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Content

Biological sciences

- Tetiana Moskalets, Petra Olejníková, Vladimir Leksa*
CURCUMA LONGA L. IN THE CHALLENGE OF THE COVID-19 PANDEMIC 3

Chemical sciences

- Abdusattorova Sayyora Obidjon, Khojiev Abdurakhim*
ADHESIVES USED IN APPAREL PRODUCTION 7

Economic sciences

- Jolia Guram, Makhviladze Davit, Jangavadze Irakli*
THE PARADIGM OF INNOVATIVE DEVELOPMENT AS A MODERN CHALLENGE OF SOCIAL PROGRESS 10
- Sevinc İbrahimova, Mayil Orujov, Shafa Nazarli, Azer Orujov, Nermin Orujova*
CROWDFUNDING AS A FINANCING TOOL A CONCEPTUAL ANALYSIS 19
- Karibaev Asylbek Amirkhanovich, Kamieva Almagul Akbulatovna*
ON ANALYSIS OF INVESTMENT PROJECTS IN INFLATION CONDITIONS (on the example of the Republic of Kazakhstan) 29

Medical sciences

- I.E.Suleimenova, N.C.Bozhbanbaeva, M.E.Atke, S.N.Urazova*
WORKING CLASSIFICATION OF CYTOMEGALOVIRUS INFECTION IN NEWBORN CHILDREN 33
- Arman Khozhayev, Alla Anfinogenova, Anastasiya Lee, Bagdatkhan Sembayeva, Alfiya Babasheva, Rifat Aidinov, Aisulu Amirkulova*
UP-TO-DATE DIAGNOSTIC AND CLINICAL ASPECTS OF OVARIAN CANCER 43
- Arman Khozhayev, Gulsim Nurmukhanova, Assel Mukhanova, Zhuldyzay Kamzina, Sardor Baimenov, Zaure Bayakhmetova, Bakhtiyar Malikov, Tamilla Karimova, Aidana Mekemtas*
LARYNGEAL CANCER: CONTEMPORARY STATE OF THE PROBLEM 54

Pedagogical sciences

- Samedov Kamran Enver oglu*
THE NEGATIVE SOCIAL-PSYCHOLOGICAL AND PEDAGOGICAL ATMOSPHERE OF FAMILY AS A FACTOR OF LOW SPIRITUAL-INTELLECTUAL LEVEL OF DEVELOPMENT OF TEENAGERS 63
- Salmanov Vidadi Karim*
THE INFLUENCE OF PHYSICAL EDUCATION AND SPORTS ON THE DEVELOPMENT OF INTELLECT 68

Philological sciences

- Mussatayeva Manatkul, Bagymbayeva Fariza, Zhanalyk Turlygul, Abai Kazakh National*
AXIOLOGEM REVIVAL AS A CHALLENGE OF MODERNITY AND A MEANS OF ITS REPRESENTATION 71

Technical sciences

- Erzhan Zheenbekov*
BIG DATA AND ANALYTICS 77
- Omar Ismailzade Ismail*
TERAHERTZ (THZ) COMMUNICATIONS IN AEROSPACE SYSTEMS 83
- Mukolyants Arsen, Ergasheva Dilbar, Jonibek Nizomov*
INCREASING THE ENERGY EFFICIENCY OF EXPANDER-GENERATOR PLANTS BY ADSORPTION DRYING OF NATURAL GAS AT INDUSTRIAL ENTERPRISES 90
- Nataliya Dokukova, Pavel Konon*
ASYMPTOTIC DECAY OF OSCILLATIONS IN AN ENGINEERED VIBRATION-ISOLATED SYSTEM 97
- Doskhan Issayev*
LEVERAGING DIGITAL TECHNOLOGIES TO STRENGTHEN ANTI-CORRUPTION EFFORTS 102

Biological sciences

CURCUMA LONGA L. IN THE CHALLENGE OF THE COVID-19 PANDEMIC

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The pandemic caused by Covid-19 has led to widespread morbidity, mortality and socio-economic crisis worldwide. After the emergence of several types of coronavirus infections, the problem of developing effective drugs is becoming increasingly urgent. Influenza and Covid, which in recent years have been 'working' in symbiosis and causing severe complications and a difficult course of the subsequent disease, are, unfortunately, often not limited to these two infections. However, if during 'this symbiosis' the phenomenon of 'interference' occurs (in which the virus, penetrating the cell, stimulates it to produce interferon – its own antiviral protein) – a protective mechanism against viruses, then the frequent weakening of immunity against this background leads to the appearance and development of unwanted bacterial and fungal diseases, as secondary infections.

The addition of bacterial pneumococcal and other infections (*Streptococcus pneumoniae*, *Haemophilus influenzae*, *Staphylococcus aureus*), micromycetes and other pathogens (such as *Pneumocystis jirovecii*, *Mycoplasma pneumoniae*, *Chlamydia pneumoniae*, *Legionella pneumophila*, and others) after viral diseases (SARS-CoV-2, RSV) can cause pneumonia and irreversible complications. One of the consequences of COVID-19 is the complication of the lung condition of incompletely understood etiology, which progresses to fibrosis and has limited treatment options (Hama Amin et al., 2022). Difficulty in gas exchange after viral infection due to thickening of lung tissue and the appearance of scars, which is essentially nothing more than fibrogenesis (Fig. 1), very often ends in organ failure and premature death. The progressive deposition of extracellular matrix (ECM) proteins is the cornerstone of fibrotic pathology (Chattopadhyay et al., 2022; Wells, 2022).

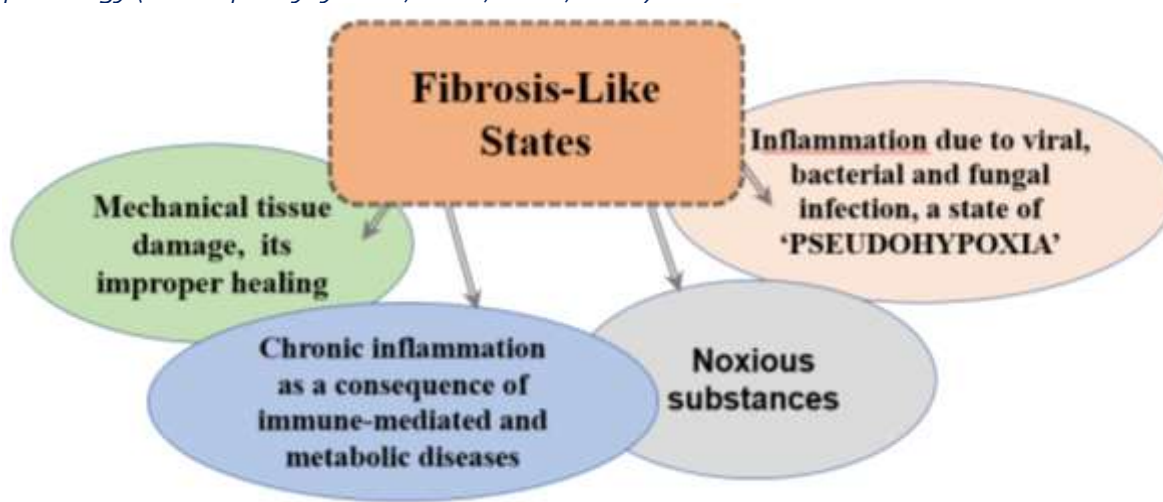


Fig. 1. The main triggers of damage to human pulmonary alveolar epithelial cells

Idiopathic pulmonary fibrosis (IPF) is the most rapidly progressive and fatal of all fibrotic diseases (approximately 3-5 years after diagnosis). Although the approval of antifibrotic drugs (pirfenidone and nintedanib) for the treatment of IPF was a turning point for the development of effective drugs, these drugs slow down, but, unfortunately, do not stop the progression of the disease, do not stop the

formation of scars. Therefore, the need for the development of effective therapeutic strategies is very acute today. Among the many already officially developed drugs, side effects also have their place. Therefore, the search, development and study of substances with complex antiviral, antibacterial and antifungal activity with no or minimal side effects is an urgent task. The study of such substances and the elucidation of the molecular mechanisms of their action in vitro open up new possibilities for their therapeutic properties, which can form the basis for the development of new effective drugs.

Among the number of substances that exhibit a wide range of medicinal properties, various plant active substances are known (vitamins, glycosides, phytoncides, alkaloids, terpenoids, catechins, tannins and other phenolic compounds). Plant substances, as shown by numerous experimental and clinical experience, have high efficiency, but low bioavailability and limited solubility in water. However, compared to synthetic drugs, they have a higher level of safety and are even able to enhance the effect of chemical drugs, which is an important element in treatment. Diferuloylmethane, as a 'yellow dye' was first discovered in 1815 by researchers Vogel and Pelletier, who isolated it from the rhizome of *Curcuma longa* L. (turmeric) and named it curcumin (Jafari et al., 2024). Although turmeric, the main source of curcumin, has been consumed as a dietary spice and as a medicine for diseases for more than a millennium in Asian countries, it was only in the mid-20th century that its biological properties were recognized. This compound has demonstrated antithrombotic, anti-inflammatory, antioxidant, antiproliferative, chemopreventive, antiangiogenic, and proapoptotic effects (Gupta et al., 2012; Jafari et al., 2024).

Curcumin has been found to be safe and effective in human clinical trials, and the US Food and Drug Administration has approved curcumin as a 'generally recognized as safe' compound. Although curcumin has shown therapeutic efficacy against many human diseases, its main drawback is its poor bioavailability, which is mainly due to poor absorption, rapid metabolism, and rapid systemic elimination (Gupta et al., 2012). Curcumin is now considered a 'new drug' with great potential and is used as a supplement in several countries (in India, turmeric is used in curry; in Japan, it is often served with tea; in Thailand, in cosmetics; in China, as a dye; in Korea, it is served in drinks; in Malaysia, it is used as an antiseptic; in Pakistan, as an anti-inflammatory to relieve gastrointestinal discomfort; and in the United States, it is used in mustard sauce, cheese, butter, and chips as a preservative and dye. Curcumin, as shown by numerous experimental and clinical experiences, can have a high efficacy and a reliable level of safety, and even enhance the action of chemical drugs, which is an important element in treatment. Although most currently available single-target treatments are associated with numerous side effects, curcumin has been found to be safe for human use in gram doses. Its miraculous properties have been known since ancient times in the treatment of diabetes, obesity, neurological disorders, as well as inflammation and cancer, which is what drew our attention to it as a potential antimicrobial agent and antifibrotic modulator and was chosen as a subject of research.

Research Methodology

To study the fibrotic process, we used the human lung adenocarcinoma alveolar basal epithelial cell line A 549 as a model cell. The cell culture was incubated in RPMI 1640 medium supplemented with 10% FBS and 1% penicillin suspension with streptomycin and glutamine and HEPES 0.5% at 37 °C in a humidified incubator with 5% CO₂. Curcumin was purchased from Sigma-Aldrich Co. (Switzerland), which was dissolved to micromolar concentrations in DMSO. The fibrosis process was induced by the cytokine TGF- β ₁. Western blot analysis was used to determine fibrotic and inflammatory proteins. Protein from cell lysates and supernatants was extracted and subjected to electrophoresis on SDS-PAGE acrylamide gels of different densities, using PVDF membranes. The membranes themselves were blocked in 5% dry milk, with washing in Tris-buffered saline. Incubation with antibodies was carried out at room temperature, using mono- and polyclonal primary and secondary antibodies. To obtain images of the blots for protein bands, iBright Imaging Systems with a high-resolution camera 9.0 Azure biosystems were used.

We evaluated the antibacterial activity of curcumin against a Gram-positive strain of *Staphylococcus aureus*, susceptible and resistant to antibiotics, as well as Gram-negative *Escherichia coli*. Bacterial strains were cultured in Mueller-Hinton broth (MHB) as an overnight culture. For antimicrobial assays, cultures were adjusted to a turbidity equivalent to 0.5 McFarland standard. Test compounds were serially diluted in MHB in 96-well microplates to achieve a range of concentrations. Each well was inoculated with a standardized bacterial suspension and incubated at 37°C for 9 hours until the bacterial cells reached stationary phase. Negative controls (medium only – blank) and growth controls (bacteria without compound) were included. Bacterial growth was assessed by measuring the optical density at 660 nm. Each experiment was repeated at least three times. All data were expressed as mean $\pm$ standard

deviation (SD). Student's *t*-test was used to compare data between two groups. One-way analysis of variance (ANOVA) was used for comparisons between different groups, and a *P* value < 0.05 was considered statistically significant.

Results and Discussion

Human lung epithelial cell culture (A 549) has been shown to be a convenient model for studying the *in vitro* fibrotic process initiated by the systemic cytokine TGF- β_1 . Curcumin exhibits a low cytotoxic effect on the cells. Its use in the presence of TGF- β_1 slows down the process of epithelial cell transformation into myofibroblasts, as evidenced by the low expression of alpha-smooth muscle actin (α -SMA) protein by the cells. α -SMA is an isoform of actin and plays an important role in fibrogenesis (Rout-Pitt et al., 2018). Transformed myofibroblast-like cells are metabolically and morphologically distinct from epithelial cells, the former of which overexpress alpha-SMA. We also observed that activated cells with a myofibroblast-like phenotype synthesize significantly more extracellular matrix proteins, in particular collagen and fibronectin, compared to control cells (without TGF- β_1 and without curcumin). Curcumin significantly (*P* < 0.05) inhibits the transformation of the cellular phenotype and inhibits the synthesis and accumulation of extracellular matrix components (α -SMA, collagen and fibronectin). Recently, in fibrotic diseases, increasing importance is given to collagen, which constitutes from 30% to 70% of ECM proteins in all types of tissues (Raote et al., 2024). Collagen biosynthesis and maturation are attractive therapeutic targets for fibrosis, and therefore reducing its synthesis and deposition is an important indicator of the efficacy of new potential drugs, which are evaluated *in vitro* and *in vivo*.

Excessive deposition of another ECM component, the glycoprotein fibronectin, precedes the deposition of collagen, and is a characteristic feature of pathological conditions of organs and tissues after their damage (in our case, after treatment of cells with a systemic cytokine). Significant inhibition of the expression of this protein by curcumin reflects the ability of the flavonoid to influence the moderate repair of damaged tissue, which occurs through a series of regulated stages: the formation of a fibrin clot (acting as a platform for the assembly of granulation tissue) and subsequent reduction and remodeling of the ECM to restore normal tissue. No less important is the property of curcumin, which we observed, to stop further post-translational modification of ECM proteins by suppressing the expression of cell adhesion receptors (integrin proteins), which prevents the formation of a more rigid structure of ECM components. Reducing the expression of collagen, fibrillin, fibronectin and integrins has an important functional significance in the formation of scars during uncontrolled wound healing. What happens when intact lung tissue is damaged due to past infections and its incomplete regeneration.

Curcumin demonstrated bacteriostatic activity against both Gram-positive and Gram-negative strains of microorganisms. In particular, the flavonoid exhibited significantly stronger antibacterial activity against Gram-positive *Staphylococcus aureus* compared to Gram-negative *Escherichia coli*. Antibiotic-sensitive *S. aureus* strains were completely inhibited. In contrast, *E. coli* showed maximal growth inhibition of approximately 80%.

Conclusion

Our data on the modulation of extracellular matrix protein secretion by curcumin, the inhibition of excessive extracellular matrix deposition, and the high antibacterial activity confirm the promising therapeutic approach of this flavonoid, which is able to support human immunity and suppress fibropathogenic states. The valuable antifibrotic, antibacterial, and regenerative properties of curcumin, as well as its known antioxidant, antiviral, and antifungal properties, are promising in adjunct therapy in the fight against coronavirus infection and the elimination of its associated consequences, including concomitant bacterial infections. Curcumin, not being approved for the treatment of any human disease, requires larger and controlled studies in humans to demonstrate its safety and efficacy.

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Chemical sciences

ADHESIVES USED IN APPAREL PRODUCTION

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Abstract

Research purpose clothes working in the release applicable glues analysis from doing consists of. In the province and leader in enterprises used glues different to the features They have. In the thesis current on the day used polymer glues about general information cited.

Keywords: glue, fabric, clothing, polymer, thermoplastic.

Clothing working in the release the most many used to glues the following includes: polyethylene, polyamide, polyvinyl chloride, polyvinyl acetate, polyester, polyacrylate. [1-8, 11-12]

Polyethylene glue substances washable in products used gasket materials adhesive as. They are used chemically to the effects durability, water and wash to the effect, to the cold to the endurance has. PEHMMW branded polyethylene glue your coat small in parts use for intended, sealed in materials permanent adhesive the coating to take for used. HDPE branded polyethylene glue often washable men dresses, women blouses and other of products collars, cuffs, stripes and other parts to form resistant processing to give for intended in gaskets, materials adhesive coating as is used.

Polyethylene adhesives, including Surebonder 725 sturgeon in appearance working Polyethylene is first granule in the form of working is extracted, (Fig. 1, a), from which in step 2 for example sturgeon in the form of Surebonder 725 glue working is removed (Fig. 1, b). In the form of a rod polyethylene glue using a pistol (Fig. 1, c) is applied.

Polyethylene is a thermoplastic polymer of ethylene, forming a long molecular bond consisting of one molecule of carbon and two molecules of hydrogen (Figure 1, g).

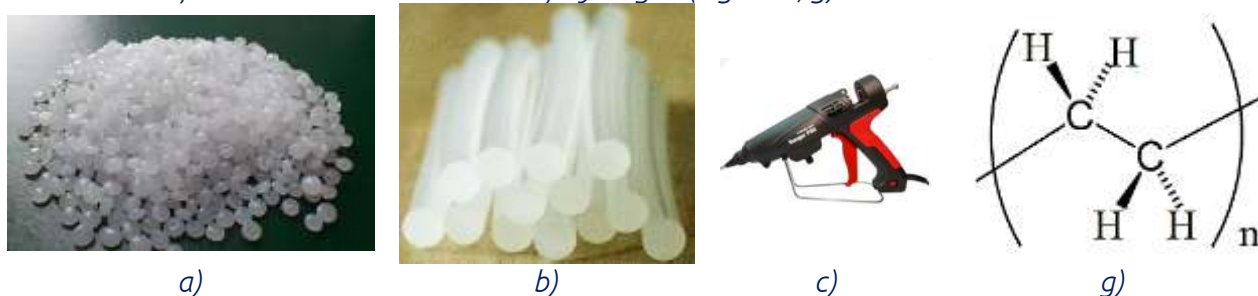


Fig. 1. Polyethylene glue

Polyamide glue is used in powder form or as a coating on textile materials, mainly for gluing their upper parts. Of the domestic copolyamides, the following are used as adhesives: Pa - 54 (Pa-6/6,6); Pa-548 (Pa-6/6, 6/6,10) and Pa-12ACR (Pa-12/6/6,6). Under the influence of hot water, they swell, as a result of which the adhesive composition delaminates - separates into layers.

Pa-54 glue is used as a powder, which forms an irregular dot adhesive coating on gaskets and edge materials by spraying. However, due to its high melting point (165-1750C), it has limited use.

Pa-548 glue is a raw material for obtaining adhesive threads and adhesive spider webs in powder form, and a raw material for obtaining irregular dot adhesive coatings on gaskets and edges of materials in powder form. The melting point is quite high (155-1600C), which causes some difficulties in gluing materials obtained from a mixture of fibers. and fibers from a mixture taken materials in gluing some to difficulties take is coming.

The melting point of Pa-12AKR glue is 125 OC, which gives the joints superior elasticity compared to Pa-54, Pa-548 glues, and also increases the frost resistance of the joints. It is used to obtain adhesive threads; adhesive cobwebs; powders used for dot coating.

Polyvinyl chloride glue (PVC) is used in the form of films, powders and pastes, as well as for coating textile materials. The melting point is 80-180 OC. PVC dot coatings provide very light bonds to the touch, adhere well to pleated fabrics, knitted fabrics and fabrics that are sensitive to pressure and temperature. PVC is resistant to washing; it has low resistance to dry cleaning. Due to the volatility of the plasticizer during gluing, an unpleasant odor is formed, as a result of which the use of PVC is limited.

Polyvinyl acetate adhesives (PVA) have a melting point of 80-95 OC, but they have limited use in clothing production, as they produce adhesive compounds with low resistance to cotton and washing. PVA is used to reinforce side seams in places where there are loops, as elements of jewelry and appliques, and for the production of seams in the production of men's shirts.

Polyester adhesives are used in powder form for fastening outerwear parts, with a melting point of 115-120 OC.

Polyacrylate adhesives can withstand the effects of weather factors and high temperatures without losing their properties; their transparency allows them to glue even the thinnest fabrics. They are firmly held on the surface of textile materials, slightly increase their hardness, and are resistant to washing.

Due to local economic expediency, copolyamides and polyethylenes are the most common.

All adhesives used for gluing clothing parts can be in different physical states: liquid (adhesive solutions), paste (adhesive pastes), films, powders, in the form of cobwebs, meshes, fibers and threads.

Conclusion. One of the positive aspects of the use of adhesive materials is the improvement of shape retention properties, the strength of the adhesive joint during operation, a decrease in the thickness and quality of the seams, and other properties. The provision of the garment industry with new high-quality thermo-adhesive composite materials and the processing of composite materials with new compositions and structures, the production of non-woven materials with an adhesive coating with a surface density of 30-50g/m is of particular importance.

The technology of bonding is based on the use of one of the basic properties of a material, such as the welding of thermoplastic materials. Adhesion is a surface appearance that occurs as a result of molecular contact, leading to the formation of a new heterogeneous system. (A heterogeneous system consists of independent phases limited by a surface boundary). Thus, adhesion occurs as a result of the joining of dissimilar surfaces.

For the production technology of mass sewing products, the adhesion properties of polymers are considered, since the fibers and adhesives used are based on high-molecular compounds. [10-11]

An adhesive bond is an integral connection of two or more textile materials with the help of glue. The adhesive properties of textile materials allow the materials to bond with solutions or aqueous gels of polymer adhesives and form adhesive bonds with them, which in turn contributes to the preservation of consumer properties and value of sewing products during their service life.

The quality of adhesive bonded materials is mainly determined by the polymer surface applied. Table 1 below lists the main types of adhesive materials.

Table 1

The main types of adhesive materials used in clothing manufacturing.

Glue material type	Base fabric	Glue, powder, resin type	Application area
Glue is good. art 302-111 108-111 385-111	Linen, cotton fibers madapolam soup cologne	Polyamide resin PA-548	Clothing details forty and curls from the heart save (sideboard, adip (the phrase))
Glue various tape, glue thread	Not a bullet. isotropic material	PA-54(check) PA-6/6, 6, 10 PA-12 AKR Sopolyamides" Platamid" (FRG) "Sarpifan" (FRG) Polyethylene	Clothing details to reduce the edges, to be invisible stitch to give and to attach (clothes) skirt sleeve tip)
Adhesive tape	Various shaped checkered	High-pressure polyethylene "Shettifix" (140, 400) Switzerland	Women, men and children on his coat to the details form guardian processing to give
Glue film, glue powder and pastes	Thermoplastic polymers	Polyamide PA-548 polyethylene, polyvinyl chloride, lavender	Applications h axis to do and to attach, to sew and adhesive compounds to hermetically seal m is intended

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Economic sciences

THE PARADIGM OF INNOVATIVE DEVELOPMENT AS A MODERN CHALLENGE OF SOCIAL PROGRESS

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Abstract

The modern world has long lost its sense of calm and stability. It feels as though **the Earth is spinning "faster than before."** A phone model released yesterday is already outdated today, replaced by a more modern version. Companies are forced to constantly refine their production technologies and offer the market new products, projects, ideas, and approaches.

By the end of the 20th century, it had become clear that the industrial society was becoming a thing of the past, and a **completely new, "stormy" era of development was beginning.**

Today, the importance of knowledge and innovation in the process of a society's socio-economic development is growing immeasurably. That is why the 21st century is often referred to as **"the era of innovation."**

In the modern global political-economic system, where hypercompetition prevails in all areas of activity, three general models of national development have emerged:

- The **raw material model** is characteristic of countries that possess large reserves of natural resources and import essential science-intensive industrial products.
- The **technological model** ensures the production of high-tech products through the import of intellectual property objects.
- The **innovative model** is oriented toward the creation of proprietary science-intensive technologies and their implementation in economic circulation, based on fundamental scientific research.

For development, it is precisely this latter model that is the most progressive and vital for the future.

It is noteworthy that innovative development is recognized as an indispensable factor for global economic progress. Innovation-based production, founded on scientific and technical knowledge, determines the creation of greater economic wealth by increasing production efficiency (labor productivity), which simultaneously leads to a reduction in production costs.

In the age of innovations, a country may lack natural resources (minerals, raw materials) and may not stand out in terms of territorial size, yet still be economically highly developed. This further emphasizes the relevance of this work for our country.

In developed countries, 75-100% of the gross domestic product (GDP) growth is attributed to innovations, highlighting the necessity for the state to develop an innovative economy.

Keywords: industrial revolution; innovative development; creative destruction; social progress, theory of innovation.

Chronology of Industrial Revolutions

The modern world is progressing at an exceptionally rapid pace. The economic fabric of the 21st century differs significantly from the system of economic relations of previous periods. Many professions

and industries are disappearing, yet at the same time, new directions, job opportunities, and possibilities are emerging.

Fundamental changes in the historical process of social development have been driven by industrial revolutions, which began in the second half of the 18th century and continue to this day.

The first industrial revolution (1760–1860) began in 18th-century England with the invention of the steam engine. For centuries, agriculture had been the leading sector of the economy, but from this period onward, machines began to replace human physical labour. As a result, labour productivity increased, the textile and metallurgical industries developed, factories were opened, and the construction of railways began. Consequently, industry gained a dominant position in the global economy and became a generator of fundamentally new types of jobs.

The second industrial revolution (1915–1970) was linked to mass production through the use of electrification, which led to an irreversible process of urbanization. The conveyor, automotive, oil, and chemical industries also advanced significantly. These two revolutions fundamentally changed not only the economic structure but also the social way of life—transformations that had taken centuries to achieve.

During **the third industrial revolution (1970–2000)**, with the help of information technologies, the production process was transformed into an automated system. Robotics and the space industry developed, leading to humankind's first journey into space.

We are currently experiencing **the fourth industrial revolution, which began in the early 21st century**. This is the era of digital technologies and the dominance of artificial intelligence. According to researchers, this phase will be characterized by "smart production" based on cyber-physical systems, which will promote the growth of technological development and production efficiency. Additionally, the so-called "Internet of Things" will evolve—a virtual network through which all electronic devices will connect and actively exchange necessary information. Entirely new types of consumer services will emerge, further simplifying and improving the quality of social life.

Considering the pace of global innovative development, experts are forecasting a **fifth global technological revolution**, the effects of which are expected to become especially apparent in the second half of the 21st century. This revolution envisions the mass replacement of humans with AI-powered robots across all areas of activity, as well as the migration of humans to other planets, among other developments.

Gradually, human talent and abilities are becoming more valuable than capital for achieving economic success. This, in turn, is increasing segregation in the labour market—individuals with low competence will earn lower wages, while highly qualified professionals will receive correspondingly higher incomes. These changes may lead to growing social tensions, political destabilization, and even revolutions in various countries.

It is noteworthy that the time intervals between industrial revolutions are becoming shorter. The first industrial revolution took many centuries to emerge, the second took nearly a century, the third required only half a century, and the interval between the third and fourth was just 20 years. Therefore, over the last half-century, the pace of technological revolutions has significantly accelerated.

The last two technological revolutions are qualitatively much more extensive and complex than the first two, which primarily transformed the field of production rather than the social sphere.

Compared to pre-industrial revolutions, the fourth industrial revolution is unfolding at an exponential, rather than linear, pace, which is fundamentally transforming production, management, and governance.

Over the past centuries, the use of human physical capabilities in the labour market has significantly decreased, a trend driven by the advancement of technology. There is a growing demand not for physical strength, but for intellectual ability.

After each industrial revolution, the number of people employed in labour-intensive sectors decreased, while at the same time, the employment rate of highly qualified individuals in knowledge-intensive fields increased. In other words, there is an inverse relationship between the demand for physical labour and the sequence of industrial revolutions.

In the near future, **technological breakthroughs will lead to socio-economic inequality**, particularly in the labour market, which will in turn transform people's **economic, social, and cultural environment**, as well as their **moral values**, and more.

Stages of Societal Development and the Three-Sector Economic Model

Starting particularly from the **second half of the 20th century**, scientists such as **Clark, Bell, Fisher, and Fourastié** became especially interested in studying the changes brought about by the development

of economic production sectors and society. Based on their work, **three main stages of societal development** have been identified:

Three-sector economic model according to Colin Clark		
Sector I – Agricultural Sector	Sector II – Industrial Sector	Sector III – Service Sector
Pre-industrial stage	Industrial stage	Post-industrial stage
• Agriculture • Extractive industry • Fishing • Forestry	• Mechanical engineering and metalworking • Chemistry and petrochemistry • Light and food industry • Energy, transport, and construction • Metallurgy	• Science • Education • Art • Healthcare • Tourism • business consulting • banking services • public administration

1) **Pre-industrial stage** – The majority of society was employed in the agrarian sector, primarily in agriculture. Activities such as the extraction of natural resources, fishing, and forestry were common. This stage is characterized by low labour productivity.

2) **Industrial stage** – At this stage, industrial and manufacturing sectors developed significantly, including machinery and metal processing, light and food industries, chemicals and petrochemicals, construction, energy, metallurgy, and others.

3) **Post-industrial stage** – This is the modern stage of social development, which is referred to in economic literature in various ways, such as "post-industrial society", "information society", or "knowledge-based society." At this stage, the main sector of the economy is no longer agriculture or industry, but rather key branches of the service sector - such as education, science, healthcare, tourism, business and legal consulting, banking, and others. A new type of social structure is emerging, reflected in the diminishing role of material production, the growth of the service and information sectors, and qualitative changes in the employment structure.

The French economist **Jean Fourastié** describes the **structural transformation of the workforce** based on economic sectors, which evolved in parallel with the stages of social development:

- **First stage** – The era of traditional civilization (pre-industrial), where 70% of the workforce was employed in the primary sector, 20% in the secondary sector, and only 10% in the tertiary sector. Science was minimally developed during this stage.

- **Second stage** – The era of the industrial society, in which the share of employment in the primary and secondary sectors was each about 40%, while the tertiary sector accounted for 20%. There was a noticeable increase in the role of technology in the production process and a decrease in the number of workers.

- **Third stage** – The post-industrial society, marked by fundamental changes in employment structure. Employment in the primary sector dropped to 10%, in the secondary sector to 20%, and the tertiary sector rose to 70%. There was a sharp decline in the workforce in the first and second sectors, driven by the automation of production processes. As a result, the tertiary sector expanded significantly and became the main area for workforce concentration.

In general, the **employment structure in developed countries** reveals the following trends:

- Jobs in the agricultural sector are sharply declining – the average share of employment is around 5–10%;
- Employment in industry is also decreasing – the average employment rate is 20–30%;
- The service sector is growing enormously – average employment is around 60–70%;
- Self-employment and underemployment are increasing daily;
- Nearly all sectors of the economy are becoming knowledge-intensive;
- Education and healthcare, as well as business, legal, and banking consulting, have become rapidly growing fields.

The characteristics of modern post-industrial society are mainly reflected in the reduced role of material production, the development of the service and information sectors, the diversification of production resources, the transformation of social structures, and so on.

Post-industrialization was driven by the process of globalization, during which, as a result of the global division of labour, the incomplete cycle of production (such as research and development work) was massively transferred to newly industrialized countries. As a result, developed countries were able to concentrate their resources on the development of the service sector.

A post-industrial economy is an economy based on the production of services, and the main criterion for classifying an economy as post-industrial is that **the share of the service sector in GDP exceeds 50%**, for example, in the U.S. – 80%, in the UK – 78%, in Japan – 72%, and globally the average is 60–65%.)

In a post-industrial society, the main economic resource of economic production is intangible assets. These include know-how, patents and licenses, securities, brands, and so on.

Evolution of the theory of innovative development

In the historical development of the theory of innovative development, three important stages can be distinguished:

First stage: Late 19th century – 1930s

During this stage, the fundamental foundations of innovation theory were formed. The essential theoretical basis was laid by N. Kondratiev's theory of "long waves" and J. Schumpeter's theory of innovation development, through which the essence of innovation and the role of entrepreneurship in economic development were clarified. Concepts were developed that explored the causes of economic growth within the frameworks of economic cycles and the "long wave" theory. A general pattern of market economy development was identified – innovative economic development. Continuous change was defined by the cycle of "expansion – recession – expansion," and innovation was recognized as the main factor of economic growth. This stage also laid the foundation for a new economic theory of evolutionary development.

Second stage: 1940s – mid-1970s

During this stage, research into basic innovation ideas deepened. Based on the exploration of innovation management functions, several details of the previous period's innovation ideas were clarified. Research took on a practical and applied direction. The functional aspects of innovation management were developed in areas such as planning, organization, and the evaluation of innovation project effectiveness.

Third stage: 1970s – early 21st century

During this stage, new theoretical breakthroughs occurred in connection with epoch-making and fundamental innovations. Based on the study of innovation as a systemic phenomenon, the interconnection between technology, the economy, and society was established. Significant theoretical advancements were made in multiple fields—for example, new types of innovation classification were defined, and the essence of innovation as a systemic phenomenon was clarified. Additionally, the fundamental foundations of national innovation system concepts were formed, among other developments.

Economic theory of large cycles according to N. Kondratiev

The development of innovation theory was initiated by the prominent Russian economist and scientist **Nikolai Kondratiev** (1892–1938), who was one of the first to take interest in the cycles of economic conjuncture—so-called "**long waves**" (with an average duration of 45–60 years)—and noted the influence of innovative processes within them.

Kondratiev's **theory of long waves (cycles)** gained wide recognition because it was based on concrete historical facts. He demonstrated a strong connection between the cyclic nature of economic crises and these "long waves." Kondratiev viewed economic cycles as a continuously recurring process of disruption and restoration of economic equilibrium over the long term.

Various concepts are used to describe these "long waves" (e.g., the theory of capital flows, the theory of labour migration), but among them, the **theory of innovation** is relatively widespread.

Through his theory of long cycles, Kondratiev substantiated the close relationship between major technological inventions and the patterned alternation of waves of **economic expansion and recession**.

According to Kondratiev's theory, each new economic cycle begins with a **groundbreaking discovery**. During the "expansion" phase of the cycle, society experiences powerful social shifts, and new countries emerge as major players on the global economic stage. For example: In the first cycle, **England** was the leader; In the second, **England, Germany, and the USA**; In the third, **the USA and Germany**; In the fourth, **the USA and Japan**; In the current cycle, **newly industrialized countries**, especially the **Republic of Korea and Singapore**, as well as **China**, have emerged as leading forces.

The **expansion phase** begins with the revitalization of a country's economy, which gradually transitions into **economic growth**. After reaching the peak of development—the **boom phase**—the economy enters a phase of **recession**, which ultimately ends in **depression**. (See Fig. 5).

Depression (also known as stagnation or downturn) forces society to seek new, previously unused opportunities for survival, which is achieved through the **intensification of innovative processes**. As a result, **productive capacities are renewed and expanded**, new production facilities are launched, and new

jobs are created, all of which lay the groundwork for the beginning of a new economic expansion phase. [Yakovenko, "Economy...", 2011]

From the **18th century to the present**, five full **techno-economic dynamic cycles** are considered to have been completed, and the **sixth cycle is currently underway**. (See Fig. 6.)

It is also noteworthy that each **"long cycle"** (wave) corresponds to a distinct **technological paradigm**. This is a **complex system of interrelated new technologies**, which drives fundamental transformations in society—mainly in **energy, production, transport, and services**.

The economic outcomes of the evolution of the 'long cycles' are as follows:

1st Cycle, First Industrial Revolution (1770–1830) – Invention of the steam (water) engine. Results of progress: Textile machinery manufacturing and the textile industry; Metal processing; Cast iron production; Iron processing; Construction of canals; Mechanization of labour. Leading countries: United Kingdom, Belgium, and France.

2nd Cycle, Age of Steam (1830–1880) - Refinement and widespread use of the steam engine.

Results of progress: Development of black metallurgy; Creation of transportation networks (railways); Growth of machine-building and shipbuilding; Coal mining; Expansion of tool-making and machinery industries; Further mechanization of production. Leading countries: United Kingdom, France, Germany, USA.

3rd Cycle, Age of Steel, Second Industrial Revolution (1880–1930) – Invention of the internal combustion engine, as well as the telephone and radio. Results of progress: Development of electrical engineering and heavy industry; Exploration and extraction of oil reserves; Chemical industry; Production of plastics; Electrical industry; Construction of power transmission lines. Leading countries: Germany, USA, and the United Kingdom.

4th cycle, the oil era (1930 - 1970) - large-scale extraction and use of oil and gas. The result of progress: automotive and aviation industries; machine building; production of durable goods; mass production of synthetic (artificial) materials; production of conveyors; discovery of nuclear energy; chemical industry and electronics production; oil production and refining. Leading countries: USA, Western European countries and Japan.

5th cycle, the era of computers and telecommunications, the third scientific and technical revolution (1970-2010) – microelectronics, the Internet, social networks, robotics, sensor devices, drones. The result of progress: electrical industry; computing and fiber-optic equipment; software; telecommunications; robotics; information services. Leading countries: the USA and Japan.

