroauric acid with sodium citrate. After adjusting the pH, it was saturated with specific IgG or Ar in one step (Zagoskina T.Yu. et al., 1998, 1999a). Silver nanoparticles were prepared by reduction from a solution of silver nitrate with sodium borohydride. The resulting sol was added to a solution of specific IgG or Ar (Zagoskina T.Yu. et al., 2002a). Diagnosticum using a carbon marker is an aqueous suspension of activated carbon particles sorptionally bound to Ag brucella and stabilized with a high molecular weight polymer (Zagoskina T.Yu. et al., 2002b).

DIA was set by the traditional method, including the adsorption of the test material containing Ag (Ab) of the pathogens of AOI on a nitrocellulose membrane filter, blocking free binding sites on the membrane with an inert protein solution, and detection of adsorbed Ag (Ab) using a conjugate of specific IgG (diagnostically significant Ag) with nanoparticles of gold or silver or carbon particles. DIA results were visualized when colloidal metal particles were used as markers by immersing the membrane in a developer solution. The total analysis time is 30–40 minutes.

We investigated 22 strains of the plague microbe of the main, Altai, Hissar, Caucasian and Ulegei subspecies from natural foci of plague, 19 strains of brucella of all known species, 5 strains of the causative agent of tularemia, 10 strains of *Yersinia pseudotuberculosis*. Fraction 1 (F1 antigen), Fc antigen (Pla), main somatic antigen, lipopolysaccharide (LPS), "mouse" toxin, cell membranes (32 antigenic fractions in total) isolated from cells of the *Y. pestis* strain were used as antigenic fractions. EV; LPS, protein polysaccharide Ar, salt, urea, and cetavlon extracts (30 antigenic fractions in total) isolated from cells of the *Brucella abortus* 19 BA strain; LPS and urea extracts (20 antigenic fractions in total) from cells of

the *Francisella tularensis* vaccine strain, urea extracts, cell membranes and *Y. pseudotuberculosis* protein-lipopolysaccharide antigen (20 antigenic fractions in total).

The DIA sensitivity using colloidal metal particles (gold and silver) as markers of specific Ab was  $\geq 2.5 \cdot 10^4$  CFU/ml corpuscular and  $\geq 5$  ng/ml soluble Ag pathogens of plague, brucellosis, tularemia, and pseudotuberculosis. In environmental objects and biological material, the causative agents of plague, brucellosis, tularemia, and pseudotuberculosis are found in concentrations of  $2.5 \cdot 10^4$ - $10^7$  CFU/ml. The type of test sample (water, soil, feed, milk, washings from different objects, blood serum or internal organs of animals, bird pellets, aquatic organisms, rodent feces) does not significantly affect the sensitivity of the analysis. However, DIA testing of some samples (hemolyzed blood, bile, etc.) is limited due to the permanent staining of membrane filter pigments upon application of the test sample.

The informative value of DIA was shown by us when comparing the results of DIA, PCR and bacteriological method in the detection of brucella in the dynamics of the infectious process in guinea pigs infected with virulent strains of the pathogen. The largest number of positive responses was recorded in DIA (72.0%), which is significantly higher than in bacteriological research and PCR (18.7 and 36.0%, respectively). In our opinion, the higher percentage of positive findings in DIA compared to PCR is explained by the possibility of detecting subcellular fractions and soluble Ar along with corpuscular Ar.

To create a universal diagnosticum, staphylococcal protein A was used instead of specific (plague, brucellosis and tularemia) immunoglobulins (Zagoskina T.Yu. et al., 1999b). The principle of the method is that staphylococcal protein A, including those labeled with particles of colloidal metals, is capable of binding to the Fc-fragment of almost any IgG. Proceeding from this, the test sample applied to the membrane is first treated with antisera to the target Ar and then immuno-manifestation is carried out with protein A labeled with GNPs or NPA. The desired Ar in this case is easily detected by interaction with the used homologous antiserum. The sensitivity of DIA with a protein A – GNPs conjugate in detecting Ag of brucella, plague and tularemia microbes in artificially contaminated environmental objects was  $5.0 \cdot 10^4$ - $10^6$  CFU/ml. An advantage of the protein A – GNPs conjugate is its versatility, since it can be used to indicate corpuscular and soluble Ar from a number of infectious agents, for which it is necessary to have only a set of antisera to the desired pathogens.

When designing diagnostic kits for detecting specific antibodies in blood sera of humans and animals, we used the most diagnostically significant antigenic fractions of brucella (cetavlon supernatant), plague (F1 antigen), tularemia (lipopolysaccharide), and pseudotuberculosis (protein-lipopolysaccharide complex) microbes.



To detect specific antibodies, blood sera of people with brucellosis from the city infectious diseases hospital, cattle sera taken at the Irkutsk meat-packing plant, sera of the institute employees vaccinated against plague, tularemia and brucellosis, blood serum from donors from the Irkutsk regional blood transfusion station, hyperimmune rabbit sera against the listed pathogens and pseudotuberculosis microbe obtained for scientific purposes were studied.

In parallel with DIA, the material was examined in traditional serological tests. It was found that routine reactions are inferior in sensitivity to DIA. In a number of cases, specific antibodies in traditional serological reactions, in particular, to brucellosis, were not detected even in the sera of patients with a documented diagnosis. We have shown the possibility of detecting a post-vaccination response in DIA, which undoubtedly has a positive meaning.

Due to the special relevance of the development of methodological techniques for the detection of atypical forms of the causative agent of brucellosis and taking into account the accumulated experience, we managed to design diagnostic test systems for detecting brucella in the L-form and Ab to them. Brucella in an atypical form was detected at a concentration of  $\geq 10^6$  CFU/ml. Specific antibodies in experimental rabbit sera obtained against Brucella in L-form were found in titers  $\geq 1:1600$ . A parallel study of the material in traditional serological tests (AR, PHGR) gave negative results.

The results obtained allow us to state that DIA with colloidal metals is a highly sensitive, specific, highly informative and accessible express method, effective when used not only under experimental conditions, but also when working with clinical material, and catalytically active immunosols of heavy metals in their performance characteristics are not inferior to enzyme conjugates used in ELISA, but at the same time have a number of advantages over them: they are much cheaper and easier to prepare, more stable during storage, capable of providing a reliable visual recording of results, and can be manifested in indicator systems that are harmless to human health.

In parallel with colloidal metals, we have tested an even more accessible and cheap corpuscular marker - activated carbon.

The carbon diagnosticum for DIA is used for the qualitative or semi-quantitative detection of anti-brucellosis Ab in the blood serum of rabbits immunized with corpuscular and soluble Ab of Brucella. The method of using the developed test system is simple, does not require operator qualifications and recording equipment. The low cost of the marker, the economical use of immunoreagents, as well as low energy and labor costs in the production of the diagnosticum economically distinguish it from the existing analogues. The DIA variant with carbon diagnostics can be recommended for the primary screening of human or animal sera for the presence of specific Ab.

The materials presented indicate the prospects of designing diagnostic test systems for DIA using inorganic corpuscular markers, characterized by high sensitivity and specificity, ease of implementation, rapidity, demonstrativeness of obtaining results. The developed test systems are informative, economically and technologically accessible, do not require special training of personnel, can be used in any, even poorly equipped laboratories, at sanitary control points (SCP), in the field, in the working conditions of specialized anti-epidemic brigades (SAEB) in the emergency situations as signal tests.

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取决于主要校准溶液的化学成分的光度法测定水中的硅(IV)离子质量浓度的校准图的陡度研究

**STUDY OF THE STEEPNESS OF CALIBRATION GRAPHS FOR DETERMINING THE MASS CONCENTRATION OF SILICON (IV) IONS IN WATER BY PHOTOMETRIC METHOD DEPENDING ON THE CHEMICAL COMPOSITION OF THE MAIN CALIBRATION SOLUTION**

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抽象。 本文考虑了建立校准溶液规模的可能性,该校准溶液的规模可以通过光度法使用两种类型的认证标准样品(俄罗斯制造)和结晶二氧化硅与碱熔融后的光度法测定水中的Si(IV)离子质量浓度。 融合。 使用钼硅酸体系在最大波长 $\lambda_{\max} = 396.8 \text{ nm}$ 和Si(IV)离子浓度为 $0.28 \text{ mmol} / \text{dm}^3$ 时的摩尔吸光系数对所得结果进行分析,并决定在实际应用中使用 硅酸钠水溶液作为校准的基本溶液。

关键词: 光度法钼硅酸硅酸钠六氟硅酸钠二氧化硅校正图校正溶液

**Abstract.** *The paper considers the possibility of constructing a scale of calibration solutions for determining the mass concentration of Si (IV) ions in water by the photometric method using two types of certified standard samples, made in Russia, and crystalline silicon dioxide after its fusion with alkaline fusion. The results obtained were analyzed using the molar light absorption coefficients in*

*the system of molybdosilicic acid at a maximum wavelength  $\lambda_{max} = 396.8 \text{ nm}$  and an Si (IV) ion concentration of  $0.28 \text{ mmol/dm}^3$ , and it was decided for practical purposes to use an aqueous solution of sodium silicate as the basic solution for calibration.*

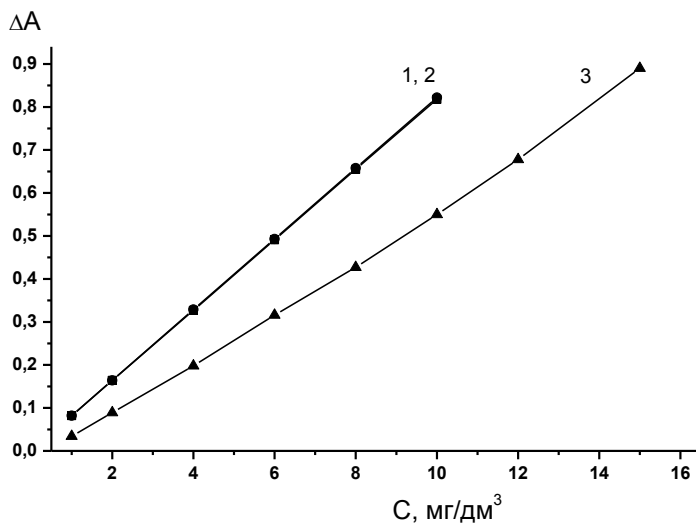
**Keywords:** *photometry, molybdosilicic acid, sodium silicate, sodium hexafluorosilicate, silicon dioxide, calibration graph, solution for calibration.*

Physicochemical methods of analysis are based on the relationship between the composition of the system and its physical and physicochemical properties. The functional relationship between the numerical value of a given physical or physicochemical property and the content of the analyte can be expressed by a graph or formula [1].