6th cycle, the era of eco-technologies, the 4th industrial revolution (Industry 4.0) (from 2010 to the present) - the convergence of nano-, bio-, eco-, helio-, information and cognitive technologies. The concept of "Industry 4.0" was first developed in Germany, the purpose of which was to create the foundations of the competitiveness of the country's industry. Expected results of progress: nano-electrical engineering; molecular and nano-photonics; nano- and optical materials; nano-biotechnologies; nano-devices; digital, "green" and "blue" economy; use of new sources of renewable energy and resources; ecological and sustainable industrial production; eco-transport and services.

"Creative Destruction" - Theory of Innovation according to J. Schumpeter

In economic literature, innovation is perceived as the transformation of potential scientific and technological progress into actual progress, which is materialized in new products and technologies.

The term **"innovation"** is of Latin origin and means the introduction and implementation of something new. The concept of innovation is constantly changing. It was first used by cultural scientists in the 19th century and expressed the transfer of elements from one culture to another.

At the beginning of the 20th century (1912), based on Kondratiev's theory of "great cycles", the Austrian-American economist **Joseph Schumpeter (1883-1950)** developed the innovation theory of great waves and formulated it as a general innovation doctrine of economic development.

Schumpeter paid special attention to the innovative function of entrepreneurship, since the dynamic development of the economy depends to a large extent on its activity. Accordingly, the activity/passivity of the entrepreneur determines the economic "expansion" and "recession", which have a cyclical nature.

In the theory of economic development, **Schumpeter considered innovation as the main entrepreneurial way of increasing profits**. He wrote: "Profit is not without development, development is not without profit."

He was the first who analysed the issues of new combinations of changes (innovations) and gave them a complete description of the development of the innovation process. In particular, in the work he

distinguished two sides of economic life - routine circulation and development, or innovation, and distinguished **5 types of innovative changes in development**:

1. **Introduction of a new product** that the customer is not yet familiar with, or significant modification of an existing product;
2. **Implementation of a new production method** based on scientific discoveries, or one that may represent a new method for the commercial use of a product or raw material;
3. **Identification and development of a new market** in which the given industry was previously not represented, regardless of whether this market existed before or not;
4. **Development of a new source of raw materials or semi-finished products**, regardless of whether this source existed before or not;
5. **Implementation of changes in any sector**, specifically the acquisition of a monopoly position (e.g., through the creation of trusts).

According to Schumpeter, **"creative destruction"** (figuratively: "innovators take resources away from conservatives") is the process of replacing an old development paradigm with a new one, which happens in a leap-like, explosive manner. Schumpeter wrote: "In the period of introducing innovations into the economy, so-called 'creative destruction' is observed, which drives outdated technologies and organizational structures out of the market, and new, viable sectors take their place. This is followed by economic growth and an increase in people's welfare. Thus, innovations become the main driving force of economic development, determining its efficiency and the increase of labour productivity."

The struggle for existence and the survival of the fittest received a specific Schumpeterian interpretation: **"The struggle occurs between routine and the introduction of innovations,"** as a result of which the one who manages to successfully master some segment of the market survives and remains until others become ready for the market. Then a new innovation is introduced, and the innovator remains in the market for some time, and this process goes on endlessly.

Schumpeter gave the first classification of innovations, distinguishing basic, improving, technological, economic, process, and product innovations.

The issue of studying innovation and technological development has also attracted the interest of numerous researchers in recent times. For example:

In 1957, American economist **Robert Solow** discovered an interesting fact while analysing the post-war industrial growth of the United States: **only 12.5% of the increase in output per person/hour could be attributed to increased use of capital, while the remaining 87.5% was due to technological changes — that is, innovations.**

Around the same period, Moses Abramovitz reached a similar conclusion, defining innovations as 'the measure of our ignorance regarding the true causes of economic growth in the United States.

The Russian scientist **A. Kruglov** believes that innovation is the result of the materialization of a new idea or scientific thought in technology, engineering, and the forms of labour and production organization.

The views of prominent figures from various professions in modern society are important. For example, according to American professor **R. Lyons**, innovation is 'a new way of thinking that creates value.' In **P. Drucker's** view, 'innovation is a specific tool, an act of entrepreneurial activity that enables resources to create wealth through new opportunities.' Motivational speaker **M. Vance** believes that 'innovation is the creation of something new, or the reorganization of the old in a new way.' According to business coach **V. Kotelnikov**, 'innovation is a process of satisfying the customer through the generation of new ideas.

According to international standards, **innovation is defined as 'the final result of innovative activity, which is expressed through the appearance of a new or improved product (or service) on the market, the practical application of a new or improved technological process, or a new approach to social services.**

The main function of innovative activity is change oriented toward development. It is worth noting that, in practice, the terms 'novation' and 'innovation' are often used interchangeably; however, there is a significant difference between them – a novation is something new that has not yet been implemented, while an innovation is a commercialized and already implemented novation.

The main characteristic of innovation is the commercialization of novation, which implies the implementation of a scientific invention (discovery). A 'novation' cannot be considered an 'innovation' until it is realized in the market. Accordingly, **innovation is the application of scientific knowledge for commercial purposes.**

Classification of innovations

For the study of innovations, their classification — that is, grouping based on characteristic features and criteria — is important. This allows for defining the essence and specifics of innovation processes, as well as evaluating a company's innovative activity from the perspective of investors, government bodies, credit institutions, and other organizations supporting innovative entrepreneurship.

One of the main forms of categorizing innovations is classification based on two criteria: the technology it uses and the market in which it operates.

Incremental Innovations

Most innovations are the result of gradually improving existing concepts, products, and services on the market. Incremental innovation involves a slightly improved version of a previous model of a product (or service), without changing its core function. For example, an item may become smaller in size, easier to use, or more visually appealing with a refined design.

Although incremental innovation does not create new markets and often does not involve radically new technologies, it takes into account modern consumer behaviour (demand) and attracts higher-paying customers. A classic example of this is modern televisions and smartphones.

Incremental innovations are also convenient in terms of sales, as the public is already familiar with the basic functions of the product, and thus, no explanation of how to use it is needed.

The main drawback of this type of innovation is that it does not lead to significant improvements over existing products. Moreover, considering that current market conditions can change at any time (and inevitably will), focusing solely on incremental innovations is unlikely to bring substantial long-term success to a company.

Disruptive Innovations

The concept of disruptive innovation was first introduced by professor and business consultant Clayton Christensen in his work "The Innovator's Dilemma." It refers to entering an existing market — or creating an entirely new market segment — by establishing a new network of consumer value.

The challenge lies in the fact that companies already operating in the market usually make rational and pragmatic decisions — they tend to favor modernizing existing, successfully functioning products (incremental innovations) over creating something entirely new, which involves additional risks.

This phenomenon is called the "Innovator's Dilemma," because the existing market is often significantly larger and more attractive than a new, untested one.

Disruptive innovation typically emerges in areas where traditional business methods no longer work, and entirely new approaches are needed. Despite the high level of risk, when managed correctly, disruptive innovation holds significant potential for economic growth.

Often, before experienced market players recognize the need to adopt revolutionary innovations, new market entrants offer society entirely new and more effective ways of solving problems. Let's explain a few examples:

*1. **Tesla** uses fundamentally different technologies compared to traditional car manufacturers. Its software, battery technology, and ability for rapid iteration are the very components in which other corporations struggle to compete.*

*2. Another example of revolutionary innovation is **Netflix**, whose original service involved mailing DVDs to subscribers. Although this service did not appeal to the majority of consumers at the time, it successfully attracted a new type of customer who was already familiar with online shopping. Netflix, however, became widely popular after it replaced its DVD-by-mail model with a streaming platform. This innovative platform set a new industry standard and significantly contributed to the development of the entire sector.*

Sustaining Innovations

Sustaining innovations are the opposite of disruptive innovations, as they operate within existing markets and focus on developing and enhancing what already exists, rather than creating a new value network.

By nature, sustaining innovations partially resemble incremental innovations, since with each repeated production cycle, the number of defects tends to decrease.

The advantage of this type of innovation lies in its flexibility to increase profits through both high- and low-pricing strategies. A company can either raise the price of an improved product to target a high-demand customer segment and increase profit margins, or lower the price if this results in a significant increase in sales volume (and therefore profit).

Traditional business management approaches (aligned with sustaining innovation strategies) are often an acceptable path for most companies, as they remain profitable even under low-risk conditions. At the same time, sustaining innovations are typically characterized by slower market development.

A prime example of this is the **iPhone**, which does not create new consumer value, and even the latest versions are targeted at a loyal customer segment. Despite much criticism that recent iPhone models are not particularly innovative, the company's profit growth has not declined.

New iPhone models are based on the company's traditional business model, which is aimed at the premium market segment — that is, meeting the needs of high-demand consumers who are willing to pay significantly more for even slightly improved versions.

Radical Innovations

Radical innovations are extremely rare and, in some ways, resemble disruptive innovations. However, unlike disruptive ones, radical innovations simultaneously involve both revolutionary technology and a new business model.

Radical innovation is characterized by entirely new ways and methods of solving global problems. It often identifies and satisfies consumer needs that people were previously unaware of or could not even imagine.

A key example of this is **personal computers and the internet**, which, through the creation of a unique communication platform, fundamentally changed the standards of global economic functioning and greatly accelerated both economic growth and social progress.

According to the investment firm ARK Invest, the world is on the verge of a powerful new wave of radical innovations that will soon become mainstream in the innovation-driven economy. These include: **robotics, artificial intelligence (AI), blockchain technology, energy storage, and genome sequencing.**

Because the nature of radical innovations significantly departs from the routine behaviours and norms that have dominated society over long periods, the initial public response is often highly controversial. Therefore, market readiness for such innovations requires considerable time and technological advancement. This phenomenon represents the main challenge of radical innovations — but if successful, they lay the foundation for the beginning of a new era.

Social Innovations

In recent times, the role of social innovations has become increasingly prominent. According to German sociologist J. Howaldt, industrial innovations should give priority to social innovations, as they more adequately reflect the modern demands of post-industrial society.

Social innovations are related to improving working conditions for employees, social protection, and enhancing the psychological climate among workers. They improve social life as a whole and lead to desirable outcomes: increasing customer satisfaction, improving worker safety, and providing more comfortable conditions for work and leisure, among others.

Social innovations involve new forms of social practice. They are collective, creative processes through which their authors develop essential cognitive, cooperative, and organizational skills. Their goal is not to generate profit or gain power but to solve social problems.

A subcategory, **eco-social innovations**, also serves the goal of public welfare by contributing to the improvement of the ecological environment and offering protective effects on nature.

Types of Innovations Based on Their Impact on Social Life

- **Primary (Fundamental) Innovations** - According to J. Schumpeter, these are innovations with no historical analogues. They create entirely new markets, industries, or segments within existing ones. They fundamentally transform the established order of social life and spread widely around the globe. They are based on scientific discoveries and inventions, characterized by their fundamental novelty and rarity. Typical examples include **electricity, radio communication, the automotive and aviation industries, atomic energy, and space tourism.** These innovations have significant weight in terms of societal progress and enhancing a company's competitiveness, as they enable a transition to a new technological paradigm.

- **Secondary (Incremental, Modified, Evolutionary) Innovations** - These are improvements or refinements of primary innovations — enhancing their efficiency and competitiveness through the "new combination of elements" (Schumpeter's term). Their flow generally follows the waves of primary innovations. While they may not be as groundbreaking in terms of novelty, they surpass primary innovations in terms of mass adoption and spread. The aim of incremental innovations is to develop and modify foundational innovations. They are characterized by minor, non-revolutionary novelty and a shorter life cycle. In market economies, such innovations involve less risk and are typically more affordable. They form the backbone of innovative economic development.

- **Pseudo-Innovations (Imitative)** - These are hard to classify as true innovations because they involve only minor technical or cosmetic changes, while the core structure, parameters, features, value, materials, and components of the product remain virtually the same. According to G. Mensch, such

*innovations often have a counterproductive effect. Pseudo-innovations usually appear during the final stage of a product's (or system's) life cycle — when its potential has already been exhausted, yet it resists being replaced by a more advanced alternative. These are often driven by **conservatism**, where certain social groups fear change and are unable to make decisions.*

- **Anti-Innovations** (as defined by I. Yakovets) These signify regression in certain fields of human activity. Anti-innovations can be observed in many systems — economics, ecology, technology, etc. For example, **fracking technology** used to extract shale gas and oil causes massive environmental damage and contributes to global warming. This method is banned in France. Through such anti-innovations, some companies gain short-term profits at the expense of society and the environment.

Conclusion

In conclusion, we want to reinforce our viewpoint that the development of an innovative economy is a necessary prerequisite for enhancing a country's economic competitiveness. Innovation is seen as a key tool for achieving long-term economic growth, gaining a competitive advantage in the global market, and addressing social problems.

Public needs are constantly growing and evolving — both quantitatively and qualitatively. As a result, meeting these needs is impossible without scientifically advanced products and services, which in turn pushes entrepreneurs with commercial interests to introduce and widely apply innovations.

To borrow from Darwin: "It is not the strongest or the smartest who survive, but those who are the quickest to adapt to change."

Focusing on innovation means striving for continuous development and increased productivity. It involves shifting the axis of competitive advantage from traditional strengths (such as natural resources) toward intellectual and entrepreneurial potential.

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CROWDFUNDING AS A FINANCING TOOL A CONCEPTUAL ANALYSIS

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<https://orcid.org/0009-0007-1222-4238>**Abstract**

Crowdfunding has currently become a popular tool for financing commercial and non-commercial projects. However, the existing literature does not offer a clear contrast between crowdfunding and other methods of attracting financial resources. The purpose of the study is to determine the distinctive features of crowdfunding and identify its place in the system of direct financial interactions. The work explicitly formulates the features of crowdfunding. Its differences from financial P2P interactions are shown. Its new variety is revealed - stock exchange crowd-game. The concept of two-level centralization as a key feature of crowdfunding is proposed, on the basis of which a typology of models of direct financial interactions is built.

Keywords: crowdfunding, platform, investment, financial resource, cash, bond, coordinated investment, share, P2P lending.

Introduction

Crowdfunding has currently gained great popularity, as it allows attracting monetary and material resources to solve problems that are difficult to finance using existing tools. Crowdfunding is actively used to raise funds for both commercial and non-commercial projects. Thanks to the development of international payment systems, crowdfunding allows project initiators to attract funding from donors not only from their own country, but also from abroad. Crowdfunding has been the subject of many scientific and practical publications, which examine in detail its advantages and disadvantages, as well as implementation methods. An important place in all studies is occupied by the construction of crowdfunding classifications, which allow a more accurate understanding of the nature of its individual varieties and enable initiators of crowdfunding campaigns and potential donors to choose the optimal interaction model. Despite the large number of works on this topic, a number of issues, as far as we know, have not received sufficient coverage. These include the following:

- the difference between crowdfunding and other forms of direct interaction between recipients and providers of financial resources (for example, P2P lending). In sources, crowdfunding and financial P2P relations are often considered as synonyms, but there are substantive differences between them;
- the influence of models for attracting and using financing on the nature of crowdfunding relations. Existing literature is limited only to assessing the influence of the nature of the funded project (commercial or non-commercial) on the content of the reward provided to donors. However, this aspect does not exhaust the influence of project goals on the model of organizing crowdfunding;
- place in the system of financial interactions. Crowdfunding, as a rule, is considered separately from other models of attracting financing. The only exception is probably a comparative analysis of the initial placement of shares and the initial issue of tokens (Initial Coin Offering, ICO).

The above-mentioned gaps in the literature, on the one hand, do not allow us to contrast crowdfunding with other models of project resource provision, and on the other hand, hinder the identification of the crowdfunding component in other types of financial activity. As a result, it is impossible to build a holistic picture of crowdfunding and determine its place in the system of similar models of attracting financing, which creates problems for the theoretical understanding of its nature, practical application and, most importantly, legislative and regulatory regulation. This article is an attempt to fill these gaps. The goal is to determine the distinctive features of crowdfunding and identify its place in the system of direct financial interactions. The article is conceptual in nature and does not rely on empirical quantitative or qualitative data. The examples provided only illustrate the provisions we put forward and should not be considered as a case study.

MATERIALS AND METHODS

The theoretical basis of the study is the concept of crowdfunding, developed in world and Azerbaijani literature, as a way to attract funding for various projects by collecting small contributions (usually in cash, but material resources can also be provided) from an unlimited number of potential donors. In fact, such a definition only indicates the source of funding, but not its purpose. Note that, as a rule, the term "donor" is used in Russian-language literature to designate persons providing funds. Strictly speaking, this is incorrect, since this person can receive a certain compensation or reward for their contribution. Nevertheless, we will use this term, since there is no adequate alternative to it yet (the term "backer", borrowed from English, does not seem convenient). To construct a classification of financial interaction methods, we used the method of strategic matrices and the method of continua.

RESEARCH RESULTS

As a rule, it is assumed by default that crowdfunding is characterized by the following features:

- there is only one recipient of funds raised within the framework of a crowdfunding campaign;*
- the initiator of the crowdfunding campaign is the recipient of funds;*
- the recipient of funds attracts donations for the targeted financing of a specific project;*
- all participants in the fundraising (donors) provide their resources for the implementation of the same project of the initiator of the crowdfunding campaign;*
- the recipient of funds is a third-party structure in relation to the donors;*
- the recipient of funds independently creates value for donors (using the attracted financing for*

this

purpose). This refers to both the implementation of the project for which the recipient attracts resources (i. e. the project is valuable for donors in itself), and the reward that donors want to receive for their contribution (obviously, both factors can be combined). Of course, by implementing the project, the recipient of funds also creates value for himself;

- the recipient and donors interact directly, without the mediation of financial institutions (which only support these interactions, for example, by making payments, but do not assume responsibility for the relations between the parties to crowdfunding).*

As far as we know, these features have not been explicitly described in the existing literature, but crowdfunding campaigns implicitly assume their presence. It can be argued that campaigns that meet them can be called standard. To identify the differences between crowdfunding and other methods of raising resources, as well as to classify its varieties, it is advisable to use the criterion of their compliance with the conditions listed above.

This set of characteristics allows us to assert that crowdfunding is a form of:

- external financing (since funds are received by a structure third party to the donors);*
- collective financing (since resources are provided to one structure by a large number of donors);*
- targeted financing (it is provided to solve specific problems);*
- direct financing (there are no intermediaries between recipients and providers of financial resources, who take responsibility for their relations and, in particular, for the risks of failure to achieve fundraising goals).*

It should be noted right away that crowdfunding is very close in content to such forms of raising finance as the issue of shares and bonds, since they are also characterized by the participation of a large number of investors (donors), the contribution of each of whom is relatively small compared to the total volume of resources attracted. In particular, it is easy to see that the issue of shares and bonds meets almost all the crowdfunding characteristics described above (which, therefore, are of a more general nature, being characteristics of external collective financing in general). Only the requirement for direct interaction between investors and the issuer is not met, since when issuing securities, an underwriter is

usually involved, who ensures their guaranteed placement. Targeted requirements may also not be met (although in some cases the issuer attracts financing to solve specific problems).

The main differences are purely legal in nature, since the issue of shares and bonds is strictly regulated by law and at the same time the corresponding securities are put into circulation, for which there is a secondary market. In crowdfunding, there are no such assets, economic and legal relations only link the direct donor and the recipient of financial resources, and the donor, as a rule, cannot transfer their rights to third parties.

However, innovative forms of crowdfunding have recently appeared (ICO and IEO (Initial Exchange Offering)), when the donor receives a digital token as confirmation of their contribution, which can be sold on the secondary market (which brings ICO closer to the issue of securities). Taking this into account, it would not be a mistake to say that crowdfunding, in essence, represents a new stage in the development of external collective financing, which is distinguished by greater flexibility in terms of managing relationships with donors and meets the needs of project initiators and holders of financial resources in the context of the digital transformation of the economy.

Since participants in crowdfunding campaigns, along with greater opportunities to satisfy their requests, agree to a lower level of guarantees for the observance of their interests and the protection of their rights (due to insufficient legislative regulation of crowdfunding relations) compared to holders of company securities, crowdfunding can be described as an atypical, or precarious, collective financing (in contrast to which is different from traditional collective financing – issuing shares and bonds). We use the terms “atypical” or “precarious” by analogy with atypical (precarious) employment, which provides a higher level of flexibility in labor relations, but at the same time increases the risks for workers. As a result, we can conclude that there is a tendency towards precarization (or increased flexibility) of economic relations in general, which is typical for the current stage of economic development.

Taking this into account, we can construct a continuum of forms of external collective financing from the point of view of the level of formalization of relations between providers and recipients of financial resources and the presence of a secondary market for assets (liabilities) generated by these relations (figure). Note that the absence of formal obligations, typical of gratuitous crowdfunding, does not mean that the recipient of funds has no obligations at all towards donors. In gratuitous crowdfunding, the funder typically reports to its audience on the use of the funds raised, while in reward crowdfunding, the funder is obliged to provide the promised reward to the donors. However, such obligations are not formalized and, as a result, do not generate a secondary market in which they could be traded.

As mentioned above, the initiator of a crowdfunding campaign typically attracts funds only for the implementation of some specific project of their own (i.e., for the creation of an asset in the broad sense of the word). Thus, crowdfunding campaigns are characterized by two-level centralization (at the recipient level and at the asset level).

Although P2P financing (primarily debt financing) is often equated with crowdfunding, in general this is not the case. In P2P relationships, centralization is most often absent (there is no prohibition on its presence, but the nature of the economic relations between the parties does not require it). An individual recipient of funds interacts with only one provider of financial resources (this is the essence of P2P relationships – peer to peer, i.e. “equal to equal” or “one on one”).

In other words, there is no “crowd” of donors attracted by the initiator of the crowdfunding campaign to finance the project (since a sufficient amount of funds can be obtained from one source). In other words, there is no collective collection of funds. There is also no single value created for various funding providers (each recipient of funds in the P2P format independently creates their own individual value for their partner who provided the funding). The external similarity of financial P2P interactions with crowdfunding is due to the following reasons:

- both can be implemented on platforms where many recipients and providers of financial resources

- are simultaneously present;

- P2P interactions between recipients and providers are carried out directly, without the mediation of financial institutions, as in crowdfunding (the platforms through which these interactions occur only create a platform for cooperation, but do not assume the risks of financial relations).

Thus, the similarity is purely superficial. Therefore, in particular, P2P lending should not be considered as a synonym for crowdlending. The analogue of crowdlending in the system of traditional financial instruments is the issue of bonds, and the analogue of P2P lending is the issuance of a bill of exchange to a specific partner.

An analogy with crowdsourcing is appropriate here, where crowdsourcing itself and P2P relations are also often mixed. In crowdsourcing, the structure that attracts human resources centralizes them to release a single product. An example is the Uber transport platform, which provides passenger transportation services on uniform terms. On the contrary, in the P2P model, each worker determines the composition of their labor service and tariffs and independently interacts with each specific customer (for example, the Yandex Services service).

Taking into account centralization as a key feature of crowdfunding allows us to better understand the nature of non-standard campaigns, which include the well-known story of collective investment in GameStop shares (a retail chain selling game consoles and computer games). Note that in the literature this campaign is classified as investment crowdfunding. However, this does not reflect its nature (and, moreover, simplifies and distorts it), since, as we will show below, it does not correspond to the above-listed features of crowdfunding.

In January 2021, large investors played for a decline in GameStop shares. To prevent the game from succeeding, users of the social news site Reddit's r/wallstreetbets subreddit began to collectively invest in GameStop, buying assets from current holders and managing to increase the price several times in a short period of time. Analysts cite both the established culture of mass gambling on the stock market in the United States with the aim of making a quick profit and the anger of small investors at large financial players for their role in the financial crisis of 2007–2008 as reasons for such joint investment. As a result of such joint investment (which can be called a crowd-run game for an increase), large investors suffered significant losses (up to \$70 billion).

The example of coordinated investments in GameStop is interesting for a number of reasons:

- there was no single recipient of funds – each investor independently purchased GameStop assets from the current holder (which partly makes this campaign similar to P2P investing);
- a single fund of funds was not formed (each payment was sent to a separate recipient);
- collective actions to invest in GameStop assets were not initiated by this company. The crowdfunding game was conducted by self-organized investors;
- although the crowdfunding game was conducted with GameStop assets, the company itself did

not

receive the financial resources mobilized during the game and was not involved in creating value for investors;

- funds were transferred to economic agents that did not participate in creating value for investors within the framework of the crowdfunding campaign (these agents simply transferred GameStop assets to investors). Value for crowdfunding investors was created due to their own investment activity by receiving profit from the growth of the GameStop share price (achieved through the crowdfunding game for an increase) and/or preventing large financial structures from receiving profit by playing for a decrease in the value of these shares;

- participants in this crowdfunding campaign took active steps to invest, that is, they not only provided financial resources, but also independently carried out investment activities. This brings the nature of this campaign closer to crowdsourcing (which can be defined as the use of human capital of the crowd).

It can be argued that, unlike traditional crowdfunding, the accumulation of funds occurred not at the stage of their receipt (since there was no single recipient), but at the stage of sending (when users of the r/wallstreetbets subreddit showed their willingness to jointly invest in GameStop assets). This confirms that the entire campaign was carried out on the basis of self-organization. From the point of view of the two-level model of crowdfunding centralization (a single recipient and a single asset), such a crowd game is characterized by a paradoxical nature - in the absence of a single recipient of funds, investments were made in a single asset.

The described stock market crowd game turned out to be a complete surprise for the US financial market. Some authors even described it as a rebellion against the existing model of its organization. Large investors assessed it extremely negatively, and analysts expressed concerns about what asset would be the next target of crowd investors, including the possibility of playing against the US dollar. However, this kind of practice has not become widespread.

Despite the singularity of this precedent, it is of considerable interest in terms of understanding the nature of crowdfunding. It shows that crowdfunding campaigns can be conducted not only at the initiative of a third-party recipient of funds, but also on the basis of self-organization of donors (investors). At the same time, there may be no single recipient of funds, and those participants in economic activity to whom funds are transferred do not necessarily participate in creating value for their senders.

In addition, we can talk about the presence of a new type of crowdfunding that has not yet been described in the literature, namely, an exchange crowd game.

Our proposed concept of a two-tier centralization model of fundraising allows us to construct a classification of crowdfunding types (more precisely, types of direct interaction between providers and recipients of financial resources) in terms of their compliance with this model (Table 1). Quadrant I includes traditional crowdfunding, for which the requirements of the two-tier centralization model are fully met.

A crowd game (quadrant II) assumes the presence of a single asset, for the support of which donors allocate funding, but there is no single recipient of funds (this is exactly the situation with the crowdfunding campaign in support of GameStop). In the case of GameStop, the campaign was carried out at the initiative of investors, but an option in which the organizer I myself appeal to third parties with a request to finance an asset related to me but not belonging to me (in this case, the asset has no single owner) in order to improve my position (for example, to prevent a hostile takeover). The crowd game does not correspond to a number of the features of traditional crowdfunding formulated above, however, from a substantive point of view, it has a crowdfunding nature, since it relies on attracting financial resources from the crowd. For this reason, it should be described as a non-standard type of crowdfunding.

Table 1.

Typology of types of direct financial interactions

		Centralized (single) recipient	
		Present	Absent
Centralized (single) asset	Present	I. Traditional crowdfunding	II. Crowd game
	Absent	III. Non-target crowdfunding	IV P2P financing

In non-targeted crowdfunding (quadrant III), the fundraising initiator attracts funding not for a specific project, but to support its activities in general. This approach was widely used during the lockdown associated with the COVID-19 pandemic, when a number of small and medium-sized businesses faced a sharp drop in revenue, the amount of which became insufficient to continue operating, as a result of which they turned to crowdfunding as a way to attract resources for their activities [26, source 2]. Such a model can be called atypical, since one of the important features is missing - the targeted nature of the use of the attracted financial resources.

Fundraising can be a synonym for non-targeted crowdfunding, since fundraising campaigns do not have specific goals for raising funds [source 3]. Thus, taking into account the centralization factor allows us to more accurately distinguish between fundraising and crowdfunding (which are often mixed up in the literature). Finally, the absence of both a centralized recipient and a single asset corresponds to financial P2P interactions (quadrant IV). In this case, all users represented on the financial platform (both recipients and providers of funds) build individual relationships. Collective actions are absent (unlike the previous three models). Thus, the two-level centralization model allows us to describe the essence of the actions of investors in GameStop assets as a special kind of crowdfunding that does not imply a single recipient of funds.

Discussion

The classification we have constructed (see Table 1) allows us to offer a comprehensive approach to understanding the content of various methods of direct interaction between the recipient and the provider of financial resources (Table 2).

We would like to draw attention to the following important points:

- the presence of direct interaction is not yet a sufficient condition for the financial relations arising between the recipient of resources and donors to be classified as crowdfunding (see Table 1, quadrant IV). Crowdfunding occurs only if there is centralization of the resources attracted (at the levels of either the recipient or the asset, or both). It is this that ensures the collective nature of crowdfunding;
- the absence of a single recipient does not prevent the collective actions of investors from being classified as crowdfunding - it is important that these actions are aimed at financing a single asset;
- Crowdfunding can act not only as a tool for passive collective financing (when donors simply provide their financial resources to an external structure), but also as a tool for collective actions by investors aimed at jointly creating value through their own efforts (as in the case of investments in GameStop assets) without involving a third-party centralized structure for whose benefit funds are collected.

Table 2.

Map of direct financial interaction models

Types of direct financial interactions	Crowdfunding (collective)		Non-crowdfunding (individual)
Criteria	Centralization is present		There is no centralization
Signs	Two-level centralization	Single-level centralization	
Types	Standard crowdfunding	Non-targeted crowdfunding, crowd games	P2P interactions (P2PLending)

Conclusion

The main results of the study, in our opinion, are:

- a detailed description of the distinctive features of crowdfunding;
- an approach to crowdfunding as an atypical (precarious) form of collective financing (which serves as a reflection of the general trend towards precarization of business relations);
- a continuum of forms of collective external financing;
- the concept of two-level centralization as a distinctive feature of crowdfunding; - a generalized classification of various types of direct financing.

The results obtained, as we believe, allow us to more accurately understand the nature of crowdfunding, as well as to identify such a new type of it as a stock exchange crowd game. The opposition of crowdfunding to other methods of direct financing is substantiated, which can be used in the development of a regulatory framework for regulating the relevant financial instruments. Promising directions for further research may include identifying and describing other types of crowdfunding that do not meet one or more of the characteristics of standard crowdfunding (e.g., campaigns in which a community raises resources not for an external recipient, but for itself).

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ON ANALYSIS OF INVESTMENT PROJECTS IN INFLATION CONDITIONS (on the example of the Republic of Kazakhstan)

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УДК 338.02

ОБ АНАЛИЗЕ ИНВЕСТИЦИОННЫХ ПРОЕКТОВ В УСЛОВИЯХ ИНФЛЯЦИИ (на примере Республики Казахстан)

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Abstract

In the article the authors analyze investment projects under conditions of inflation in Kazakhstan. The authors emphasize that inflation is the main factor destabilizing the economy, in which the real income of the population decreases and production costs increase. Also, the authors have given an estimation of efficiency of the investment project taking into account inflation.

Аннотация

В статье авторами дается анализ инвестиционных проектов в условиях инфляции в Казахстане. Авторами подчеркивается, что инфляция является основным фактором, дестабилизирующий экономику, при которой снижаются реальные доходы населения и растут издержки производства. Также авторы дали оценку эффективности инвестиционного проекта с учетом инфляции.

Keywords: analysis, inflation, investment, efficiency, economy, growth index, investment project, income

Ключевые слова: анализ, инфляция, инвестиции, эффективность, экономика, индекс роста, инвестиционный проект, доходы

В процессе принятия управленческих инвестиционных решений основную роль играет оценка эффективности инвестиционного проекта. Для того, чтобы максимально снизить степень риска при принятии инвестиционного решения нужно объективно оценить проект, т.е. необходимо учитывать все факторы, которые могут повлиять на эффективность инвестиционного проекта. Одним из таких факторов является инфляция.

Как известно, инфляция цен имеет существенное влияние в той или иной степени на экономику как развитых стран, так и развивающихся. В данной статье, на примере данных экономической статистики Казахстана за последние 10 лет обсуждается дискуссионный вопрос методологии оценки и расчета показателей инвестиционных проектов в инфляционных ситуациях.

В табл. 1 приведена динамика изменения инфляции в Республике Казахстан.

Таблица 1.

Инфляция в Казахстане за 1996 - 2017 гг.

Год	Значение инфляции (%)	Год	Значение инфляции (%)	Год	Значение инфляции (%)	Год	Значение инфляции (%)
1996	147,1	2002	11,2	2008	6,8	2014	6,2
1997	2960,8	2003	1,9	2009	6,7	2015	7,8
1998	2165	2004	17,8	2010	7,5	2016	7,4
1999	1158,3	2005	9,8	2011	8,4	2017	6,0
2000	60,3	2006	6,4	2012	18,8		
2001	28,7	2007	6,6	2013	9,5		

Из таблицы 1 следует, что инфляция за период с 1997 по 1999 гг. имела тенденцию к снижению, а в 2001 и 2007 гг. произошли резкие скачки. Высокий уровень инфляции в 2009 г. был обусловлен, прежде всего, экзогенными факторами. Это финансовый мировой кризис, продовольственный и энергетический кризисы. Высокий кредитный рейтинг страны открыл коммерческим банкам доступ на международные финансовые рынки, благодаря чему кредитные ресурсы, как для предпринимателей, так и для населения стали в течение 2009 - 2011 гг. весьма доступными. Это стало толчком к усилению инфляции в стране. Повышение цен на углеводороды, моторное топливо, зерно и другие продукты питания также внесли свою лепту в этот процесс [1].

Высокий уровень инфляции является основным фактором, дестабилизирующий экономику. При ней снижаются реальные доходы населения и растут издержки производства. Помимо этого, высокая инфляция обычно является нежелательной для большинства организаций, которые ориентированы на внутренний спрос на рынке, так как они теряют значительную часть своих доходов. Некоторые организации выигрывают от инфляции. Например, организации, которые ориентируются на экспорт, исчисляя свою выручку в твердой валюте, имеют выигрыш от внутренней инфляции, так как это позволяет дополнительно экономить на издержках. Для того, чтобы наглядно показать влияние инфляции на эффективность инвестиционного проекта на каждом шаге расчетного периода (m) используются следующие показатели:

- базисный общий индекс инфляции (отражает отношение среднего уровня цен в конце m -го шага к среднему уровню цен в начальный момент времени);
- общий индекс инфляции за m -й шаг (отражает отношение среднего уровня цен в конце m -го шага к среднему уровню цен в конце шага $m-1$);
- темп (уровень, норма) общей инфляции;
- средний базисный индекс инфляции на m -м шаге (отражает отношение среднего уровня цен в середине m -го шага к среднему уровню цен в начальный момент времени).

Описывающие инфляцию индексы делятся на базисные и цепные. При определении базисных показателей инфляции рассчитывается отношение уровня цен определенного состава и набора товаров или услуг отчетного шага к базисному шагу:

$$I_{i6} = P_{im} / P_{i6}, \quad (1)$$

где I_{i6} - базисный индекс роста цен на i -й товар, работу, услугу на шаге m ; P_{im} - цена на i -й товар, работу, услугу на шаге m ; P_{i6} - цена на i -й товар, работу, услугу в базисном периоде, тенге.

При определении цепных показателей инфляции находится отношение уровня цен определенного состава и набора товаров и услуг отчетного шага к уровню цен предыдущего шага:

$$I_{i4} = P_{im} / P_{im-1}, \quad (2)$$

где I_{i4} - цепной индекс роста цен на i -й товар, работу, услугу на шаге m ; P_{im-1} - цена на i -ый товар, работу, услугу на шаге $m-1$, тенге.

Для того, чтобы оценить эффективность инвестиционного проекта с учетом инфляции нужно произвести расчет денежных потоков в базисных (текущих), прогнозных и дефлированных ценах [2, с. 131].

Рассмотрим методику оценки эффективности инвестиционного проекта с учетом инфляции. Традиционная методика оценки эффективности инвестиционного проекта в условиях инфляционных процессов заключается в следующем:

1. Моделируются денежные потоки по инвестиционному проекту в текущих (базисных) ценах, на основе которых определяется значение показателя чистого дохода по проекту (суммарного накопленного эффекта).

2. Прогнозируются индексы роста цен по шагам реализации инвестиционного проекта для всех видов товаров, услуг, работ, входящих в этот проект и определяющих как расходную, так и доходную часть проекта.

3. Прогнозируется общий индекс инфляции по шагам реализации инвестиционного проекта

4. На основе значений показателей в текущих(базовых) ценах и индексов роста цен рассчитываются денежные потоки по проекту в прогнозных ценах.

5. На основе показателей инвестиционного проекта в прогнозных ценах рассчитывается показатель чистого дохода по шагам реализации инвестиционного проекта.

6. Значение показателя чистого дохода по инвестиционному проекту на каждом его шаге делится на его общий базисный индекс инфляции, в результате чего получаем значение чистого дохода в дефлированных ценах.

7. На основе показателя чистого дохода на каждом шаге t инвестиционного проекта рассчитывается чистый доход (суммарный накопительный эффект) в целом по проекту за весь срок его реализации.

8. На основе значения показателя чистого дохода по проекту (суммарного накопительного эффекта) в дефлированных ценах делается вывод об устойчивости проекта в условиях прогнозируемой инфляции.

Инфляционные процессы сказываются на фактической эффективности инвестиций, поэтому фактор инфляции обязательно следует учитывать при анализе и выборе проектов капиталовложений. Особенно это актуально в Казахстане, экономическая ситуация в которой характеризуется высоким уровнем инфляции и серьезными структурными изменениями в ценообразовании.

Проведем анализ влияния инфляции на оценку эффективности инвестиционного проекта для двух случаев:

- 1) разный темп инфляции по отдельным составляющим ресурсов (входных и выходных);
- 2) одинаковый темп инфляции для различных составляющих затрат и издержек.

В первом случае, который больше приближен к реальной ситуации, используется метод чистого современного значения в стандартной форме, но все составляющие расходов и доходов, а также показатели дисконта корректируются в соответствии с ожидаемым темпом инфляции по годам. Во втором случае инфляция влияет своеобразно: инфляция влияет на числа (промежуточные значения), получаемые в расчетах, но не влияет на конечный результат и вывод относительно судьбы проекта. Рассмотрим это явление на конкретном примере.

Организация «Сана» приобретает оборудование за 2000000 тенге.

В течение 3-х лет оборудование обеспечивает 1200000 тенге экономии затрат в виде входного денежного потока ежегодно, за которые оборудование подвергнется полному износу. Стоимость капитала организации составляет 18%. Согласно таблице 2, предположим, что ожидаемый темп инфляции - 6% в год.

Для начала нужно оценить проект без учета инфляции:

Рассчитываем NPV:

$$NPV = -CF_0 + CF_1 / (1 + d) + CF_2 / (1 + d)^2 + CF_3 / (1 + d)^3 + CF_4 / (1 + d)^4 = 609128 \text{ тенге.}$$

Таблица 2.

Решение без учета инфляции

Показатели	Год	Сумма средств, тенге	18%-й множитель	Современное значение, тенге
Инвестиции	0	-2000000	1	-2000000
Приток денег	1	1200000	0,8475	1016949
	2	1200000	0,7182	861821
	3	1200000	0,6086	730357
NPV				609128

Получаем $NPV = 609128$. Из расчетов можно сделать вывод, что проект следует принять, отмечая высокий запас прочности. Теперь при оценке проекта учтем эффект инфляции. Прежде всего, необходимо скорректировать требуемое значение показателя отдачи на влияние инфляции. Для этого пусть организация «Сана» планирует реальную прибыльность его вложений в соответствии с процентной ставкой 18%. Это означает, что при инвестировании суммы в 105500 долл. через год оно должно получить: $2000000 \cdot (1 + 0,18) = 2360000$ тенге. Если темп инфляции составляет 6 %, то необходимо скорректировать эту сумму в соответствии с темпом: $2360000 \cdot (1 + 0,06) = 2501600$ тенге. В общем случае, если g_p - реальная процентная ставка прибыльности, а i - темп инфляции, то номинальная (контрактная) норма прибыльности будет отражаться формулой:

$$g_p = g + i + gi. \quad (3)$$

Тогда при реальной процентной ставке прибыльности в 18% и темпе инфляции в 6% рассчитываем номинальную норму прибыльности:

$g_p = 18 + 6 + 1,08 = 25,08$. Рассчитаем величину критерия NPV с учетом инфляции (табл. 23), т.е. пересчитаем все денежные потоки и продисконтируем их с показателем дисконта 25,08 %.

Таблица 3.

Решение с учетом инфляции

Показатели	Год	Сумма денег, доллар США	Индекс инфляции	Приведенный денежный поток, доллар США	25,08% - й множитель	Современное значение, доллар США
Инвестиции	Сейчас	2000000	1	2000000	1	2000000
Годовая экономия	1	1200000	1,0600	1272000	0,7995	1016949
	2	1200000	1,1236	1348320	0,6392	861821
	3	1200000	1,1910	1429219,2	0,5110	730357
	3	1200000	1,1910	1429219,2	0,5110	730357
NPV						609128

Ответы обоих решений в точности совпадают [3, с. 125].

В примере результаты получились одинаковыми, так как мы скорректировали на инфляцию и входной поток денег, и показатель отдачи. Поэтому многие фирмы западных стран не учитывают инфляцию в процессе расчета эффективности капитальных вложений. Естественно, оба метода оценки при корректном использовании должны давать одинаковые результаты. Но в более сложных ситуациях, когда учитывается заемное финансирование и изменение оборотного капитала, возможны расхождения в оценках инвестиционного проекта. Эффект инфляции сводится к потере прежней покупательской способности денег. Что приводит к изменению доходностей и коэффициентов дисконтирования. В макроэкономической ситуации, когда есть основания ждать резкого спада инфляции, следует отдавать предпочтение проектам, для которых инвестирование не сконцентрировано в начальный момент времени, а более растянуто во времени. При таком эшелонировании вложений на затратах сказывается эффект снижения темпов роста цен и разрыв между динамикой дисконтированных затрат и дисконтированных результатов становится меньше. А, следовательно, уменьшается и опасность убыточности проектов из-за сильной чувствительности к инфляции [4].

Таким образом, инфляция оказывает существенное влияние при выборе и принятии финансовых инвестиционных решений, так как организация производит инвестиции сегодня, номинальная стоимость инвестиций равна реальной стоимости, а свои доходы организация получит только через некоторое время, и к этому моменту может уменьшиться не только текущая стоимость будущих денежных поступлений, но и сами деньги могут обесцениться под действием инфляции [5, с. 189]. Так, инфляция усложняет процесс оценки инвестиционного проекта и решений. В следствии этого возникает потребность в дополнительных источниках финансирования, увеличиваются процентная ставка по заемному капиталу и ставки дисконтирования, затрудняется выпуск корпоративных облигаций, растет степень диверсификации инвестиционного портфеля организации. Для общего случая можно применить правило: «В условиях влияния инфляции инвестировать денежные фонды в любые операции оправданно лишь тогда, когда доходность вложений превышает темпы инфляции».

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Medical sciences

WORKING CLASSIFICATION OF CYTOMEGALOVIRUS INFECTION IN NEWBORN CHILDREN

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Abstract

Relevance: Cytomegalovirus (CMV) infection is the most common infection that is most commonly found in sick newborns and maybe the leading cause of their morbidity and mortality. Current research and clinical observations confirm the likelihood of contracting CMV infection not only in the antenatal period but also in the perinatal and postnatal periods.

The study aimed to comment on the current understanding of neonatal CMV infection, its clinical manifestations depending on the time of infection, perinatal outcomes, and long-term consequences to develop a functional classification of CMV infection in newborns.

Materials and methods: A systematic review and analysis of the literature sources published by scientists in neonatology and perinatology, healthcare practitioners, and professional associations was carried out. Literature searches were conducted in PubMed, Embase, Scopus, and Euro-Peristat over the past decade by the study keywords. A total of 30 sources were included in the analysis.

Results: Delayed sequelae, symptomatic and a symptomatic congenital and perinatal infections have been identified. A review shows that, to date, the incidence of asymptomatic congenital CMV infection has not been established. There is no systematization of the clinical manifestations and out comes of congenital, perinatal, and postnatal CMV infection in newborns.

Conclusion: Based on the literature review, we have developed a functional classification of CMV infection in newborns by the time of infection. Thus, CMV infection can be congenital, perinatal, or postnatal. The classification presents manifestations of symptomatic forms of CMV infection, perinatal and distant outcomes. However, there are no clear diagnostic criteria for a symptomatic forms of CMV infection. There is no clear rationale for etiopathogenetic therapy, prognostic and preventive criteria for various forms of CMV infection. All of the above tasks require further prospective cohort studies.

Keywords: newborn, congenital, perinatal, postnatal, cytomegalovirus (CMV) infection.

Introduction: In recent decades, the problem of congenital and perinatal infections has been widely studied worldwide. The number of cases reaches 65.6% of all causes of perinatal morbidity and 31% of mortality in newborns. The relevance of this problem is due not only to significant peri- and postnatal losses but also to the high risk of disability of such patients. Among congenital and perinatal infections, cytomegalovirus (CMV) infection is the most common, causing manifestations ranging from asymptomatic to severe generalized forms with damage to many organs and systems. Currently, many publications are devoted to modern methods of diagnosing congenital CMV infection, features of clinical manifestations, therapeutic possibilities, prognosis, and long-term outcomes. However, despite many research works in the field of perinatology and neonatology concerning aspects of transmission routes, early detection, and treatment of CMV infection in newborns, questions on approaches to managing infected full-term and premature newborns are still not clarified. Establishing a clinical diagnosis of "congenital and perinatal CMV infection" is a difficult task due to the absence of specific symptoms and polymorphism of clinical symptoms. In addition, to date, there is no accurate data on the incidence of asymptomatic CMV infection.

The study aimed to comment on the current understanding of neonatal CMV infection, its clinical manifestations depending on the time of infection, perinatal outcomes, and long-term consequences to develop a functional classification of CMV infection in newborns.

Materials and Methods: A systematic review in PubMed, Embase, Scopus, and Euro-Peristat databases included literature sources published over the past decade. The search was done by the keywords "cytomegalovirus infection" and "newborn," "congenital, perinatal and postnatal cytomegalovirus infection," "symptomatic, asymptomatic form of CMV infection," "immediate and long-term outcomes," and "classification," including variants of these terms. The terms of medical subject headings (MeSH) were used where possible. The search was limited to data on newborns; the language restrictions were "English" and "Russian." In addition, the search was limited only to full texts of works. Restrictions on the availability of articles were not considered (all sources can be requested from the authors). Case reports, case series, and reviews were excluded. The authors used the "snowball" method when navigating through the links in the studied articles, including reviews, to find additional sources. A total of 33 sources were included in the analysis.

Results: CMV infection etiology

The pathogen belongs to the Cytomegalovirus hominis species, subclass Deoxyvira, class Deoxybika, order Haplovirales, family Herpesviridae (human herpesvirus type 5), subfamily Betahepresviridae, genus Cytomegalovirus. Four strains of CMV (AD69, Davis, Towne, Kerr), which are pathogenic to humans, are currently registered.

According to a phylogenetic analysis by Alwan et al., three genotypes of the virus have been identified: gB1, gB2, and gB3 (Figure 1) [1].

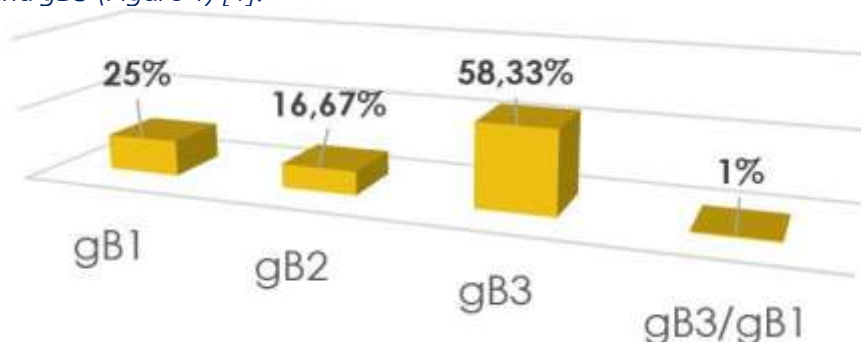


Figure 1—Cytomegalovirus genotype structure [1]

As can be seen, gB3 human cytomegalovirus was the most frequent genotype detected in 58.33% of infants with symptoms of CMV infection, followed by gB1 (25%) and gB2 (16.67%). However, the gB4 genotype was not detected.

Mixed CMV with gB3/gB1 infection was detected in only one case. Thus, gB3 human cytomegalovirus was the most predominant genotype among newborns with symptoms of congenital and perinatal CMV infection [1].

Epidemiology of CMV infection CMV infection is widespread in all regions of the world (Figure 2).

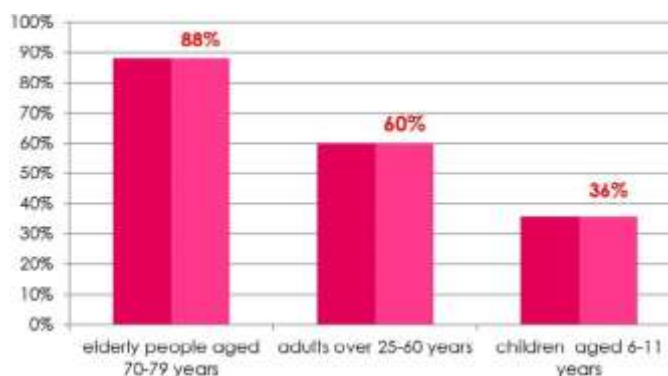


Figure 2—CMV seropositivity in people of different ages [2]

As shown in the diagram, specific antibodies (CMV seropositivity) are present in 88% of people aged 70-79 years, 60% of adults aged 25-60 years, and 36% of children of 6-11 years [2].

An infected person remains a lifelong virus carrier; most often, the virus remains latent. The higher the population's economic well-being, the higher the average age of contracting CMV and the lower the proportion of infected women of childbearing age (Figure 3) [3]. The chart provides no data on West Europe or the USA.

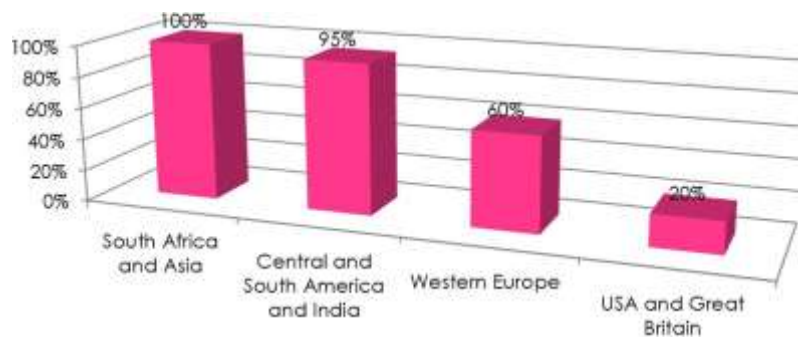


Figure2–CMV seropositivity in people of different ages[2]

The percent age of seropositivity of women of childbearing age is: in South Africa and Asia–100%, in Central and South America and India – 95%, in Western Europe – 60%, in the US and the UK – 20% [3].

The incidence of CMV infection in newborns ranges from 0.2-2.0%. In preterm infants, it is significantly higher and amounts to 16.0-18.0% [4].

Five percent of CMV-infected newborns will have symptoms at birth, including cytomegalic inclusion disease. Complications such as hearing loss and mental retardation will eventually develop in 15% of cases.

In a systematic review and meta-analysis, including 77 studies from 36 countries with a total of 515,646 newborn children under three weeks, the overall prevalence of congenital CMV infection was 0.67%. Worth noting that the infection rate in low-and middle-income countries was thrice higher than in high-income countries [5].

Thus, the prevalence of CMV infection in populations of different age groups is largely determined by socioeconomic status.

CMV persistence

A special variant of the disease is the latent form of infection, in which the pathogen is defective and maintains its vital activity due to intracellular parasitism without being released into the external environment. After primary and non-primary infection, strains of congenital CMV infection are in a latent state. All herpesviruses are distinguished by the ability to latency in an infected person's body. For life, the virus is localized in blood lymphocytes, but it can persist in monocytes, polymorphonuclear leukocytes, nerve cells of regions of sensitive nerves, cells of salivary glands, kidneys, and other organs. Under the influence of certain factors (intercurrent illness, stressful situations, etc.), a latent infection reactivates and transforms into an acute manifestation (manifestation from the latent manifestation – detection, manifestation) with the usual properties of the pathogen restored. Conversely, a manifest form may transform into a latent form [6].

CMV infection transmission pathways

An infected person is the only source of infection. The CMV transmission ways are diverse: airborne, contact, sexual, and transplacental (from mother to fetus) during organ transplantation and blood transfusion of an infected donor [3].

Congenital CMV infection

It is an infectious disease resulting from the antenatal transmission of the pathogen from mother to fetus through primary infection of the pregnant woman, reactivation of a previously acquired infection during pregnancy, or infection of a seropositive pregnant woman with another CMV strain [7].

Congenital CMV infection, the most frequent infectious fetopathy, is a pressing problem due to the possibility of a severe generalized process, congenital malformations, and the potential risk of developing chronic pathology [5].

This infection can occur due to primary or non-primary CMV infection in pregnant women. The risk of intrauterine transmission increases when primary infection occurs during pregnancy [8], with a higher rate of vertical transmission in mothers with older gestational age at the time of infection, while the risk of adverse effects on the fetus increases significantly if the infection is contracted during the first half of pregnancy. During pregnancy, reactivation or reinfection of CMV occurs much more often than primary infection with the virus. At that, some studies report that secondary CMV infection causes 50-80% of all cases of intrauterine infection. It has been established that the clinical manifestations and severity of congenital infection depend on the type of pathogen, its virulence, and the level of immunological reactivity of the organism. With antenatal infection, the clinical symptoms of the disease, as a rule, manifest

themselves already at birth. At that, within prenatal infection, the clinical manifestation of congenital infection may be not only in the first weeks of life but also much later, in the post-neonatal period [9].

Congenital CMV infection can cause congenital malformations, ante- or intranatal fetal death, severe generalized disease of the newborn up to death, and irreversible disabling disorders, such as sensorineural hearing loss, blindness, cerebral palsy, neuropsychiatric development delay.

In the study by H. Imafuku et al. (2020), a combination of flu-like symptoms during pregnancy in the mother, fetal ultrasound abnormalities, or premature birth at less than 34 weeks of pregnancy showed a sensitivity of 90.6%, specificity of 66.4%, and a maximum Youden index of 0.57, and they can be considered as optimal prognostic factors [10].

Infection can affect most all organs and systems:

- Central nervous system and sensory organs (microcephaly, encephalitis with possible calcification, hearing loss, chorioretinitis, cataract, microphthalmia);
- hepatobiliary system (hepatomegaly, hepatitis, cholangitis, and intrahepatic cholestasis);
- hematopoiesis system (thrombocytopenia, anemia, extramedullary hematopoiesis);
- urinary system (interstitial nephritis);
- respiratory system (pneumonitis);
- gastrointestinal system (esophagitis, gastritis, enterocolitis with ulceration of the mucous membrane)
- endocrine glands (adrenal glands, pancreas, thyroid gland, salivary glands);

According to Alwan et al., jaundice is the most common clinical sign in symptomatically infected newborns, followed by hepatosplenomegaly [1].

Congenital CMV infection is still one of the main causes of hearing loss in the pediatric population, and there is a broad debate about the introduction of universal screening of newborns for CMV infection [11].

With the widespread use of assisted reproductive technologies in obstetrics, publications on perinatal outcomes of pregnancies conceived by in vitro fertilization (IVF) have appeared in the literature.

According to A.A. Permyakova et al., preterm birth occurs in 65.2% of IVF cases. At that, the infection rate of CMV infection in PCR samples of saliva and urine in this group of premature babies in the first year of life is 21%. According to the authors, the high prevalence of herpes virus infection in children born through IVF dictates the need for a non-invasive screening PCR study of saliva and urine to identify CMV DNA and determine the viral load [12].

Thus, congenital CMV infection is a highly prevalent, adverse neonatal disease. Joint activity of obstetrician-gynecologists, infectious disease specialists, and neonatologists is required to improve the perinatal outcomes of CMV infection.

Perinatal and postnatal CMV infection

Perinatal CMV infection in term infants is often asymptomatic. Extremely rarely manifests as CMV enterocolitis with a clinic of watery diarrhea complicated by exsiccosis, hemocolitis, stenosis, or intestine perforation [11]. Postnatal infection through breast milk is discussed since PCR detects CMV DNA in the mother's milk. At that, it is not found in dry spots of the child's blood (on Guthrie's map) [3].

Iwanaga et al. describe the manifestation of severe enterocolitis in a girl of 6 weeks on mixed feeding. She developed watery diarrhea with a loss of protein, exsiccosis, hypoproteinemia (30 g/L), hypoalbuminemia (17 g/L), a marked increase in ALT (581 units/L) and AST (280 units/L) levels, and anemia [18].

Sue et al. describe a severe course of CMV enterocolitis in 2 children, eight weeks and ten months old. Histological examination revealed pronounced destruction of crypts, inflammatory infiltration, and immunohistochemically – multiple CMV inclusions. CMV DNA was detected in blood plasma by PCR. The child received four weeks of parenteral antiviral treatment (ganciclovir) and valganciclovir orally for the next four weeks [13].

CMV infection can cause severe enterocolitis postnatally and in the first months of life, aggravating the course of necrotizing enterocolitis (NEC). Vajnshtejn and co-authors presented cases of CMV enterocolitis and NEC. Two full-term infants developed severe watery diarrhea, and one had blood in the feces. A premature newborn with CMV infection had a worsening of the NEC course. Those patients received ganciclovir and specific intravenous immunoglobulin with a favorable outcome [3].

In Minihan et al. studies, 48 CMV-positive newborns were identified out of 1,659 newborns (average gestational age 25.3 weeks, birthweight 695g, age 58 days) (frequency of 2.9%). The most common symptoms were bloating (43.8%), sepsis-like syndrome (29.2%), thrombocytopenia (60.5%), and conjugated hyperbilirubinemia (60.9%). Compared with the controls, there was no significant difference in the

combined number of fatal cases or bronchopulmonary dysplasia (56.3% vs. 37.5%; $P = 0.1$) or neurodevelopmental disorders after 1 and 2 years (51.9% vs. 44%; $P = 0.8$; 71.4% vs. 50%; $P = 0.4$) [14].

According to Mukhopadhyay et al., symptomatic postnatal CMV infection has been diagnosed in 1.3% of extremely low and very low birth weight children, most commonly among those weighing less than 1000 grams with respiratory instability and thrombocytopenia [15]. The author summarized that, like late-onset bacterial infection, symptomatic postnatal CMV infection may contribute independently to the development of bronchopulmonary dysplasia. This possibility should be considered in a prospective study of newborns with extremely low body weight [15].

Restrepo-Gualteras and others claim that CMV infections of the respiratory system are more common in premature newborns. At the pulmonary level, active CMV infection is usually characterized by an alveolar disorder leading to hypoxemia, opaque glass-type darkening, and interalveolar infiltrates with CMV inclusions, according to lung biopsy. The detection of active CMV infection in the respiratory tract organs is accompanied by an additional assessment of immune defects (primary or secondary) that disrupt the function of T and NK cells or the innate antiviral response, as well as other changes in immune regulation. General clinical and radiological patterns, such as hypoxemia and pulmonary darkening by the type of frosted glass, make it possible to detect CMV infection of the respiratory organs in the early stages and begin specific treatment of the liver [16].

Acquired CMV infections should be suspected in children with very low and extremely low body weight, breastfed by seropositive mothers, and showing severe symptoms, especially sepsis with negative cultures [17]. This may allow pediatricians to make better diagnoses, conduct supportive therapy, provide antiviral treatment if necessary, or establish "preventive" therapy for these high-risk newborns.

In the research by Weimer et al., postnatal CMV infection is associated with long-term consequences for the hearing and growth of children with extremely low and very low body weight and prolonged hospitalization. Prospective studies are needed to determine all the consequences of postnatal CMV infection and the effectiveness of antiviral treatment [18].

Thus, a high-risk group for developing perinatal and postnatal CMV infection comprises deeply premature infants who do not have passively acquired maternal antibodies, contributing to their morbidity and mortality [19].

CMV infection of the fetus and newborn: detection by laboratory diagnostic methods

Indirect diagnostic methods and serological studies are the main tools for assessing CMV infection during pregnancy. CMV-specific class M antibodies (IgM) have been used as a diagnostic marker of primary CMV infection in pregnant women, although CMV-IgM has been detected in non-primary CMV infections. According to a systematic review by Iijima, IgG avidity testing can help distinguish primary CMV infection from non-primary; however, there is no standardized analysis to detect this difference. Besides, when the mother is positive for CMV-IgG and negative for specific IgM, the probability of vertical transmission after primary CMV infection is often excluded. However, symptomatic congenital CMV infections have recently been reported regarding negative outcomes for maternal CMV-IgM [20]. The absence of CMV-IgM occurred in both primary and non-primary CMV infections. In addition, non-primary CMV infections in the mother during pregnancy may lead to a greater proportion of symptomatic congenital CMV infections than previously thought. If universal prenatal screening is performed, an ultrasound examination to detect fetal abnormalities should be performed regardless of the presence of antibodies to CMV-IgM in a pregnant woman. Screening for CMV antibodies should be performed whenever routine fetal ultrasound reveals abnormality [20].

If a CMV infection of the fetus is suspected, an examination of the amniotic fluid or urine of newborns for DNCCMV is required. The gold standard for diagnosing congenital CMV infection is an invasive procedure called amniocentesis. Tanimura & Yamada found that the presence of CMV DNA in the secretion of the mother's cervix is a prognostic criterion for congenital CMV infection in pregnant women with anti-CMV IgM-emia. According to the authors, maternal serological screening for primary CMV infection does not always allow for diagnosing newborns with congenital CMV infection. This screening detects CMV-specific immunoglobulins G, avidity index IgG, or specific IgM. In this regard, scientists suggest identifying potential biomarkers for predicting congenital CMV infection [8].

The IgG or specific IgM AVIDITY index misses several newborns with congenital CMV infection. Scientists suggest finding potential biomarkers for predicting congenital CMV infection [21].

Congenital CMV infection in a newborn is diagnosed in the presence of a clinical and laboratory picture before the 21st day of life. The laboratory diagnostics of CMV is based on detecting CMV-infected cells, the virus itself or its DNA, antigens, and specific antibodies to the virus in the studied samples [1].

The polymerase chain reaction method, which combines high sensitivity and specificity, allows the detection of viral DNA directly in the samples under study. The advantage of the method is the possibility of early detection of the pathogen in the patient's body; even an immune response is formed [33].

Saliva PCR seems to be the optimal method of screening newborns for CMV [4]. Some authors report the possibility of using PCR as a screening method for detecting CMV in newborns' saliva and urine [12].

According to H. Imafuku et al. (2020), tests for CMV DNA in the urine of newborns born to mothers with clinical manifestations (age < 25 years: OR – 2.7, 95% CI 1.1–6.6, $p < 0.05$; presence of fever in the mother or flu-like symptoms: OR – 5.4, CI 2.6–11.2, $p < 0.01$; ultrasound abnormalities of fetal development: OR – 12.7, CI 5.8–27.7, $p < 0.01$; premature birth at less than 34 weeks of gestation: OR – 2.6, CI 1.1–6.0, $p < 0.05$) can be an effective method of detecting CMV as a targeted screening with high sensitivity [22].

P. Ssentongo et al. reported lower rates in screening methods using blood compared to urine or saliva [5].

Thus, the PCR method of saliva and urine samples in newborns has advantages as a non-invasive diagnostic method and is of diagnostic value in neonatology, especially in premature infants with extremely low and very low body weight.

CMV infection treatment in newborns

CMV is the most common pathogen causing congenital infection and can lead to significant adverse consequences for the development of the nervous system. For this reason, in many regions, the standard of treatment for congenital CMV infection is a six-week course of ganciclovir [21].

Currently, there is no evidence of the benefit of antiviral therapy in asymptomatic children. In case of symptomatic CMV infection, oral treatment with valganciclovir for 12 months is recommended [22]. This therapy has proven effective and tolerable for hearing and neurodevelopment in the long term. Valganciclovir is intended for newborns with disease symptoms at birth, such as microcephaly, intracranial calcifications, chorioretinitis, or sensorineural hearing loss. A multicenter study was conducted with a group of CMV-infected newborns for specific treatment with valganciclovir. The data obtained showed the efficacy and safety of oral treatment with valganciclovir, which allowed this drug to be approved as a treatment for infants with congenital CMV pathology by Japan's state health insurance system [23].

Treatment with antiviral drugs is usually not recommended for newborns with mild symptoms of the disease at birth or newborns under the age of 32 weeks of gestational age link. However, since these populations comprise the vast majority of newborns and infants with CMV infection, they are at risk of developing late complications. In this regard, it is necessary to study biomarkers capable of predicting long-term consequences to justify the initiation of treatment and reduce the percentage of complications associated with CMV.

The literature describes cases of neonatal cholestasis with positive dynamics from antiviral therapy with ganciclovir [24]. And published data on the use of high doses of valganciclovir to prevent congenital CMV infection in pregnant women with primary CMV infection in the first trimester [25].

According to the literature, ganciclovir, and valganciclovir improve long-term audiological and neurological outcomes in patients with CMV infection. However, resistance to antiviral drugs has been documented in some studies link. Thus, Japanese researchers with their co-authors (2022) have identified resistance to antiviral drugs in patients with CMV receiving long-term therapy (for six months). Full-size analysis of UL97 and UL54 using long sequencing made it possible to quickly and comprehensively detect drug resistance mutations [26]. The literature discusses the treatment of CMV with Cyclosporine A, which performs a dual function in the pathogenesis of CMV. It has an immunosuppressive effect that promotes virus replication by inhibiting T-cell function and an anti-CMV effect mediated by early intermediate protein 2 [27].

Thus, the problem of inpatient and outpatient treatment of CMV infection in premature babies remains relevant. The effectiveness of treatment in these patients to prevent further complications was not monitored.

Long-term consequences of CMV infection in children

Recently, progress has been made in the field of congenital CMV infection associated with the antiviral treatment of pregnant women and infants, the introduction of newborn screening programs for CMV, and the frequency and diagnosis of complications among infected children. Today, perinatal CMV infection is increasingly recognized as a potential cause of long-term consequences in addition to acute complications in premature infants, which raises important issues related to treatment and prevention. A study of children who did not undergo newborn hearing screening revealed a higher level (16%)

of hearing impairment in the group with the perinatal CMV infection compared to 9% in the control group [28].

New studies show a high incidence of vestibular dysfunction and neuropsychiatric disorders in children with CMV [28]. Some studies report an association between postnatal CMV infection and long-term consequences, including delayed development of the nervous system and bronchopulmonary dysplasia among newborns with very low birth weight. [18] The above was the motivation for strengthening research on the elimination of the virus from breast milk using various methods [29]. To study more distant complications of CMV, previously considered asymptomatic.

Thus, CMV, first of all, negatively affects the child's hearing and contributes to neurological complications, especially in its asymptomatic forms, which requires strengthening monitoring of these children by pediatricist, neurologist, surdologist, and ophthalmologist.

Prevention of congenital CMV infection

Non-randomized studies confirm the potential of CMV hyper immunoglobulin in preventing CMV transmission from mother to fetus, but prospective interventional studies show questionable results. Thus, in a randomized study by R. Devlieger et al. [30], there were no statistically significant differences in CMV infection of the fetus and newborn between a group of pregnant women (average gestational age 24-25 weeks) treated with intravenous immunoglobulin during pregnancy and a group of mothers who did not receive immunotherapy. The incidence of congenital CMV infection was 13/28 newborns (46.4%; CI 27.51; 66.13) versus 16/45 newborns (35.6% [CI 21.87; 51.22]) in the control and main (treated) groups, respectively ($p = 0.46$). Neonatal CMV disease was predominantly mild and resolved spontaneously without major safety concerns. [31].

Regarding vaccination against CMV infection, G. Gerna et al. (2020) noted that future efforts are required to confirm if the new recombinant gB vaccine serves better to prevent both primary and non-primary infections [31].

Conclusion: Based on the review of literature sources on the problem of CMV infection in neonatology, we present the functional classification of CMV infection in newborns developed by us (Table 1).

Table 1—Functional classification of CMV infection in newborns

Types of CMV Infection in Newborns		
I. Congenital CMV infection	II. Perinatal CMV (CMV) infection	III. Postnatal CMV (post-CMV) infection
II. Perinatal CMV (pCMV) infection		
Transmitted by the transplacental route	Transmitted through the birth canal of the mother	Through breast milk, transfusion of blood products after birth
Asymptomatic form	Manifestations	
Heavy and medium-heavy	- deterioration of the general condition - sepsis-like syndrome - prolonged jaundice without obvious causes - pneumonia - hepatosplenomegaly - hepatitis - thrombocytopenia - hemorrhagic rash	- more often in children with extremely low body weight, very low body weight - sepsis - necrotizing enterocolitis with negative cultures and surgical complications (perforation, stenosis, etc.) - pneumonia with the development of bronchopulmonary dysplasia - prolonged jaundice without obvious reasons - enlargement of the liver, spleen - hemorrhagic rash, etc.
Easy	- isolated lesion of one or two organs - clinically insignificant or transient (unexpressed hepatomegaly, splenomegaly) - single changes – thrombocytopenia, increased hepatic transaminases (ALT, AST).	
Isolated bath-room hearing loss	there are no clinical and laboratory signs of the disease except for isolated hearing loss	
Asymptomatic form		
- CMV+ in blood, urine, saliva - there are no clinically significant signs of the disease - hemogram and biochemical blood test – no changes - instrumental examinations – no changes		
!!! During the first 3-6 months of life, delayed psychomotor development, sensorineural hearing loss, and chorioretinitis ("late" manifestations)		

of congenital CMV infection) gradually begin to form.

Complications–long-term outcomes

- -centralnervoussystemdamage-neurologicaldysfunctions, motordisorders, hearingandvisionloss, decreased learning ability, speech defect, etc.
- -thedefeatofthehepatobiliary system– biliarycirrhosis(hepatitis, biliarytract infection)
- -cardiomyopathy, arrhythmias

It follows from the presented classification that both symptomatic and asymptomatic forms of congenital, perinatal, and postnatal CMV infection may have delayed complications, primarily from the nervous-system and sensory organs, which requires constant clinical and laboratory monitoring of CMV infection in children in the post-neonatal period, especially during early development.

It should be noted that there is insufficient data today, and clear diagnostic criteria for asymptomatic forms of CMV infection have not been established. The latter manifest at different ages; in this regard, it is important to develop criteria for the prognosis and prevention of various forms of CMV infection.

Although the serological criteria for diagnosing primary CMV infection are well known, the criteria for diagnosing

non-primary infection are still incomplete. There is a need for clear clinical and laboratory justifications for conducting one or another etiopathogenetic therapy. The problem of treating CMV infection is aggravated by CMV strains resistant to ganciclovir. Therefore, optimizing treatment regimens in children with CMV infection continues and remains an urgent problem. The issues of their further dispensary observation have not been fully resolved.

There is still debate about whether human hyperimmune globulin is capable of protecting against vertical transmission of CMV. In conclusion, it should be noted that developing a CMV vaccine that will prevent a significant part of congenital CMV infection will be an important progressive step in the development of vaccination and prevention of both primary and non-primary infections during pregnancy.

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UP-TO-DATE DIAGNOSTIC AND CLINICAL ASPECTS OF OVARIAN CANCER**Arman Khozhayev***Professor of the S.N. Nugmanov Department of Oncology,
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Asfendiyarov Kazakh National Medical University, Almaty, Kazakhstan***Abstract**

This scientific and analytical work presents modern world and local-regional data on incidence, mortality, lethality and five-year survival rate of such a common oncological pathology as ovarian cancer. The issues of etiology and pathogenesis, modern approaches and principles of complex diagnostics, prospects for improving treatment results, as well as the prognosis are covered in detail. The epidemiological characteristics of this pathology in our republic are given in the context of the regions of the country.

Keywords: *oncology, gynecology, ultrasound examination, ovarian cancer, biomarkers, cancer antigen 125, human epididymis protein 4, BRCA1/2 mutation, DNA, RNA, epidemiology, incidence, mortality, lethality, five-year survival rate, prognosis.*

Ovarian cancer (OC) is a malignant tumor that most often develops from the ovarian epithelium. Requirements for the pathomorphological conclusion in OC: 1) macroscopic description of the specimen separately for each ovary [size and weight, color, capsule condition, cross-sectional view, approximate ratio of cystic and solid components (in %), presence of papillary structures (if any, in % approximately), and other involved organs]; 2) tumor [total size (3 dimensions: height, width, length), location, type, invasion depth (in relation to the myometrium/endometrium border), myometrium thickness (mm), endometrium, involvement of the serous membrane of the uterus, involvement of the cervix, appendages)]; 3) other findings (presence of invasion into other organs); 4) lymph nodes (if present: size, location, size of the largest lymph node, number, number of cassettes); 5) microscopic description [primary tumor: histologic type, degree of differentiation, invasion, capsule/surface involvement, lymphovascular invasion, immunohistochemical (IHC) markers, metastases (preferably described separately): location of metastases (lymph nodes involved/number of nodes, size of largest metastasis, extension beyond lymph node)] [1].

The diagnostic criteria are as follows. Complaints and anamnesis: all patients are recommended to have a thorough collection of complaints and anamnesis; in the early stages, OC may be asymptomatic or cause minor discomfort; in the advanced stage, the disease manifests itself with non-specific symptoms: an increase in abdominal volume, dyspeptic symptoms, weight loss, loss of appetite, pain in the abdomen or pelvis, shortness of breath, general weakness. The level of evidence for recommendations is A (the level of evidence is 1). Comment: collecting information about complaints and anamnesis details,

including family history, is carried out in order to identify factors that may influence the choice of treatment tactics.