The basis for building the scale of the calibration graph is the preparation of standard solutions. Standard solutions are prepared from certified reference materials (CRM). If there are none, it is allowed to use compounds of at least analytical grade.

To determine the mass concentration of silicon in water by the method of a calibration graph, the Mullen and Riley technique based on the formation of molybdosilicic acid [2] was used. Calibration solutions were prepared using GSO 8212, which was a solution of sodium fluorosilicate in distilled water (Russia), GSO 8934, which was an aqueous solution of sodium silicate in a  $0.1 \text{ mol/dm}^3$  sodium hydroxide solution (Russia) and a certified solution prepared from silicon dioxide (GOST 9428) after fusion with alkaline flux [3].

The dependences of optical densities on the concentration of the determined element  $\Delta A=f(C)$  are shown in fig. 1.



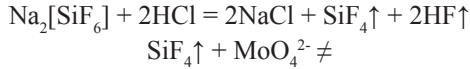
*Fig. 1. - Calibration graphs for determining the mass concentration of Si (IV) ions using calibration solutions based on: 1) GSO 8934; 2) certified solution (GOST 9428); 3) GSO 8212*

The values of the molar coefficients at the absorption maximum  $\lambda_{\max} = 396.8$  nm and the Si (IV) ion concentration of  $0.28 \text{ mmol/dm}^3$  are presented in tab. 1.

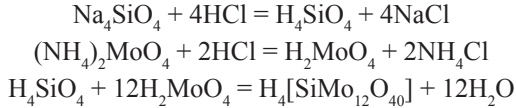
**Table 1**  
*Molar coefficient values*

Calibration solution	Molar coefficient ( $\epsilon$ ), $\text{dm}^3 \cdot \text{mol}^{-1} \cdot \text{cm}^{-1}$
GSO 8934	2339
Certified solution (GOST 9428)	2350
GSO 8212	1525

Consequently, when determining the mass concentration of Si (IV) ions by the photometric method in the form of molybdosilicic acid using GSO 8212, the optical density in the analyzed sample is underestimated. This leads to overestimated mass concentrations of silicon in water. This is due to the fact that the substance of which GSO 8212 consists (sodium fluorosilicate  $\text{Na}_2 [\text{SiF}_6]$ ) does not enter into chemical interaction with ammonium molybdate  $(\text{NH}_4)_2\text{MoO}_4$  in a hydrochloric acid medium ( $5 \text{ mol/dm}^3 \text{ HCl}$ ):

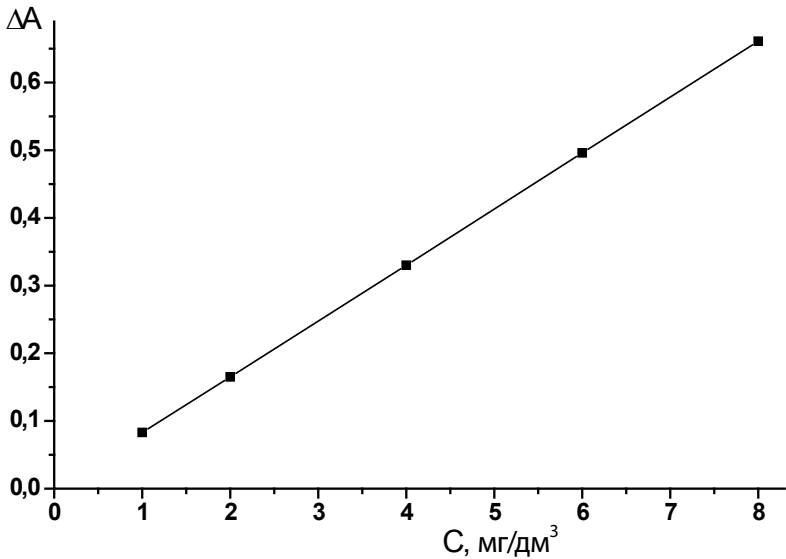


The reactions of interaction of sodium silicate ( $\text{Na}_4\text{SiO}_4$ ), which is part of GSO 8934 and is the product of the fusion reaction of silicon dioxide (GOST 9428) with alkaline flux, and ammonium molybdate ( $(\text{NH}_4)_2\text{MoO}_4$ ) in a hydrochloric acid medium ( $5 \text{ mol/dm}^3 \text{ HCl}$ ) are presented below:



To convert sodium hexafluorosilicate to sodium silicate, the scale of calibration solutions of Si (IV) ions prepared using GSO 8212 was subjected to heat treatment in the presence of sodium hydroxide with a molar concentration of  $0.5 \text{ mol/dm}^3$ .

The dependence of the optical densities on the concentration of the determined element  $\Delta A=f(C)$ , after thermal treatment of the calibration solutions, is shown in fig. 2.



*Fig. 2. - Calibration graph for determining the mass concentration of Si (IV) ions using the GSO 8212 calibration solution after heat treatment in the presence of sodium hydroxide with a molar concentration of  $0.5 \text{ mol/dm}^3$*

As a result of heat treatment of the scale of calibration solutions with sodium hydroxide, significant changes are seen in the calibration dependence ( $\Delta A=f(C)$ ). The sensitivity of the determination of Si (IV) ions increases. The molar coefficient at the absorption maximum  $\lambda_{\max}=396.8$  nm and the Si (IV) ion concentration of  $0.28 \text{ mmol/dm}^3$  increases 1.4 times ( $\epsilon=2175 \text{ dm}^3 \text{ mol}^{-1} \text{ cm}^{-1}$ ).

Despite the change in the slope of the calibration curve, the determination of Si (IV) ions using GSO 8212 is not possible. Converting sodium hexafluorosilicate ( $\text{Na}_2[\text{SiF}_6]$ ) to sodium silicate ( $\text{Na}_2\text{SiO}_4$ ) by heat treatment of the calibration solution scale with sodium hydroxide increases labor costs for research, requires expensive laboratory glassware (platinum cups), highly qualified specialists. The actual content of Si (IV) ions in the analyzed samples does not correspond to the true value of its mass concentration.

Thus, to determine the mass concentration of Si (IV) ions in water by the photometric method in the form of molybdosilicic acid, it is optimal to use an aqueous solution of sodium silicate as the basic solution for calibration.

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铈与多齿有机配体的络合物  
**COMPLEX COMPOUNDS OF EUROPIUM WITH POLYDENTATE  
ORGANIC LIGANDS**

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抽象。通过萃取法，红外光谱和发光光谱研究了and和with与多官能有机化合物的络合作用。发现用混合萃取剂萃取REE可导致REE在有机相中有效络合。显示了从饱和提取物中合成REE的混合配体配位化合物的可能性，并分离出各个晶体复合物。

关键词：多官能化合物；红外光谱和发光光谱

**Abstract.** *The complexation of europium and terbium with polyfunctional organic compounds was studied by the extraction method, IR and luminescence spectroscopy. It was found that the extraction of REE with mixed extractants leads to effective complexation of REE in the organic phase. The possibility of synthesis of mixed-ligand coordination compounds of REE from saturated extracts was shown, and individual crystalline complexes were isolated.*

**Keywords:** *europium, polyfunctional compounds, IR- and luminescence spectroscopy*

In recent years, much attention has been paid to the synthesis and study of REE coordination compounds with organic ligands, since these compounds are widely used in various technological and research areas: from the development of advanced optical and light-converting devices to obtaining bioimages and the treatment of oncological diseases by photodynamic therapy [ 1-3]. The weak absorption coefficients of f-f-transitions in REE ions are overcome by introducing the corresponding organic ligands into their coordination sphere (the well-known "antenna effect").

One of the most studied in complexes with  $\text{Ln}^{3+}$  ions is the class of  $\beta$ -diketonates. These ligands can act as bidentate due to their delocalized charge, and can also be associated with one, two or three additional neutral ligands. Rare-earth trivalent ions, being coordinated with  $\beta$ -diketonate ligands, are capable of producing complexes with a high total quantum yield of radiation of more than 70%, which is associated with the efficient intramolecular energy transfer ligand  $\rightarrow \text{Ln}^{3+}$ .

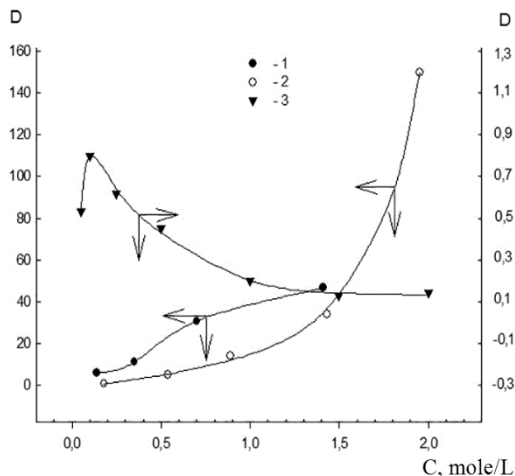
Studies of the properties of complex compounds of  $\text{Eu}^{3+}$  have received the greatest development due to the simplicity of interpretation of the Stark splitting of levels and wide practical application.

The use of extraction for the synthesis of mixed-ligand REE complexes may in some cases be preferable to traditional methods. In this case, a reduction in the number of stages of the synthesis process is achieved, the reproducibility of the synthesis conditions is improved, and it becomes possible to isolate individual complex compounds, the preparation of which is difficult, for example, due to poor solubility of the organic complexing compound or premature hydrolysis of the REE salt.

Investigation of the complexation of europium with polydentate ligands in multicomponent extraction systems is of not only practical but also theoretical interest.

As the initial aqueous phase, we used nitrate or chloride solutions containing  $6.6 \times 10^{-3}$  mol/l of europium, as well as variable amounts of acrylamide (AAm), phenanthroline (PEN) and tris-(hydroxymethyl)-aminomethane (THMAM), amino acids. The extraction was carried out with benzene solutions of extractants: benzoic acid (BA), tributyl phosphate (TBP), acetylacetone (AA), diphenylguanidine (DPGA), triphenylphosphine oxide (TPPO), dibenzoylmethane (DBM), tenoyltrifluoroacetone (HFAA). The extraction was carried out at a temperature of  $(20 \pm 2)^\circ\text{C}$  with intensive stirring of the phases for 30 minutes at a ratio of organic and aqueous phases equal to 1:1. The distribution coefficients were calculated with a correction for the change in phase volume.