Physical examination: a thorough physical examination is recommended; it includes a recto-vaginal examination, palpation of the abdominal organs and all groups of peripheral lymph nodes, auscultation and percussion of the lungs, palpation of the mammary glands. The level of evidence for recommendations is A (the level of reliability of evidence is 1). Comment: special attention should be paid to assessing the patient's condition according to the WHO/ECOG and/or Karnofsky scale, assessing nutritional status, pain syndrome, body temperature, hemodynamics, enlarged peripheral lymph nodes, and the presence of pleurisy and ascites.

Laboratory diagnostic tests: it is recommended to perform a complete general (clinical) blood test, a general therapeutic biochemical blood test with assessment of liver and kidney function, a complete (clinical) urine test, and a study of the blood coagulation system for all patients with OC in order to assess the patient's condition, determine the patient's treatment tactics and algorithm, and assess the prognosis of the disease. The level of evidence for recommendations is C (the level of reliability of evidence is 4). Comments: A complete blood count is performed (repeated) at least 5 days before the start of the next course of chemotherapy; in a complete general (clinical) blood test, it is advisable to assess the following parameters: hemoglobin, hematocrit, erythrocytes, mean corpuscular volume, erythrocyte distribution by size, mean corpuscular hemoglobin content, mean corpuscular hemoglobin concentration, leukocyte platelets, leukocyte formula, erythrocyte sedimentation rate; in a general therapeutic biochemical blood test with an assessment of liver and kidney function indicators - total protein, glucose, bilirubin, creatinine, urea, iron, alanine aminotransferase, aspartate aminotransferase, total bilirubin, lactate aminotransferase, alkaline phosphatase, plasma electrolytes (potassium, sodium, chlorine), in a general (clinical) urine test - determination of color, transparency of urine, its specific gravity, protein in urine, pH, glucose, ketone bodies, urobilinogen, leukocyte esterase, by hardware microscopy of epithelial cells, erythrocytes, cylinders, salt, mucus, bacteria and fungi; as part of the study of the blood coagulation system, a coagulogram (an indicative study of the hemostasis system) is assessed (fibrinogen, prothrombin (according to Quick), international normalized ratio, prothrombin time, prothrombin index, activated partial thromboplastin time, thrombin time, if indicated, additionally - antithrombin III, D-dimer, plasminogen, % activity); it is recommended that all patients undergo a study of the level of adenogenic cancer antigen CA 125 in the blood in order to identify OC and its recurrence. The level of evidence for recommendations is A (the level of reliability of evidence is 1) [1].

In the absence of morphological verification of the diagnosis, it is recommended that all patients with suspected OC undergo determination of human epididymis protein 4 (HE4) in the blood and determination of the Risk of Ovarian Malignancy Algorithm (ROMA) index in order to assess the probability of OC. The strength of the recommendations is B (the level of evidence is 2). Comment: determination of HE4 in the blood and the ROMA index does not replace the need for morphological verification of the diagnosis, but an elevated HE4 level increases the specificity of OC diagnostics; if mucinous carcinoma is suspected, it is recommended, in addition to testing the level of adenogenic cancer antigen CA 125 in the blood, to test the level of adenogenic cancer antigen CA 19-9 in the blood and test the level of carcinoembryonic antigen (CEA) in the blood serum for the purpose of differential diagnosis. The strength of the recommendations is A (the level of evidence is 2). Comment: CEA and CA19-9 may increase in mucinous OC, which allows for subsequent monitoring of the effectiveness of the treatment; for women under 40, who have a high probability of non-epithelial tumors, it is recommended to perform a study of the alpha-fetoprotein level in the blood serum, a study of the level of chorionic gonadotropin in the blood, and a study of the level of inhibin B in the blood at the diagnostic stage. The level of evidence for recommendations is C (the level of reliability of evidence is 5). Comment: non-epithelial ovarian tumors predominate at a young age (detailed information is provided in the section on non-epithelial ovarian tumors). All patients with high-grade serous and endometrioid carcinomas are recommended to undergo molecular genetic testing for mutations in the BRCA1 and BRCA2 genes in the blood or by scraping the oral mucosa and/or in biopsy (surgical) material as predictors of the disease outcome and the choice of the patient's treatment algorithm. The level of evidence for recommendations is B (the level of reliability of evidence is 2). Comment: the frequency of mutations in the BRCA1 and BRCA 2 genes in the indicated histological types of tumors is about 15%. Information about the presence of a BRCA mutation is useful for determining a higher sensitivity of the tumor to therapy with alkylating agents, platinum derivatives and poly (adenosine diphosphate-ribose) polymerase (PARP) inhibitors [1].

1. All patients with OC or suspected OC are recommended to undergo computed tomography (CT) of the chest, abdominal cavity, retroperitoneal space, and kidneys at the diagnostic stage, with or

without intravenous contrast in order to determine the extent of the tumor process and plan the treatment algorithm. The level of evidence for recommendations is A (the level of reliability of evidence is 1). Comment: CT allows (a) to visualize the primary tumor, (b) to identify metastases of the disease, (c) to assess the possibility of performing an optimal cytoreductive surgery. If CT is contraindicated or insufficiently informative, magnetic resonance imaging (MRI) with intravenous contrast may be performed. If distant metastasis is suspected, positron emission tomography (PET)/CT may be performed.

2. All patients with OC or suspected OC are recommended to undergo MRI of the pelvic organs with or without intravenous contrast at the diagnostic stage in order to determine the extent of the tumor process and plan the treatment algorithm. The strength of the recommendations is A (the level of evidence is 1). Comment: MRI allows (a) to visualize the primary tumor, (b) to identify metastases of the disease, (c) to assess the possibility of performing an optimal cytoreductive surgery. In case of contraindications to MRI examination or its insufficiently informativeness, as well as when it is not possible to perform MRI, CT with or without intravenous contrast is indicated. If distant metastasis is suspected, PET/CT can be performed.

3. All patients with OC or suspected OC are recommended to undergo chest X-ray at the diagnostic stage if CT of the chest is not possible. The strength of the recommendations is C (the level of evidence is 5). Comment: CT of the chest organs is more sensitive and specific in detecting metastases in the lungs and mediastinal lymph nodes.

4. All patients with OC or suspected OC are recommended to undergo ultrasound examination of the lymph nodes in the cervical-supraclavicular region, axillary, inguinal lymph nodes, ultrasound of the abdominal cavity, retroperitoneal space and pelvis at the diagnostic stage if CT/MRI/PET-CT cannot be performed in order to determine the prevalence of the tumor process and plan the treatment algorithm. The level of evidence for recommendations is B (the level of reliability of evidence is 2). Comment: Ultrasound is the simplest method for visualizing formations in the abdominal cavity, in the pelvic cavity, and secondary lymph node damage. However, this method is significantly inferior to CT/MRI/PET-CT in terms of making a decision on the first stage of treatment. Evaluation of the effect of chemotherapy according to RECIST 1.1 criteria is also impossible based on the results of ultrasound.

5. All patients with OC or suspected OC at the diagnostic stage are recommended to undergo examination of the mammary glands in order to exclude secondary (metastatic) ovarian lesions or primary multiple malignant neoplasms. The level of evidence for the recommendations is A (the level of reliability of the evidence is 1). Comments: Women under 40 years of age undergo ultrasound examination of the mammary glands in the first phase of the menstrual cycle, if available; women over 40 years of age are recommended to undergo mammography in the first phase of the menstrual cycle, if available. Examination of the mammary glands is carried out in accordance with the principles set out in the clinical guidelines for malignant neoplasms of the mammary glands.

6. For patients with OC, diagnostic laparoscopy is recommended to clarify the extent of the process, morphologically verify the diagnosis and assess resectability, as well as in cases where the performance of optimal cytoreduction is questionable for staging or if it was not adequately performed during previous cytoreduction, as well as for morphological verification of the diagnosis if less invasive methods are not effective [1].

As noted by Zhu B. et al. [2] the incidence and mortality of gynaecological cancers (GCs) can significantly impact women's quality of life and increase the health care burden for organisations globally. The objective of study was to evaluate global inequalities in the incidence and mortality of GCs in 2022, based on The Global Cancer Observatory (GLOBOCAN) 2022 estimates. The future burden of GCs in 2050 was also projected. Data regarding to the total cases and deaths related to GCs, as well as cases and deaths pertaining to different subtypes of GCs, gathered from the GLOBOCAN database for the year 2022. Predictions for the number of cases and deaths in the year 2050 were derived from global demographic projections, categorised by world region and Human Development Index (HDI). In 2022, there were 1 473 427 new cases of GCs and 680 372 deaths. The incidence of gynecological cancer reached 30.3 per 100 000, and the mortality rate hit 13.2 per 100 000. The age-standardised incidence of GCs in Eastern Africa is higher than 50 per 100 000, whereas the age-standardised incidence in Northern Africa is 17.1 per 100 000. The highest mortality rates were found in East Africa (age-standardised mortality rates of 35.3 per 100 000) and the lowest in Australia and New Zealand (age-standardised mortality rates of 8.1 per 100 000). These are related to the endemic areas of HIV and HPV. Very high HDI countries had the highest incidence of GCs, with age-standardised incidence rates of 34.8 per 100 000, and low HDI countries had the second highest incidence rate, with an age-standardised incidence rates of 33.0 per 100 000. Eswatini had the highest incidence and mortality (105.4 per 100 000; 71.1 per 100 000)

and Yemen the lowest (5.8 per 100 000; 4.4 per 100 000). If the current trends in incidence and mortality are maintained, number of new cases and deaths from female reproductive tract tumours is projected to increase over the next two decades. In conclusion, the authors point out that in 2022, GCs accounted for 1 473 427 new cases and 680 372 deaths globally, with significant regional disparities in incidence and mortality rates. The highest rates were observed in Eastern Africa and countries with very high and low HDI, with Eswatini recording the most severe statistics. If current trends continue, the number of new cases and deaths from GCs is expected to rise over the next two decades, highlighting the urgent need for effective interventions.

OC is a leading cause of death in women worldwide, with more than 300,000 new cases and nearly 200,000 deaths globally each year [3].

Medina J.E. et al. emphasize in their work that [4], OC is a leading cause of death for women worldwide, in part due to ineffective screening methods. Unfortunately, OC is usually detected in advanced stages (stages III and IV) due to nonspecific clinical symptoms at earlier stages and the lack of an effective screening approach. Consequently, there is a clear unmet clinical need for the development of highly specific and sensitive assays to detect OC in its earliest stages. In their study, the authors used whole-genome cell-free DNA (cfDNA) fragmentome and protein biomarker [cancer antigen 125 (CA-125) and HE4] analyses to evaluate 591 women with OC, with benign adnexal masses, or without ovarian lesions. Using a machine learning model with the combined features, researchers detected OC with specificity >99% and sensitivities of 72%, 69%, 87%, and 100% for stages I to IV, respectively. At the same specificity, CA-125 alone detected 34%, 62%, 63%, and 100%, and HE4 alone detected 28%, 27%, 67%, and 100% of OCs for stages I to IV, respectively. This approach differentiated benign masses from OCs with high accuracy (AUC = 0.88, 95% confidence interval, 0.83-0.92). These results were validated in an independent population. These findings show that integrated cfDNA fragmentome and protein analyses detect OCs with high performance, enabling a new accessible approach for noninvasive OC screening and diagnostic evaluation.

Qian F. et al. [5] in their study note that OC is the fifth leading cause of cancer deaths in US women, due to its typically advanced stage at presentation. Furthermore, unlike breast or colorectal cancer, there is no proven screening method for OC to identify early disease and initiate treatment to improve survival. Family history, oral contraceptive use, parity, body mass index (BMI), and genetic variants are potentially useful in estimating lifetime risk. Along with this, because of differences in age at onset and tumour histology/grade, risk factors for OC might be different for BRCA1/2 mutation carriers than women in the general population. Penetrance of BRCA1/2 mutations is likely modified by other genetic variants and lifestyle or reproductive factors. Investigation of these factors could aid in implementation of strategies to reduce OC risk among mutation carriers. In their work, the authors point out that height and BMI are associated with higher OC risk in the general population, but whether such associations exist among BRCA1/2 mutation carriers is unknown. The researchers applied a Mendelian randomisation approach to examine height/BMI with OC risk using the Consortium of Investigators for the Modifiers of BRCA1/2 data set, comprising 14,676 BRCA1 and 7912 BRCA2 mutation carriers, with 2923 OC cases. They created a height genetic score using 586 height-associated variants and a BMI genetic score using 93 BMI-associated variants. Associations were assessed using weighted Cox models. Observed height was not associated with OC risk (hazard ratio [HR]: 1.07 per 10-cm increase in height, 95% confidence interval [CI]: 0.94-1.23). Height genetic score showed similar results (HR = 1.02, 95% CI: 0.85-1.23). Higher BMI was significantly associated with increased risk in premenopausal women with HR = 1.25 (95% CI: 1.06-1.48) and HR = 1.59 (95% CI: 1.08-2.33) per 5-kg/m² increase in observed and genetically determined BMI, respectively. No association was found for postmenopausal women. Interaction between menopausal status and BMI was significant (pinteraction < 0.05). Our colleagues emphasize that the results of their observation of a positive association between BMI and OC risk in premenopausal BRCA1/2 mutation carriers is consistent with findings in the general population.

Jara-Rosales S. et al. [6] in their work they say that in 2020, OC ranked fourth in incidence among gynecological cancers worldwide, following breast cancer, cervical cancer, and uterine cancer. In terms of mortality, it ranked third, establishing itself as one of the most lethal gynecological cancers. A 2021 study revealed that the variability in the incidence depends on each country and region, but the mortality rate remains similar among the 185 countries included. This behavior is attributed to nonspecific symptoms and the lack of screening programs, leading to diagnoses at advanced stages with unfavorable prognoses for patients [7]. OC constitutes a group of diverse diseases, each characterized by its own morphology and biological behavior. This heterogeneity implies that different subtypes may respond differently to treatments and show variations in their progression rates [8]. It is therefore essential to

recognize this diversity to effectively address the different manifestations of OC. The risk factors for OC are divided into two categories: modifiable and non-modifiable. Modifiable factors include smoking, hormone replacement therapy, and dietary elements, among others. Non-modifiable factors include heredity, mutations in the BRCA1 and BRCA2 genes, family history, Lynch syndrome, uninterrupted ovulation cycles, and the presence of endometriosis, among others [7].

Our colleagues conducted an exhaustive search was conducted to identify literature to describe the OC biology and physiopathology for new readers, in particular focused on clinical researchers. In addition, a more stringent search was performed to find studies related to the genetic components, social determinants, and comorbidities associated with OC in South America. The search was performed through PubMed and Google Scholar, using the MeSH descriptors and keywords such as "Hereditary Breast and Ovarian Cancer Syndrome", "Latin America", "BRCA1 Genes", "BRCA2 Genes", and "Ovarian Neoplasms". Additionally, the keywords "Obesity", "chronic disease", "Comorbidity", "poverty", "education", "race", "ethnicity", "menarche", "menopause", "multiparity", "urbanization", "epidemiology", and "risk factors" were utilized to capture relevant studies. Due the reported disparities in clinical trials and other biomedical studies, the Latin American population is greatly underrepresented in most of the cancer and genomic databases, including local investigations. For this reason, the number of identified reports according to the specific topics was very small for further analysis. The revision of the literature was conducted based on original articles, including cohort studies, case-control studies, cross-sectional studies, and experimental research investigating the risk factors for OC in the South American population, and the selected articles were published within the last 10 years, with full-text availability, and were written in English or Spanish. The authors considered studies involving women from 12 South American countries, without age restrictions, focusing particularly on those analyzing genetic components, socioeconomic determinants, and comorbidities. Considering the main goal of this work, they excluded studies focused on OC treatment, research validating laboratory tests for detecting OC-related mutations, and non-original content such as reviews, opinions, editorials, letters to the editor, and conference abstracts. Articles that did not clearly specify the region or country of interest, or those centered on education about OC risk factors, were also excluded. [6].

In the conclusions following from the study, the researchers note that based on the revised articles, it can be concluded that although there are reports on the prevalence of mutations in the BRCA1 and BRCA2 genes in South American countries, such as Chile, Colombia, Argentina, Uruguay, and Brazil, including Mexico as Hispanic, the general prevalence is close to 15-20% in women with hereditary risk factors or those diagnosed with ovarian and/or breast cancer. However, it is important to highlight that the available studies are limited. More research is needed to accurately determine the prevalence of the punctual mutation in each country, as well as those mutational signatures that could be unique for the Latin American population. In terms of the social, demographic, and economic factors that influence the incidence of OC, these vary by country, but similarities are observed in age, being more prevalent in women over 50 years old, and in women with poor education and difficulties in accessing healthcare. Similarly, the absence of studies regarding the effect of contraception and hormone replacement therapy in the Latin American population is highlighted, despite being widely studied factors in the international scientific literature. This gap in the research underscores the need to address these aspects in future research in the region. This article has several limitations, starting with the very limited number of studies published and the number of participants in each study. The revised literature covers several years of research conducted in each country; these years may represent disparities in funding for biomedical research, the number and capabilities of each research group and the possibility of enrolling patients, and the access to technological facilities. For now, it is not possible to conduct a more comprehensive analysis; however, this work may promote the interest of other researchers to collaborate in the systematic revision of current and future data. Regarding the need to improve lifestyles as a preventive measure to reduce the possibility of morbidities and the concomitant development of OC, although the literature may not be sufficient to conclusively establish a direct link between obesity and/or diabetes and the development of OC, the indirect association suggests the importance of conducting additional clinical studies. These studies could confirm or dismiss the hypothesis that obesity and diabetes could be related to the risk of developing OC, thereby providing a more solid basis for future interventions and prevention strategies [6].

Bryant A. et al. [9] provide data showing that OC is the seventh most common cancer among women and a leading cause of death from gynaecological malignancies. Epithelial OC is the most common type, accounting for around 90% of all OCs. This specific type of OC starts in the surface layer covering the ovary or lining of the fallopian tube. Surgery is performed either before chemotherapy [upfront

or primary debulking surgery (PDS)] or in the middle of a course of treatment with chemotherapy [neoadjuvant chemotherapy and interval debulking surgery (IDS)], with the aim of removing all visible tumour and achieving no macroscopic residual disease (NMRD). The aim of this study was to investigate the prognostic impact of size of residual disease (RD) nodules in women who received upfront or interval cytoreductive surgery for advanced (stage III and IV) epithelial OC (EOC). To assess the prognostic impact of RD after primary surgery on survival outcomes for advanced (stage III and IV) EOC. In separate analyses, primary surgery included both upfront PDS followed by adjuvant chemotherapy and neoadjuvant chemotherapy followed by IDS. Each RD threshold is considered as a separate prognostic factor. The authors searched CENTRAL (2021, Issue 8), MEDLINE via Ovid (to 30 August 2021) and Embase via Ovid (to 30 August 2021). Our colleagues included survival data from studies of at least 100 women with advanced EOC after primary surgery. RD was assessed as a prognostic factor in multivariate prognostic models. They excluded studies that reported fewer than 100 women, women with concurrent malignancies or studies that only reported unadjusted results. Women were included into two distinct groups: those who received PDS followed by platinum-based chemotherapy and those who received IDS, analysed separately. The researchers included studies that reported all RD thresholds after surgery, but the main thresholds of interest were microscopic RD (labelled NMRD), RD 0.1 cm to 1 cm [small-volume residual disease (SVRD)] and RD > 1 cm [large-volume residual disease (LVRD)]. Two review authors independently abstracted data and assessed risk of bias. Where possible, they synthesised the data in meta-analysis. To assess the adequacy of adjustment factors used in multivariate Cox models, authors used the 'adjustment for other prognostic factors' and 'statistical analysis and reporting' domains of the quality in prognosis studies tool.

Our colleagues also made judgements about the certainty of the evidence for each outcome in the main comparisons, using GRADE. The researchers examined differences between FIGO stages III and IV for different thresholds of RD after primary surgery. They considered factors such as age, grade, length of follow-up, type and experience of surgeon, and type of surgery in the interpretation of any heterogeneity. The authors also performed sensitivity analyses that distinguished between studies that included NMRD in RD categories of < 1 cm and those that did not. This was applicable to comparisons involving RD < 1 cm with the exception of RD < 1 cm versus NMRD. They evaluated women undergoing PDS and IDS in separate analyses. The researchers found 46 studies reporting multivariate prognostic analyses, including RD as a prognostic factor, which met inclusion criteria: 22,376 women who underwent PDS and 3697 who underwent IDS, all with varying levels of RD. While we identified a range of different RD thresholds, authors of the work mainly report on comparisons that are the focus of a key area of clinical uncertainty (involving NMRD, SVRD and LVRD). The comparison involving any visible disease (RD > 0 cm) and NMRD was also important. SVRD versus NMRD in a PDS setting In PDS studies, most showed an increased risk of death in all RD groups when those with macroscopic RD (MRD) were compared to NMRD. Women who had SVRD after PDS had more than twice the risk of death compared to women with NMRD (HR 2.03, 95% CI 1.80 to 2.29; I² = 50%; 17 studies; 9404 participants; moderate-certainty). The analysis of progression-free survival found that women who had SVRD after PDS had nearly twice the risk of death compared to women with NMRD (HR 1.88, 95% CI 1.63 to 2.16; I² = 63%; 10 studies; 6596 participants; moderate-certainty). LVRD versus SVRD in a PDS setting. When authors compared LVRD versus SVRD following surgery, the estimates were attenuated compared to NMRD comparisons. All analyses showed an overall survival benefit in women who had RD < 1 cm after surgery (HR 1.22, 95% CI 1.13 to 1.32; I² = 0%; 5 studies; 6000 participants; moderate-certainty). The results were robust to analyses of progression-free survival. SVRD and LVRD versus NMRD in an IDS setting The one study that defined the categories as NMRD, SVRD and LVRD showed that women who had SVRD and LVRD after IDS had more than twice the risk of death compared to women who had NMRD (HR 2.09, 95% CI 1.20 to 3.66; 310 participants; I² = 56%, and HR 2.23, 95% CI 1.49 to 3.34; 343 participants; I² = 35%; very low-certainty, for SVRD versus NMRD and LVRD versus NMRD, respectively). LVRD versus SVRD + NMRD in an IDS setting meta-analysis found that women who had LVRD had a greater risk of death and disease progression compared to women who had either SVRD or NMRD (HR 1.60, 95% CI 1.21 to 2.11; 6 studies; 1572 participants; I² = 58% for overall survival and HR 1.76, 95% CI 1.23 to 2.52; 1145 participants; I² = 60% for progression-free survival; very low-certainty). However, this result is biased as in all but one study it was not possible to distinguish NMRD within the < 1 cm thresholds. Only one study separated NMRD from SVRD; all others included NMRD in the SVRD group, which may create bias when comparing with LVRD, making interpretation challenging. MRD versus NMRD in an IDS setting. Women who had any amount of MRD after IDS had more than twice the risk of death compared to women with NMRD (HR 2.11, 95% CI 1.35 to 3.29, I² = 81%; 906 participants; very low-certainty). Summing up the results of the

study, the authors point out that in a PDS setting, there is moderate-certainty evidence that the amount of RD after primary surgery is a prognostic factor for overall and progression-free survival in women with advanced OC. Our colleagues separated our analysis into three distinct categories for the survival outcome including NMRD, SVRD and LVRD. After IDS, there may be only two categories required, although this is based on very low-certainty evidence, as all but one study included NMRD in the SVRD category. The one study that separated NMRD from SVRD showed no improved survival outcome in the SVRD category, compared to LVRD. Further low-certainty evidence also supported restricting to two categories, where women who had any amount of MRD after IDS had a significantly greater risk of death compared to women with NMRD. Therefore, the evidence presented in this review cannot conclude that using three categories applies in an IDS setting (very low-certainty evidence), as was supported for PDS (which has convincing moderate-certainty evidence) [9].

What knowledge is available today about the specifics of OC treatment? Drug resistance is the bottleneck in OC treatment. The increasing use of novel drugs in clinical practice poses challenges for the treatment of drug-resistant OC. Although maintenance therapy with PARP inhibitors (PARPis) has prolonged progression-free survival and 5-year overall survival, unfortunately, many patients do not respond to PARPis treatment due to intrinsic or acquired resistance [10].

Wang L. et al. [11] indicate that despite receiving standard-of-care therapy (optimal cytoreductive surgery followed by adjuvant chemotherapy), most patients develop recurrent disease, which is resistant to chemotherapy, resulting in a 5-year survival rate of approximately 30-40% worldwide. Drug resistance is a formidable challenge in the treatment of OC and is the primary contributor to poor prognosis. According to the National Comprehensive Cancer Network guidelines (version 1.2023), there are many therapeutic regimens for resistant OC, including some novel agents. However, the objective remission rate is still low, and the median survival time is less than 12 months due to complicated resistance mechanisms. In resistant OC, the classical mechanisms of action of common drugs can be disrupted or altered, possibly resulting in impaired therapeutic effects. Thus, treatment regimens should not rely only on empirical options. As the number of categories of agents increases, after the development of multidrug resistance, the decision of appropriate later-line therapeutic regimens is very challenging. The authors reviewed the literature regarding various drug resistance mechanisms in OC and found that the main resistance mechanisms are as follows: abnormalities in transmembrane transport, alterations in DNA damage repair, dysregulation of cancer-associated signaling pathways, and epigenetic modifications. DNA methylation, histone modifications and noncoding RNA activity, three key classes of epigenetic modifications, constitute pivotal mechanisms of drug resistance. One drug can have multiple resistance mechanisms. Moreover, common chemotherapies and targeted drugs may have cross (overlapping) resistance mechanisms. MicroRNAs (miRNAs) can interfere with and thus regulate the abovementioned pathways. A subclass of miRNAs, "epi-miRNAs", can modulate epigenetic regulators to impact therapeutic responses. Thus, they also reviewed the regulatory influence of miRNAs on resistance mechanisms. Moreover, researchers summarized recent phase I/II clinical trials of novel drugs for OC based on the abovementioned resistance mechanisms. A multitude of new therapies are under evaluation, and the preliminary results are encouraging. Summarizing the results of the study, our colleagues emphasize that with the increasing use of novel therapeutic drugs for OC, the development of later-line treatments has been under enormous pressure. Recently, resistance to a variety of therapeutic drugs, such as PARPis, angiogenesis inhibitors, and immune checkpoint inhibitors, has been found to occur. In the past, therapeutic agents for OC have been limited, and researchers have usually described the underlying mechanism and explored therapeutic strategies for overcoming resistance based on the drug classification. However, as increasing numbers of new agents are applied in clinical practice, the resistance mechanisms of these various new drugs must be identified, and these mechanisms may be similar or even identical to those of other drugs. Thus, the classification of drug resistance should not be confined to the drug category, and all should attempt to obtain insight into classification of resistance based on molecular mechanisms. The concept of drug resistance classification provides a sound basis for further research to develop more precise reversal strategies.

Instead of simply distinguishing resistance by agent, researchers attempted to classify drug resistance by mechanism. The authors summarized four major mechanisms from the published literature: 1) abnormalities in transmembrane transport, 2) alterations in DNA damage repair, 3) dysregulation of cancer-associated signaling pathways, and 4) epigenetic modifications. In the context of the increasing number of novel agents, summary of the four resistance mechanisms of OC provides a new concept for resistance classification by molecular mechanism, not by drug category. Given the intersections between drug resistance mechanisms, this concept is likely to result in the realization of "two birds with one stone"

effects on the reversal of drug resistance in OC. Furthermore, these findings are anticipated to have broad implications for the development of precise therapeutic approaches for reversing drug resistance in OC. On this basis, umbrella trials can be carried out to explore the diagnostic and therapeutic targets of the four resistance mechanisms, and this may be a direction of future researches on drug resistance in OC [11].

As Porter J.M. et al. [12] note in their study epithelial OC (ovarian carcinoma) is the most common form of the disease and comprises multiple histological types (histotypes): high-grade serous (70% of patients), endometrioid (10%), clear cell (10%), low-grade serous ($\leq 5\%$), and mucinous ($\leq 5\%$). Ovarian carcinosarcomas - previously considered a separate disease entity - are now recognized to represent metaplastic carcinomas and account for no more than 5% of diagnoses. A wealth of evidence now demonstrates that each histotype represents a unique disease entity, each with distinct developmental origins, molecular landscapes, intrinsic chemosensitivity, survival profile, and susceptibility to targeted molecular therapeutics.

The authors emphasize that complete macroscopic resection is a key factor associated with prolonged survival in OC. That being said, patients with clear cell ovarian carcinoma and low-grade serous ovarian carcinoma represent some of the groups that benefit most from achieving complete macroscopic resection; given that these cases are unlikely to respond well to neoadjuvant chemotherapy, complete primary cytoreduction is a major priority for these patients. Endometrioid ovarian carcinoma also represents a histotype in which complete macroscopic resection is associated with marked patient survival benefit. Engagement with multiple surgical teams to improve the likelihood of resecting disease at hepatobiliary, gastrointestinal, and other anatomical sites beyond the pelvis will be key for delivering optimal outcomes for such cases that present with extensive advanced-stage disease. More work is also required to understand the impact of resecting disease outside of the pelvis and abdomen. Achievement of complete macroscopic resection across the overall OC patient population is associated with markedly prolonged survival time, though differences in the degree of survival benefit are apparent across different histotypes. Patients with clear cell ovarian carcinoma derive one of the greatest survival benefits associated with complete macroscopic resection. High-grade serous ovarian carcinoma patients demonstrate highly clinically and statistically meaningful survival benefit, but the magnitude of benefit is lower than in some of the other histotypes. The extent of benefit from complete macroscopic resection does not appear to relate solely to levels of intrinsic chemosensitivity of each histotype [12].

Now, as for this pathology in our country at the republican level. The incidence of OC in the Republic of Kazakhstan in 2023 was 6.3 per 100 thousand population (6.2 in 2022) with a growth rate of 2.1% compared to the previous year, amounting to 1,251 people in absolute numbers (1,201 women a year earlier). The proportion of cases with a diagnosis established for the first time in life, recorded by oncological organizations, was 3.4%, as in the previous year in the general population, and 6.0% among women (in 2022 also 6.0%) and 4th rank place after breast cancer, cervical cancer and endometrial cancer [13].

Above the national average, OC was established in 8 regions of the country: the city of Almaty - 10.4 (maximum indicator); Pavlodar - 9.7; Karaganda - 8.6; Abay - 8.4; Akmola - 7.7; Kostanay - 7.6; North Kazakhstan - 7.5; West Kazakhstan - 7.2. Aktobe, Atyrau and Kyzylorda regions are on par with the national average. This indicator is lower than the national average in the remaining 9 regions: Turkestan - 2.9 (the lowest level); Mangistau - 3.5; Ulytau - 3.6; Almaty - 3.7; Zhambyl - 4.3; the city of Shymkent - 4.6; East Kazakhstan - 5.8; Zhetysay - 5.9 regions and the city of Astana - 6.2 per 100 thousand people. The mortality rate from this pathology in 2023 was 2.1, a year earlier - 2.4 per 100 thousand population. The regions where the mortality rate from OC is higher than the average in the republic (2.1 per 100 thousand population) include: Abay - 3.0 (maximum level); the city of Astana - 2.9; Karaganda and Pavlodar - 2.5; Kyzylorda - 2.4; Aktobe and the city of Almaty - 2.2. This indicator is at the same level with the national average in the East Kazakhstan region. The lowest rates were noted in Turkestan - 1.5 (minimum rate); Almaty and Atyrau - 1.6; Zhambyl - 1.7; Ulytau and Mangistau - 1.8; North Kazakhstan and Kostanay - 1.9; West Kazakhstan, Zhetysay, Akmola regions and the city of Shymkent - 2.0 per 100 thousand population [13].

The one-year mortality rate was 7.2% (7.9% in 2022). At the same time, the ratio between one-year mortality and neglect (stage IV) was quite high - 1.7 (a year earlier it was even higher - 2.1. At the same time, it should be noted that the farthest from "1" is the worst ratio between one-year mortality and neglect.

Now, regarding preventive examinations. It should be noted that during large-scale preventive examinations of the population in 2023, significantly more patients with malignant neoplasms were

actively identified than in 2022. This is 25,193 patients against 23,623 patients identified in 2022, i.e. +6.6%. This is due to the further abatement of the epidemiological troubles due to coronavirus and the increased availability of preventive care for the population. The proportion of patients identified during preventive examinations increased from 62.0% to 62.4% of the total number of patients identified per year.

Of course, with in the analysis of the epidemiological situation, the indicators of early diagnostics are very important issues. In general, in terms of the amount of detected cases of cancer of all localizations, in 2023 the proportion of forms detected at early stages (0, I-II stages) increased from 66.3% to 67.9%. As for OC, the early detection of this pathology during preventive examinations increased from 40.5 to 44.8%. The number of newly diagnosed patients with OC registered with oncology organizations amounted to 1,218 people (1,173 - a year earlier). At the same time, the absolute number of cases detected during preventive examinations in 2023 was 863, in 2022 - 875; the proportion of cases detected during preventive examinations was 70.9% and 74.6%, respectively. Of these, patients with stages I-II - 387 in 2023 and 354 in 2022.

The regions where the proportion of patients with early stage I of the pathology in question is above the national average (31.0% and 9th place among all nosological forms of malignant neoplasms) include the following regions: the city of Almaty - 45.3%; (the best indicator); Zhetysu - 43.9%; the city of Astana - 42.2%; Zhambyl - 38.5%; Kyzylorda - 35.8%; East Kazakhstan and Akmola - 35.0%; Kostanay - 33.9%; Almaty - 33.3%.

The lowest rates of early diagnosis were recorded in 11 regions. Against this background, two regions stand out - Aktobe and Turkestan, where stage I of the disease was established at only 5.2% and 6.5%, respectively (the worst rates in the republic). Next come: Mangistau - 16.0%; the city of Shymkent - 18.5%; Pavlodar - 23.3%; Abay - 23.4%; Ulytau and West Kazakhstan - 25.0%; Karaganda - 25.5%; Atyrau - 28.6% and North Kazakhstan - 30.8% of the region [13]. It should be noted that only two patients out of every five were detected in the early (I-II stages) of this pathology, making up 41.7% in the republic. The regions where the proportion of patients with OC detected at stages I-II is higher than the national average include the following regions. The best indicator is in the Zhetysu region - 51.2%. Then come two megacities - the cities of Almaty (51.6%) and Astana (50.6%); then - East Kazakhstan and Atyrau (50.0%); Akmola (48.3%); Mangistau (48.0%); Kostanay (45.2%); Zhambyl (44.2%); North Kazakhstan (43.6%); Karaganda (42.6%) regions. Low rates of early diagnosis were recorded in the following regions. Against the general background, the Aktobe region stands out negatively, where only every tenth patient was detected in the early stages of the disease - 10.3%. Then come the following regions: Turkestan (16.1%); Shymkent city (31.5%); West Kazakhstan (33.3%); Abay (34.0%); Almaty (37.0%); Ulytau (37.5%); Pavlodar (41.1%) and Kyzylorda (41.5%) regions [13].

As can be clearly seen from the above data, there is a very large spread in early diagnostic rates across the country, from good to disappointing. Of course, it is necessary to take into account migration processes and other factors that affect early diagnostic rates, but nevertheless, the results obtained give reason not to stop there, both for oncologists and gynecological oncologists, as well as for obstetricians and gynecologists, visual diagnostic doctors, and general practitioners, since improving the rates of early diagnostics of malignant tumors has remained one of the main postulates and one of the main tasks of medicine in general, and continues to be relevant today. The proportion of stage IV OC among all nosological forms of malignant neoplasms was 7.2%, and this is the 17th rank. In general, in 2023, the proportion of malignant neoplasms of stage IV in the republic for the sum of all nosologies decreased from 12.58 to 11.7% (from 4790 to 4735 patients).

As for the average national indicator of the proportion of stage IV (7.2%), Zhetysu and Mangistau regions stand out against this background - 0.0%. Then come: Kyzylorda and Zhambyl (1.9%); Atyrau (2.4%); North Kazakhstan (2.6%); the city of Almaty (3.6%); East Kazakhstan (5.0%); Pavlodar (5.5%). The city of Astana is on the same level with the average national indicator. The indicators are lower in the following regions. Abay region stands apart from all others, where every fifth patient is diagnosed in the terminal stage of the disease (21.3%). Next come: Turkestan (12.9%); Karaganda (12.8%); Ulytau (12.5%); Aktobe (12.1%); the city of Shymkent (11.1%); Akmola (10.0%); Kostanay (9.7%); West Kazakhstan (8.3%); Almaty (7.4%) regions.

The morphological verification rate of the disease in the country was 84.3%. In 5 regions out of 20, this is a 100% figure (East Kazakhstan, Zhambyl, Ulytau regions, as well as the cities of Astana and Shymkent). The lowest figure is in the Kyzylorda region (32.1%). Next on this list are the city of Almaty (55.2%); Zhetysu (78.0%); Mangistau and Akmola (80.0%); Aktobe (91.4%); Atyrau (92.9%); West Kazakhstan (93.8%); North Kazakhstan (94.9%); Turkestan and Kostanay (95.2%); Karaganda (95.7%);

Pavlodar (95.9%); Almaty (96.3%) and Abay (97.9%) regions [13].

The total number of patients with malignant neoplasms, consisting of registered in specialized oncological organizations of the republic, continued to grow and by the end of 2023 amounted to 218,186 people, with an increase of 6.0% compared to the level of the previous year (2022 - 205,822, +5.8%). The overall incidence rate of malignant neoplasms increased by 3.9%, from 1055.3 to 1096.4 per 100 thousand population. The growth of this indicator is due to both the increase in the incidence and detection of pathology, and the increase in the survival rate of cancer patients. In addition, statistical data on patients diagnosed with malignant neoplasms, who have been under observation for 5 years or more, and continue to be observed in 2023, showed that the number of patients under observation by oncological organizations in Kazakhstan for over five years continued to grow and at the end of the reporting year amounted to 117,616 people, with an increase of 6.2% (2022 - 110,790 people, +6.6%) (form. No. 7).

It is impossible to ignore such an important clinical aspect as the coverage of patients with a first-ever diagnosis of OC in the Republic of Kazakhstan with specialized treatment.

In 2023, the number of hospitalizations for all nosological forms of malignant tumors in the country's oncology organizations amounted to 108,252 cases (2022 - 101,095), with an increase of 7.1% compared to the previous year, which is associated with a constant increase in the number of cancer patients, improved standardization of oncological care, and the development of palliative and restorative services.

At the end of 2023, the absolute number of patients with OC who completed specialized treatment amounted to 697 people, continuing treatment - 387 patients. The following results were obtained in percentage terms by methods and types of treatment. The overwhelming majority of patients received complex treatment - 68.4%, only surgical treatment - 21.1%, only drug treatment - 8.3%; combined - 0.3%, chemo-radiation - 0.1%.

Next, regarding the five-year survival rate of patients. As for OC, at the end of 2023, 8229 people or 41.4 per 100 thousand of the population were registered with the dispensary (at the end of 2022 - 7864 patients or 40.3 per 100 thousand of the population, respectively); and this is the 9th rank place among all nosological forms of malignant neoplasms.

At the same time, the mortality rate of the observed contingents in 2023 was 5.0% (6.0% - in 2022).

The five-year survival rate of patients with OC was 58.2% in 2023 (57.5% - a year earlier) [13].

Summarizing the above, we can conclude that OC occupies a significant place among all existing malignant tumors of other localizations. At the same time, despite the small percentage of patients detected at stage IV, taking into account a number of factors, the indicators of early diagnostics do not allow oncologists to "sleep peacefully", since the locally advanced stage III, which significantly prevails over all stages, in addition to the prevalence itself, gives a large number of complications and locoregional metastases, and these patients are subject to aggressive complex treatment, constituting the overwhelming percentage (68.4%) among all methods of treating this pathology. The variability and veiling of symptoms, its similarity with various non-core processes (sometimes the only symptom is a gradual increase in the abdomen due to ascites), leads to the neglect of the disease. All this requires both oncologists and gynecological oncologists, and, first of all, primary health care workers, as well as obstetricians and gynecologists and visual diagnostics doctors, to increase the level of cancer alertness, inform the population about early symptoms that may indicate this pathology or the onset of proliferative changes and conduct high-tech diagnostic measures and, as a result, timely treatment. Women at risk are advised to visit specialized specialists annually and, if necessary, undergo an examination.

An epidemiological assessment of the situation with OC in our country suggests that there are sometimes significant differences between regions not only in incidence rates, but also in the parameters of early diagnosis and mortality from this pathology. In connection with the above, this pathology continues to be a serious problem in modern clinical oncology.

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LARYNGEAL CANCER: CONTEMPORARY STATE OF THE PROBLEM**Arman Khozhayev***Professor of the S.N. Nugmanov Department of Oncology,
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This scientific and analytical work presents modern world and local-regional data on incidence, mortality, lethality and five-year survival rate of such oncological pathology of head and neck tumors as laryngeal cancer. The issues of etiology and pathogenesis, features of distribution, modern approaches and principles of complex diagnostics, prospects for improving treatment results, as well as prognosis are covered in detail. The epidemiological characteristics of this pathology in our republic are given in the context of regions of the country.

Keywords: *oncology, otorhinolaryngology, laryngeal cancer, human papillomavirus, biomarkers, RNA, immune-related genes, autophagy, epidemiology, incidence, mortality, lethality, five-year survival rate, prognosis.*

Laryngeal cancer (LC) is a malignant tumor that develops from elements of the non-keratinizing epithelium of the larynx.

The etiologic factors remain unclear to date. In most cases, the patient's medical history includes untreated inflammatory and precancerous diseases of the larynx (laryngitis, papillomas, papillomatosis, dyskeratosis, leukoplakia, pachydermia, fibroma); a long period of smoking, alcohol consumption, work in dusty conditions (textile production), inhalation of harmful carcinogenic substances (oil, its distillation products, benzene, phenolic resins, asbestos); genetic predisposition (the presence of malignant diseases in relatives), as well as age and gender (males over 55 years of age) [1,2].

The diagnostic criteria are as follows. Complaints and medical history. Complaints: cough; hoarseness; sore throat radiating to the ear; difficulty breathing; choking when taking liquid food; enlarged cervical, supraclavicular, subclavian, submandibular, and submental lymph nodes. History: early symptoms of the disease in LC are: hoarseness and cough, which appear already at stage I of the disease; when,

at the initial visit of patients, hoarseness has been observed for six months with the addition of other symptoms, this may indicate later stages (III-IV) of the disease. In this case, complaints of shooting pain in the ear, difficulty breathing, choking when taking liquid food or water, and the appearance of enlarged nodes on the neck are also added [1].

Physical examination: indirect laryngoscopy (tumor, formation of one of the parts of the larynx, limited mobility of the true vocal cord or fixation of the affected half of the larynx, narrowing of the glottis); palpation examination of the lymph nodes of the neck on both sides (the presence of enlarged cervical lymph nodes of a dense consistency, immobile or stiff, slightly painful or possibly not painful, more than 1.0 cm in size).

Laboratory tests: cytological examination (increase in cell size up to giant, change in the shape and number of intracellular elements, increase in the size of the nucleus, its contours, different degrees of maturity of the nucleus and other cell elements, change in the number and shape of nucleoli); histological examination (large polygonal or spiky cells with well-defined cytoplasm, round nuclei with clear nucleoli, with the presence of mitoses, cells are located in the form of cells and cords with or without keratin formation, the presence of tumor emboli in the vessels, the severity of lymphocytic plasmacytic infiltration, mitotic activity of tumor cells).

Instrumental examinations: ultrasound examination of the cervical, submandibular, supraclavicular, subclavian lymph nodes (contours are clear, uneven, echogenicity is reduced, there may be areas of mixed echogenicity, the structure of the node is heterogeneous, increased vascularization is possible); computed tomography of the larynx (a tumor formation of the larynx, occupying the right or left half, spreading to the piriform sinus or the root of the tongue or soft tissues of the anterior surface of the neck, or to the trachea area, conglomerates of lymph nodes of various sizes are possible, compressing or displacing or growing into the vascular-nerve bundle of the neck); biopsy of a laryngeal tumor (cytological examination of the material reveals an increase in the size of the cell up to giant, a change in the shape and number of intracellular elements, an increase in the size of the nucleus, its contours, different degrees of maturity of the nucleus and other elements of the cell, a change in the number and shape of nucleoli; histological examination of the material reveals large polygonal or spiky cells with well-defined cytoplasm, round nuclei with clear nucleoli, with the presence of mitoses, the cells are arranged in the form of cells and cords with or without the formation of keratin, the presence of tumor emboli in the vessels, the severity of lymphocyte-plasmocyte infiltration, mitotic activity of tumor cells); fine-needle aspiration biopsy of enlarged lymph nodes of the neck (during cytological examination of the material - an increase in the size of the cell up to giant, a change in the shape and number of intracellular elements, an increase in the size of the nucleus, its contours, different degrees of maturity of the nucleus and other elements of the cell, a change in the number and shape of nucleoli) [1].

As noted by Huang J. et al. [3] though the LC only has 1% of the total cancer cases and related deaths, it is a type of head and neck cancers with the highest prevalence. Cigarette smoking and alcohol consumption was found to have the strongest relation with LC; other potential risk factors include age (≥ 65), sex (male), family history of cancer, chemical workplace exposure, gastro-esophageal reflux, and exposure to human papillomavirus (HPV).

In their work, the authors emphasize that the global incidence and mortality rates of LC in 2020 was extracted from the Global Cancer Observatory (GLOBOCAN) database, developed by the International Agency for Research on Cancer, World Health Organization (WHO) [4].

The Gross Domestic Products (GDP) and Human Development Index (HDI) for each country were retrieved from World Bank and United Nations. For the categorization of HDI rates, <0.550 , $0.550-0.699$, $0.700-0.700$, and ≥ 0.800 are considered low, medium, high, and very high. Data from 1980 to 2020 were obtained, and the data of the most recent 10 years were used for trend analysis. The WHO mortality database was used for cancer-related death data for each country and region. Cancer mortality data was collected from national civil cancer registries on a local and national level with the registering system logging verified cancer deaths and their causes, which is then reported to WHO annually. To ensure the quality of data, only figures with medium quality or above were published by the WHO mortality database based on the timeliness, completeness and coverage of registration and the proportion of deaths assigned to ill-defined causes. All incidence and mortality figures of LC were transformed - using the Segi-Doll world reference population for various nations - into an age-standardised rate (ASR) per 100 000 individuals. Weighting was allocated in accordance with proportions of people in the standard population's corresponding age groups. This enabled the current study to compare incidence and mortality rates across different countries over time [3].

There were 184 615 newly reported cases of LC in 2020, with an ASR incidence of 2.0 per 100 000

persons. Incidence varied geographically, region with the highest incidence was Caribbean (ASR=4.0) followed by Central and Eastern Europe (ASR=3.6) and Southern Europe (ASR=2.9). Regions with the lowest incidence include Middle Africa (ASR=0.76), Western Africa (ASR=0.79), and Central America (ASR=0.86). There was a remarkable disparity among the two sexes in terms of incidence, as the global ASR of males (ASR=3.6) was more than seven times higher than that of females (ASR=0.49). The highest incidence was in countries with medium HDI (ASR=2.5), followed by very high HDI (ASR=2.3), high HDI (ASR=1.6), and low HDI (ASR=0.94). In 2020, 99 840 LC-related deaths were reported, which was slightly more than 1% of the total cancer-related deaths. Globally, LC has an ASR of 1.0 per 100 000 persons in mortality. In terms of the geographical distribution, the Caribbean region (ASR=2.1) had the highest mortality rate, doubling the global average, followed by Central and Eastern Europe (ASR=1.9), and South-Central Asia (ASR=1.7). Regions with the lowest mortality were Australia and New Zealand (ASR=0.34), Micronesia (ASR=0.45), and Middle Africa (ASR=0.54). Similar to incidence, the highest mortality was in countries with medium HDI (ASR=1.6), followed by high HDI (ASR=0.92), very high HDI (ASR=0.86), and low HDI (ASR=0.71). Among males LC incidence was associated with a higher HDI [$\beta=0.175$, 95% confidence interval (CI): 0.111-0.239, $P<0.001$], prevalence of smoking ($\beta=0.051$, 95% CI: 0.041-0.061, $P<0.001$), alcohol drinking ($\beta=0.040$, 95% CI: 0.028-0.052, $P<0.001$), unhealthy dietary ($\beta=0.012$, 95% CI: 0.006-0.018, $P<0.001$), obesity ($\beta=0.022$, 95% CI: 0.012-0.031, $P<0.001$), hypertension ($\beta=0.031$, 95% CI: 0.022-0.041, $P<0.001$), diabetes ($\beta=0.032$, 95% CI: 0.014-0.051, $P=0.001$), and lipid disorders ($\beta=0.021$, 95% CI: 0.013-0.029, $P<0.001$). Among females, incidence was associated with a higher HDI ($\beta=0.114$, 95% CI: 0.050-0.178, $P<0.001$), prevalence of smoking ($\beta=0.049$, 95% CI: 0.033-0.065, $P<0.001$), inactivity ($\beta=0.040$, 95% CI: 0.009-0.072, $P=0.011$), obesity ($\beta=0.013$, 95% CI: 0.004-0.022, $P=0.004$), hypertension ($\beta=0.012$, 95% CI: 0.002-0.023, $P=0.024$), diabetes ($\beta=0.051$, 95% CI: 0.031-0.071, $P<0.001$), and lipid disorders ($\beta=0.015$, 95% CI: 0.007-0.023, $P<0.001$). Among males LC mortality was associated with a higher HDI ($\beta=0.094$, 95% CI: 0.025-0.163, $P<0.001$), prevalence of smoking ($\beta=0.044$, 95% CI: 0.033-0.054, $P<0.001$), alcohol drinking ($\beta=0.025$, 95% CI: 0.013-0.038, $P<0.001$), unhealthy dietary ($\beta=0.009$, 95% CI: 0.003-0.015, $P=0.002$), obesity ($\beta=0.016$, 95% CI: 0.006-0.025, $P=0.001$), hypertension ($\beta=0.025$, 95% CI: 0.015-0.034, $P<0.001$), and lipid disorders ($\beta=0.013$, 95% CI: 0.004-0.021, $P=0.003$). Among females, mortality was associated with a lower GDP per capita ($\beta=-0.076$, 95% CI: -0.126-0.027, $P=0.003$), and prevalence of alcohol drinking ($\beta=-0.060$, 95% CI: -0.085-0.035, $P<0.001$) [3].

Overall, more countries were showing decreasing trends than increasing trends in LC while such trends were less evidence among female population, younger subjects, and countries from Europe. The overall incidence for males was decreasing while females reported mixed trends. For males, significant increases were found only in Cyprus [average annual percent change (AAPC)=5.88; 95% CI: 0.52-11.52; $P=0.035$], whilst decreasing trends were reported in 24 countries evenly distributed in different continents, Chile (AAPC=-11.5; 95% CI: -20.99-0.88; $P=0.038$) reported the largest decrease, followed by the Philippines (AAPC=-7.71; 95% CI: -12.15-3.05; $P=0.006$), and Norway (AAPC=-5; 95% CI: -8.71-1.14; $P=0.018$). For females, three countries showed significant increasing trends: Japan (AAPC=6.01; 95% CI: 1.51-10.71; $P=0.015$), Switzerland (AAPC=5.61; 95% CI: 0.05-11.49; $P=0.048$), and Czech Republic (AAPC=3.31; 95% CI: 1.28-5.39; $P=0.005$). Evident decreases were found in six countries, with India (AAPC=-8.35; 95% CI: -13.62-2.75; $P=0.009$), Korea (AAPC=-8.28; 95% CI: -11.68-4.74; $P=0.001$), and Turkey (AAPC=-6.05; 95% CI: -10.21-1.69; $P=0.013$) reporting the largest decreases. Similar to the incidence trends, there was a remarkable difference between the mortality trends of males and females. For males, only Thailand (AAPC=5.41; 95% CI: 3.56-7.30; $P<0.001$) reported significant increases. On the contrary, significant decreases were observed in 30 countries. The largest decreases were found in Korea (AAPC=-7.17; 95% CI: -8.65-5.66; $P<0.001$), Singapore (AAPC=-7.10; 95% CI: -13.59-0.11; $P=0.047$), and France (AAPC=-5.96; 95% CI: -6.76-5.15; $P<0.001$). For females, significant increasing trends were found in Israel (AAPC=12.49; 95% CI: 0.81-25.51; $P=0.038$); while significant decreases were reported in eight countries, with Korea (AAPC=-10.58; 95% CI: -15.61-5.24; $P=0.002$), Belarus (AAPC=-7.93; 95% CI: -13.55-1.95; $P=0.010$), and Colombia (AAPC=-5.68; 95% CI: -8.04-3.27; $P=0.001$) reported the most evident decreases. For the older males aged 50 or above two countries reported significant increases: Cyprus (AAPC=6.87; 95% CI: 1.16-12.91; $P=0.024$), and Belarus (AAPC=1.41; 95% CI: 0.28-2.55; $P=0.021$). In contrast, significant decreases were observed in 21 countries sporadically distributed worldwide. The largest decreases were found in Chile (AAPC=-10.31; 95% CI: -19.44-0.14; $P=0.048$), Philippines (AAPC=-7.57; 95% CI: -11.86-3.08; $P=0.005$), and Norway (AAPC=-5.69; 95% CI: -8.87-2.41; $P=0.004$). For females aged 50 or above, three countries, all European countries, reported significant increases: Spain (AAPC=6.76; 95% CI: 2.03-11.72; $P=0.01$), Switzerland (AAPC=5.38; 95% CI: 0.25-10.78;

$P=0.042$), and Czech Republic (AAPC=4.00; 95% CI: 1.73-6.32; $P=0.003$) reported the largest increases. On the other hand, four populations showed significant decreasing trends, Turkey (AAPC=-6.50; 95% CI: -11.64-1.07; $P=0.025$) reported the largest decline, followed by Canada (AAPC=-4.36; 95% CI: -6.94-1.70; $P=0.006$), and the white population in the USA (AAPC=-2.98; 95% CI: -5.13-0.78; $P=0.014$). Similar distribution but larger increase was found in males aged below 50 Norway (AAPC=18.77; 95% CI: 4.55-34.92; $P=0.014$) and Thailand (AAPC=10.24; 95% CI: 0.36-21.09; $P=0.044$) reported significant increasing trends, whereas evident decreasing trends were observed in 17 countries, predominately Asian and European countries, with Germany (AAPC=-17.17; 95% CI: -26.66-6.44; $P=0.007$), Denmark (AAPC=-9.88; 95% CI: -17.74-1.26; $P=0.030$), and France (AAPC=-9.66; 95% CI: -14.70-4.32; $P=0.004$) showing the greatest decreases. From the raw data, the highly significant increasing trend observed in the younger male population of Norway and Thailand was likely due to the statistical base effect as unusually low ASR was reported in the start of the 10-year interval 2010-2011 (Norway); 2003 (Thailand). For their younger females aged below 50, significant decreases were observed in two countries/regions: Hong Kong, SAR, China (AAPC=-12.44; 95% CI: -21.77-1.99; $P=0.026$) and Korea (AAPC=-11.79; 95% CI: -21.66-0.67; $P=0.041$), while no country reported significant increase [3].

In conclusion, our colleagues point out that the reported incidence for LC has been decreasing remarkably for the past decades, especially for the male population, potentially due to the reduced consumptions of cigarettes and alcohol. Its mortality has also been decreasing, possibly attributable to broader availability and applications of treatments. However, regional disparity in mortality remains due to difference in level of access to surgical care. On the contrary, it is alarming that some evident increases were observed in the female populations and younger subjects from some countries. If no mitigation interventions are implemented, such trends may continue. It is also recommended that governments should continue the implementation of smoking and alcohol reduction campaigns, to minimize further burden on healthcare system.

Nocini R. et al. in their work they say that [5] LC is a form of malignancy originating from the anatomic site called larynx (also commonly known as "voice box"), which is anatomically divided in three regions including the supraglottic larynx (encompassing the epiglottis, false vocal cords, ventricles, aryepiglottic folds and arytenoids), the glottis (encompassing the true vocal cords and the anterior and posterior commissures) and the subglottic region. Among squamous cell carcinomas, the well and moderately differentiated forms slightly prevail over poorly differentiated tumors; the larger number of LC cases originate from the glottic region (i.e., approximately two-third), followed by the supraglottic area (about 30%), whilst transglottic and purely subglottic tumors are generally less frequent. The more important risk factors for LC include tobacco use, excessive alcohol ingestion, gastro-esophageal reflux, Plummer-Vinson syndrome, anatomical malformations, exposure to heat, chemicals, asbestos, nickel or ionizing radiations, along with some viral infections (e.g., HPV). The most frequent symptoms of laryngeal malignancies include hoarseness, sore throat, dysphagia and/or painful swallowing, impairment in voice quality, otalgia, cough and hemoptysis. Despite hoarseness can develop early in patients with laryngeal malignancies, in many cases the cancer has already deeply involved the vocal cords and spreads to regional lymphatics at diagnosis. Primary tumor volume, composite nodal volumes, composite primary tumor and nodal volumes are significant predictors of unfavorable prognosis, along with advanced age, performance status, grade and depth of invasion.

In their work, the researchers note that LC is an important oncologic entity, whose prognosis depends on establishing appropriate preventive and diagnostic measures, especially in populations at higher risk. The current incidence, prevalence and mortality of LC are estimated at 2.76 cases/year per 100,000 inhabitants, 14.33 cases/year per 100,000 inhabitants and 1.66 deaths/year per 100,000 inhabitants, respectively, averaging 3.28 million Disability-Adjusted Life Years each year. Incidence and prevalence have increased by 12% and 24%, respectively during the past 3 decades, whilst mortality has declined by around 5%. The epidemiologic burden of this malignancy is approximately 5-fold higher in males and increases in parallel with ageing, peaking after 65 years of age. Both incidence and mortality rates are higher in Europe and lower in Africa, but the ratio between deaths and incidence is the highest in Africa. Incidence has gradually declined in Europe during the past 3 decades, whilst it has increased in South-East Asia and Western Pacific. Cigarette smoking and alcohol abuse contribute for about 90% of overall worldwide mortality for LC. At the same time, the conclusions state that LC still poses a high clinical and societal burden, with an escalating temporal trend not expected to reverse soon [5].

An interesting work was presented by Li C. et al. [6]. In this study, authors aimed to explore the roles of cuproptosis-related genes in LC and their potential as prognostic markers and therapeutic targets. LC, characterized by high recurrence rates and a lack of effective biomarkers, has been associated

with cuproptosis, a regulated cell death process linked to cancer progression. They collected comprehensive data from The Cancer Genome Atlas and Gene Expression Omnibus databases, including gene expression profiles and clinical data of LC patients. Using clustering and gene analysis, researchers identified cuproptosis-related genes with prognostic significance. A risk model was constructed based on these genes, categorizing patients into high- and low-risk groups for outcome comparison. Univariate and multivariate analyses were conducted to identify independent prognostic factors, which were then incorporated into a nomogram. Gene Set Enrichment Analysis was employed to explore pathways distinguishing high- and low-risk groups. This risk model, based on four genes, including transmembrane 2, dishevelled binding antagonist of β -catenin 1, stathmin 2, and G protein-coupled receptor 173, revealed significant differences in patient outcomes between high- and low-risk groups. Independent prognostic factors were identified and integrated into a nomogram, providing a valuable tool for prognostic prediction. Gene Set Enrichment Analysis uncovered up-regulated pathways specifically associated with high-risk patient samples. The authors point out that this study highlights the potential of cuproptosis-associated genes as valuable prognostic markers and promising therapeutic targets in the context of LC and sheds light on new avenues for understanding and treating this complex disease.

In a study by Ren L. et al. [7], immune signatures of LC were systematically analyzed and their role in tumor progression was assessed. Differentially expressed immune-related genes (IRGs) were screened between LC and normal tissues from The Cancer Genome Atlas (TCGA) dataset. Then, two prognosis-related IRGs aquaporin 9 (AQP9) and zeta chain of T cell receptor associated protein kinase 70 (ZAP70) were analyzed by a series of survival analysis. Based on them, molecular subtypes were constructed by unsupervised cluster analysis. Differences in survival outcomes, human leukocyte antigen (HLA) expression and immune cell infiltrations were assessed between subtypes. Expression of AQP9 and ZAP70 was validated in LC tissues and cells by reverse transcription-quantitative polymerase chain reaction (RT-qPCR) and immunohistochemistry. After silencing and overexpressing AQP9 and ZAP70, cholecystokinin-8 (CCK-8), 5-ethynyl-2'-deoxyuridine (EdU), wound healing and transwell assays were performed in TU212 and LCC cells. Totally, 315 IRGs were abnormally expressed in LC. Among them, AQP9 and ZAP70 were distinctly correlated to patients' prognosis. Two subtypes were developed with distinct survival outcomes, HLA expression and immune microenvironment. Low expression of AQP9 and ZAP70 was confirmed in LC. AQP9 and ZAP70 up-regulation distinctly suppressed proliferation, migration, and invasion of LC cells. The opposite results were investigated when their knockdown.

Our colleagues focus on the fact that the obtained findings revealed the roles of AQP9 and ZAP70 in progression of LC, and suggested that AQP9 and ZAP70 could potentially act as candidate immunotherapeutic targets for LC. Collectively, this study proposed two prognosis-related IRGs AQP9 and ZAP70. Two molecular subtypes based on AQP9 and ZAP70 may reflect immune microenvironment of LC. In vitro, their up-regulation inhibited proliferation, migration and invasion of LC cells. Results obtained demonstrated that AQP9 and ZAP70 might be candidate therapeutic targets and prognostic signatures for LC, which may assist guide clinical therapy in the future [7].

Liu W. et al. [8] in their work they say that LC is one of the most common malignant tumors among head and neck cancers. Accumulating studies have indicated that long noncoding RNAs (lncRNAs) play an important role in LC occurrence and progression, however, the functional roles and relative regulatory mechanisms of lncRNA growth arrest-specific transcript 5 (GAS5) in LC progression remain unclear. The expression of lncRNA GAS5 in both LC tissues and cell lines was evaluated using quantitative RT-qPCR assay.

The relationships between lncRNA GAS5 expression and clinical parameters were also analyzed. To determine the biological function of lncRNA GAS5, a lncRNA GAS5-specific plasmid was first transfected into LC cells using lentiviral technology. Cell counting kit-8 assay, flow cytometry, and Transwell assays were used to detect in vitro cell proliferation, apoptosis, cycle distribution, and metastasis abilities, respectively. Furthermore, in vivo cell growth experiments were also performed using nude mice. Additionally, western blotting was performed to identify the underlying regulatory mechanism. In the current study, lncRNA GAS5 was downregulated in LC tissues and its low expression was closely associated with poor tumor differentiation, advanced TNM stage, lymph node metastasis, and shorter overall survival time. In addition, lncRNA GAS5 upregulation significantly inhibited LC cell proliferation both in vitro and in vivo. Moreover, in response to lncRNA GAS5 overexpression, more LC cells were arrested at the G2/M stage, accompanied by increased cell apoptosis rates and suppressed migration and invasion capacities. Mechanistically, this data showed that the overexpression of lncRNA GAS5 significantly regulated the PI3K/AKT/mTOR signaling pathway. lncRNA GAS5 might act as a suppressor gene during LC development, as it suppressed cell proliferation and metastasis by regulating the PI3K/AKT/mTOR signaling

pathway; thus, lncRNA GAS5 is a promising therapeutic biomarker for the treatment of LC. Overall, lncRNA GAS5 could serve as a tumor suppressor gene in LC, which would be a promising therapeutic biomarker for LC treatment.

Liberale C. et al. [9] note that LC is one of the most frequent tumors of the upper aero-digestive tract. While certain factors such as alcohol consumption and tobacco smoking have been established as risk factors for LC, the correlation of many other risk factors with the mechanism of carcinogenesis remains unclear. The process of laryngeal carcinogenesis has been well described; however, there are still aspects that lack understanding, and the underlying biological mechanisms have not been fully elucidated. Indeed, the emerging role of lncRNAs, miRNAs, and mRNAs is becoming increasingly important in our understanding of cancer development and its clinical and therapeutic implications. These non-coding RNAs have been shown to play critical roles in various aspects of cancer biology, including tumor initiation, progression, metastasis, and response to treatment. Gaining insight into the molecular mechanisms involved in carcinogenesis could enable the prediction of tumor progression and facilitate targeted interventions at various stages of the disease. The ultimate goal is to develop precise and effective therapies through a precision medicine approach. Achieving this objective requires further comprehensive studies on the molecular biology of cancer and the role of different risk factors.

Özdaş T. et al. [10] point out that while LC does not show any obvious early symptoms, it tends to have a poor prognosis in advanced clinical stages. Chromosome region maintenance 1 (CRM1) mediates the nuclear export of some RNAs, major and tumor suppressor proteins and has been associated with the pathogenesis of many tumors. However, the clinicopathological significance of CRM1 gene expression in LC has not been clarified yet. CRM1 expression in matched tumor and normal tissues obtained from 43 LC patients were evaluated intracellular for protein and mRNA levels by immunohistochemical staining (IHC), western-blot, and quantitative real-time qRT-PCR, respectively. IHC, western-blot, and qRT-PCR analyses showed that CRM1 expression was significantly increased in LC tissue compared to normal tissue. Increased expression of CRM1 has been associated with poor prognostic clinicopathological features, including advanced tumor stage, increased tumor invasion, larger tumor size, positive lymph node metastasis, distant metastasis, and invasive histological type by IHC, western-blot, and qRT-PCR. Kaplan–Meier survival analysis showed that patients with high expression of CRM1 exhibited lower overall survival compared to those with low expression (Log-rank = 7.16, $p = 0.007$). According to the TCGA datasets, elevated CRM1 expression in head and neck cancer including cases of squamous cell laryngeal origin is associated with advanced tumor stage and histological grade ($p > 0.05$, for all). Consequently, CRM1 plays an important role in LC and may serve as an indicator and prognostic factor for poor overall survival in LC patients. In conclusion, this study revealed that CRM1 is a predictive biomarker for poor overall survival in LC patients, and that the evaluation of the clinical pTNM staging system of the tumor and CRM1 expression together may provide additional prognostic information. Moreover, inhibition of CRM1 expression may be a new therapeutic strategy for LC. Furthermore, prospective large-scale studies are needed to explore the true prognostic role of elevated CRM1 expression in laryngeal squamous cell carcinoma.

The aim of the study by Luo M.S. et al. [11] was to develop an autophagy-related model to predict the prognosis of patients with LC. Autophagy, a major cause of cancer-related death, is correlated with the pathogenesis of various diseases including cancers. Our colleagues analyzed the correlation between expression profiles of autophagy-related genes (ARGs) and clinical outcomes in 111 LC patients from TCGA. Afterward, gene functional enrichment analyses of gene ontology and Kyoto Encyclopedia of Genes and Genomes were performed to find the major biological attributes. Univariate Cox regression analyses and multivariate Cox regression analyses were performed to screen ARGs whose expression profiles were significantly associated with LC patients overall survival (OS). Furthermore, to provide the doctors and patients with a quantitative method to perform an individualized survival prediction, we constructed a prognostic nomogram. Thirty eight differentially expressed ARGs were screened out in LC patients through the TCGA database. Related functional enrichments may act as tumor-suppressive roles in the tumorigenesis of LC. Subsequently, 4 key prognostic ARGs (IKBKB, ST13, TSC2, and MAP2K7) were identified from all ARGs by the Cox regression model, which significantly correlated with OS in LC. Furthermore, the risk score was constructed, which significantly divided laryngeal cancer patients into high- and low-risk groups. Integrated with clinical characteristics, gender, N and the risk score are very likely associated with patients OS. A prognostic nomogram of ARGs was constructed using the Cox regression model. As the researchers note this study could provide a valuable prognostic model for predicting the prognosis of LC patients and a new understanding of autophagy in LC. A novel autophagy-related model and a predictive nomogram were conducted to robustly estimate LC patients survival.

Now, regarding this pathology in our country at the republican level. The incidence of LC in the Republic of Kazakhstan in 2023 was 2.2 per 100 thousand population with an increase rate of 15.5% compared to the previous year (1.9 in 2022), which in absolute numbers amounted to 436 people (370 cases a year earlier), second only to prostate cancer (16.7%). The proportion of cases diagnosed for the first time in life, recorded by oncology organizations, was 1.2% (1.1% in 2022). At the same time, 384 men fell ill (the proportion is 2.4%, 13th rank place), women - 52 (the proportion is 0.2%, 22nd rank place), which clearly shows the gender difference in the incidence of this pathology with a pronounced predominance of the male population [12].

The LC level above the national average was established in 9 regions of the country: North Kazakhstan - 5.8 (the maximum indicator); Pavlodar - 3.8; Kostanay - 3.6; East Kazakhstan - 3.4; Abay - 3.3; Karaganda - 3.0; Akmola and Atyrau - 2.9; Mangistau - 2.6. This indicator is below the national average in 11 regions: Turkestan - 0.6 (the lowest level); the city of Astana - 1.0; Kyzylorda - 1.2; the city of Shymkent - 1.5; Ulytau and Almaty - 1.8; West Kazakhstan and Zhambyl - 1.9; Aktobe and Zhetysu regions and the city of Almaty - 2.1 per 100 thousand population. Mortality from this pathology was 0.8 per 100 thousand population, the same as a year earlier. The regions where the mortality rate from LC is above the average in the republic include: Abay - 2.5 (maximum level); North Kazakhstan - 1.9; Pavlodar - 1.6; Mangistau and Karaganda - 1.2; Zhetysu - 1.0; Aktobe - 0.9. Akmola, East Kazakhstan, Kostanay regions and the city of Almaty are on par with the national average. The lowest rates were noted in Ulytau - 0.0; Turkestan - 0.1; West Kazakhstan and the city of Shymkent - 0.3; Kyzylorda - 0.5; Atyrau and the city of Astana - 0.6; Zhambyl and Almaty - 0.7 regions per 100 thousand people [12].

One-year lethality was 19.2%, taking the 13th place among all nosological forms of malignant neoplasms. At the same time, the ratio between one-year lethality and neglect (stage IV) was 1.6. At the same time, we recall that the farthest from "1" is the worst ratio between the indicators of one-year lethality and neglect.

Next, regarding preventive examinations. It should be noted that during large-scale preventive examinations of the population in 2023, significantly more patients with malignant neoplasms were actively identified than in 2022. This is 25,193 patients versus 23,623 patients identified in 2022, i.e. +6.6%. This is due to the further abatement of the epidemiological trouble with coronavirus and the increased availability of preventive care for the population. The proportion of patients identified during routine examinations increased from 62.0% to 62.4% of the total number of patients identified per year. As for LC, the early detection of this pathology during preventive examinations increased significantly - from 50.6 to 60.9%. The number of newly identified patients with LC registered with oncology organizations amounted to 425 patients (365 patients in 2022). At the same time, the absolute number of patients with LC identified during medical examinations was 274 people (231 a year earlier), and the proportion was 64.5% and 63.3%, respectively. 167 people out of 274 are patients with stages I and II (in 2022 - 117 patients out of 231). The proportion of patients with LC detected at early stages, as indicated above, was 60.9% against 50.6% a year earlier.

Of course, when analyzing the epidemiological situation, early diagnosis indicators are very important issues.

The regions where the proportion of patients with early stage I of the pathology in question is above the national average (16.5% - 14th rank) include the following regions: the city of Almaty - 34.8% (the best indicator); Abay and Kyzylorda - 30.0%; West Kazakhstan and the city of Astana - 23.1%; North Kazakhstan - 22.6%; Karaganda - 18.8%; Akmola - 18.2%. The lowest rates of early diagnosis were recorded in the Ulytau region (not a single patient with stage I of the disease - 0.0%). Next come: Mangistau - 5.3%; the city of Shymkent - 5.6%; Kostanay - 6.7%; Pavlodar, Zhetysu and Almaty - 7.1%; Atyrau - 10.0%; Zhambyl - 13.0%; East Kazakhstan - 14.3%; Aktobe - 15.0% and Turkestan - 15.4% of the country's regions [12].

It should be noted that every second patient with LC is detected in the early (I-II) stages of this pathology (51.1%). However, the situation with this indicator is deplorable in the Ulytau region - there is not a single patient detected in the early stages of the disease. The regions where the proportion of patients with LC detected at stages I-II is above the national average include the following regions. The best indicator is in the city of Astana - 76.9%. Then follow: Pavlodar - 75.0%; West Kazakhstan - 69.2%; North Kazakhstan - 67.7%; Zhambyl - 65.2%; Aktobe - 65.0% regions and the city of Almaty - 63.0%. Low rates of early diagnosis were recorded in Ulytau - 0.0% (the worst result in the country); Turkestan - 15.4%; Almaty - 21.4%; the city of Shymkent - 22.2%; Zhetysu - 35.7%; Mangistau - 42.1%; East Kazakhstan - 42.9%; Atyrau - 45.0%; Kostanay - 46.7%; Abay, Akmola, Karaganda and Kyzylorda - 50.0% regions [12].

As is clearly seen from the above data, there is a very large spread in early diagnostics rates across

the country, from very good to dismal. Of course, it is necessary to take into account migration processes and other factors that affect early diagnostics rates, but nevertheless, the results obtained give reason not to stop there, both for oncologists and otolaryngologists, general practitioners, since improving early diagnostics rates of malignant tumors, as one of the main postulates and one of the main tasks of medicine in general, continues to be relevant today. The proportion of stage IV LC was 9.4%. At the same time, as mentioned above, the proportion of patients with this nosological form of malignant neoplasms detected at stages I-II was 51.1% (stage I - 16.5%, stage II - 34.6%), which indicates that the largest number of patients with LC was detected at locally advanced with loco-regional damage - stage III of the disease. This stage was 39.5%, i.e. almost two patients out of every five, and we know what aggressive, often complex treatment is used with such a spread of the oncological process and what a disappointing prognosis is for these patients. As for the average national indicator of the proportion of stage IV (9.4%), against this background, West Kazakhstan, Mangistau, Turkestan regions and three megalopolises - the cities of Astana, Almaty, Shymkent stand out, where not a single patient was detected in the terminal stage - 0.0%. Then come: Almaty - 3.6%; Aktobe - 5.0%; North Kazakhstan - 6.5%; Zhetysay and Pavlodar - 7.1%; Zhambyl - 8.7%; Kyzylorda - 10.0%; Kostanay - 13.3%; East Kazakhstan - 14.3%; Atyrau - 20.0%; Akmola - 22.7% regions. This list is closed by three regions, where every fourth patient was detected in the incurable stage of the disease with the worst indicator of 25.0% - Abay, Karaganda and Ulytau regions [12].