The study of the extraction of mixed complex compounds of europium in the presence of acrylamide (AAm) is of particular interest due to the good solubility of acrylamide in water and, thus, the possibility of its introduction into the aqueous phase and the formation of complexes that can be easily extracted into the organic phase. Theoretical interest in amides as objects of fundamental research is caused by, in addition, the fact that their molecules contain two electron-donor centers - carbonyl oxygen and amine nitrogen atoms - the electronic interaction between which provides amide molecules with significant dipole moments and unique physicochemical properties. Fig. 1 shows some of the obtained extraction curves.



**Fig. 1.** Extraction of europium from nitrate solutions with benzene solutions TBP (1,2) and BA (3) depending on the initial concentration of AAm (1,3) and TBP (2). Initial concentrations, mol/l:

$$C_{Eu^{3+}} = 0,033;$$

$$C_{AAm}(2) = 1,41;$$

$$C_{TBP}(1) = 1,79;$$

$$C_{BA}(1) = 0,123; pH - 7$$

With an increase in the AAm concentration, the distribution coefficients of europium increase (Fig. 1, curve 1); however, this cannot unambiguously indicate the formation of coordination compounds of europium with acrylamide in the aqueous phase, since the benzene TBP solution extracts acrylamide itself from the aqueous phase in the absence of europium and, therefore, an increase in the distribution coefficients of europium may be due to a change in the composition of the organic phase.

Europium from nitrate solutions is extracted by TBP in the form of a complex containing three TBP molecules. It has been established by extraction methods that during the extraction of europium by TBP from nitrate solutions containing AAm, the mixed-ligand complex contains two TBP molecules. This seems to indicate that europium is extracted as a complex compound containing both TBP and AAm in its composition. The transition of AAm from the aqueous to the organic phase is evidenced by the IR spectrum of a benzene solution of TBP after contact with an aqueous solution of AAm. In the spectrum of this solution, as in the spectrum of the europium extract, there is an intense narrow absorption band with a maximum at  $1690\text{ cm}^{-1}$ , which corresponds to the vibrations of the amide group.

Comparative analysis of the IR spectra of free acrylamide, TBP extract, and acrylamide in the presence and absence of europium showed the presence of a simultaneous shift of the absorption bands of stretching vibrations of both the NH and C=O groups of acrylamide to the low-frequency region. In this case, the shift of the absorption bands of stretching vibrations of the C=O-group of acrylamide in extracts with europium is more significant and amounts to  $\sim 5\text{-}10\text{ cm}^{-1}$ , which may indicate the coordination of acrylamide to europium through the oxygen atom.

In the extraction of europium with benzoic acid in the presence of acrylamide, a slight synergistic effect is observed (Fig. 1, curve 3), which indicates the complexation of europium with BA and AAm.

REE ions form ternary complexes with  $\beta$ -diketones or inorganic and organic acids and 1,10-phenanthroline. The incorporation of PEN into the molecule of europium complex compounds promotes better transfer of excitation energy from the organic part of the molecule to the REE ion, which leads to a significant increase in the luminescence intensity of europium.

In aqueous solutions of nitrates at  $\text{pH} > 5$ , the first coordination sphere of  $\text{Eu}^{3+}$  contains equally aqua and nitrate ions, and in the presence of PEN or AA, aqua ions are replaced by molecules of these ligands, and mixed ternary complexes of the composition  $\text{Eu}(\text{NO}_3)_3 \cdot 2\text{PEN}$  or  $\text{Eu}(\text{NO}_3)_x \text{AA}_y$ , where  $x$  and  $y$  take values from 1 to 3, depending on the concentration of ligands. The transition during extraction with benzene to the organic phase of the complex compound  $\text{Eu}(\text{NO}_3)_3 \cdot 2\text{PEN}$  is evidenced by an increase in the distribution coefficients of europium with an increase in the concentration of PEN in the aqueous phase. In addition, the fact that a complex compound of just such a composition is formed in the organic phase is confirmed by the data of luminescence spectroscopy. Complexes with a composition similar to  $\text{Eu}(\text{NO}_3)_3 \cdot 2\text{PEN}$  were isolated from the organic phase in a crystalline form.

The extraction of complex compounds of europium from nitrate solutions with benzene solutions of AA and DBM in the presence of TPPO is also characterized by a synergistic effect. In these extraction systems, mixed complex compounds of europium with AA and TPPO, which contain two molecules of each ligand, are extracted into the organic phase. Taking into account the neutrality of the complex compound and the coordination number of the europium ion, the complex should contain a nitrate group during extraction from an aqueous solution of europium nitrate.

Interest in coordination compounds of europium with amino acids is associated with the possibility of replacing them with biogenic metals with the subsequent use of the spectral properties of the europium ion as a luminescent probe.

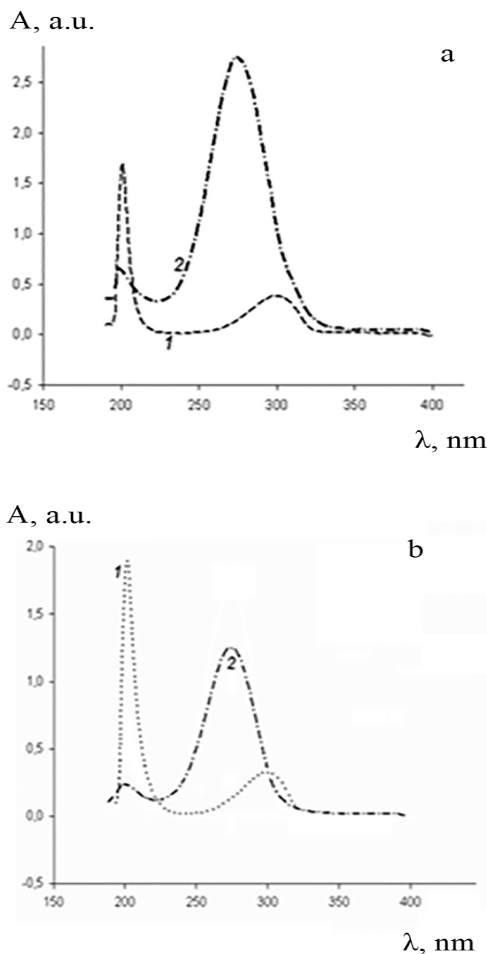
The determining factor influencing both the extraction performance and the composition of the extracted compounds is the pH value of the aqueous phase. In turn, an amino acid in an aqueous solution at  $\text{pH} < 7$ , or rather close to the pI - isoelectric point, is a zwitterion with a coordination-saturated nitrogen atom  $\text{H}_3\text{N}^+\text{CHRCOO}^-$ . For most amino acids, the pH of the betaine form in solution is 6-6.5. Betaine nitrogen cannot coordinate lanthanide and coordination is carried out by oxygen atoms of the carboxyl group. However, upon going to a pH equal to or greater than 7, the charge of betaine nitrogen decreases and stable five-membered metallocycles can arise. It is obvious that the methods of amino acid coordi-

nation will determine both the composition of the extracted europium complexes and the extraction parameters. The distribution coefficients of europium for AA extraction in the presence of various amino acids are shown in the table.

**Table**  
*Partition coefficients of europium for AA extraction in the presence of amino acids.*

Extraction system, mol/l		$D_{Eu}$
Water phase $Eu^{3+} - 6,6 \cdot 10^{-3}$ ; pH = 6-7	Organic phase, benzene	
glycine – $3,4 \cdot 10^{-3}$	AA – 1,0	7,1
$\alpha$ -alanine – $3,3 \cdot 10^{-3}$	AA – 1,0	6,1
valine – $3,2 \cdot 10^{-3}$	AA – 1,0	5,4
asparagine – $3,5 \cdot 10^{-3}$	AA – 1,0	5,8
arginine – $3,1 \cdot 10^{-3}$	AA – 1,0	3,9
cysteine – $3,6 \cdot 10^{-3}$	AA – 1,0	2,4
histidine – $3,4 \cdot 10^{-3}$	AA – 1,0	8,3
glutamine – $3,4 \cdot 10^{-3}$	AA – 1,0	5,2
glutamic acid – $3,4 \cdot 10^{-3}$	AA – 1,0	3,2
methionine – $3,3 \cdot 10^{-3}$	AA – 1,0	2,8
ornithine – $3,0 \cdot 10^{-3}$	AA – 1,0	3,1
proline – $3,3 \cdot 10^{-3}$	AA – 1,0	9,4
serine – $3,7 \cdot 10^{-3}$	AA – 1,0	7,9

It was found by extraction methods that a mixed complex with a ratio of components Eu:  $\beta$ -diketone: Gly = 1:3:2 is extracted into the organic phase. The formation of mixed-ligand complexes of europium with acetylacetonone and amino acids is evidenced by an increase in the absorption intensity and changes in the absorption spectra of solutions of the complexes in comparison with the spectra of the initial europium tris-acetylacetonate and amino acid (fig. 2).



**Fig. 2.** Absorption spectra: a – Ser (pH=7) (1) and the complex  $Eu(AA)_3(Ser)_2$ (2), b – Pro (pH=7) (1) and the complex  $Eu(AA)_3(Pro)_2$  (2)

The intensity of absorption of the mixed-ligand complex increases with an increase in the concentration of the amino acid. Since  $\beta$ -diketones are bidentate ligands, and the formation of europium tris- $\beta$ -diketonates in the organic phase in these extraction systems has been proven, then to achieve the most characteristic coordination number of europium, two glycine molecules can coordinate to the central europium atom. At the same time, taking into account the data of studies

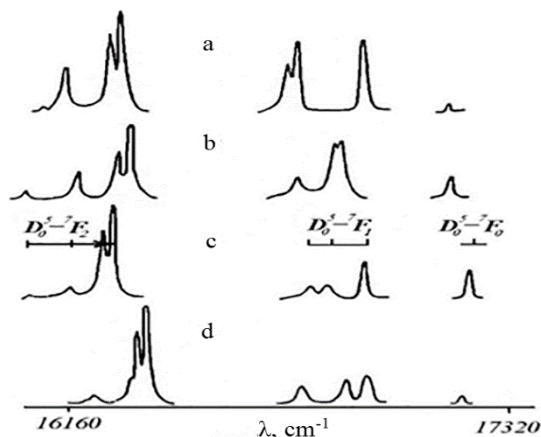
of similar extraction systems and the fact that at the indicated pH values of the aqueous phase, the amino acid is predominantly in the betaine form [4], it can be argued that glycine, when mixed with complex compounds with europium  $\beta$ -diketonates during the formation in the organic phase, will retain betaine structure. The fact of the formation of such mixed complex europium tris- $\beta$ -diketonates with glycine in the organic phase is confirmed by the data of studies of extraction systems by IR and luminescence spectroscopy.