The morphological verification rate of LC in the country was 98.8%, second only to non-melanoma skin cancer (99.6%), breast cancer (99.4%) and lip cancer (99.1%) in the first three positions. At the same time, in the Pavlodar region, the morphological verification rate was 92.9%, in Akmola - 95.5%, in Almaty - 96.4%. In other regions, the disease verification rate was 100%.

The total number of patients with malignant neoplasms registered with specialized oncology organizations of the republic continued to increase and by the end of 2023 amounted to 218,186 people, with an increase of 6.0% compared to the previous year (2022 - 205,822, +5.8%). The overall incidence rate of malignant neoplasms increased by 3.9%, from 1055.3 to 1096.4 per 100 thousand people. The growth of this indicator is due to both the increase in the incidence and detection of pathology, and the increase in the survival of cancer patients. In addition, statistical data on patients diagnosed with malignant neoplasms, who have been under observation for 5 years or more, and continue to be observed in 2023, showed that the number of patients under the observation of oncological organizations in Kazakhstan for over five years continued to grow and at the end of the reporting year amounted to 117,616 people, with an increase of 6.2% (2022 - 110,790 people, + 6.6%) (form No. 7).

It is impossible to ignore such an important clinical aspect as the coverage of patients with a first-time diagnosis of LC in the Republic of Kazakhstan with special treatment.

In 2023, the number of hospitalizations for all nosological forms of malignant tumors in the country's oncology organizations amounted to 108,252 cases (2022 - 101,095), with an increase of 7.1% compared to the previous year, which is associated with a constant increase in the number of cancer patients, improved standardization of oncological care, and the development of palliative and restorative services.

At the end of 2023, the absolute number of LC patients who completed specialized treatment was 247 people, continuing treatment - 135 patients. The following results were obtained in percentage terms by methods and types of treatment. Only 12.6% of patients received surgical treatment, only radiation - 19.4%, only drug treatment - 8.9%, combined - 26.7%, complex - 21.5% and chemo-radiation - 10.1%.

Further, regarding the five-year survival of patients. As for LC, at the end of 2023, 2032 people were registered for dispensary care, or 10.2 per 100 thousand of the population. At the end of 2022 - 1899 patients or 9.7 per 100 thousand of the population, respectively.

At the same time, the mortality rate of the observed contingents in 2023 decreased compared to the previous year and amounted to 7.6% in 2023 (8.6% in 2022).

The five-year survival rate of patients with LC was 52.2% in 2023 and 53.2% in 2022 [12].

Summarizing the above, we can conclude that LC, despite not having the highest place in terms of incidence among all existing malignant tumors of other localizations, deserves close attention from specialized specialists. At the same time, taking into account a number of factors, the indicators of early diagnostics do not allow oncologists to "sleep peacefully", since the locally advanced stage III, which prevails over all stages, in addition to being widespread, gives a large number of complications due to the location of vital centers and tissue structures near the primary focus and locoregional metastases. The veiled and variable symptoms, its similarity with various non-core processes, leads to the neglect of the

disease. All this requires both oncologists and, first of all, primary health care workers and, of course, otolaryngologists to increase the level of cancer alertness, inform the population about early symptoms that may indicate this pathology or the onset of proliferative changes and conduct high-tech diagnostic measures, including for the purpose of differential diagnosis and, as a result, timely treatment. People from the risk group are recommended to visit specialized specialists annually and, if necessary, undergo an examination.

An epidemiological assessment of the situation with LC in our country suggests that there are sometimes significant differences in the regions not only in incidence rates, but also in the state of early diagnosis and mortality from this disease. In connection with the above, this pathology continues to be a serious problem in modern clinical oncology.

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Pedagogical sciences

THE NEGATIVE SOCIAL-PSYCHOLOGICAL AND PEDAGOGICAL ATMOSPHERE OF FAMILY AS A FACTOR OF LOW SPIRITUAL-INTELLECTUAL LEVEL OF DEVELOPMENT OF TEENAGERS

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НЕГАТИВНАЯ СОЦИАЛЬНО-ПСИХОЛОГИЧЕСКАЯ И ПЕДАГОГИЧЕСКАЯ АТМОСФЕРА СЕМЬИ КАК ФАКТОР НИЗКОГО ИНТЕЛЛЕКТУАЛЬНО-ДУХОВНОГО УРОВНЯ РАЗВИТИЯ ПОДРОСТКОВ

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Abstract

The given article is dedicated to one of an actual problem of pedagogues - to work with teenagers of unhappy families. In the article are uncovered reasons of appearance such a phenomenon as an unhappy family. In the article is talked that unhappy families must be one of the actual problems of work of social institutions of society. An article notes that negative social-psychological and pedagogical atmosphere of family must be a reason of low spiritual-intellectual level of development of teenagers. In this process a high level of pedagogical culture of parents plays an important role. In the article is given necessary recommendations for improvement of work with teenagers of unhappy families.

Аннотация

Статья посвящена вопросам работы с подростками из неблагополучных семей. В ней раскрываются причины возникновения такого социального явления, как «неблагополучная семья». Отмечается, что проблема неблагополучных семей должна рассматриваться как одна из приоритетных задач в деятельности социальных институтов общества. Особое внимание уделяется тому, что негативный социально-психологический и педагогический климат в семье является одним из ключевых факторов, способствующих низкому духовно-интеллектуальному развитию подростков. В заключение статьи представлены рекомендации по организации эффективной работы с подростками, находящимися в условиях семейного неблагополучия.

Keywords: teenagers, on unhappy family, secondary school, spiritual-intellectual level of development of teenagers, atmosphere of family, social institutions of society

Ключевые слова: подростки, неблагополучная семья, средняя школа, духовно-интеллектуальный уровень развития подростков, атмосфера семьи, социальные институты общества

Формирование социально развитого, обладающего высшим уровнем духовно-интеллектуального потенциала подрастающего поколения является первостепенной задачей, стоящей перед всеми социальными институтами общества. От их чётко выверенной предметно целенаправленной деятельности с молодёжью зависит эффективная социализация молодых людей, систематическое вооружение их позитивным стремлением более активно участвовать в различных областях жизни государства – общественно-политической, социально-экономической, духовно-профессиональной и т. д. Одним из важных социальных институтов общества, можно сказать базовым социальным институтом общества, который располагает неограниченными возможностями и высоким уровнем потенциала воспитательно-формирующего воздействия на молодых людей является семья. Роль этого социального института переоценить невозможно, так как практически все задачи, стоящие перед

обществом, саккумулированы в семье и при надлежащем уровне семейного воспитания очень легко могут найти своё позитивное разрешение.

Молодые люди (в дальнейшем мы сузим это понятие до «подростки» и будем рассматривать именно процесс социализации подростков), по утверждению практически всех специалистов в области педагогики, психологии, социологии, полностью бывают зависимы от внутрисемейных отношений, от социально-психологического и педагогического микроклимата семьи. «В семьях, ориентированных в семейном воспитании на претворение в жизнь исключительно позитивных социальных установок, формируются социально активные, духовно и интеллектуально высоко развитые подростки, которые, по большому счёту, являются важной движущей конструктивно-созидательной силой общества на его пути демократического развития» (8, 14). Однако, и это тоже стоит отметить, ещё нередко можно встретить семьи, где вопросы семейного воспитания подростков практически находится на нулевом уровне, где царит весьма напряжённая социально-психологическая и педагогическая атмосфера, где члены семьи несмотря на то, что живут под одной крышей, практически не контактируют друг с другом на позитивном уровне. В таких семьях обычно наблюдаются низкий уровень педагогической и социальной культуры обоих родителей, более того, часто можно наблюдать и констатировать (к большому сожалению) явно антисоциальный образ действий таких родителей. Не будет являться большим секретом, что подростки, живущие в такой семье и ежедневно сталкивающиеся с негативным семейным климатом, будут заметно отставать в духовно-интеллектуальном развитии от своих сверстников, товарищей по классу, школе. Такие семьи являются большой проблемой для общества, которое постоянно проводит работу по консолидации усилий всех социальных институтов общества для полного искоренения этого фактора в реальной жизни. Это более сложная задача, связанная с привлечением многих факторов социума, однако это проблема должна быть кардинальна решена или же, по крайней мере таких фактов должно быть как можно меньше. Напряжённая семейная атмосфера способствует тому, что у подростков практически не формируется позитивный круг интересов, отсутствуют какие-либо возвышающие личность в обществе, желания, а, наоборот усиленно начинают превалировать негативные явления в их сознании и поведении. «Компонентная характеристика понятия «низкий уровень духовно-интеллектуального развития подростков» очень многомерен, многоаспектен и различается по своему социальному наполнению» (7, 27). Сюда можно отнести девиантное поведение подростков – воровство, хищение государственного имущества (например, школьной инвентарь), отсутствие читательских интересов, уход из дома, бродяжничество, алкоголизм, наркоманию, токсикоманию, азартные игры, нежелание вообще трудиться и т.п. По наблюдениям специалистов, классных руководителей в таких семьях практически нет какой-либо семейной библиотеки, которая хоть немного могла бы поднять уровень духовно-интеллектуального развития всех членов семьи, и в первую очередь, подростков. В процессе нашей профессиональной педагогической деятельности мы неоднократно встречались с представителями таких семей, интересовались очень многими параметрами, которые способствовали тому, что среди специалистов социальных служб и работников системы образования про такую семью твёрдо утвердилось мнение – «неблагополучная семья». Можно привести в качестве примера вопросы, которые мы задавали практически всем членам семьи. 1. Как вы думаете, почему в вашей семье внутрисемейная обстановка такая напряжённая, можно сказать, негативная? 2. Почему в межличностных отношениях в семье ни один член семьи не заинтересован в судьбе другого? 3. Пробовали ли Вы (хотя бы с помощью соответствующих организаций) изменить сложившуюся ситуацию?

Ответы, полученные нами, собственно говоря, не удивили нас, да других ответов невозможно было и ожидать. На первый вопрос были получены ответы практически всех членов семьи: «Мы никогда над этим не задумывались. С другой стороны, как ко мне относятся, так и я отношусь к другим членам семьи». Ответ на второй вопрос – «А чего интересоваться, каждый человек сам по себе, живёт так, как ему хочется и удобно. Мы считаем, что вклиниваться, вмешиваться в чужую жизнь будет с нашей стороны неправильным шагом». Ответ на третий вопрос – «Нас уже многие считают неблагополучной семьёй, и мы как-то привыкли к этому. Через некоторое время мы все разбежимся из этой семьи – это непреложный факт. По этой причине, зачем нам привлекать какие-то госорганы себе в помощь и лишний раз опять позориться». Полученные нами ответы убедительно показывают, что с такой неблагополучной семьёй надо самым серьёзным образом работать. Необходимо отметить, что

степень неблагополучия таких семей настолько высок, что ни один в отдельности взятый социальный институт общества в одиночку, со своим потенциалом с этим явлением не справится, это будет только лишь напрасной тратой времени.

Мы задавали вопросы и самим подросткам в таких семьях и получили примерно такие же ответы. Нас, однако, насторожил один, очень важный, на наш взгляд факт. Когда мы спрашивали подростка из такой неблагополучной семьи «Почему ты не читаешь книги, неужели тебе не интересны различные приключения? Ответ – «Вы знаете, у меня просто нет таких книг и потом, мой папа практически каждый день ругает маму и поднимает на неё руку, поэтому я практически каждый день должен находиться дома, чтобы защитить маму». Очень часто классные руководители жалуется руководству школы, что они понимают всю сложность ситуации в таких семьях, пытаются им помочь, но всякие их усилия встречают со стороны других членов семьи, особенно родителей, непонимание, выраженную агрессию и злобу. Классные руководители упоминают такой случай, когда они принесли несколько книг приключенческого сюжета, чтобы подростки могли бы хотя бы дома их прочитать. В результате, такая благая акция со стороны учителей закончилась тем, что отец ребёнка просто-напросто выбросил книги во двор, сопровождая это нецензурной бранью.

Ученые-специалисты и практические работники высокого профессионального уровня (А.И. Кочетов, А.Е. Тарас, Д.И. Водзинский, Ю.П. Азаров, А.Г. Громцева, А.Д. Джумабаев, Т.В. Воликова, Н.Ф. Федотова, Р.М. Капралова, Г.В. Казнова и др.) в своих опубликованных работах утверждают, что с неблагополучными семьями, где подрастает будущее поколение страны, надо заниматься самым серьёзным образом, не откладывая проблему на будущее и наивно полагать, что жизнь сама внесёт необходимые коррективы и всё наладится должным образом. «Учителя-предметники, воспитатели средней школы практически в один голос утверждают, что подростки из таких неблагополучных семей отличаются от своих сверстников выраженной инфантильностью, безразличием, практически не участвуют в общественных мероприятиях и очень плохо посещают учебные занятия» (4, 48). Принимая всё вышесказанное во внимание, мы считаем, что несмотря на выраженное несогласие родителей, их систематический отказ от предлагаемой школой помощи, необходимо всеми средствами и методами объединив свою работу с работой правоохранительных органов, кардинальным образом повысить эффективность своей работы по всем направлениям. Иногда родители, да и другие члены таких неблагополучных семей говорят, что семья поит, кормит, одевает своих детей, что еще нужно. Если же школа так сильно обеспокоена уровнем духовно-интеллектуального развития подростков, то пусть сама и занимается этим делом, но только лишь исключительно на территории школы. Такие родители откровенно лукавят и стараются перенести проблему с «больной головы на здоровую». Дело в том, что они прекрасно знают, что их дети практически не посещают школу, соответственно, с ними никакой работы не будет проведено. Специалисты отмечают, что часто можно встретиться и с такой проблемой, когда, допустим мать пьёт и принимает психотропные вещества, она практически становится невменяемой и ничего толком понять не может

Как было отмечено в работе психолога Г.А.Гасановой «изменение отношения к ребенку в семье, замена авторитарного типа родительского отношения с использованием доминирующего, потворствующего, гипопротекции, неустойчивого стиля семейного воспитания на сотрудничество и взаимопонимание, предотвращает возникновение у детей и подростков эмоциональной неуравновешенности» (2, 119).

Одна девочка-подросток нам говорила, что, пытаясь как-то оградить мать от употребления спиртных напитков, она решила с ней очень тактично поговорить. В ответ мать ей нахамила, обругала, сказала, что она вообще нежелательный ребёнок, и что её ожидает такое же будущее, в каком состоянии она находится сама. «Нередко специалисты социальных служб и работники системы образования упоминают и такие факты, которые самым вопиющим образом подчеркивают неблагополучный характер конкретной семьи» (6, 39). Мы все понимаем, что иногда супружеская жизнь не заглаживается и в результате происходит развод. Отец семейства, несколько раз создавая семью с другими женщинами, совершенно отгораживается от своих детей и, более того, специально препятствует налаживанию межличностных контактов с другими детьми от других браков. На просьбу социальных служб не препятствовать налаживанию межличностных контактов между молодыми людьми, получают ответ – «Моя семья, что хочу, то и делаю. Вы мне совершенно не указ». Часто можно наблюдать, к большому сожалению, и такой факт – в неблагополучной семье отец и мать ведут

откровенно асоциальный образ жизни, пьянствуют, дебоширят, ругаются с соседями, оскорбляют их. Практика показывает, что обычно такие родители нигде не работают, а если работают, то очень небольшими промежутками времени. Соответственно такие родители практически всегда испытывают недостаток в материальном плане. Чтобы купить очередную бутылку спиртного или же очередной препарат токсического характера, такие родители посылают своих детей на улицу попрошайничать и приносить домой деньги. О том, какой вред психике своих детей они наносят, насколько унижают их – эти проблемы их совершенно не волнуют и остаются вне поля их зрения и интересов. Такое отношение к своим детям считается просто преступным и, постоянные своеобразные разборки между членами семьи, убеждают подростков, живущих в таких семьях, что нечего напрягаться, вероятно весь мир устроен таким образом – в итоге у молодых людей формируется негативные отношения ко всему человеку. Часто люди, живущие по соседству с такими неблагополучными семьями, пытаются как-то повлиять на это и стараются помочь молодому поколению этой семьи. Однако, к их большому удивлению, их благие намерения вызывают у подростков негативные чувства, истерический хохот – совсем не потому, что они психически больные, а в силу того, что они изо дня в день видели совсем другой, негативный алгоритм межличностных отношений, где сама идея или мысль помочь другому звучит как что-то вопиющее, направленное исключительно во вред человеку, которому протягивают руку помощи. Работники системы образования, с которыми мы встречались, рассказывали нам об одном случае, произошедшее с подростком из неблагополучной семьи. Средняя школа организовала тематическую выставку книг для молодёжи, которую посетили практически все учащиеся школы. Среди них был и подросток из неблагополучной семьи. Ему выставка очень понравилась, и он задавал множество вопросов о книгах. Видя такой интерес подростка к книжной выставке и желая ещё больше смотивировать его на чтение художественной литературы, организаторы выставки подарили ему несколько экземпляров книг так приглянувшихся этому подростку. В результате такого позитивного опыта получилось совсем непонятное и вопиющее. Несколько дней этот подросток не приходил в школу, а когда пришёл на его лице отчётливо виднелись синяки от ударов. Выяснилось, что отец и мать строго наказали своего ребёнка только за то, что он посетил выставку книг, не попрошайничал и родители остались без очередной дозы спиртного. Для наглядности и серьёзности своих намерений и впредь наказывать своего ребёнка за такого рода поступка, отец собственноручно сжёг во дворе книги, которые ему подарили организаторы выставки. Этот молодой человек убежал из дома и только лишь через неделю его нашли правоохранительные органы. Специалистами также были зафиксированы случаи, когда родители сами учили своих детей (чаще всего подростков) воровать мелкие вещи у своих одноклассников, мотивируя и объясняя это тем, что только лишь наличие каких-либо материальных ценностей, неважно как добытых, делает молодых людей уважаемыми персонами в глазах всего общества. Родители говорят подросткам, что такие факты мелкого воровства обществом не осуждается, а наоборот, приветствуется и про таких молодых людей говорят, что он очень активный и в жизни нашёл своё место. То, что такие родители практически уничтожили жизнь своему ребёнку, им непонятно и, скорее всего, они не хотят этого понимать. Такие подростки, по «совету родителей» предпочитают иметь золотые цепочки, браслеты от часов, серебряные запонки вместо книг, журналов, вместо обращения своих личностных интересов к периодической печати. «Одним из негативных составляющих системы семейного воспитания (если она вообще имеет место быть) является личный негативный пример самих родителей» (3, 54). Если отец и мать каждый раз, придя с работы, хвастаются друг перед другом украденными какими-то вещами, причем рассказывая об этом как об каком-то акте героизма, подростки, частично недопонимая такую модель жизни, частично (в силу своего возраста и недостаточного уровня житейного и социального опыта) принимая ее, часто, идут по линии накопившего сопротивления и принимают вторую модель жизни, тем более она приветствуется со стороны самых близких ему людей – родителей. Такие ограниченные интересы родителей, скудость их духовных потребностей, сводящихся только лишь к наличию материальной выгоды, очень разрушающе и деструктивно действуют на их детей-подростков. В такой обстановке отсутствие наличия какой-либо системы социальных, духовно-интеллектуальных ценностей, дети-подростки формируются как личности, негативно воспринимающие молодых людей, которые заинтересованы в своём духовно-интеллектуальном развитии.

Иногда это видимое противостояние молодых людей, заикленных только лишь на потребительских интересах, исключительно материального благополучия и молодых людей, активно совершенствующих себя в плане духовно-интеллектуального развития, нередко выходит за рамки простого неприятия друг друга и заканчивается более серьёзными деструктивными фактами. Специалисты отмечают, что практически любая неблагополучная семья с деструктивным характером межличностных семейных отношений выступает как целенаправленно ориентированный источник антиобщественных установок. Такие антиобщественные установки способствуют тому, что мир воспринимается исключительно через призму антисоциальной и социальной модели жизни. И, что особенно важно, такие деструктивные модели жизни своеобразно заражают некоторую часть подростковой молодёжи, которые в силу различных причин живут, формируются рядом с представителями неблагополучных моделей семьи.

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THE INFLUENCE OF PHYSICAL EDUCATION AND SPORTS ON THE DEVELOPMENT OF INTELLECT

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Abstract

The aim of this work is to study the influence of physical education and sports on the development of intellect. The research tasks include analyzing theoretical approaches, studying the physiological and psychological mechanisms of the influence of physical activity, as well as an empirical study of cognitive indicators in those engaged in sports and those leading a sedentary lifestyle.

Keywords: *Intellect, sports, personality, physical education*

In the context of dynamic societal development, issues of comprehensive personality development become especially relevant. Physical education and sports are important components in forming a healthy lifestyle and harmonious development. However, beyond strengthening physical health, they also significantly influence the intellectual abilities of a person.

Intellect represents a set of mental processes that ensure the perception, processing, and application of information. The development of cognitive functions such as memory, attention, thinking, critical and logical reasoning is a necessary condition for successful academic and professional activities.

The objective aspect of engaging in physical culture and sports in relation to intellectual development lies in the unity and interconnection of mental and physical activity. Many phenomena occurring in the surrounding world and within our bodies can be comprehended only through motor activity. Participation in physical culture and sports has an impact on the development of the following aspects of intelligence:

Attention – mastering complex coordination exercises requires focused concentration on the movements being performed, the arising motor sensations, and the accompanying situations;

Observational skills – enhanced through the development of sensory analyzers;

Ingenuity and quick-wittedness – necessitated by the high demands placed on the ability for rapid and adequate motor orientation in dynamically changing situations;

Thinking – necessitated by the need to search for the causes of successful and unsuccessful movements, and to comprehend their purpose, structure, and outcomes.

A correlation between motor and intellectual giftedness has been established. Children with an active motor regimen generally demonstrate higher and more stable academic performance. Conversely, children with intellectual disabilities tend to exhibit poor motor coordination and face significant challenges in acquiring motor skills.

Engagement in physical culture and sports contributes to improved mental performance. Moreover, adherence to a structured daily routine, often characteristic of student-athletes, positively influences academic achievement. Sports activities also stimulate the acquisition of knowledge in areas such as training techniques and methodology within a chosen sport, sports pedagogy, physiology, hygiene, and more.

According to some researchers (A.N. Gusev, G.S. Petrova, A.V. Stafeyeva), mental and physical activity in humans are closely interconnected at the level of the brain regions that control them. This interdependence makes it possible to stimulate a person's mental activity through the activation of physical activity.

Athletes' travel to other cities and countries, as with any form of travel, can further contribute to educational objectives. Different types of sports exert varying effects on intellectual development. Some primarily foster observational skills and speed of thought (e.g., combat sports and team sports); others promote memory (e.g., chess, checkers, gymnastics, figure skating); still others enhance the ability to concentrate attention on a single powerful action (e.g., athletics jumps, weightlifting), and so forth.

However, negative effects of sports on intellectual functioning are also possible. There is considerable evidence of poor academic performance among schoolchildren and students involved in sports. This is often due to a one-sided focus on sports at the expense of other activities, particularly academic pursuits, or due to fatigue resulting from excessive training loads. The intellectually suppressive influence may also arise from the conditions of prolonged training camps, which eliminate the athlete's usual physical or mental activities.

The Connection Between Physical and Mental Development

The renowned scientist I.M. Sechenov noted that muscular movements have a significant impact on brain activity. This idea was further developed by another prominent Russian scientist, I.P. Pavlov, who emphasized the unity of intellectual and physical development.

The best catalysts for brain cell growth are aerobic exercises such as running, yoga, interval training, and CrossFit. However, physical exercise alone is not enough for intellectual development. In order for new brain cells to survive and function effectively, it is also necessary to train memory, develop speech, and practice logical thinking.

This highlights the deep interconnection and interdependence between physical and mental development: physical growth contributes to the enhancement and maintenance of cognitive functions, while intellectual efforts reinforce the progress achieved.

Physical Education and Sports as Factors in Personality Development

Physical education is a systematic process of forming motor skills, strengthening health, and developing physical qualities. Sports, as a more specialized form of physical activity, contribute to the development of strength, endurance, coordination, as well as volitional and moral qualities.

Modern concepts of physical education rely on the understanding of its role not only in shaping the body but also in ensuring psycho-emotional balance and intellectual development.

The Concept of Intellect and Its Structure

Intellect is a complex of mental abilities that ensure cognitive activity. It includes attention, memory, thinking, imagination, and the ability to solve problems. Modern psychological theories, such as Gardner's theory of multiple intelligences, distinguish various types of intellect: linguistic, logical-mathematical, spatial, bodily-kinesthetic, and others.

The development of intellect depends on many factors, among which physical activity holds a significant place.

The Connection Between Physical Activity and Cognitive Functions

Scientific studies indicate a positive effect of systematic physical exercises on cognitive processes. Physical activity improves blood circulation, enhances metabolic processes in the brain, promotes neurogenesis, and strengthens neural connections. Psychological studies confirm that sports activities increase concentration, improve learning abilities, and foster creative problem-solving.

Physiological and Psychological Mechanisms of Physical Activity's Influence on Intellect

Physiological Mechanisms

Physical exercises stimulate the cardiovascular system, improving the supply of oxygen and nutrients to the brain. This contributes to increased neuroplasticity—the brain's ability to change and form new neural connections. The production of neurotrophic factors, such as BDNF, plays a key role in the growth and survival of neurons.

In addition, regular physical activity activates the prefrontal cortex, responsible for higher cognitive functions such as planning, decision-making, and self-control.

Psychological Mechanisms

Sports activity requires concentration, self-discipline, the ability to control emotions, and overcome stressful situations. The development of these mental qualities contributes to the improvement of cognitive functions and resistance to mental fatigue.

Psychological studies show that physical activity raises the levels of neurotransmitters (serotonin, dopamine), which improve mood and motivation for study and work.

Socio-Pedagogical Aspect

Sports games and team sports contribute to the development of communication skills, the ability to solve tasks collectively, and social interaction. This broadens horizons, develops critical thinking, and emotional intelligence, which are also important aspects of overall intellectual competence.

Empirical Study of the Influence of Physical Activity on Cognitive Functions

Aim and Methodology of the Study

The aim is to assess the influence of regular sports activities on the development of cognitive functions in schoolchildren.

The study involved 60 students aged 14-16, divided into two groups: experimental (engaged in sports at least 3 times a week) and control (leading a sedentary lifestyle). The following methods were used:

Attention tests (e.g., the Schulte test)

Tests of working and long-term memory

Tasks on logical thinking (analytical and verbal)

The experimental group showed significant improvement compared to the control group in attention tests (20% increase in concentration time), memory (15% increase in recall accuracy), and logical thinking (18% increase in correct answers).

The results confirm the hypothesis of the positive influence of physical activity on intellectual development. The improvement in cognitive indicators is related to the physiological and psychological mechanisms described in the second chapter. The data indicate the need to include systematic sports activities in educational programs to enhance learning effectiveness.

In the course of the study, it was revealed that physical education and sports have a significant positive impact on the development of intellect. Regular physical activity improves the physiological condition of the brain, promotes the development of cognitive functions, and psycho-emotional stability.

The results of the work confirm the necessity of integrating physical exercises into the educational process for comprehensive personality development. Physical culture not only strengthens health but also serves as an effective tool for increasing intellectual potential.

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Philological sciences

AXIOLOGEM REVIVAL AS A CHALLENGE OF MODERNITY AND A MEANS OF ITS REPRESENTATION

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ФРАЗЕОЛОГИЧЕСКИЕ ЕДИНИЦЫ КАК РЕПРЕЗЕНТАНТЫ АКСИОЛОГЕМЫ ЖИЗНИ В РУССКОЙ И КАЗАХСКОЙ ЯЗЫКОВЫХ КАРТИНАХ МИРА

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Abstract

At the heart of any culture is the axiologem life, which is of great value. And the way a person lives his life reveals his mentality, worldview, attitude and worldview. Each person, being a carrier of a certain national culture and language, perceives life through the prism of his ethnic culture. Accordingly, the axiologeme life is a multicomponent, multistructural axiological phenomenon that contains both universal and culturally determined national and individual personal traits. And this circumstance is of great research interest in the humanities. And this circumstance is of great research interest in the humanities. From a linguistic point of view, it is important to study the representatives of a given axiologeme, one of which is phraseological units. As you know, the phraseological corpus of any national language is its treasury, which embodies the entire history and original culture. Based on this, this article is devoted to a comparative analysis of the phraseology of the Kazakh and Russian languages, actively functioning in the communicative space of multinational, multilingual and multi-confessional Kazakhstan.

Аннотация

В основе любой культуры лежит аксиологема жизнь, которая представляет огромную ценность. И в том, как человек проживает свою жизнь, проявляется его менталитет, мировосприятие, миропонимание, мироощущение и мирооценка. Каждый человек, являясь носителем определенной национальной культуры и языка, воспринимает жизнь сквозь призму своей этнической культуры. Соответственно, аксиологема жизнь является многокомпонентным, многоструктурным аксиологическим феноменом, содержащим в себе как общечеловеческие, так и культурно обусловленные национальные и индивидуально-личностные черты. И это обстоятельство вызывает огромный исследовательский интерес в гуманитарных отраслях науки. С лингвистических позиций актуально изучение репрезентантов данной аксиологемы, одним из которых являются фразеологические единицы. Как известно, фразеологический корпус любого национального языка является его сокровищницей, воплотившей в себе всю историю и самобытную культуру. Исходя из этого, данная статья посвящена сопоставительному анализу фразеологии казахского и русского языков, активно функционирующих в коммуникативном пространстве многонационального, полиязычного и поликонфессионального Казахстана.

Keywords: axiologeme, representation, phraseology, Kazakh, Russian, language, culture
Ключевые слова: аксиологема, репрезентация, фразеология, казахский, русский, язык, культура

Любой национальный язык является ретранслятором этнической культуры. Сопоставительный анализ языковых единиц, репрезентирующих конкретные аксиологемы, позволяет выявить шкалу ценностей носителей сопоставляемых национальных языковых картинах мира.

Аксиология языка как научное направление изучает ценности, закреплённые и реализуемые в лексико-семантической и фразеологической системах. В рамках лингвистической аксиологии ключевым понятием выступает **аксиологема** — языковая единица, репрезентирующая определённую ценность (или антиценность) и фиксирующая отношение этноса к значимым компонентам действительности [1].

Ключевой в каждой культуре является аксиологема жизнь, о чем свидетельствует солидный арсенал научных исследований. Аксиологема жизнь относится к универсалиям ценностной системы и является базовой для любой языковой картины мира. По словам Н.Д. Арутюновой, язык организован таким образом, что позволяет «вербализовать и иерархизировать те аспекты реальности, которые представляют ценность для человека» [2]. Жизнь как концепт охватывает не только биологическое существование, но и его осмысление, морально-этическое содержание, социальные и духовные смыслы.

Данная аксиологема изучается учеными с разных позиций: лингвокогнитивной, лингвокультурологической, лингвоаксиологической и др. В связи с этим следует отметить, что в лингвокогнитивных и лингвокультурологических исследованиях рассматривается концепт жизнь. Как известно, разница в исследовании концепта в этих двух отраслях состоит в том, что в лингвокогнитологии на первый план выступает язык, а культура является фоном (т.е. от языка к культуре), тогда как в лингвокультурологии анализ осуществляется от культуры к языку.

Возникает вопрос: в чем разница между терминами концепт и аксиологема. Поскольку в нашу задачу не входит изучение концепта, лишь ограничимся констатацией факта наличия множества определений концепта, характеризующих этот феномен с разных позиций: лингвофилософской (В.В. Колесов и др.), семантической (Е.А.Кубрякова, И.А.Стернин, З.Д.Попова), культурологической (А.Вежбица, Ю.С.Степанов и др.).

Аксиологема — центральная единица аксиологической науки. Соответственно, в лингвоаксиологии, возникшей на стыке аксиологии и лингвистики, изучаются языковые единицы, репрезентирующие ту или иную аксиологему.

Перечислим лишь ряд работ, посвященные изучению концепта жизнь: О.А.Ипановой (образная составляющая), Е.Н.Руднев (семантическая структура), М.В.Деевой (понятийная и символическая составляющие), В.В.Опрышко, Т.М. Горшковой, М.А. Кульковой, Е.Федоткиной (на материале фольклора, парелий) и др., которые выполнены на материалах словарей, художественного текста прессы и др.

В этих исследованиях уделяется внимание и аксиологическому аспекту: О.А. Ипановой выделены смыслы «жизнь — ценность» и «жизнь — показатель чего-то важного». По мнению автора, «Несмотря на большое количество негативных определений, сама жизнь в русской языковой картине мира концептуализируется как нечто положительное, как наслаждение, радость, удовольствие» [3].

И.В.Бочарникова выделяет такие ценностные смыслы, отражающие определенную область содержания данной аксиологемы: «существование», «деятельность», «совокупность», «темпоральность», «духовность», «ценность», «реальная действительность», «антропоцентризм», выражающиеся через концептуальные смыслы «движение», «принадлежность», «биография», «комплексность», «ограниченный период», «полнота», «дар», «цена», «духовность», «реальная действительность», «человек», «форма существования материи», «физиологическое существование», «место и сфера жизни», «образ жизни». И. В. Бочарникова отмечает, что концептуальные смыслы «отражают определенную область концептуального содержания и могут изменяться в своей процентной представленности в содержании концепта» [4].

Аксиологема жизнь репрезентируется различными языковыми единицами: лексическими и синтаксическими (фразеологическими и палемиологическими). При анализе фразеологических репрезентантов аксиологема жизнь в русском и казахском языковых картинах мира мы опираемся на определение В.Н.Телия: «Фразеологизмы — это „зеркало, в котором лингвокультурная общность идентифицирует свое национальное самосознание» [5].

Как отмечается в коллективной статье С.К.Башиевой и др., «...жизнь предстает как:

- нечто единственное и ценное – жизнь одна дана, жизнь прожить – не поле перейти;
- источник борьбы и преодоления – идти на смерть, жизнь висит на волоске;
- предмет высокой заботы или пренебрежения – класть/положить жизнь (на что-то),

играть жизнью;

- естественный ход вещей – такова жизнь, жизнь бьет ключом;

- переживание полноты бытия – вкус жизни, радоваться жизни» [6].

Как справедливо отмечает И.В. Зыкова, «до конца нерешенным остается ряд общетеоретических и методологических вопросов, связанных с выявлением и описанием фактов того, как концептосфера культуры влияет на формирование фразеологических знаков, каким образом информация о культуре сохраняется и/или передается в значении фразеологизмов» [7].

Действительно, в фразеологическом корпусе русского национального языка доминируют ФЕ, в которых характеризуются и оцениваются различные жизненные ситуации:

Таблица 1.

1	Этическая оценка	напр.: жить по совести, жить разгульно, коптить небо, жить чужим трудом
2	Социальная оценка	напр.: родиться в рубашке, жить на широкую ногу, жить милостыней, перебиваться с хлеба на воду
3	Психологическая оценка	- позитивная (душа в душу, делить хлеб и кров) - негативная (жить в стороне, жить для себя)
4	Гедонистическая оценка	напр.: в своё удовольствие, прожигать жизнь
5	Оценка физического состояния	напр.: жить чужой век, жизнь на волоске, идти под гору

Фразеологизмы, поскольку они обладают высокой образностью, экспрессивностью и устойчивостью в языке, играет большую роль в отражении шкалы ценностей носителей той или иной национальной культуры. В.В. Виноградов отмечал, что фразеологизмы представляют собой «сконцентрированные формулы народного опыта, быта, менталитета» [8].

Именно фразеологические единицы выступают в качестве **репрезентантов** аксиологических смыслов, отражая социальные установки, моральные нормы, идеалы и повседневные ценности. Так, ФЕ-репрезентанты аксиологема жизнь в казахской и русской языковых картинах мира можно представить следующим образом.

В русской и казахской языковых картинах мира фразеологизмы с компонентом жизнь (в рус. — жизнь, жить; в каз. — өмір, өмір сүру) формируют особую **фразеоаксиологическую зону**, внутри которой моделируются представления о качестве жизни, её трудностях, радостях, смысле, продолжительности и пр. Эти выражения фиксируют не только отношение к жизни как к дару или испытанию, но и транслируют глубинные культурные установки этноса.

Современные исследователи акцентируют внимание на том, что аксиологема реализуются в языке через фразеологические поля, состоящие из ядерных и периферийных единиц. Так, в аксиосфере «жизнь» ядром выступает сама лексема жизнь, а периферийные репрезентанты — это устойчивые выражения, содержащие оценочные признаки: положительные (жить по совести, жизнь удалась), отрицательные (прожигать жизнь, влечить жалкое существование) и амбивалентные (жить на грани).

Фразеологическая картина мира является одним из фрагментов ЯКМ. Соответственно, в каждом национальном языке существует фразеологический корпус, расширяющий круг репрезентантов той или иной аксиологема. Рассмотрим ФЕ-репрезентанты аксиологема жизнь в русском и казахском ЯКМ.

В русской и казахской языковых картинах мира концепт «жизнь» реализуется через множество фразеологических единиц, каждая из которых фиксирует определённые представления о жизненных приоритетах, нормах, социальных ожиданиях и менталитетных установках. Сопоставительное изучение таких фразеологизмов позволяет выявить общие и специфические черты в аксиологических системах двух языков и культур.