Thus, in the IR spectra of extracts with glycine, additional bands appear in the region of  $3100\text{ cm}^{-1}$ , which are characteristic of the absorption of stretching vibrations of ionized amino groups  $\text{NH}_3^+$ . In contrast to the IR spectrum of extracts of tris-acetylacetonate or europium hexafluoroacetylacetonate, the IR spectra of the extract of these  $\beta$ -diketonates with glycine also contain an intense absorption band near  $1300\text{ cm}^{-1}$  characteristic of amino acids [5]. Also, in the range of  $1560\text{--}1750\text{ cm}^{-1}$ , along with absorption bands due to stretching vibrations of (C=O) AA or HFAA groups, additional absorption bands associated with stretching vibrations of ionized carboxyl groups ( $\text{COO}^-$ ) and deformation vibrations of  $\text{NH}_3^+$  groups glycine. Consequently, in the studied extracts, the amino acid molecules, when mixed with europium  $\beta$ -diketonates, retain their betaine structure, coordinating to the europium ion through the oxygen of the deprotonated carboxyl group.

To confirm the composition and structure of mixed-ligand complex  $\beta$ -diketonates of europium with amino acids formed in the organic phase, we performed quantum chemical modeling of the geometric structure of the complex without taking into account the influence of the medium.

According to quantum-chemical calculations, when the second glycine molecule enters the coordination sphere of yttrium in tris-complexes with both AA and HFAA, the stability of the complex increases, and compared with complexes of the composition Y:AA:Gly and Y:HFAA:Gly, the energy gain is, respectively 97.243 and 131.524 kcal/mol. It was found that glycine molecules coordinate the lanthanide ion with the oxygen of the deprotonated carboxyl group, and a hydrogen bond is formed between the  $\text{NH}_3^+$  - Gly group and the oxygen of  $\beta$ -diketone.

The luminescence spectra of europium hexafluoroacetylacetonates  $\text{Eu}(\text{HFAA})_3 \cdot 2\text{AK}$  adducts consist of one intense and three weak lines of the  ${}^5\text{D}_0\text{-}{}^7\text{F}_2$  transition, three intense lines of the  ${}^5\text{D}_0\text{-}{}^7\text{F}_1$  transition, and a single line of the average intensity of the  ${}^5\text{D}_0\text{-}{}^7\text{F}_0$  transition (fig. 3, a, b).



**Fig. 3.** Luminescence spectra of Eu (HFAA)<sub>3</sub>·2Pro (a); Eu (HFAA)<sub>3</sub>·2 Val (b); Eu(HFAA)<sub>3</sub>·2(β-Ala)(c); Eu(HFAA)<sub>3</sub>·2H<sub>2</sub>O (d) at 77 K (the intensity of the <sup>5</sup>D<sub>0</sub>-<sup>7</sup>F<sub>0,1</sub>- transition bands with respect to I (<sup>6</sup>D<sub>0</sub>-<sup>7</sup>F<sub>2</sub>) is increased 5 times)

By the nature of the splitting of the transition bands, the luminescence spectra of the synthesized adducts differ from the spectrum of europium tris-hexafluoroacetylacetonate dihydrate (fig. 3). Chemical and spectroscopic analysis shows that the compounds do not contain coordinated water molecules (there is no absorption of  $\nu$  (OH) in the region of 3400-3000 cm<sup>-1</sup>). The change in the nature of the luminescence spectra of the studied compounds in comparison with the spectrum of europium hexafluoroacetylacetonate dihydrate indicates a change in the nearest environment of the Eu<sup>3+</sup> ion associated with the replacement of water molecules by amino acid molecules. It can be assumed that the amino acid in the studied compounds acts as a neutral ligand, replacing two water molecules in the coordination sphere of the Eu<sup>3+</sup> ion. The presence of a single line in the luminescence spectra of the considered europium adducts in the region of the <sup>5</sup>D<sub>0</sub>-<sup>7</sup>F<sub>0</sub> transition (17226-17242 cm<sup>-1</sup>), along with X-ray data, indicates the homogeneity of the composition of the compounds obtained. The intensity of the <sup>5</sup>D<sub>0</sub>-<sup>7</sup>F<sub>0</sub> transition line in the luminescence spectra of the studied europium adducts is higher than the intensity of the line of the same transition in the Eu(HFAA)<sub>3</sub>·2H<sub>2</sub>O spectra. This is apparently associated with a decrease in the symmetry of the nearest environment of the Eu<sup>3+</sup> ion when amino acid molecules enter the complex.

Ligands containing several pairs of donor groups, for example, 1,2,4,5-benzenetetracarboxylic acid or pyromellitic acid, can act as bridging ligands when interacting with a metal salt, which leads to the formation of polynuclear compounds. By changing the ratio of reagents and temperature, tris-chelates of europium with pyromellitic acid of the following composition were isolated from the reaction mixture at pH=6: Eu<sub>4</sub>(PM)<sub>3</sub>(H<sub>2</sub>O)<sub>6</sub>; Eu<sub>2</sub>(PM)<sub>3</sub>(H<sub>2</sub>O)<sub>6</sub>; Eu<sub>4</sub>(PM)<sub>3</sub>(H<sub>2</sub>O)<sub>9</sub>(L)<sub>m</sub>, where l - a neutral ligand - PEN, TPPO, TIBP, TBP; DMF; m = 1; 2; 3 for PEN;



$m = 1$  for TPPO and DMF;  $m = 3$  for TIBP and TBP. The molecular weights of the obtained polynuclear compounds, calculated from the content of end groups, have the values  $(8-20) \cdot 10^3$ . Polychelates of europium with pyromellitic acid of the largest molecular weight are obtained with an equimolar ratio of reagents.

When irradiated with ultraviolet light, mixed-ligand polynuclear complexes with pyromellitic acid give intense luminescence. The presence in the luminescence spectra of the considered polychelates of a single line in the region of the  ${}^5D_0 - {}^7F_j$  transition ( $17230 - 17280 \text{ cm}^{-1}$ ), along with the data of X-ray diffraction studies, indicates the homogeneity of the composition of the coordination centers of the obtained compounds, that is, the identity of the environment of  $\text{Eu}^{3+}$  ions in polychelates. The mixed-ligand complex with 1,10-phenanthroline has the highest quantum yield.

The complexation of europium by  $\beta$ -diketones in the presence of polyfunctional organic compounds has been studied. Extraction systems characterized by a synergistic effect have been identified, and the compositions of the extracted compounds have been established. It is shown that an increase in the distribution coefficients in the studied systems is due to the formation of well-extractable mixed-ligand complexes. Ways of coordination of  $\beta$ -diketone and amino acids in the mixed-ligand complex have been determined by the methods of quantum-chemical modeling, IR and luminescence spectroscopy.

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圣诞树关闭装置用聚合物复合材料密封件的应力场的精细计算

## REFINED CALCULATION OF THE STRESS FIELD OF A POLYMER-COMPOSITE SEAL FOR CHRISTMAS TREE SHUT-OFF DEVICES

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抽象。 在本文中，考虑了确定密封件应力的新方法。 在这方面，使用了 Kantorovich 方法，其中考虑了位移方程组中的静水应力，计算了比势能，并确定了端面和中段的应力分布。 各种比例的密封高度。

关键词： 闸阀密封胶应力变形袖带磨损聚合物圣诞树

**Abstract.** *In the article, new approaches for determining the stresses in seals are considered. In this regard, the Kantorovich method was used, in which the hydrostatic stress in the system of equations of displacement was taken into account, the specific potential energy was calculated, and the stress distribution in the end face and in the middle section was determined for various ratios of the seal height.*

**Keywords:** *gate valve, sealant, stress, deformation, cuffs, wear, polymer, Christmas tree*

To ensure increased reliability of the sealing of existing rubber seals for Christmas trees and pipeline connections under high pressure and corrosive environments, a more refined study of stress distributions is required.

Correct fit of the sealing assemblies used in the gate devices of the Christmas tree in the cells and when designing the preparation of the dimensions of these cells in accordance with the limiting deformation value will increase the life of the seals [6,7].

In O-rings, depending on the deformation, the rapid failure of the seal from fatigue can be caused by an excessive change in the inner diameter during deformation. In case of deformation, to ensure permanent sealing of the O-rings in the cells, it is necessary to determine the dependence of the axial displacement on the radius  $r$  of the cross-section of the side ends of the seal [8].

The purpose of the work is to determine in the annular seals the dependence of the displacements on the radius of the seal, formed from deformation under conditions of minimizing potential energy [2,3,4,5].

To facilitate the solution of the problem, as a prerequisite, the displacement formed due to the force of pressure during the landing of the seal is taken to be rectilinear.

For this purpose, using the Kantorovich method [1] of deformation in the variable  $x$  of the straightness system, and taking into account the hydrostatic stress and displacement of the deformation [1,2,3], the process equation will take the following form:

$$\begin{aligned}
 U_1 &= \sum_{i=1}^{\infty} f_{1i}(x)\phi_{1i}(y); \\
 U_2 &= \sum_{i=1}^{\infty} f_{2i}(x)\phi_{2i}(y) \\
 S_0 &= \sum_{i=1}^{\infty} \varphi_{1i}(x)\varphi_{2i}(y)
 \end{aligned} \tag{1}$$

Here  $\phi_{1i}(y), \phi_{2i}$  - functions that are given in advance and express the following relationship.

$$\frac{d\phi_{2i}}{dy} = -\phi_{1i} \tag{2}$$

This relationship allows the incompressibility condition to be met. These functions  $f_{1i}(x); f_{2i}(x)$  also satisfy geometric boundary conditions. Also, these functions are not subject to any prior restrictions.

The ratio  $\frac{d}{dx}f_{1i} = f_{2i}$  is formed from the condition of material incompressibility:

$$\Delta = \frac{\partial U_1}{\partial x} + \frac{\partial U_2}{\partial y} = \frac{df_{1i}}{dx}\phi_{1i} + f_{2i}\frac{d\phi_{2i}}{dy} = 0 \tag{3}$$

Functions  $f_{1i}; f_{2i}$  are considered as additional equations for the required functions. Function  $\varphi_{2i}(y)$  forming a fully functional system, allows you to expand the expression for the hydrostatic stress  $S_0$ .

Supplying the received displacements  $U_1, U_2$  and stresses  $S_0$  in the variational equation and integrating over  $y$ , we obtain the following formula [6].

$$\int_x^{\delta} F(x, f_{1i}, f_{2i}, \frac{df_{1i}}{dx}, \frac{df_{2i}}{dx}, \varphi_{1i})dx = 0 \quad (i=1,2,...n). \tag{4}$$

After variation of the function 2n-shaped  $f_{1i}(x); f_{2i}(x)$ , we obtain a simple system of equations for the 3n shaped function  $f_{1i}, f_{2i}, \varphi_{1i}$  [2,3].

$$\frac{\partial F}{\partial f_{1i}} - \frac{d}{dx} \left( \frac{\partial F}{\partial f'_{1i}} \right) = 0; \tag{5}$$

$$\frac{\partial F}{\partial f_{2i}} - \frac{d}{dx} \left( \frac{\partial F}{\partial f'_{2i}} \right) = 0 \quad (i=1,2,\dots,n)$$

The derivatives of the function corresponding to the strokes of the variable  $x$  are indicated in expression (5).

System of equations (5)  $i = (1,2, \dots, n)$  are interrelated with the values of the contacts.

$$\frac{d}{dx} f_1 = f_{2i} (i = 1,2,\dots, n) \tag{6}$$

Note that the sought functions in the process of variation are derived from the true boundary conditions  $f_{1i}, f_{2i}$ .

The displacement and hydrostatic stresses in the first approximation will take the following form,

$$\begin{aligned} U_1 &= R f_{11}(\zeta) \phi_{11}(\rho) \\ U_2 &= R f_{21}(\zeta) \phi_{21}(\rho) \\ S_0 &= \varphi_{11}(\zeta) \varphi_{21}(\rho) \end{aligned} \tag{7}$$

Here, taking the cross section of the seal to be a straight section, on the basis of the hypothesis of a straight section, we accept the conditions  $\phi_{1i}(\rho) = 1$ ,  $\phi_{2i}(\rho) = 1$ ,  $\varphi_{2i}(\rho) = 1$  Under these conditions, we calculate the specific potential energy  $W$ -:

$$W=U_1=G(\varepsilon_z^2 + \varepsilon_r^2 + \varepsilon_\theta^2 + \frac{1}{2} \gamma_{rz}^2) = G(f_{11}^2 + 2f_{21}^2 + \frac{1}{2}\rho^2 f_{21}^2) \tag{8}$$

We define the change in the volume of the deformation components at one point as follows

$$\Delta = f'_{11} + 2f_{21} = 0 \tag{9}$$

According to the above expression, the extremum of the  $r$ -function after integrating the (4) -function with radius

$$J = \int_{-\infty}^{\infty} F(f'_{11}, f'_{22}, f_{21}, \varphi_{11}) d\zeta + PR[f_{11}(m)f_{11}(-m)], \tag{10}$$

Here,

$$F = 2\pi GR^3 \left( \frac{1}{2} f_{11}^2 + f_{21}^2 + \frac{1}{8} f_{21}^2 + \frac{1}{2G} f' \varphi_{11} + \frac{1}{G} f_{21} \varphi_{11} \right) - \text{equals}$$

Taking  $\delta J = 0$  in the stationarity mode by expression (4), we obtain the system of two-linear differential equations

$$\begin{aligned} \frac{\partial F}{\partial f_{1i}} - \frac{d}{d\zeta} \left( \frac{\partial F}{\partial f_{1i}} \right) &= 0 \\ \frac{\partial F}{\partial f_{2i}} - \frac{d}{d\zeta} \left( \frac{\partial F}{\partial f_{2i}} \right) &= 0 \end{aligned} \quad (11)$$

or

$$F_{2i} + \frac{1}{2G} \varphi_{1i}^l = 0$$

and the actual boundary conditions

$$\left. \frac{\partial F}{\partial f_{11}^l} \right|_{\zeta} = \pm 2m = \left. \frac{\partial F}{\partial f_{11}^l} \right| + PR = \left. \frac{\partial F}{\partial f_{11}^l} \right|_{\frac{z}{R} = \pm \frac{h}{R}} \quad \left. \begin{array}{l} +PR = 0 \\ \frac{z}{R} = \pm \frac{h}{R} \end{array} \right| \quad (12)$$

$$\left( \frac{\partial F}{\partial f_{11}^l} = f_{11}^l + \frac{1}{2G} \varphi_{11} \right) \quad (13)$$

assume

Completing the system of equations (12) with the constraint equation (4), we obtain

$$f_{21} = -\frac{1}{2} f_{21}^l \quad (14)$$

For these dependencies, the sought functions  $f_{11}, f_{21}$ , should provide the following equation:

$$\begin{aligned} f_{11}(0) &= 0 \\ f_{21}^i(0) &= 0 \end{aligned} \quad (15)$$

$$f_{21}(m) = 0$$

This expression ensures that the formed boundary conditions are met. The following functions correspond to equations (12) - (15):

$$f_{11} = -\frac{1}{3} \left( \xi - \frac{Sh\alpha\xi}{ch\alpha m} \right) \frac{\sigma_0}{G} \quad (16)$$

$$f_{21} = \frac{1}{6} \left( 1 - \frac{ch\alpha\xi}{ch\alpha m} \right) \frac{\sigma_0}{G} \quad (17)$$

$$\varphi_{11} = -\frac{1}{3} \left( 1 + 2 \frac{ch\alpha\xi}{ch\alpha m} \right) \sigma_0 \quad (18)$$

Here, we assume  $\alpha = 2\sqrt{6}$  [2].

Let's calculate the normal stress  $\sigma_Z$  in the free section  $Z$  of the seal.

$$\sigma_Z = 2\varepsilon_Z G + \sigma_0 = 2Gf'_{11} + \varphi_{11} = -\sigma_0$$

Thus, in contrast to the Rits method, in any free section of the region  $Z$ , the force  $\sigma_Z$  is equal to the load  $P$ . From the equality of forces

$$\sigma_Z \pi R^2 = -\sigma_0 \pi R^2$$

Here,

$$\sigma_0 = \frac{P}{\pi R^2} \tag{19}$$

Let us consider the ranking of the solutions of these problems for the series  $r$ , disregarding the Kantorovich method and the hypothesis of the section plane. Then for the displacements we write down

$$\begin{aligned} U_1 &= R[f_{11}(\xi) + \rho^2 f_{12}(\xi)] \\ U_2 &= R[f_{21}(\xi) + \rho^2 f_{22}(\xi)] \\ S_0 &= \phi_{11}(\xi) + \rho^2 \phi_{12}(\xi) \end{aligned} \tag{20}$$

In these changes in the displacements  $U_1, U_2$  the incompressibility conditions can be satisfied.

If we revise those noted above in the integral (10), we obtain the expression

$$J = \int_{-m}^m F(f, \phi_{11}, \phi_{12}) dS + PR[f_{11}(m) - f_{12}(-m)] \tag{21}$$

From this expression, it turns out that in the lateral ends of the seal, the axial displacement  $U$  does not depend on the radius  $r$ , that is, it can be assumed to be

$$f_{11}(m) = 0$$

$$f_{12}(-m) = 0 \tag{22}$$

If we take into account expression (22) in expression (21), we obtain expression (23):

$$J = \int_{-m}^m F(f, \phi_{11}, \phi_{12}) dS \tag{23}$$

The resulting expression satisfies the condition for minimizing the potential energy.

### Conclusions

1. An expression is obtained for the condition of minimizing the potential energy for the stressed state of annular sealing elements of gate devices operating under high pressure and aggressive media.
2. The distribution of stress for different ratios of height to radius in the lateral and middle parts of the sealing element was determined and it was found that this distribution does not depend on the radius of the seal.

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确定分形天线的频率特性的特征

## FEATURES OF DETERMINING THE FREQUENCY CHARACTERISTICS OF FRACTAL ANTENNAS

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抽象。 本文讨论了在确定分形和线性天线的谐振频率和信号传播速度方面的差异。 给出了使用计算机辅助设计工具和实验数据对分形天线的谐振频率进行建模的比较结果。

关键词：分形天线谐振频率频率系数

**Abstract.** *The article discusses the differences in determining the resonance frequency and signal propagation speed of fractal and linear antennas. Comparative results of modeling the resonance frequency of fractal antennas using computer-aided design tools and experimental data are presented.*

**Keywords:** *fractal antenna, resonant frequency, frequency coefficient*

In conventional antennas, the resonant frequency is determined by the length of the web. In fractal antennas, the length of the canvas determines only the main (lower) frequency of the range, while the fractal segments of a shorter length will determine resonances at higher frequencies of the range. At first glance, it might seem that the resonance of a fractal antenna should coincide with the resonance of a conventional antenna with a canvas of the same length. However, their resonances are always different.

In work [1], the resonances of fractal antennas of the same dimensions were experimentally measured. Figure 1 shows the experimental readings for zero, first and second iterations of the "Koch Triangle" fractal antenna:





*Figure 1 – Experimental data for FA "Koch triangle" [1]*

The numerical data of the experiment are shown in the table:

*Table – Numerical data of the experiment*




Type of antenna	Iteration number	Length $\lambda/4$ ,mm	Resonant frequency, MHz
	0	78	900
	1	78	767
	2	78	658

Figure 1 and the table clearly show that the frequency of the main resonance decreases with an increase in the number of iterations, and at the same time the real resonance frequencies are noticeably higher than the frequencies calculated along the length of the canvas. This is because the signal propagates faster in the fabric of fractal antennas than in linear antennas.

In linear antennas, the signal propagates linearly along a line whose dimension is 1, and therefore the propagation speed of the signal in the linear antenna web is close to the speed of light. The signal propagation speed in the fractal antenna web will exceed the signal propagation speed in the linear antenna. This is mathematically explained by the dimension of the fractal. The dimension of fractals is almost always greater than 1.