Целью настоящей статьи является выявление и анализ фразеологических единиц, выступающих репрезентантами аксиологема жизнь в русском и казахском языках, а также описание

их семантической структуры и аксиологического содержания. Исследование проводится в рамках лингвокультурологического и когнитивно-дискурсивного подходов, с учётом аксиологической парадигмы, в центре которой находится оппозиция «жизнь – смерть». Особое внимание уделяется таксономической структуре аксиологического поля, включающего ядерные и периферийные репрезентанты, а также амбивалентности ценностных характеристик, отражённой в фразеологической системе.

Таблица 2. Фразеологизмы

№	В русском языке	В казахском языке	Значение
1.	Жить как сыр в масле кататься	Майдай балқып өмір сүру	Жить в роскоши и комфорте.
2.	Жизнь бьёт ключом	Өмір қайнап жатыр	Активная, насыщенная событиями жизнь
3.	Жить на широкую ногу	Кең өмір сүру	Вести роскошный образ жизни
4.	Жизнь не мёд	Өмір бал емес	Жизнь полна трудностей
5.	Жизнь как зебра: полоса белая, полоса чёрная	Өмірде ақ пен қара қатар жүреді	Чередование хороших и плохих периодов в жизни
6.	Жить одним днём	Бүгінмен өмір сүру	Не думать о будущем, жить настоящим
7.	Жизнь висит на волоске	Өмір жіпке ілулі	Находиться в опасности, быть на грани смерти
8.	Жить не тужить	Қамсыз өмір сүру	Жить без забот
9.	Жизнь прожить – не поле перейти	Өмір сүру – дала кезу емес	Жизнь сложна и полна испытаний
10.	Жить душа в душу	Жан-тәнімен өмір сүру	Жить в гармонии и согласии
11.	Жизнь – не сахар	Өмір тек қант секілді тәтті емес	Жизнь трудна и полна испытаний
12.	Жить по совести	Армен өмір сүру	Жить честно и справедливо
13.	Жить как на вулкане	Өмірі оттың үстінде	Жить в постоянном напряжении
14.	Жизнь – театр, а люди в нём актёры	Өмір – театр, адамдар – актерлер	Жизнь как сцена, где каждый играет свою роль
15.	Жить по средствам	Шамасына қарап өмір сүру	Жить по своим возможностям
16.	Жизнь – не сказка	Өмір ертегі емес	Жизнь далека от идеала
17.	Жить без оглядки	Алды-артына қарамай өмір сүру	Жить, не оглядываясь на прошлое
18.	Жизнь – борьба	Өмір – күрес	Жизнь требует усилий и преодоления трудностей
19.	Жить в своё удовольствие	Қалағанынша өмір сүру	Жить так, как хочется, наслаждаясь жизнью
20.	Жизнь учит	Өмір үйретеді	Опыт приходит с жизнью

Таблица 3. Пословицы и поговорки

№	В русском языке	В казахском языке	Значение
1.	Жизнь прожить — не поле перейти.	Өмір – күрес.	Жизнь — это борьба.
2.	Береги платье снову, а честь смолоду.	Жас кезінде жинағаның – кәрілікке қор.	Что соберёшь в молодости — пригодится в старости.
3.	Не та жизнь, что прожита, а та, что запомнилась.	Өмірді мәнді еткен – жақсы іс.	Жизнь ценна добрыми делами.
4.	Где жизнь, там и надежда.	Үмітсіз шайтан.	Без надежды — только шайтан (т.е. надежда всегда есть).
5.	Не в красоте счастье, а в доброй жизни.	Сұлу емес, ақылы бар.	Ценится не красота, а ум (или душевные качества).
6.	Жизнь дана на добрые дела.	Өмір – бір-ақ рет беріледі.	Жизнь даётся только один раз.
7.	Коротка жизнь — спеши делать добро.	Жақсылық қылсаң, өзіңе қайтады.	Делай добро — оно к тебе вернётся.
8.	Без труда нет жизни.	Еңбексіз нан жоқ.	Без труда не будет хлеба.
9.	Век живи — век учись.	Оқу – инемен құдық қазғандай.	Учение — как колодец копать иголкой.
10.	Хорошая жизнь — добрыми делами строится.	Жақсы сөз – жарым ырыс.	Доброе слово — половина счастья.
11.	Живи век — забот не впрок.	Өмір өзен, кезекпен ағады.	Жизнь — как река, течёт по очереди.
12.	Не по жизни жить, а по совести.	Ар ұят болмаса, адамда не қасиет бар?	Если нет совести и стыда — что за человек?
13.	Каково начало, таков и конец.	Басы қатты болса, соңы тәтті болады.	Начало тяжёлое — конец сладкий.
14.	Жизнь даётся на добрые дела, а не на праздность.	Тірі адам тіршілігін жасайды.	Живой человек — живёт (занимается делом).
15.	Что посеешь, то и пожнёшь.	Не ексең, соны орасың.	Что не посеешь, того не пожнёшь.
16.	Лучше горькая правда, чем сладкая ложь.	Ащы да болса шындықты айт.	Говори правду, даже если она горькая.
17.	Жизнь не малина — с шипами.	Өмір – күрделі жол.	Жизнь — сложный путь.

18.	Без прошлого нет будущего.	Өткенді ұмытқан болашақтан айырылады.	– Кто забывает прошлое — лишается будущего.
19.	С кем поведёшься, от того и наберёшься.	Жаман дос жолда қалдырар.	Плохой друг оставит тебя на дороге.
20.	Жизнь — учитель без книги.	Өмір — оқулығы жоқ ұстаз.	Жизнь — учитель без учебника.

Понятие «жизнь» репрезентировано в языке на разных уровнях: от лексического до дискурсивного. Однако именно фразеология наиболее концентрированно и выразительно передаёт отношение этноса к жизни – как ценности, как пути, как борьбе, как удовольствию.

Русская картина мира: аксиологема «жизнь» во фразеологических единицах

В русском языке «жизнь» представлена как:

- ценность (жизнь одна дана, жизнь прожить – не поле перейти);
- риск и опасность (жизнь висит на волоске);
- игра или театр (жизнь – театр, играть жизнью);
- трудности (жизнь – не сахар, жизнь не мёд);
- наслаждение (жить в своё удовольствие, не житьё – а масленица);
- борьба (жизнь – борьба, идти на смерть);
- честность (жить по совести);
- бедность и нужда (перебиваться с хлеба на воду, сосать лапу);
- долголетие (жить чужой век, мафусаилов век);
- гармония и согласие (жить душа в душу).

Фразеологическая картина демонстрирует как позитивную, так и негативную интерпретацию жизни. Наличие таких метафор, как «жизнь – путь», «жизнь – игра», «жизнь – труд» указывает на полифоничность концепта.

Казахская картина мира: фразеологизмы и пословицы

Казахский язык также богат фразеологизмами с компонентом «өмір» (жизнь). Примеры:

- өмір қайнап жатыр – жизнь кипит (активная жизнь);
- майдай балқып өмір сүру – жить как в масле кататься (благополучие);
- өмір тек қант секілді тәтті емес – жизнь не сахар (трудности);
- өмір – күрес – жизнь – борьба;
- армен өмір сүру – жить по совести.

Паремнология отражает аксиологическую специфику казахской культуры: акцент на общественную пользу, коллективизм, духовные качества. Например:

- Өмір – оқулығы жоқ ұстаз – жизнь – учитель без учебника;
- Жақсылық қылсаң, өзіңе қайтады – делай добро – вернётся тебе;
- Ар ұят болмаса, адамда не қасиет бар? – без совести и стыда нет человека.

Казахская языковая картина демонстрирует уважительное, философское отношение к жизни как к ценности, одарённой Творцом и предназначенной для добрых дел.

Сравнительный анализ

Анализ позволяет выделить общие черты:

- представление о жизни как о ценности;
- присутствие метафоры пути;
- аксиологическое противопоставление жизни и смерти;
- наличие концептов борьбы, радости, испытаний.

Национально-специфические черты:

• В русском языке — преобладание индивидуалистических и эмоционально-насыщенных оценок;

• В казахском — ориентация на нравственные и коллективные ценности, выраженные в пословицах и образах традиционной культуры.

Проведённый анализ показал, что в обеих языковых картинах мира фразеологические единицы с компонентом «жизнь» выполняют функцию ценностных маркеров. Они отражают отношение к жизни как к величайшей ценности, передают установку на активное, осмысленное, моральное существование. При этом наблюдаются как универсальные, так и национально-специфические смысловые доминанты, обусловленные историко-культурным контекстом.

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Technical sciences

BIG DATA AND ANALYTICS

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Abstract

In the context of rapid digital transformation, the role of Big Data and analytics is becoming strategically important. This article explores the evolution of analytics technologies - from cloud platforms to edge-computing — and reveals how data is transformed into a tool for decision-making and economic growth. The key benefits of analytics are considered, including revenue growth, increased forecast accuracy, and cost reduction. Maturity models describe the development paths of organizations — from the basic reporting level to the strategically oriented use of analytics. Particular attention is paid to implementation barriers: personnel shortage, data quality, and ethical issues. The final part presents promising areas — data markets, synthetic datasets, and quantum computing — that are shaping the analytical environment of the future. The work will be useful for researchers, managers, and technologists seeking to build a sustainable and value-oriented data processing infrastructure in the context of a rapidly changing technological paradigm.

Keywords: analytics, big data, edge-computing, quantum technologies, digital maturity.

Introduction: *The modern world is immersed in information overload: social networks, sensor networks, scientific instruments and mobile devices generate terabytes of diverse and disparate data every day. These data arrays – the so-called Big Data – do not fit into the framework of classical processing and pose new challenges and tasks for analysts and engineers [1; pp. 2–3]. They include structured tables and databases, semi-structured formats such as JSON or XML, as well as unstructured sources – texts, images, audio and video.*

Big Data is not just volume: it is a fundamentally new quality that goes beyond the volumes that traditional tools can no longer handle [3; p. 4]. Processing such data requires new platforms, such as Hadoop and Spark, as well as approaches [5; pp. 6–7]. Analytics is emerging that can suggest solutions for unknown scenarios, where previously only past data and intuition were relied upon [2; p. 12].

But the introduction of artificial intelligence and machine learning into big data processing opens up more than just technical possibilities – analytics is becoming a transformer of processes that change the way businesses, healthcare, or urban infrastructure are managed [10; p. 45]. For example, predictive analytics can predict demand surges, detect fraud, or identify risks before they become so obvious that they can be recorded by traditional indicators [2; p. 27].

Having discussed the relevance of Big Data, we move on to consider the technological foundation that allows us to turn piles of data into valuable insights.

Initially, everything developed around cloud platforms — AWS, Azure, Google Cloud. These systems offer virtually unlimited computing and storage, scalable for the most complex analytical tasks [6; pp. 9–10]. Cloud infrastructure is convenient for training large models, aggregating data streams in real time (via services like Kinesis), and creating centralized analytical panels [11; p. 8]. However, for solutions where response speed is critical or communication is limited, clouds are not always suitable.

An edge computing architecture has emerged that brings data processing closer to the sources themselves, such as sensors, cameras, and controllers. This approach dramatically reduces latency, eases the load on the network, and enhances security, since data rarely leaves the local environment [5; p. 10].

Then it was Edge AI – the request for inference models directly on devices – that became a natural continuation: recognition of images, accidents in real time, devices with trained algorithms – is no longer science fiction, but reality [4; p. 6].

Comparison of Cloud AI and Edge AI

<i>Parameter</i>	<i>Cloud AI</i>	<i>Edge AI</i>
<i>Location of Computations</i>	<i>Centralized - powerful data centers</i>	<i>On devices or local nodes</i>
<i>Delay</i>	<i>Higher, depends on the network</i>	<i>Minimal - instant reaction</i>
<i>Scalability</i>	<i>Almost unlimited thanks to cloud</i>	<i>Limited by device resources</i>
<i>Security and privacy</i>	<i>Data is transmitted and stored centrally - measures are required</i>	<i>Often critically higher - data is stored and processed locally</i>
<i>Communication addiction</i>	<i>Complete dependence on a stable internet connection</i>	<i>Independence is critical for remote/autonomous systems</i>
<i>Model updates and training</i>	<i>Convenient via the cloud - centralized and mass</i>	<i>Less common and more difficult; requires OTA but rarely teaches online</i>

Therefore, cloud infrastructure provides power, scale and centralized management, while edge-Computing is about speed, security and autonomy [5; p. 9].

Companies are increasingly turning to a hybrid model: training and mass analysis in the cloud, deployment and primary analytics directly at the “data collection point” [6; p. 11]. This compatibility allows:

1. Prepare mathematical models in the cloud.
2. Expand them to the edge-devices for local reactive analysis.
3. The obtained local insights are grouped back into the cloud for reference summary and further training [6; p. 12].

An example of this are projects in the IoT and industry, where the edgecloud AI framework with distributed processing and federated learning is used - this increases accuracy, reliability and response speed without unnecessary costs [10; pp. 44–45].

Finally, technologies are being integrated into real life: for example, McDonald's is implementing edge AI in its restaurants to monitor equipment, prevent breakdowns, and improve operations through local voice AI - all processed on-site with minimal latency and without transmitting data to the cloud [11; p. 9]. Initiatives by Intel, AWS, and Ericsson confirm that this trend is already covering industry, transportation, medicine, and smart cities [8; p. 5].

Moving on from the presented technological foundation, we should next highlight the value content: how exactly this core converts computing power and speed into specific benefits - acceleration of processes, strong analytics, economic effect and new opportunities.

After describing the technological core, it becomes clear that the infrastructure is only the basis. Real value appears when the collected and processed data is transformed into specific benefits: increased revenue, reduced costs, increased efficiency [2; pp. 21–22].

Benefits of Big Data Analytics

Companies that are able to quantify the impact of analytics are seeing sustainable profits:

- Revenue growth by an average of 8%, cost reduction by 10% [10; p. 48].
- Improved sales conversion by 12% and reduced inventory costs by 15% using predictive analytics [3; pp. 5–6].
- Increase in forecast accuracy in trade promotion (for example, at Danone) from 62% to 92%, which reduced losses by 30% [9; p. 8].

Performance metrics allow you to see the real impact:

<i>Category</i>	<i>Performance indicators</i>	<i>Examples</i>
<i>Revenue growth</i>	<i>+8% average growth when analyzing data</i>	<i>Telco and Retail Optimize Sales Strategies</i>
<i>Cost reduction</i>	<i>-10% due to process optimization</i>	<i>GE Reduces Equipment Downtime</i>
<i>Sales Conversion</i>	<i>+12% thanks to personal targeting</i>	<i>Fintech: refinancing, product subscriptions</i>
<i>Inventory</i>	<i>-15% warehouse costs due to forecasts</i>	<i>Retail — automated product control</i>
<i>Operational solutions</i>	<i>Speeding up decision-making time from weeks to days</i>	<i>Marketers optimize campaigns in real time</i>
<i>Accuracy of forecasts</i>	<i>92% instead of 62% in promotional analysis</i>	<i>Reduction in write-offs of expired products by 30%</i>

These figures illustrate not just abstract efficiency, but specific cases where analytics moved from idea to profit and organizational improvements [10; p. 49].

Linking metrics to business results

The transition from insight to economic effect is achieved through the following factors:

- Predictive Analytics allows you to anticipate demand, identify fraud, and set up discount campaigns based on historical and behavioral data [2; pp. 34–35].
- Optimization of supply chains and logistics reduces costs and improves service levels [1; p. 6].
- Personalization of customer experience – based on Big Data, increases retention and customer lifetime value (LTV) [3; pp. 6–7].

- Reducing equipment downtime – through monitoring and predictive maintenance, which is especially valuable in the industrial sector [5; p. 12].

How to measure the return on analytics

To ensure that the transition from insight to economic effect does not remain a declaration, it is necessary to clearly measure ROI. Effective metrics:

- Return on investment ratio - typically expected to return 7x on every dollar invested [11; p. 7].
- Svitla Methodology: (data value is its simplicity) / investments – allows to include real and hidden costs [4; p. 8].
- Project-based financing: companies invest in reportable cases that demonstrate substantiated results [6; p. 14].

Regularly measuring ROI is key to continued funding and expanding the analytics function by showing which initiatives are delivering the greatest return.

The value of Big Data analytics is therefore not simply access to data, but turning it into informed decisions that improve business efficiency, profitability, and sustainability. In the next section, we discuss key barriers to this, from human resource challenges to ethical constraints.

Challenges and barriers to implementation

Moving beyond the value proposition, it's worth considering why Big Data analytics adoption so often faces significant barriers. Here are the key barriers, backed up by data and examples.

Companies are experiencing an acute shortage of qualified specialists: as studies have shown, about 60–63% of organizations are faced with a shortage of analysts and IT engineers, especially in industry and the public sector [7; pp. 2–3]. This slows down projects, increases the risk of errors when setting up platforms, and makes implementation more expensive and time-consuming.

An equally serious problem is the quality and heterogeneity of data. “Dirty,” incomplete, or inconsistent data requires complex cleaning and standardization, which is often underestimated. Medical, IoT, and industrial data are particularly susceptible to this, making it much more difficult to obtain reliable insights [9; p. 5].

Software and infrastructure limitations add their share, especially for organizations with less mature IT environments. Low internet speeds, limited cloud infrastructure, and a lack of integration platforms create technological barriers [6; p. 9].

The issue of privacy, security and ethics is key. Mass collection of personal data creates privacy issues: algorithms can be “black boxes”, and using data without proper consent threatens user trust and compliance with regulatory requirements such as GDPR or HIPAA [4; pp. 5–6].

Another barrier is the high cost of projects. Typically, large-scale Big Data implementations require from 10 to more than 50 million rubles from Russian companies; medium-sized businesses are often limited by budget, which prevents pilots from scaling up [1; p. 7].

Overview of Key Barriers

Barrier	Description
Staff shortage	60-63% of companies suffer from a shortage of qualified analysts and engineers
Poor data quality	Incompleteness, inconsistency, and a large amount of “noise” create false conclusions
Technological limitations	Insufficient infrastructure: internet, clouds, integration platforms
Issues of privacy and ethics	Privacy violations, algorithmic black boxes, regulation
High costs	Investments from pilot to implementation are expensive, small businesses are limited

All of these issues are interconnected and mutually reinforcing: technologically outdated organizations make it difficult to clean data efficiently, which in turn requires additional personnel and resources, which in turn requires funding, which is complicated by regulations and risk potential [6; p. 13].

The transition of decisions through “bottlenecks” – personnel, technological, ethical or financial – is possible only with an integrated approach, where staff training, infrastructure improvement, building data governance processes and ethical standards go hand in hand with an economic strategy [2; p. 29].

The next section is devoted to maturity models and development paths, where it will become clear how building infrastructure and strengthening competencies lead to sustainable growth of analytical functions and a reduction in the listed risks [7; p. 3].

Maturity models and development paths

Following the description of the challenges, it is important to understand how organizations overcome these barriers and develop analytics systematically. Maturity models allow us to see the sequence of steps and key growth points.

Let's start with a classic analytical framework taken from Gartner. It divides development into four stages:

1. **Descriptive Analytics**— where the organization learns to understand what happened: reports, visualizations, basic KPIs [11; p. 5].

2. **Diagnostic Analytics**— in-depth analysis of causes, identification of interrelations [3; pp. 6–7].

3. **Predictive Analytics**— forecasting future events using models and ML [2; p. 37].

4. **Prescriptive Analytics**— analytics advises action, optimizes processes [10; p. 48].

If we look more broadly, maturity models cover not only analytics, but also strategy, culture, and infrastructure. Here is a generalized diagram with levels [7; pp. 3–4].

Level	Description
Explorer/Aware	Lack of systemicity - data is isolated, decisions are based on intuition
User/Informed	The Beginning of a Structured Approach - ETL-processes, KPI, self-service analytics
Leader/Proactive	Analytics is built into the process – the model is actively used in operational decisions; the data culture is expanding
Innovator/Transform	Analytics is a strategic asset: models are trained in the cloud, edgeAI is used, decision making is automated

Additionally, the Heap model identifies four stages of maturity based on the level of engagement and culture:

- Data exploration(first steps, no standards),
- Data-informed(start using tools),
- Data-driven(analytics is the driving factor of decisions),
- Data-transformed(data is the basis of strategies and processes) [7; pp. 4–5].

These models structure the organization's path:

1. Awareness: Understand the importance of data, explore opportunities.

2. Integration and management: build ETL/warehouse, introduce data governance.

3. Analytics in processes: implementing models into everyday decisions.

4. Digital transformation: Analytics transforms business models, including predictive and prescriptive analytics [2; p. 31].

According to TDWI, only about 8% of companies reach the Maturity stage or higher, and only 9% are rated as Innovator/Transform in other assessments [10; p. 49].

Moving through maturity levels requires:

- Coordinated construction: data culture, employee training, quality infrastructure, effective data management [11; p. 7].

- Specific goals at each stage: pilot projects, measurable ROI, expansion of analytical initiatives [3; p. 8].

- Hybrid approach: training models in the cloud, moving analytics to edge devices, setting up governance processes and security - all this must be aligned with business goals [6; p. 13].

Prospects: Market Transformations, Synthetic Data, Quantum Technologies

There comes a time when mature analytics solutions begin to face new challenges and enormous opportunities. I propose to discuss three key development areas that are already shaping the next round of Big Data and analytics evolution.

1. Data Markets and Monetization

Data is no longer an internal resource — it is turning into a commodity. Goldman Sachs points out that companies with rich, high-quality and structured content are already signing agreements to license their data [8; p. 4]. The first data marketplaces are appearing, where companies sell datasets, and researchers and corporations act as buyers. At the same time, demand is growing for specialized sets — medical, business reports, IoT, etc. Thus, the analytics infrastructure is acquiring a new layer — a data market, where each insight or information flow itself becomes an asset.

2. Synthetic data as a means of scaling

The lack of high-quality and legitimate real data material is stimulating the active implementation of synthetic data. In 2024, the volume of this market is \$313 million, and by 2034 it is expected to grow to \$6.6 billion with a CAGR of 35.7% [1; p. 7]. Major players - Nvidia, Google and OpenAI - are already using synthetic data factories to train large neural networks [9; p. 6]. These technologies allow you to model rare events, expand training samples and bypass restrictions with personal data - all this is becoming a powerful catalyst for the implementation of analytics in new areas.

3. Quantum technologies and analytics of the future

Quantum computing represents the next leap for Big Data. It is capable of analyzing huge amounts of data in parallel through superposition and entanglement. Experts from Quantum Zeitgeist and ISG note that quantum algorithms such as Grover and Shor will allow analyzing massive data structures orders of magnitude faster than classical systems [4; p. 7].

Some scenarios are already being implemented in practice. For example, hybrid quantum-classical models create synthetic data – QGANs – for financial data and sector analysis (banking, S&P 500) [5; p. 8]. At events like CES and SAS Innovate, P&G cases are being demonstrated: solving complex ingredient mixing problems was reduced from 6 hours to 2 minutes thanks to a hybrid approach, where the quantum core accelerates model training [10; p. 51].

Summary table: promising technologies

Direction	Current status	Possibilities and effects
Data monetization	First markets and licensing deals	New revenue stream; focus on unique or niche data
Synthetic data	Growth of 35.7% per year	ML acceleration-processes, GDPR compliance, accessibility for rare domains
Quantum Analytics	Pilot hybrid models, P&G projects	Processing Terabytes Faster; New Quantum-Enhanced Applications in Finance, Logistics

These areas are inextricably linked: synthetic data is becoming a commodity in new markets, and it is quantum computing that will begin to work with it on an industrial scale [4; p. 8]. This lays the foundation for a new analytical paradigm - from centralized platforms to flexible data ecosystems, where technologies, assets and computing resources are integrated and monetized [5; p. 9].

In conclusion, I would like to note that the analytics of the future is not only a toolkit, but also market models – Data as Asset, synthetic factories, quantum accelerators – shaping a new digital landscape [1; pp. 7–8]. In our final remarks, we will formulate recommendations for organizations wishing to be at the forefront of these transformations.

Conclusion

The project described the path from the birth of the Big Data idea to its transformation into a working system capable of providing tangible business results. Starting with the introduction, we outlined the expansion of the boundaries of traditional data processing and the transition to analytics capable of revealing hidden patterns and management opportunities [2; p. 15].

Then we took a detailed look at the technological core – clouds and edge-computations that form the basis for analytics in various scenarios and provide a balance between power and speed [6; pp. 10–11].

Once the foundation was in place, we demonstrated that the value of analytics is measured not simply by its presence, but by how it drives revenue, cost savings, increased conversion, and decision accuracy. Tabular data and real-world case studies illustrate that the ROI from such projects averages 7x or higher when analytics is embedded into operational processes [10; pp. 48–49].

The challenges of implementation — a shortage of specialists, data quality and security, technological limitations, costs — turned out to be interconnected and require a comprehensive strategic approach. We saw that without personnel training, improved data governance and a built infrastructure, no technology will give a sustainable result [7; p. 3].

Maturity models have made it possible to imagine a step-by-step progression from simple reports to prescriptive and automated analytics, where organizations become not just informed, but transformed by data and build a corresponding culture [3; pp. 6–7].

Finally, the prospects – data market, synthetic factories and quantum analytics cores – illustrate that analytics is becoming not just a tool, but an asset, a lever of innovation and a new competitive resource [8; p. 5].

Recommendations for organizations:

1. **Formalize your data strategy:** set roles, KPIs, ROI metrics [11; p. 7].
2. **Develop skills and culture:** organize Data Science training, introduce data-driven methods [2; p. 28].
3. **Integrate approaches:** Combine cloud, edge learning-inference, prescriptive analytics [6; p. 13].
4. **Create Data Governance and Be Ethical:** Build “Big Data with Privacy” [4; p. 6].
5. **Follow the trends:** participate in data markets, implement synthetic solutions, study pilots of quantum projects [9; p. 6].

Therefore, Big Data analytics is not a goal in itself, but a tool for strategic management, innovation and sustainable development. By taking a comprehensive approach – technological, personnel, ethical and financial – organizations gain not just efficiency, but the ability to transform data into a competitive advantage and major achievements [10; p. 50].

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TERAHERTZ (THZ) COMMUNICATIONS IN AEROSPACE SYSTEMS

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Abstract

The paper presents a theoretical analysis of the potential of terahertz (THz) communications in aerospace systems. The key advantages of THz communications, including high bandwidth, equipment compactness, and signal directionality, as well as the main limitations, such as attenuation, sensitivity to external conditions, ray tracing difficulties, and system overload, are considered. Particular attention is paid to current technological solutions, such as ultra-massive antenna arrays (UM-MIMO), intelligent reflective surfaces (RIS), integrated signal conditioning and sensing (ISAC), and the ICARS architecture. Innovative approaches to eliminating technical limitations are proposed using hybrid channels (THz+mmWave+FSO) and AI algorithms for dynamic beam adaptation. In conclusion, practical recommendations are formulated for the further development of THz communications systems in the context of satellite, unmanned, and cross-platform communications.

Keywords: AI algorithms, aerospace networks, hybrid channels, ICARS, RIS, THz communication, UM-MIMO

Introduction: In the modern era of active exploration of air and near-Earth space, humanity is increasingly faced with the need to transmit huge amounts of data at high speeds. Not only ground-based but also aerospace systems – from unmanned aerial vehicles to new-generation satellite constellations – require reliable and high-speed communication channels. It is in this context that the terahertz (THz) range of the electromagnetic spectrum, located between millimeter radio waves and infrared radiation, comes to the fore. Despite the relative novelty of its practical application, the potential of this area is difficult to overestimate [3: p. 1].

Compared with traditional radio communications, terahertz technologies open up entirely new horizons. First of all, we are talking about the ability to transmit information at speeds of tens, and in the future, hundreds of gigabits per second [1: p. 3]. In addition, terahertz antennas are much more compact, and the ability to directional beam formation allows for the minimization of interference, which is especially valuable in multi-level aerospace communications architectures [9: p. 111]. However, like any promising technological direction, THz communications are not without serious challenges: from significant signal attenuation in the atmosphere to technical limitations associated with the stability of equipment in space conditions [5: p. 3089].

However, the growing interest in this spectral range is not accidental. Today, THz communication is already considered a key component of future generations of wireless networks, including within the framework of the 6G and SAGIN (Space-Air-Ground Integrated Networks) concepts [20: p. 30]. This is especially relevant in connection with the rapid development of low-orbit satellite constellations, the increase in air traffic density, and the need to integrate reconnaissance and communications functions into a single system [19].

In such conditions, attention to the terahertz range becomes not only logical, but also a strategically necessary step. This article is a theoretical study of the capabilities and limitations of terahertz communications in the aerospace environment. It provides an overview of key technical solutions, compares existing approaches and identifies their weaknesses. Particular attention is paid to the formulation and justification of new proposals to eliminate the identified shortcomings. An important part of the work is the consistent and logically coherent disclosure of ideas, which will allow the reader not only to understand the current state of this area, but also to assess the directions of its further development.

1. Potential and Limitations of Terahertz Communication in Aerospace Systems

Modern communication systems in the aerospace industry are experiencing rapid development. The increase in the density of information exchange, the increased number of drones, aircraft and

satellites, as well as increasing requirements for delay and reliability of signals require a radical revision of approaches to the organization of radio channels [4].

It is in this context that the terahertz frequency range (approximately 0.1 to 10 THz) is seen as a potential technological revolution capable of meeting these requirements in the long term [2].

One of the most obvious and strategically important advantages of THz communications is the extremely high throughput. Access to wide, continuous frequency bands, often exceeding tens of gigahertz, enables data transmission at speeds unachievable in traditional radio frequency bands [11]. This is especially valuable for applications that require rapid transmission of large amounts of information, such as inter-satellite synchronization, high-definition drone video streaming, or inter-orbital scientific data [8].

In addition, due to the short wavelength (from several tens to hundreds of micrometers), terahertz radiation allows the use of compact, highly directional antennas [22: p. 1186]. This makes it possible to create miniature communication modules even for small-sized platforms, including nanosatellites and drones. Such beam directionality not only increases energy efficiency, but also reduces the level of cross-talk, especially in dense multi-level networks where several nodes operate in close proximity [13].

It should also be noted that the narrow beam in THz systems makes it difficult for third parties to intercept the signal, which significantly increases the level of security and resistance to unauthorized access [5: p. 3092]. Thus, terahertz communication can become the basis not only for high-performance, but also for secure communication platforms in space and on Earth.

Moving from advantages to limitations, it is worth noting that, like any high-frequency range, the THz range is not without significant challenges that limit its widespread use, especially in the complex aerospace environment [21: p. 141].

The key limiting factor for terahertz communications is the high signal attenuation caused by both free spatial propagation and the absorption of electromagnetic energy by atmospheric molecules, primarily water vapor and oxygen [21: p. 141]. At levels below the troposphere, this leads to a sharp reduction in transmission range, especially at high humidity or in the presence of atmospheric disturbances [5: p. 3090]. Although the influence of molecular absorption is significantly reduced outside the dense layers of the atmosphere (in the stratosphere and above), it still does not disappear completely and must be taken into account when modeling communication channels [25: p. 2335].

An additional complication is the sensitivity of the terahertz signal to environmental conditions. Unlike radio frequency or even millimeter waves, THz signals are much more susceptible to the influence of fine particles, turbulent flows, and temperature gradients [6]. This makes them vulnerable in scenarios where the external environment is unstable - for example, when transitioning between atmospheric layers or when flying through cloud formations [17].

The problem of beam tracking deserves special attention. Due to the narrow directional pattern of antennas, even minor angular displacements between the receiver and transmitter can lead to loss of communication [10]. This is especially relevant in aerospace, where both transmitting and receiving devices are constantly moving at high speed and often change their trajectory. Accordingly, it is necessary to implement complex algorithms for active tracking and beam direction control in real time, which complicates the architecture of the entire system [14].

An equally critical factor is the impact of cosmic radiation on sensitive components of THz equipment. In particular, devices for frequency multiplication, signal generation and reception are subject to high requirements for resistance to ionizing radiation, solar flares and cosmic particle fluxes [2: p. 6]. Many modern components designed for terrestrial conditions are simply not adapted to such impact, which requires a separate line of research and modification of the element base [12].

For a comprehensive understanding of the place of terahertz communication in the architecture of aerospace systems, it is advisable to compare it with two closest alternatives: millimeter waves (mmWave) and optical wireless channels (FSO - Free Space Optics) [7].

Parameter	THz communication	mmWave communication	FSO (optical)
Bandwidth	Very high	Medium/high	Very high
Antenna size	Very small	Small	Depends on the optics
Resistance to the atmosphere	Average	Tall	Low (fog, rain)
Direction	Tall	Average	Very high
Protection from interception	Tall	Average	Very high
Sensitivity to movements	High (beam tracking)	Average	Very high (adjustment)
Implementation in space	Promising	Already in use	Partially implemented

The table shows that THz communication occupies an intermediate position between mmWave and FSO. In terms of throughput, it is closer to optical systems, but requires less precise alignment. In

terms of weather resistance, it is superior to FSO, but inferior to mmWave. Thus, it is a compromise, but promising solution for building hybrid, multi-channel systems in aerospace, capable of adapting to various environmental conditions [7].

Despite these limitations, terahertz communications have unique potential that cannot be realized using existing technologies without significant compromises [4]. However, their effective implementation requires not just technical adaptation, but a rethinking of the aerospace communications architecture, including the use of smart surfaces, hybrid protocols, and active AI control [14].

In the next section we will look at these technological aspects in more detail, looking at existing architectural solutions and their maturity as they apply to aerospace.

II. Technological base and current approaches

Effective application of terahertz communications in aerospace systems is impossible without a reliable and adaptive technological basis. As in any breakthrough area, successful implementation of THz communications requires not only the creation of new components, but also a revision of the architecture of the entire communications system [3: p. 3]. Today, three key areas can be identified, within the framework of which theoretical developments and partial practical testing are already underway: ultra-massive antenna arrays (UM-MIMO), intelligent reflective surfaces (RIS), integration of communications and sensing (ISAC), and resource management in distributed environments [13].

Each of these areas deserves special attention, since it forms the basis for future aerospace communications at terahertz frequencies [15].

One of the most important challenges in the propagation of terahertz signals is high spatial attenuation, especially at large distances between the transmitting and receiving nodes. To compensate for these losses, it is proposed to use ultra-massive MIMO (Ultra Massive Multiple Input – Multiple Output) technologies, which use hundreds and thousands of antennas capable of simultaneously forming and directing several narrow, concentrated beams [12].

This approach allows not only to increase the energy efficiency of transmission, but also to increase the resistance to spatial fluctuations and Doppler shifts typical for the aerospace environment. In addition, the possibility of simultaneous use of several directional channels (spatial multiplexing) provides a significant increase in spectral efficiency, which is critical when resources are limited [10].

In addition to UM-MIMO, intelligent reflective surfaces (RIS — Reconfigurable Intelligent Surfaces) are actively developing. These structures consist of a large number of passive metaelements capable of dynamically changing the phase of the reflected signal, redirecting it in the desired direction. Thus, RIS allows:

- eliminate "blind spots" in signal reception;
- bypass obstacles (for example, the body of a satellite or drone);
- reduce losses and interference levels by optimizing beam propagation in real time [16].

For aerospace, where every gram of mass and milliwatt of power counts, the combination of UM-MIMO and RIS could be the key to creating energy-efficient, scalable and adaptive communication modules capable of providing communications over complex flight paths [14].

Modern aerospace platforms require not only stable communication, but also the ability to collect data about the surrounding space - be it navigation, position control, or object monitoring. In this context, the concept of integrated communication and sensing (ISAC - Integrated Sensing and Communication) is particularly relevant [2: p. 3].

The essence of the ISAC approach is that the same terahertz platform simultaneously performs the functions of data transmission and sensor control, for example, radar or object tracking [24].

This is particularly effective in resource-constrained environments, such as on board small satellites or unmanned platforms [11].

Benefits of ISAC include:

- savings in mass, volume and energy costs due to the elimination of duplicate systems;
- improving coordination between sensory information and communication;
- increased positioning accuracy due to high frequencies and a wide signal band;
- reduction of interference between channels, since the sensor and transmitter operate in phase matched [2: p. 4], [11].

However, the implementation of ISAC also requires solving a number of problems - first of all, the development of flexible time, frequency and code sharing protocols, as well as algorithms capable of managing priorities between the "transmission" and "sensing" functions depending on the mission context [13].

In the aerospace environment, especially in multi-layered networks including ground, air, and space segments (SAGIN), efficient use of resources becomes a priority. Resources here include spectrum, energy reserves, computing power, and spatial capabilities (beam direction, position in the network) [25: p. 2335].

The terahertz range places special demands on the intelligent management of these resources, since:• narrow signal beamwidths require coordination between moving nodes;• limited transmitter power requires optimization of energy distribution;• the need for adaptive data routing requires dynamic network response [15].

Modern approaches involve the use of artificial intelligence (AI) and reinforcement learning to adapt network parameters to changing conditions, such as satellite movement, antenna orientation changes, or channel interference [14].

In the future, such technologies will make it possible to build self-organizing distributed THz networks capable of self-configuration, load redistribution, and recovery from failures without operator intervention [12: p. 4].