For the Koch triangle, the dimension (D) is calculated by the formula (1) [1]:

$$D = \frac{\ln(4)}{\ln[2(1+\cos\theta)]} \quad (2.1)$$

$$\text{If } \theta=60^\circ D = \frac{\ln(4)}{\ln(3)} = 1,261859507.$$

The dependence of the first resonant frequency of the Koch dipole  $f_k$  on the dimension of the fractal  $D$ , the iteration number  $n$  and the resonant frequency of the rectilinear dipole  $f_d$  of the same height as the broken Koch dipole (at the extreme points) is determined by the formula (2) [1]:

$$f_k = f_d \left[ 1 - \frac{\ln D}{D} \right] \times e^{(n-1)/n}. \tag{2.2}$$

The expression in square brackets is called the frequency coefficient.  
 For the first iteration with  $n=1$ ,  $D=1.262$  we get:

$$f_k = f_d \times 0,816 = 900\text{MHz} \times 0,816\text{MHz} = 734\text{MHz}.$$

For the second iteration with  $n=2$ ,  $D=1.262$  we get:

$$f_k = f_d \times 0,696 = 900\text{MHz} \times 0,696\text{MHz} = 626\text{MHz}.$$

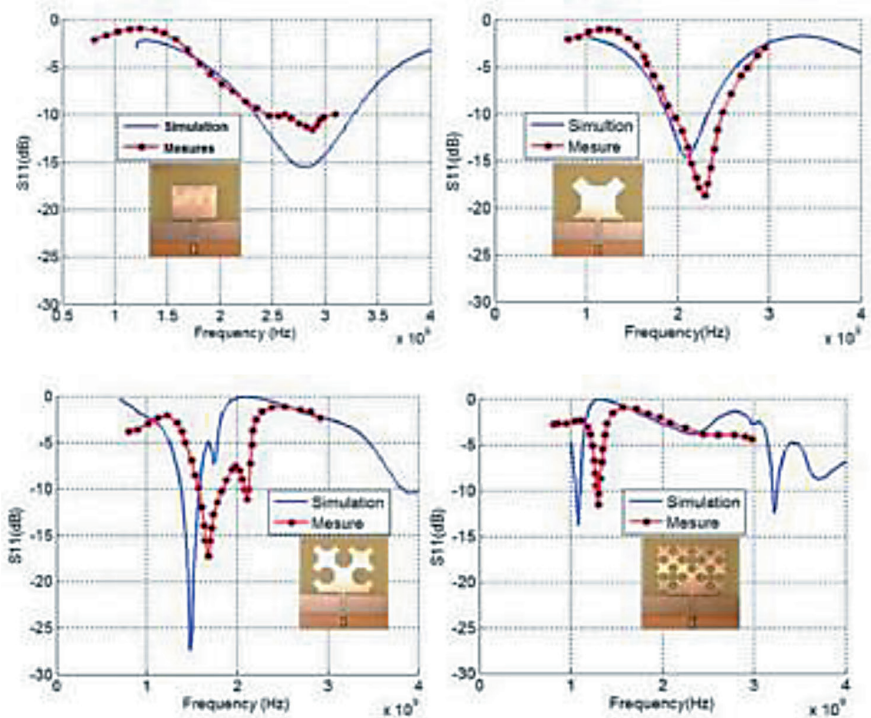
The fact that the real resonant frequency of fractal antennas is higher than the frequency calculated from the length of the web means that the signal propagates in fractal antennas at a speed that is noticeably higher than the speed of signal propagation in the linear web. From a physical point of view, this happens because inductive and capacitive coupling appears between the segments of the canvas in fractal antennas. This can significantly change the speed of wave propagation in the fabric of the fractal antenna and, as a consequence, the shortening factor. The wave propagates not only along the web, but also through inductive and capacitive couplings. Due to the transmission of a signal through capacitive (and inductive) couplings, as a result, we get that the signal in the fabric of a fractal antenna can theoretically propagate faster than along the linear fabric of a conventional antenna. The dimension of the fractal can be quite large, as well as the number of fractal iterations. This leads to the fact that the resulting signal propagation speed in a fractal antenna can be very different from the signal propagation speed in a flat line antenna, because the signal does not propagate linearly, but through capacitive couplings between the sections of the fractal antenna.

When modeling the resonance frequency of fractal antennas using automated design tools, practical values always differ from experimental ones, since all simulators use finite depth models, i.e. do not take into account all factors and details. Figure 2 shows a real antenna model, to which the Sierpinski cross fractal algorithm is applied.



Figure 2 – Fractal antenna "Sierpinski cross" [2]

Figure 3 shows the results of modeling and experimental data in determining the frequency properties of this antenna:



**Figure 3** – Frequency characteristics of the model and experimental data of the fractal antenna "Sierpinski cross" [2]

Experimentally measured results always differ from simulation results. Figure 3 shows that the frequency of the first resonance decreases with an increase in the number of iterations, while components appear near the fundamental frequency that are not associated with the second resonance. In this case, the gain at the fundamental frequency and higher resonances can both increase and decrease from iteration to iteration.

Usually the first approximation in determining the frequency properties of the antenna is the calculation by the dimension of the fractal. The second approximation is computer simulation. But none of these methods provide a reliable estimate.

Therefore, in practice, fractal antennas (or fractal antenna elements) with the desired frequency properties are selected empirically.

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评估装配过程中的风险  
ASSESSMENT OF RISKS IN ASSEMBLY PROCESSES

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注解。 本文讨论了在组装过程中识别和降低风险的可能性。 为了确定产品生命周期各阶段的风险程度，对影响产品可靠性和质量的不合格品进行了评估。 周期各个阶段的过程指标是通过以下方法确定的：统计，逻辑分析方法以及基于FMEA方法的方法。

建议使用故障类型和后果分析来评估组装过程中的风险。 在组装过程中经过深思熟虑的风险评估示例可以得出结论，可以将所考虑的方法应用于各种用途的产品。

关键字：质量，过程，组装，风险，方法，评估

**Annotation.** *The article discusses the possibility of identifying and reducing risks during assembly processes. To identify the degree of risks at the stages of the product life cycle, an assessment of nonconformities was carried out that affect the reliability and quality of the product. The indicators of processes at various stages of the cycle were determined by such methods as: statistical, method of logical analysis and based on FMEA methodology.*

*It is proposed to assess risks during assembly processes using the analysis of types and consequences of failure. The considered example of risk assessment during the assembly process made it possible to conclude that the method under consideration can be applied for products for various purposes.*

**Keywords:** *Quality, process, assembly, risks, methods, assessment*

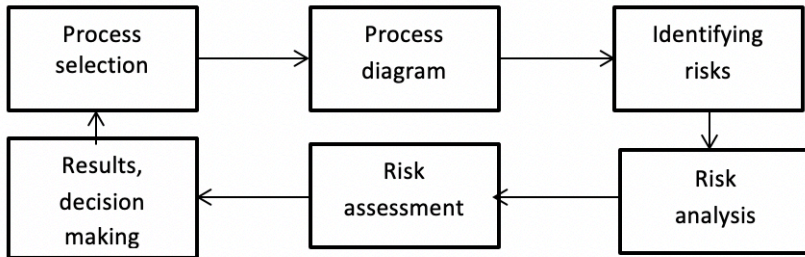
Recently, much attention is paid to the risks that may arise at any stage of the life cycle in the manufacture of products or the provision of services. Therefore, the timely identification and adoption of adequate control actions makes it possible for the organization to reduce them.

The latest version of the ISO 9000 series, based on risk-oriented thinking [1], which appeared in 2015, allows us to approach the process of improving quality management systems (QMS) from a different standpoint where the QMS is in working order. For this purpose, you can use the methods of risk assessment and analysis, which are discussed in sufficient detail in the standard. [2]

Problems arising at the beginning of the process cause the appearance of defective products at its last stages or during its operation, which leads to the occurrence of losses, which can serve as the basis for stopping the process or returning products to the manufacturer.

It should be noted that when analyzing the safety and reliability of various systems, along with various tools, the analysis of modes and consequences of failures (FMEA) can be used.

The most rational method for researching risks in assembly processes can be the approach used to systematize and schematically depict the causes, effects and possible measures to eliminate the identified problem areas [4] by a group of highly qualified specialists who carry out the analysis in the sequence shown in Fig. 1.



*Figure 1 - Control scheme for identifying potential failures*

Based on previously published works [3,4], risk assessment (R) is recommended to be carried out using the probability of process deviations from the standard (failure) - V and the significance of failure - Z.

This approach makes it possible to identify bottlenecks in assembly processes and then make corrective actions.

Table 1 shows the characteristics of assessing the probability and significance of rejection for determining risk. [4]

*Table 1 - Characteristics of the probability and significance of failure*

<b>Probability of failure (V)</b>	<b>Significance of failure (Z)</b>
1 very low	1 is unlikely to have any problems
2 low	2 does not pose any particular problems, removable
3 the probability is not very low	3 failure is not serious
4 below average	4 below average severity
5 medium	5 medium failure
6 above average	6 above average
7 pretty tall	7 pretty meaningful
8 high probability	8 significant
9 very high	9 very meaningful rejection
10 probability 100%	10 occurrence of destruction, life-threatening

The risk indicator is defined as the product of the probability of failure and its significance, i.e.  $P = VZ$ .

The weight of the priority is determined by the failure with the highest P scores (for example, P, greater than 25).

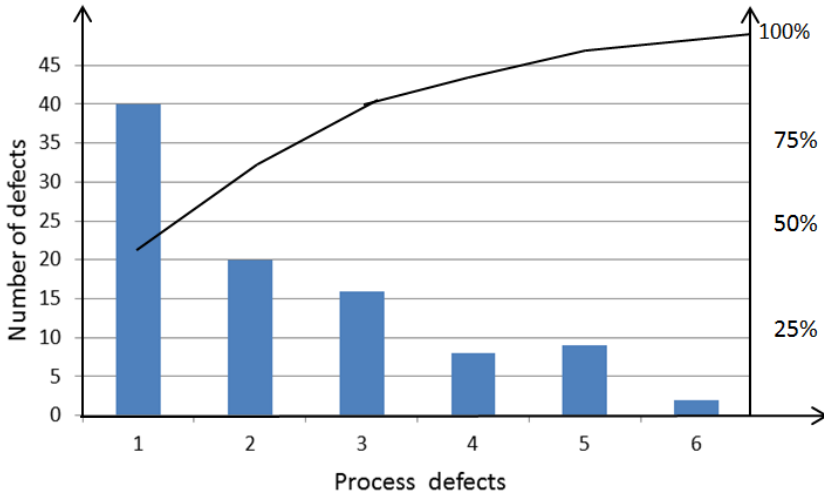
The outlined assessment methodology allows you to identify risks at various stages of the processes, including assembly, and make the necessary adjustments.

As an example, consider the analysis of the product assembly process, as a result of which a number of defects were identified, presented in Table 2.

*Table 2 - Defects of the assembly process*

<b>№</b>	<b>Defect type</b>	<b>Number of defect</b>	<b>Accumulated number of defects</b>	<b>Accumulated percent</b>
1	Riveting	40	40	42
2	Marking / drilling	20	60	63
3	Unfinished installation	16	76	80
4	Installing bolts	8	84	88
5	Layout / installation	9	93	98
6	Cleanliness of the working area	2	95	100
		95		100

Based on the results of table 2, a Pareto diagram is built, shown in Fig. 2.



**Figure 2 - Process defect diagram**

*1 - riveting, 2 - marking / drilling, 3 - unfinished installation, 4 - installation of bolts, 5 - marking / installation, 6 - cleanliness of the working area*

It can be seen from the diagram that 80% of deviations from the technical requirements are due to defects identified during such operations as riveting, marking / drilling, unfinished installation.

To assess the degree of risk arising during the execution of the assembly process, a flowchart of assembly operations was built, which made it possible to highlight the following process steps:

- 1 - installing panels and stringers in the assembly tool,
- 2 - markup according to the drawing,
- 3 - drilling holes,
- 4 - cleaning (cleanliness) of the working area,
- 5 - sealing panels with entering the controlled parameters in the passport,
- 6 - riveting of panels with stringers,
- 7 - control weighing,
- 8 - transfer of the assembled product to the subsequent process.

The analysis carried out and the highlighted steps of the process made it possible to assess the likelihood and significance of failures that can lead to certain risks of the assembly process.

Table 3 lists only those process steps that have a significant impact on the risk score.



*Table 3 - Registration of inconsistencies in the assembly of the connection*

Process steps	Failure mode	Cause	Effect	V	Z	P	Measures
Layout according to the drawing. The control.	Executed with a deviation from the design documentation (CD)	There are no risks on the lodgements, the requirements of the technological process and design documentation are not met	Termination of further work	6	9	54	Remove markings, mark devices according to risks
Drilling holes. The control.	The drill moves away from the hole axis	Non-compliance with technology when drilling	Hole ovality	6	9	54	Call a technologist or designer
	Hole diameter larger than required	Drill diameter does not meet the requirements of CD, TD	Irreparable defect	6	9	54	Call a technologist and designer
Cleaning (cleanliness) of the working area. The control.	The gap between the connection of parts	Non-compliance with the technological process	Lack of matching parts	6	5	30	Disassemble the node, remove shavings
Sealing panels with entering the controlled parameters into the passport. The control.	Uncleaned from dirt, oily surface of the parts to be sealed; the surface of the applied sealant has irregularities, burrs, bubbles, ripples	Failure to comply with the requirements of the technological process, the temperature regime is violated	Detachment of the sealant from the surface	7	10	70	Clean the surface of dust and dirt Repeat the degreasing operation. Clean the surface of the sealant. Repeat the operation.
Riveting of panels with stringers. The control.	Poor riveting; Nicks, dents on the surface of the product, the gap under the rivet	Excessive rivet pressure, rivet shank less than design, poor deburring	Broken / underburned closing / embedded rivet head, loose fit of the head along the entire contour	8	9	72	Replacement of rivets, observe the rules of riveting, knock out, settle the deformed place, follow the rules of riveting.
Preparation for acceptance control for delivery of products Control.	A complete set of documents is missing	Failure to comply with enterprise standard requirements	Deviation from BTK acceptance	7	7	49	Collect a set of documents according to the enterprise standard

As can be seen from the presented non-conformity registration, the greatest risks during the assembly process are subject to such process steps as sealing and riveting of the product, which depend on marking and drilling of holes.

From the above, it seems possible to conclude that in modern conditions, in the production of products (services) at all stages of the life cycle, great attention must be paid to risk-oriented thinking. Considering the assembly processes of technical products, it should be noted the likelihood of a risk, which leads to a violation of the assembly quality. The recommended method and the given example allow us to recommend the application of this method for various processes, both in the manufacture of products and in its service.

The proposed approach to assessing risks makes it possible to concretize the control measures for improving processes. The analysis of the results of the research shows that the quality of assembly processes is influenced by various factors (the environment, the equipped workplace, the qualifications of the assembler-riveter, etc.), the reduction of which can reduce the risks.

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达到沟渠网络的最大密度的可能性

## PROBABILITY OF REACHING THE MAXIMUM DENSITY OF THE GULLY NETWORK

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The spread of gullies is considered as one of the essential criteria for assessing the ecological tension of the regions. Analysis of topographic maps and field studies show that in areas of long-standing agricultural development in the territory of European Russia, gullies up to 200 m long prevail (up to 85%).

The number of extended gullies is only 15%, but their total length is 114 thousand km, which is commensurate with the length of short gullies - 144 thousand km. Extended gullies have a much larger area, and the area of affected economically suitable lands also increases. In this respect, the indicator of the density of the gully network is more significant.

In the Research Laboratory of Soil Erosion and Channel Processes named after N.I. Makkaveev, a map of the current density of the gully network on the European territory of the European part of Russia was compiled on a scale of 1:2500000. This indicator was determined for each catchment of the 1st order. The obtained density values varied from 0.01 to 1.3 km/km<sup>2</sup> and more. Analysis of the map made it possible to identify the following types of territories:

1) areas of very low infection (density less than 0.01 km/km<sup>2</sup>), where gullies are extremely rare, these include poorly developed or undeveloped lands with flat and ridge relief - areas of tundra and forest-tundra; flat forested and treeless lowlands with very shallow base depths; weakly dissected flat-topped low-mountains and plateaus.

2) weak gullification (0.01-0.02 km/km<sup>2</sup>), characterized by shallow dissection of the relief, occupying vast areas of tundra, forest-tundra and forest zones, separate areas along the Ural Mountains, within the Northern Uvaly, Verkhne-Kama and Bugulmino-Belebey uplands and dr.

3) moderate gullies (average density 0.06 km/km<sup>2</sup>) are noted in the north of the Bolshezemel'skaya tundra, in some areas of the Central Russian, Valdai, Smolensk-Moscow, Verkhne-Kama uplands, Oka-Don plain, in the basin of the Kuban, Kuma, Malaya and Big Uzeni and others.

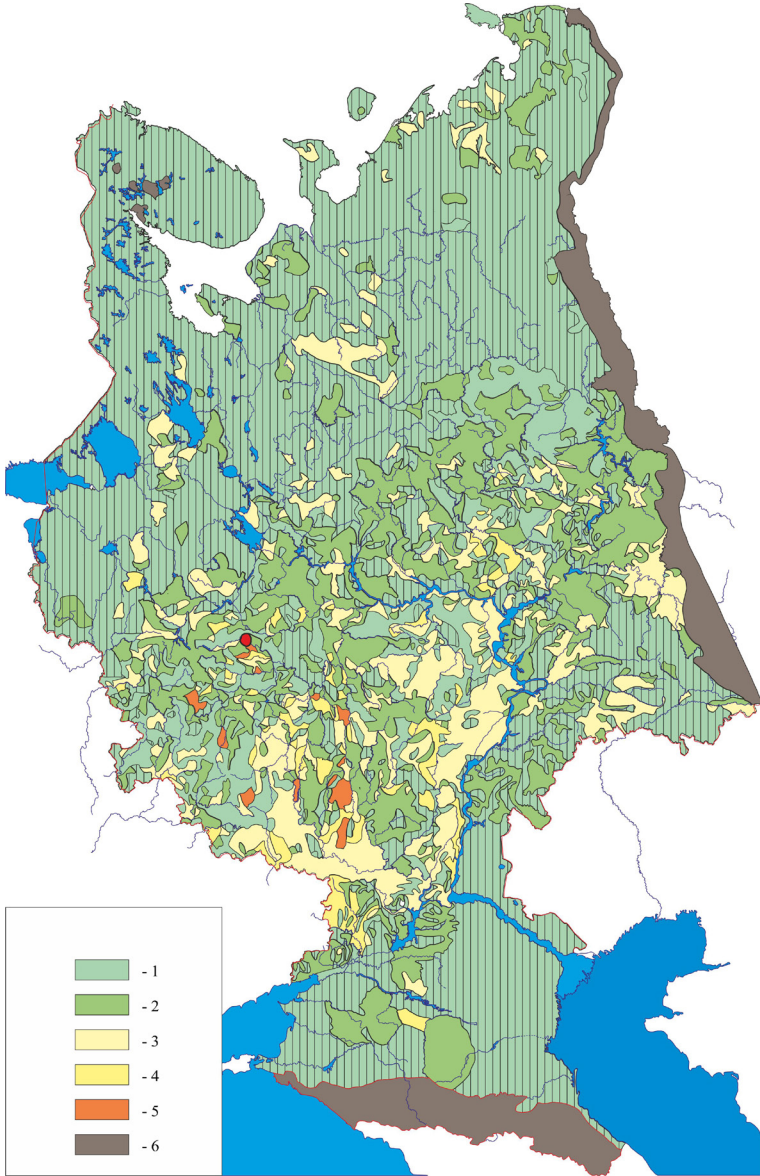
4) significant gullies (average density  $0.3 \text{ km/km}^2$ ) - are observed on elevated, dissected, intensively developed territories of the forest-steppe and steppe zones - areas of the Bolshezemelskaya tundra, some areas of the Central Russian, Verkhne-Kama and Stavropol uplands.

5) strong degree of gullification (average density -  $9 \text{ km/km}^2$ ) includes long and well-developed agricultural regions (vast areas of the Smolensk-Moscow, Central Russian, Volga, Verkhne-Kama and Stavropol uplands).

6) very strong gully ( $1.3 \text{ km/km}^2$  and more), characteristic of highly dissected, elevated, almost completely and long-plowed territories of the EC of Russia, such as: the Central Russian, Volga Uplands, Donskoe Belogorye, the southern part of the Don ridge [Geography ..., 2006].

To determine the limiting possibilities for the development of the density of the gully network, an original calculation method was applied. The values of the potential density for each catchment of the 1st order were obtained. Based on these data, a map of the maximum density of the gully network was compiled on the same scale. This indicator largely depends on the natural characteristics of the territory, since the conditions of anthropogenic interference are assumed to be the same (the vegetation cover is removed). Potential indicators in the overwhelming majority of cases exceed those of the modern gully and reach  $3 \text{ km/km}^2$  and more. In the distribution of the potential characteristics of the gully, to a greater extent than in its modern manifestation, the zonal and azonal regularities of the possible spread of gullies in the flat territories of European Russia are revealed. The zonation is clearly seen in the distribution of gullies. A low gully (no more than  $0.02 \text{ km/km}^2$ ) is typical for moraine-outwash and alluvial plains and lowlands with shallow depths of the base of erosion, straight or concave slopes. A moderate gully (no more than  $0.1 \text{ km/km}^2$ ) is confined to the hilly ridge and hilly-kam uplands of the north. A significant gully is predicted in areas with a large amplitude of relief dissection, on the convex slopes of the valley- arroyo network, in areas with easily eroded rocks (Smolensk-Moscow Upland, Klinsko-Dmitrovskaya Ridge, Oksko-Don Plain, north of the Central Russian Upland, Stavro-Polish Plateau). A high gully ( $3 \text{ km/km}^2$  or more) can develop mainly in the central part of the European territory of Russia, where a hilly-ridged relief with high absolute heights and depths of the erosion base is widespread, convex slopes intensively dissected by a valley- arroyo network.

The difference between the potential and current indicators of the density of the gully network determines its possible increase. Comparison of the estimated potential density and its current size allows us to establish the share of realization of changes in the density of the gully network to the size of the limiting, that is, the probability of gully formation. It is presented as a quotient from dividing the current density of gullies by the maximum (potential), given as a percentage.



**Fig. 1.** Map of the probability of reaching the maximum density of the gully network, in percent. 1 - 0-20, 2 - 21-40, 3 - 41-60, 4 - 61-80, 5 - 81-100. Shaded areas show areas with a probability of gully formation of 0%

Calculations of the probability of reaching the maximum density of gullies were made for each catchment of the first order using a map of scale 1:2500000 using maps of the current and potential density of the gully network of the same scale. Based on the characteristics obtained, a map was drawn up (fig. 1) of the probability of reaching the limiting values of the density of the gully network on a scale of 1: 2500000 for the territory of European Russia. The following scale steps were chosen: 1) 0-20; 2) 20-40; 3) 40-60; 4) 60-80; 5) 80-100%.

The Kola-Karelian province of European Russia is characterized by a relief formed under the conditions of a long period of continental development and continuous distribution of crystalline rocks. Intensive denudation processes proceeded together with tectonic ones. Depending on the geological structure of rocks, undulating plains or highly rugged structural-ridge relief are observed here, which in the Quaternary were exposed to the action of continental ice. Subsequently, the surface was subjected to the activity of erosional processes of nivation and frost weathering [Karadeeva, 1957]. Modern gully erosion is practically absent on the territory of the region (less than 0.02 km/km<sup>2</sup>), there are separate areas with a gully network density of up to 0.1 km/km<sup>2</sup>. The forecast indicators give the same characteristics.

The northern part of the Russian Plain, covering the territory from the Baltic Sea to the Urals and from the Barents Sea to the Moscow Region, covers vast areas of the tundra, forest-tundra and forest zone. This is a region of distribution of forms created by the processes of glacial and water-glacial accumulation on a more ancient relief, formed mainly by erosion processes. This territory is characterized by hilly, hilly-ridged and flat relief in places with a large number of lakes and swamps. By the age of the relief, two regions are distinguished: in the west - with younger glacial forms left by the Valdai glaciation, in the east - the territory covered by the glacier of the Moscow stage of the Dnieper glaciation. The territory covered by the Valdai glacier is characterized by fresh glacial forms. The largest upland is Valdai with absolute heights up to 300 m.

To the northeast of it there are extensive moraine-outwash and lacustrine-glacial depressions, in which lakes Beloye, Vozhza, Kubinskoye, etc. are located. km/km<sup>2</sup>), the potential varies in the range of 0.06-0.8 km/km<sup>2</sup>. The share of realization is mainly 5-10%, in some places 20-50%. The probability of gully formation ranges from 50 to 10%. On the plains, the current and potential density of gullies is weak, does not exceed 0.02 km/km<sup>2</sup>, and the share of realization is 100%. The current density generally reaches 0.02 km/km<sup>2</sup>, in some parts of the plateau and along the banks of large rivers - 0.1 km/km<sup>2</sup>. The potential density of the gully network ranges from 0.02 to 0.5 km/km<sup>2</sup>.

To the south, there is a strip of moraine-erosion uplands - Smolensko-Moscow, Klinsko-Dmitrov, Galich, extending from west to north-east. On the Smolensk-

Moscow Upland, the most ancient and dissected by a gully network, the current density of gullies generally does not exceed  $1.1 \text{ km/km}^2$  (moderate and strong), but in some areas it can exceed  $1.3 \text{ km/km}^2$ . On other heights, the average modern density of gullies ranges from  $0.06$  to  $0.8 \text{ km/km}^2$ . The potential for the density of gullies in these territories significantly exceeds the current indicators, varying from  $0.3$  to  $3 \text{ km/km}^2$ . The share of potential realization generally does not exceed 20% (the probability of gully formation is 80%), however, in some areas it reaches 60 and 100% - the probability is from 40% to 0.

The center of the Russian Plain is characterized by a combination of erosion-denudational highlands and accumulative lowlands. Alluvial and water-glacial plains are confined to the lowlands located at the front of the glaciers of the Dnieper and Moscow glaciers. Covered with easily eroded sandy deposits, they create a belt of woodlands stretching along the Desna, Oka, left bank of the Volga and descending south along the Don valley and its tributaries. In the interfluvium of the Klyazma and Oka rivers, there is the Meshcherskaya lowland, where gullies practically do not have the probability of gully formation 0. In the interfluvium of the Klyazma and Oka, Volga and Klyazma, the current density of gullies does not exceed  $0.02 \text{ km/km}^2$ , the potential density varies from  $0.02$  to  $0.5 \text{ km/km}^2$ . The share of realization varies from 10 to 40% (probability 90-60%), on the Meshcherskaya lowland - 100%.

The Oka-Don Plain is characterized by extensive flat plains, dissected by wide terraced valleys of large rivers, Don, Voronezh, Bitug, Khopra, etc. The strongest gullification is observed in the northern part of the plain, where the current density of the gully network reaches  $0.5$ - $1.1 \text{ km/km}^2$ . In the rest of the territory, gullies mainly cut through only steep and high slopes of the valleys of large rivers. The potential for the density of gullies in the northern part of the plain reaches  $3 \text{ km/km}^2$ , in the south it varies from  $0.5$  to  $1.0 \text{ km/km}^2$ . The share of realization has a wide range of values: from 5-10, 20-40% to 60 and 100%.

The Central Russian Upland is a wavy plain dissected by deep valleys of rivers, washouts and gullies. The depth of the incision reaches 100-150 m. The elevation has all the necessary conditions for the intensive development of modern and potential erosion processes: a tendency towards tectonic uplift, large depths of the base of erosion, unevenness of the initial relief, easily eroded composition of surface rocks, speed of snow melting and summer rains, long-standing agricultural development. The territory is characterized mainly by a moderate and dangerous degree of gully. The current density of the gully network ranges from  $0.02$ - $0.1$  to  $0.3 \text{ km/km}^2$  in the northern part of the upland and up to  $0.5$ - $1.3 \text{ km/km}^2$  in the southern and western parts. The highest modern density of gullies is noted along the right bank of the Don, the lower reaches of the Oka, on the right bank of the Psel, Donskoy Belogorie. The potential density of the gully network

is predominantly high and very high - from 1.1 to 3 km/km<sup>2</sup> and more. The share of realization of the density of mainly 5-10% is observed in the interfluves of the rivers Oka and Vitebeti, Neruchi and Trudy, Upa and Don, Svali and Seim, etc. In large areas (the right bank of the upper Don, Donskoe Belogorie), the share of realization reaches 20-40%, between the Oskol and Don rivers - 40-60%, in the lower reaches of the Oka - 60-80%.

On the Kalach Upland, the current density of gullies varies from 0.5 to 1.3 km/km<sup>2</sup>, potential - from 1.1 to 3.0 km/km<sup>2</sup> and more. The share of realization - in the central part reaches 50-100%, in the western part - 5-10%.

On the Volga Upland, the most gully-hazardous is the steep eastern slope, where the current density of gullies is more than 1 km/km<sup>2</sup>, and the maximum possible density reaches 3 km/km<sup>2</sup>. The predominant share of reaching the density of the gully network is 20-40% (probability 60-80%). Areas of full implementation are noted - a share of 100% in the Saratov region and the interfluve of the Sviyaga and Barysha rivers, as well as areas with a realization share of up to 5% - along the right bank of the Volga from Cheboksary to Ulyanovsk (95% probability). The western slope of the Volga Upland is longer and more gentle. The modern dissection density is 0.5-1.1 km/km<sup>2</sup>. Potentially possible ranges from 0.5 to 3 km/km<sup>2</sup>. There is a great variability in the probability of reaching the density of the gully network in this area. Quite large areas are noted (right bank of the Sura river) with a realization share of 20-40% (probability 60-80%), in the interfluve of the Tesha and Seryozha rivers, on the left bank of the river. Anadyr, the probability value is less than 5%, there are territories with fully realized density.

On the territory of Yergeni, the average modern density of the gully network varies from 0.06 to 0.8 km/km<sup>2</sup>, potential - from 0.3 to 0.8 km/km<sup>2</sup>. In most of the territory, the share of the probability of reaching the density of gullies is 20-40%, the probability is 60-80%.

A vast territory in the east of the Russian Plain is occupied by an area called the High Trans-Volga region. In the west, it adjoins the Low Trans-Volga region, in the east - with the foothills of the Urals, in the north - it adjoins the region of the northern Uvaly, in the south it breaks off with a steep ledge Obshche Syrto to the Caspian lowland. The modern relief is represented by flat or gently undulating surfaces crossed by ancient and modern rivers, washouts and gullies. In the High Trans-Volga region, there is a sharp difference between flat interfluves and deep incised valleys with steep slopes dissected by gullies. The current density of gullies varies from 0.1 to 1.1 km/km<sup>2</sup>, the maximum possible density varies from 1 to 3 km/km<sup>2</sup> and more. The largest areas are occupied by territories with a share of realization of up to 5 or 10% (probability 90-95%). There are areas with 20-40% (probability 60-80%) and 100% (probability 0) realization shares.

On the territory of Obshchy Syrto, the current density of gullies varies within an



average of 0.06-0.3 km/km<sup>2</sup>. potential - 0.3-0.8 km\km<sup>2</sup>. In most of the territory, the full realization of the density of the gullies is noted. However, there are insignificant areas with a realization share of up to 10% and 20-40%.

There are practically no gullies in the Caspian lowland and in the Kuma-Manych depression. On Prikubanskaya - the current and potential density does not exceed 0.02 km/km<sup>2</sup> and the growth opportunities are fully realized.

On the Stavropol Upland, both the current and potential density range from 0.1 to 0.5 km/km<sup>2</sup>. In the western part, the potential is fully realized, and in the eastern part, it is 10-20%.

#### Conclusion

In the greater part (47%) of the territory of European Russia, in conditions of unchanged natural watersheds, the probability of the development of the gully-forming process is practically zero, and only on 2% of the area it is 100%. The share of probability 20-40% accounts for 28%, 40-60% - 14%, 60-80% - 9%.

At present, the territory of the European part of Russia is characterized by a change in the seasonal structure of surface runoff in small catchments (a decrease in melt runoff and an increase in the frequency of runoff-forming showers of the warm period).

With the uncertainty of forecasts of tendencies of climatic changes, forecasting of the gully-forming process becomes problematic.

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