Today, most of these technologies are at the stage of prototyping and numerical modeling, especially in application to aerospace [10], [16].

Below is a table with a general assessment of the maturity level (Technology Readiness Level, TRL) on a scale from 1 to 9:

Technology	TRL in terrestrial networks	TRL in Aerospace	Comment
UM-MIMO	5–6	3–4	Requires adaptation to dynamic conditions
RIS	4–5	2–3	Research into materials and management is underway
ISAC	4–6	3–4	Theoretically feasible, requires algorithms
AI resource management	6–7	4–5	High potential, especially in autonomous networks

The table shows that all directions are technically feasible, but require adaptation and specific engineering modifications to the characteristics of the aerospace environment: position variability, mass and energy limitations, exposure to radiation and vacuum.

Thus, the current technological base has already laid the foundation for the introduction of terahertz communications in aerospace. However, the transition from theory to practice requires not only adaptation, but also a comprehensive architectural restructuring of communication systems, including modular integration of ISAC, the use of intelligent surfaces, and centralized resource management based on artificial intelligence.

In the next section, we will examine the main challenges and limitations faced by developers of THz systems in aerospace and propose theoretically based solutions to overcome them.

III. Main problems and suggestions for their elimination

Despite the obvious advantages of terahertz communications discussed earlier, the practical implementation of these technologies in aerospace systems is associated with a number of specific and still unresolved problems. These difficulties are not technically insurmountable, but require innovative approaches and complex adaptation of communication architectures. This section discusses three key challenges - signal attenuation, beam direction instability, and distributed system overload - and provides detailed proposals for their elimination.

One of the fundamental obstacles to the use of THz communications in aerospace remains the intense signal attenuation associated with both free propagation over long distances and energy absorption by the atmosphere. Particularly critical are spectral regions with strong water absorption, which limits the range and stability of transmission.

To solve this problem, it is proposed to use hybrid multi-frequency systems that combine terahertz communication with more mature technologies such as mmWave and free-space optics (FSO). The essence of this approach is to create an adaptive multi-band architecture in which the system automatically selects the optimal transmission channel depending on the current environmental conditions, distance, angle between nodes and noise level.

Key principles of the hybrid approach:

• **THz is used for transmission over short distances and high speeds.** (for example, between close satellites, UAVs);

• **FSO - for direct optical communication with stable visibility** (for example, satellite-Earth);

• **mmWave - as a backup channel with high resistance to atmospheric conditions.**

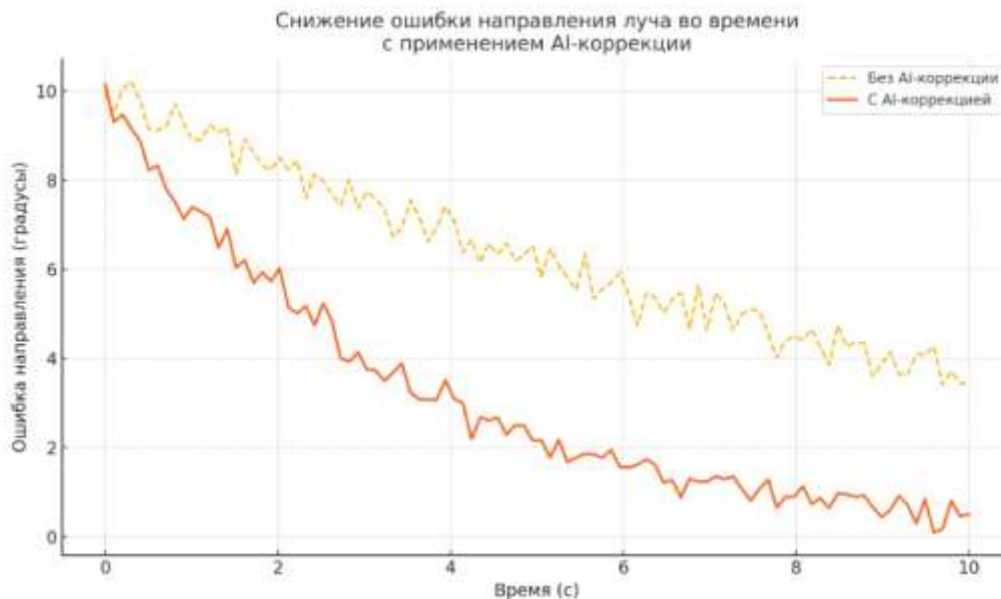
Thus, hybridization does not completely eliminate attenuation in the THz channel, but it neutralizes its effect due to intelligent routing and adaptive distribution of traffic between different channel levels.

The second most important problem is the complexity and instability of maintaining a directed terahertz beam when communication nodes are dynamically moving. In aerospace conditions, where satellites, UAVs and manned vehicles are constantly changing their position, it is necessary to continuously adjust the direction of the signal, otherwise the connection will be interrupted.

The use of static solutions is impossible here, so it is proposed to use intelligent algorithms based on artificial intelligence (AI) and machine learning, in particular, the following methods:

- **Reinforcement Learning**— for training antenna behavior models based on external feedback;
- **neural predictive models**— to predict the trajectory of an object and adapt the beam in advance;
- **deep optimization of focusing parameters**— taking into account not only the position, but also the phase and frequency shifts of the signal.

Visualization example (graph): beam direction error vs time (graph with a curve of error reduction when applying AI correction)



Thus, intelligent tracking allows implementing adaptive beam tracking even under conditions of high speed and angular oscillations, which is especially important for inter-satellite communications and mobile UAVs [23].

With the increase in the number of communication nodes and the growing density of information exchange, the problem of channel overload becomes especially acute, associated with both the limitation of the spectral resource and the architectural inefficiency of traditional schemes [4].

To address this issue, it is proposed to implement a new architectural paradigm – ICARS (Integrated Communication and Radar Systems), specially adapted for the aerospace environment. The main idea of ICARS is to combine communication and sensor analysis functions within a single hardware and software platform, where resources are redistributed in real time depending on task priorities [24].

Features of ICARS architecture: • a single module processes both data transmission signals and radar reflections; • adaptive balancing between throughput and sensing accuracy; • reduction of overall spectral pressure by eliminating duplicate systems [2: p. 4].

Comparative efficiency of traditional architecture and ICARS

Parameter	Traditional scheme	ICARS
Number of modules	≥ 2	1
Occupied spectrum	High	Moderate
Energy consumption	Higher	Below
Flexibility	Low	Tall
Reaction to overload	Hard (refusal)	Soft (adaptation)

Thus, ICARS is capable of not only saving resources, but also acting as an adaptive core of the aerospace THz network, redistributing tasks between communication and surveillance depending on the situation [24].

To sum up, it can be said that the solutions proposed above do not completely eliminate all challenges, but they allow to significantly increase the stability and flexibility of THz communications systems. Their implementation requires not only hardware changes, but also a fundamental restructuring of the logic of building aerospace networks - towards intelligence, integration and multi-channel [10].

Conclusion

Current trends in the development of aerospace systems clearly indicate the need for a qualitatively new level of communication - flexible, high-speed, adaptive and protected from interference [1: p. 2]. In this context, terahertz (THz) communication is not just an alternative to existing technologies, but a potential support platform for the entire future aerospace communications and sensor infrastructure [3: p. 1].

The theoretical analysis showed that the terahertz range has unique properties that make it extremely attractive for aerospace applications. First of all, this is high bandwidth, allowing data to be transmitted at gigabit and even terabit speeds, and high beam directivity, ensuring accuracy, confidentiality, and resistance to external interference [5].

However, the potential of THz communications comes with its own set of challenges, including signal attenuation, beam tracking difficulties, and hardware limitations in space environments [6], [25: p. 2339].

However, the prospects for successfully overcoming these limitations are quite realistic. Hybridization of transmission channels (THz + mmWave + FSO), intelligent beam tracking algorithms, and especially the ICARS architectural concept all form a stable theoretical basis for a new generation of aerospace communication systems [9], [24].

In emphasizing this point, it is important to note: we are not talking about replacing existing solutions, but about their integration, adaptation and complication in the direction of universality and self-organization [14].

Prospects for implementation

Given the current dynamics of technological development and the rapid growth of interest in the THz range from academic, military and commercial structures, several areas of practical application of terahertz communications in aerospace can be identified:

- Low Earth Orbit (LEO) satellite communications is the rapid exchange of data between satellites without delays and the need for retransmission through the Earth [19].
- Unmanned aerial vehicles (UAVs) - in missions with high traffic density and the need for instant transmission of visual and sensory information [18].
- Inter-satellite links and deep space probes – especially in missions with high telemetry and scientific data volumes (e.g. communication systems for orbital telescopes, lunar and Mars missions) [22].
- Integration with 6G and SAGIN networks – as a central part of a multi-layer architecture that unites air, space and ground segments [20: p. 30].

Recommendations for further research

At the current stage, the development of THz communications in aerospace requires concentrated attention in three key areas:

1. **Modeling channels in real conditions** — development of unified models of signal propagation that take into account altitude, atmospheric density, radiation conditions, and Doppler shifts.
2. **Algorithmic development of AI communication control systems** — creation of self-adjusting protocols that are resistant to dynamic changes in topology, orientation of objects and their speed of movement
3. **Development of lightweight and radiation-resistant hardware solutions** — improvement of THz radiation sources, integration of RIS elements into the apparatus casing, optimization of the weight and size characteristics of ICARS modules.

Thus, terahertz communication in aerospace is not just a technological innovation, but a step towards a fundamental rethinking of how information is transmitted between objects in the sky and beyond. The next step is to transform theoretical models into adapted architectures that can work in real conditions, taking into account the limitations of mass, energy and radiation background. And it is here, at the intersection of theory and engineering, that the real technological future begins [3].

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INCREASING THE ENERGY EFFICIENCY OF EXPANDER-GENERATOR PLANTS BY ADSORPTION DRYING OF NATURAL GAS AT INDUSTRIAL ENTERPRISES

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ПОВЫШЕНИЕ ЭНЕРГОЭФФЕКТИВНОСТИ ДЕТАНДЕР-ГЕНЕРАТОРНЫХ УСТАНОВОК ЗА СЧЁТ АДСОРБЦИОННОЙ ОСУШКИ ПРИРОДНОГО ГАЗА НА ПРОМЫШЛЕННЫХ ПРЕДПРИЯТИЯХ

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Abstract

This article examines the potential for improving the energy efficiency of metallurgical enterprises through more complete utilization of the energy potential of natural gas. Special attention is given to the use of expander-generator units (EGUs) for recovering the pressure energy of gas, which is typically lost during throttling before being fed into burner systems. Based on the analysis of domestic and international studies, it is shown that the integration of EGUs enables the generation of additional electricity without increasing fuel consumption, thereby supporting energy-saving strategies. At the same time, operational limitations are identified, particularly the risk of gas hydrate formation due to significant temperature drops during gas expansion, especially in winter conditions. The importance of preliminary gas treatment - specifically, adsorption drying—is emphasized as a means of preventing equipment damage. The findings confirm the relevance of a comprehensive approach to the use of EGUs in industrial settings to enhance energy efficiency and reliability of gas consumption systems.

Аннотация

В статье рассматривается возможность повышения энергетической эффективности металлургических предприятий за счёт более полного использования энергетического потенциала природного газа. Особое внимание уделено применению детандер-генераторных агрегатов (ДГА) для утилизации энергии давления газа, которая традиционно теряется при дросселировании перед подачей в горелочные устройства. На основании анализа отечественных и зарубежных источников показано, что внедрение ДГА позволяет вырабатывать дополнительное количество электроэнергии без увеличения расхода топлива, что способствует реализации принципов энергосбережения. Вместе с тем отмечаются эксплуатационные ограничения, связанные с возможностью образования кристаллогидратов при понижении температуры газа в процессе расширения, особенно в зимний период. Подчёркивается важность предварительной подготовки газа, в частности, адсорбционной осушки, для предотвращения негативного воздействия на оборудование. Полученные выводы подтверждают актуальность комплексного подхода к использованию ДГА на промышленных объектах с целью повышения энергоэффективности и надёжности газопотребляющих систем.

Keywords: *natural gas; expander-generator unit; energy efficiency; gas hydrates; adsorption drying; throttling; pressure energy recovery; energy saving.*

Ключевые слова: *природный газ; детандер-генераторный агрегат; энергетическая эффективность; кристаллогидраты; адсорбционная осушка; дросселирование; утилизация давления; энергосбережение.*

Введение. На большинстве современных промышленных предприятий одним из видов используемых топлив является природный газ, поэтому вопросы снижения потребления природного газа или увеличения выработки электроэнергии при том же расходе газа за счет более полного использования его энергетического потенциала являются актуальными. Даже небольшое увеличение эффективности его использования может дать существенный экономический эффект. На предприятиях используется только топливная составляющая природного газа и практически не используется его энергия давления, так как газ перед горелками использующих топливо технологических агрегатов дросселируется до давления лишь немногим превышающего атмосферное [1-3].

В ряде работ авторов [4-10] описано применение детандер-генераторных агрегатов для выработки электроэнергии на газораспределительных станциях и теплоэлектроцентралях (ТЭЦ), использующих в качестве топлива природный газ. Показано, что применение детандера дополнительно позволяет выработать количество электроэнергии при том же графике потребления топлива, что повышает энергетическую эффективность предприятий.

У схемы с детандер-генераторным агрегатом есть и недостатки, особенно сильно проявляющиеся в холодный период года. Газ имеет крайне низкое содержание паров воды (не более 80 мг/кг), поэтому незначительное изменение температуры газа при дросселировании не приводит к конденсации паров или образованию кристаллогидратов. Но при расширении газа в детандере его температура снижается до значений в несколько десятков градусов Цельсия ниже нуля. В этом случае возможно выпадение кристаллогидратов либо в самом детандере, либо в газопроводе после него. Появление кристаллогидратов может отрицательно сказаться на сроке службы детандера или расположенного после него газопровода

Основная часть. При применении детандер-генераторных агрегатов на ТЭЦ необходимо обеспечить недопустимость образования кристаллогидратов, однако отсутствует анализ снижения эффективности применения детандера из-за этих ограничений и эффективности мер по снятию данных ограничений.

Наиболее простым способом недопущения образования кристаллогидратов является дросселирование газа после детандера до давления, исключающего переход водяных паров в кристаллогидраты. В этом случае после детандер-генераторного агрегата устанавливается дросселирующее устройство, позволяющее поддерживать требуемое значение выходного давления, при котором не выпадают кристаллогидраты.

На рис. 1 изображена принципиальная схема установки детандер-генераторного агрегата с дросселированием газа после детандера для поддержания требуемого выходного давления.

Найдем требуемое давление газа на выходе из детандера, при котором не будут выпадать кристаллогидраты. Для этого используем следующие допущения. В первом приближении природный газ можно рассчитывать, как метан (так как содержание метана в нем составляет свыше 95 %). Из-за близкого к единице коэффициента сжимаемости природного газа для рассматриваемых диапазонов давлений и температур его можно считать по формулам для идеального газа [8]. Из-за высокой протяженности газопроводов температуру газа принимаем равной температуре окружающей среды.

Удельная работа собственно детандера определяется из зависимости:

$$l_{\text{дет}} = c_p' \cdot (T_{\text{вх}} - T_{\text{вых}}^{\text{действ}}) = c_p' \cdot (T_{\text{вх}} - T_{\text{вых}}^{\text{ид}}) \cdot \eta_d, \quad (1)$$

где $l_{\text{дет}}$ - удельная полезная работа детандера, Дж/м³;

$$T_{\text{вых}}^{\text{ид}} = T_{\text{вх}} \left(\frac{P_{\text{вых}}}{P_{\text{вх}}} \right)^{\frac{k-1}{k}} \quad \begin{array}{l} \text{- температура газа при идеальном (адиабатном)} \\ \text{расширении, К;} \end{array}$$

$P_{\text{вх}}, P_{\text{вых}}$ - давление газа на входе в детандер и выходе из детандера соответственно, Па;
 k - показатель адиабаты газа; $T_{\text{вх}}$ - температура газа на входе в детандер, К;

c_p' - изобарная объемная теплоемкость газа, Дж/(м³·К);

$T_{\text{вых}}^{\text{действ}}$ - действительная выходная температура газа, К;

η_d - внутренний относительный КПД детандера.

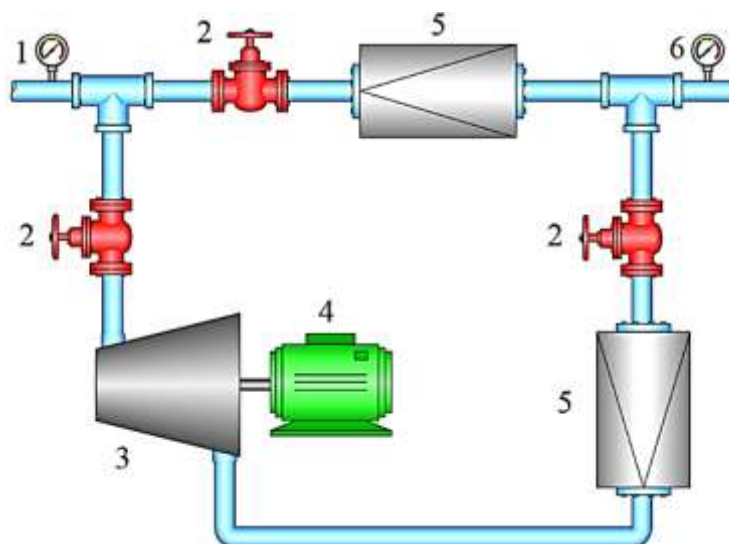


Рис. 1. Принципиальная схема установки детандер-генераторного агрегата с дросселированием газа после детандера: 1- газопровод высокого давления; 2 - задвижки; 3 - детандер; 4 - электрогенератор; 5 - дросселирующее устройство; 6 - газопровод низкого давления
Тогда зависимость температуры газа от давления для реального расширения примет вид

$$T_{\Gamma} = T_{\text{ВХ}} \left(1 - \left(1 - \left(\frac{P_{\text{ВЫХ}}}{P_{\text{ВХ}}} \right)^{\frac{k-1}{k}} \right) \cdot \eta_{\text{д}} \right), \quad (2)$$

где T_2 - температура газа, К; P_2 - давление газа, Па.

Плотность газа

$$\rho_{\Gamma} = \frac{P_{\Gamma}}{R_{\Gamma} \cdot T}, \quad (3)$$

где ρ_2 - плотность метана, кг/м³; R_2 - газовая постоянная метана, Дж/(кг·К).

Для принятой температуры находится плотность паров воды в состоянии насыщения:

$$\rho_{\text{п.нас}} = \frac{P_{\text{п.нас}}}{R_{\text{п}} \cdot T}, \quad (4)$$

где $\rho_{\text{п.нас}}$ - плотность насыщенных водяных паров, кг/м³;

$P_{\text{п.нас}}(T)$ - давление насыщения водяных паров, Па;

$R_{\text{п}}$ - газовая постоянная водяных паров, Дж/(кг·К).

Предельное влагосодержание для данной точки термодинамического процесса расширения:

$$d_{\text{пр}} = \frac{\rho_{\text{п.нас}}}{\rho_{\Gamma}}, \quad (5)$$

где $d_{\text{пр}}$ - предельное влагосодержание газа, кг/кг.

Расширение природного газа в детандере происходит до значения давления, при котором значение предельного влагосодержания сравнивается с начальным влагосодержанием газа.

Наиболее перспективным способом является применение предварительного подогрева газа, что повышает температуру газа на выходе из детандера, но этот вариант не всегда может быть реализован по техническим соображениям.

Применение ингибиторов может ухудшить качество газа и является достаточно дорогостоящим мероприятием.

Применение адсорбционной осушки позволяет снять ограничения по выходному давлению газа. В этом случае газ перед детандером поступает в блок комплексной осушки, в котором проходит через специальные цилиндрические аппараты, именуемые адсорберами, заполненные слоем сорбента-поглотителя. Сорбенты являются твердыми веществами с высоким содержанием пор и характеризуются большой площадью поверхности на 1 кг. В настоящее время в качестве сорбентов используют минеральные поглотители и ионообменные цеолиты.

Водяные пары поглощаются слоем сорбента, после чего в детандер поступает уже осушенный газ. Поры сорбента заполняются влагой вплоть до наступления насыщения, затем слой нужно регенерировать.

Так как время регенерации примерно равно времени адсорбции, на детандер устанавливают 2 блока (пока один в работе, один на регенерации).

На рис. 2 изображена схема детандер-генераторного агрегата с предварительной осушкой.

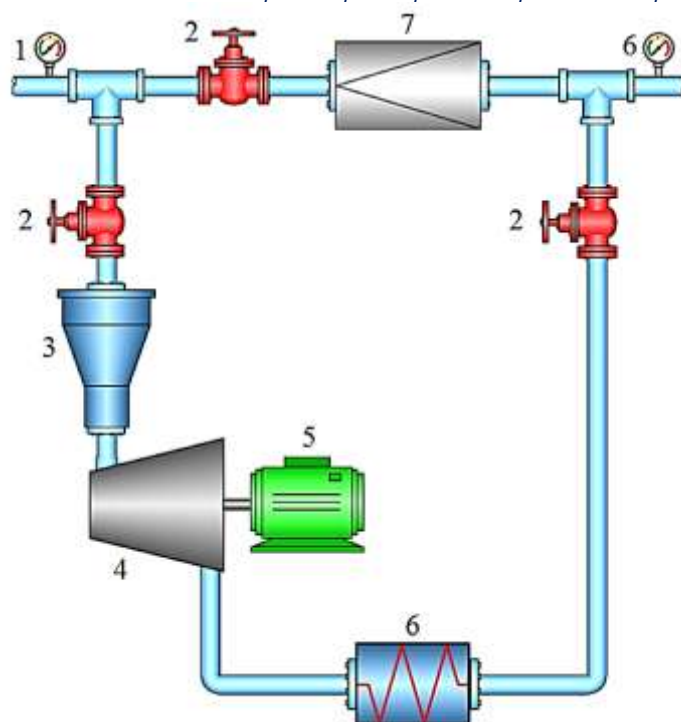


Рис.2. Принципиальная схема детандер-генераторного агрегата с предварительной осушкой: 1 - газопровод; 2 - задвижки; 3 - блок осушки; 4 - детандер; 5 - электрический генератор;

6 - теплообменник-подогреватель; 7 - дросселирующее устройство; 8 - газопровод низкого давления

Недостатком данной схемы, который может снизить энергетический эффект, является наличие потерь давления при прохождении газом блока осушки.

Потери давления при прохождении газом слоя сорбента определяются по формуле

$$\Delta p = \lambda \cdot \frac{H}{d_s} \cdot \frac{\rho_r \cdot w_d^2}{2 \cdot \Phi}, \quad (6)$$

где Δp - потери давления, м;

$$w_d = \frac{w_\phi}{\varepsilon} \quad \text{- действительная скорость газа внутри пор, м/с;}$$

$$w_\phi \quad \text{- фиктивная скорость газа, равная отношению расхода газа к площади сечения адсорбера, м/с;}$$

ε - доля пустот; λ - коэффициент гидравлического трения;

$$d_s = \frac{2}{3} \cdot \varepsilon \cdot \frac{d}{1 - \varepsilon} \quad \text{- эквивалентный диаметр частиц, м;}$$

d - действительный диаметр, м;

$\Phi = 0,9$ - коэффициент, учитывающий не сферичность частицы;

H - толщина слоя сорбента, м.

Величина удельного сопротивления (потери, приходящиеся на 1 м толщины слоя) сорбента определяется главным образом диаметром частиц поглотителя, уменьшаясь с ростом размера гранул. Расчеты по формуле (6) показывают, что для частиц диаметром 2 мм и доли пустот 0,4 при рекомендуемой фиктивной скорости 0,15-0,3 м/с величина удельных потерь давления не превышает 12 кПа/м.

Следующим этапом после определения удельных потерь давления является оценка толщины слоя сорбента.

Толщина сорбента прямо пропорциональна продолжительности цикла адсорбции. Время адсорбции для осушки крупных расходов газа находится в пределах 8-20 ч.

Расчет ведется для условия полного поглощения за период адсорбции всей содержащейся в природном газе влаги.

Действительная объемная концентрация паров воды находится по формуле

$$c_n = d_0 \cdot \rho_r, \quad (7)$$

где c_n - концентрация паров, кг/м³; d_0 - начальное влагосодержание газа, кг/кг.

Высота слоя сорбента

$$H = \frac{w_{\phi} \cdot \tau \cdot c_d}{\rho_{\text{нас}} \cdot X} \cdot k_3, \quad (8)$$

где X - поглощательная способности сорбента по влаге, кг/кг;

$k_3 = 1$, 1- коэффициент запаса; τ - время процесса сорбции, с;

$\rho_{\text{нас}}$ - насыпная плотность, кг/м³.

При насыпной плотности 300 - 400 кг/м³, величине поглощательной способности в пределах 0,05-0,2, времени 10-20 ч, для величины влагосодержания, близкой к предельному (80 мг/кг), толщина слоя сорбента находится в пределах 0,15 - 0,40 м.

Стоит отметить, что данная оценка толщины слоя является максимально возможной, так как в расчетах заложено максимально возможное значение влагосодержания.

Таким образом, максимальные потери входного давления для гранул размером свыше 2 мм не превышают 0,1 атм. В этом случае снижение входного давления после прохождения газа через блок осушки практически не влияет на выработанную детандер-генераторным агрегатом мощность.

Ввиду того, что, потери давления при прохождении регенерирующего агента через слой крайне малы, поэтому затратами электроэнергии на прокачку регенерирующего агента по сравнению с выработанной детандер-генераторным агрегатом мощностью можно пренебречь. В качестве регенерирующего агента можно использовать уходящие газы промышленных агрегатов или нагретый этими газами воздух в случае, если газы могут сильно загрязнить сорбент.

Таким образом, применение адсорбционной осушки позволяет использовать весь располагаемый перепад давлений в детандере и повысить выработку электроэнергии за счет снятия ограничений по величине выходного давления.

Для расчетов энергетической эффективности от применения адсорбционной осушки примем следующие условия: расход природного газа 95 000 м³/ч; начальное давление газа 6 атм; давление газа на выходе из детандера 1,5 атм; начальное влагосодержание газа 80 мг/кг; внутренний относительный КПД детандера 0,75; электромеханический КПД детандер-генераторного агрегата 0,96.

Мощность, выработанная детандер-генераторными агрегатами, определяется по зависимости

$$N = G \cdot l_{\text{дет}} \cdot \eta_{\text{э.м.}}, \quad (9)$$

где N - мощность, Вт; G - расход газа, м³/ч; $\eta_{\text{э.м.}}$ - электромеханический КПД детандер-генераторного агрегата.

Результаты. На рис. 3 приведен график зависимости, выработанной в детандер-генераторных агрегатах мощности от начальной температуры газа для схемы с дросселированием газа после детандера и схемы с предварительной адсорбционной осушкой.

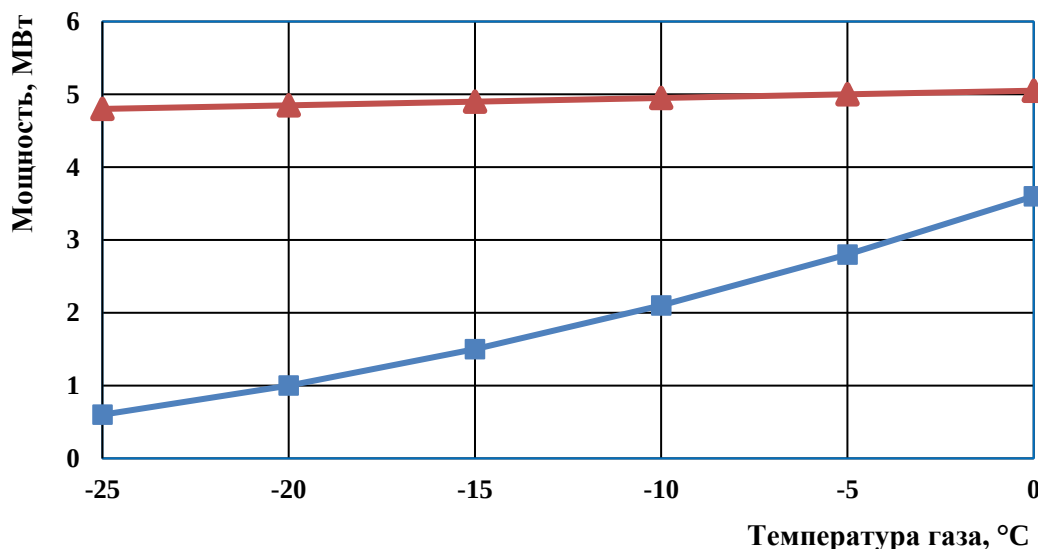


Рис.3. Зависимость выработанной в детандер-генераторных агрегатах мощности от начальной температуры газа: 1 - для схемы с предварительной адсорбционной осушкой; 2 - для схемы с дросселированием газа после детандера

Анализируя полученные данные, можно сделать вывод, что с понижением температуры газа эффективность от применения осушки будет возрастать по сравнению с вариантом с дросселированием газа после детандера, так как для схемы с ДГА и дросселированием понижение температуры резко уменьшает удельную работу детандера за счет ограничений по величине выходного давления, в то время как схема с адсорбционной осушкой позволяет снять эти ограничения. Для максимально допустимого влагосодержания в период отрицательных температур газа мощность для схемы с осушкой может быть выше в 1,5 раза при температуре для 0 °C и в 9 раз для температур -25 °C.

Применение схемы с адсорбционной осушкой позволяет выработать в детандер-генераторных агрегатах 4,2-5,0 МВт в зимнее время на каждые 95 тыс. м³/ч природного газа и снять ограничения по величине выходного давления, снижающие выработку мощности в несколько раз.

Заключение. Таким образом, предложенная интеграция блоков адсорбционной осушки позволяет значительно повысить общий уровень утилизации энергии давления, снимая ограничения, связанные с образованием кристаллогидратов. Это обеспечивает эффективную работу ДГА даже в зимний период. Кроме того, расчёты показывают высокую экономическую эффективность и быстрый срок окупаемости.

Показано, что применение адсорбционной осушки может увеличить выработку мощности детандер-генераторным агрегатом в несколько раз в зимний период за счет снятия ограничений по величине давления газа на выходе из детандера.

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ASYMPTOTIC DECAY OF OSCILLATIONS IN AN ENGINEERED VIBRATION-ISOLATED SYSTEM**Nataliya Dokukova**Professor (Associate) at Belarusian State University Belarus
PhD in Physical and Mathematical Sciences**Pavel Konon**Professor (Associate) at Belarusian State University Belarus
PhD in Physical and Mathematical Sciences**АСИМПТОТИЧЕСКОЕ ЗАТУХАНИЕ КОЛЕБАНИЙ В ИНЖЕНЕРНОЙ ВИБРОИЗОЛИРОВАННОЙ СИСТЕМЕ****Наталья Докукова**доцент Белорусского государственного университета
кандидат физико-математических наук, доцент**Павел Конон**доцент Белорусского государственного университета
кандидат физико-математических наук, доцент**Abstract**

The paper develops a methodology for selecting the physical parameters of dynamic vibration absorbers based on asymptotically stable, rapidly decaying oscillations to ensure optimal tuning of vibration isolation for mobile devices. Formulas are derived to quantify the influence on the process of asymptotic damping of natural oscillations and the reduction of forced displacement amplitudes. For the obtained coefficients, graphs of numerical calculations of dynamic processes are presented.

Аннотация

В статье разработана методика выбора физических параметров динамических гасителей на основании асимптотически устойчивых быстро затухающих колебаний для обеспечения оптимальной настройки виброизоляции мобильных устройств. Получены формулы для влияния на процесс асимптотического затухания собственных колебаний и снижения амплитуды вынужденных перемещений. Для выведенных коэффициентов представлены графики численных расчётов динамических процессов.

Keywords: vibration isolation, vibration damping, hydraulic support, inertial mass, stability criteria, damping coefficient, mathematical model, dynamic model, dynamic diagram, vibration suppression, attenuation, two-stage vibration isolation, three-mass mechanical system, kinematic excitation, vibration displacement, vibration velocity, vibration acceleration, performance indices.

Ключевые слова: виброизоляция, демпфирование, гидравлическая опора, инерционная масса, критерии устойчивости, коэффициент демпфирования, математическая модель, динамическая модель, динамическая схема, гашение вибраций, затухание, двухступенчатая виброизоляция, трехмассовая механическая система, кинематическое возбуждение, виброперемещение, виброскорость, виброускорение, показатели эффективности и качества.

Работа посвящена исследованию устранения вибраций в технических и машиностроительных устройствах от неизбежных случайных колебаний. Такие виды колебаний возникают в механических, электрических, гидравлических и других конструкциях. Их регулирование обеспечивает надежность, безопасность и эффективность работы машиностроительного устройства [1]. Вибрации могут привести к разрушению конструкций, снижению производительности оборудования. В авиационной промышленности они вызывают усталость металлов, что в конечном итоге приводит к катастрофическим последствиям. Вибрации в промышленных цехах могут негативно влиять на устойчивость зданий и

сооружений. Поэтому разработка эффективных моделей виброгашения, обеспечивающих асимптотическую устойчивость, является актуальной задачей.

В представленной работе исследуются способы двухуровневого виброгашения в механических системах с помощью четырёх основных возможных схем. Эти схемы представляют собой комбинацию пружин, демпферов и масс, подвергающихся внешнему случайному гармоническому воздействию. Целью работы является нахождение оптимальных параметров для схемы двухкаскадной виброизоляции машиностроительной конструкции посредством разработанных авторами методик. В результате достигаются асимптотически устойчивые колебательные режимы с минимальной амплитудой вибраций, обеспечивающие качественную устойчивость и устойчивость с запасом на основании критериев В.С.Воронова [2]. Значительное внимание уделяется анализу асимптотической устойчивости систем и разработке методов управления. Для анализа используются методы математического моделирования, аналитические и численные методы.

I. О законах движений физических моделей подрессорирования с гидроопорами

Рассматриваются четыре возможные схемы виброгашения в механических системах, которые представлены на рисунке 1. Они состоят из одноосной гидроопоры с инерционным трансформатором с массой m_1 , которая обладает линейным коэффициентом упругости гидроопоры – c_2 и коэффициентом демпфирования гидродинамической среды гидроопоры – b_2 . В состав пассивной виброизоляции входят: виброизолируемая масса – M , цилиндрическая пружина с коэффициентом упругости – c_1 , гидравлический амортизатор с коэффициентом демпфирования b_1 с линейными свойствами относительно вертикальной скорости хода смещения. Исследуется влияние дополнительной инерционной массы внутри гидроопоры на затухание собственных и вынужденных колебаний, представленных на рисунке 1.

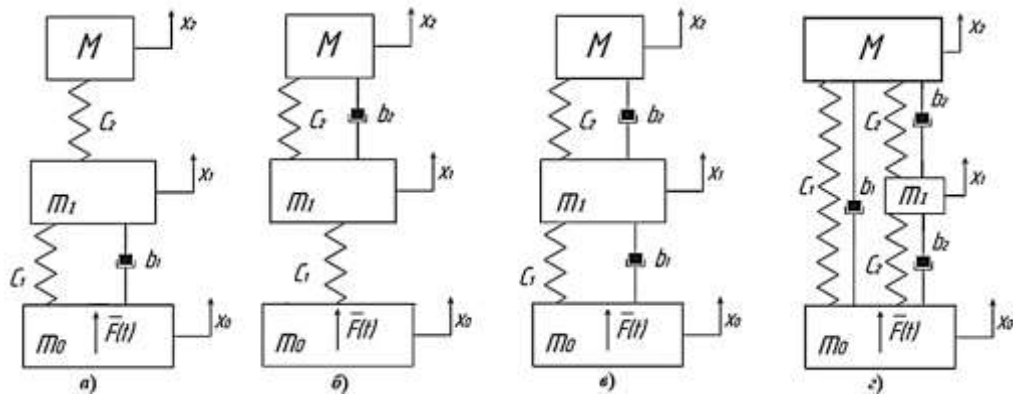


Рисунок 1 – Схемы двухкаскадных виброизоляций инженерных конструкций

Для обоснования законов движений динамических схем используются уравнения Лагранжа, которые в каноническом виде [3 – 11] примут вид обобщенной системы дифференциальных уравнений:

$$\begin{cases} L_1(x_1) - d_{12}(x_2) = -a \left(\frac{c_{10}}{\omega^2} \sin(\omega t) + \frac{b_{10}}{\omega} \cos(\omega t) \right), \\ -d_{21}(x_1) + L_2(x_2) = -a \left(\frac{c_{20}}{\omega^2} \sin(\omega t) + \frac{b_{20}}{\omega} \cos(\omega t) \right), \end{cases} \quad (1)$$

где L_1 , L_2 , d_{12} , d_{21} совокупность дифференциальных операторов вида:

$$\begin{aligned} L_1(\square) &= \frac{d^2(\square)}{dt^2} + b_{11} \frac{d(\square)}{dt} + c_{11}(\square), & L_2(\square) &= \frac{d^2(\square)}{dt^2} + b_{22} \frac{d(\square)}{dt} + c_{22}(\square), & d_{12}(\square) &= b_{12} \frac{d(\square)}{dt} + c_{12}(\square), \\ d_{21}(\square) &= b_{21} \frac{d(\square)}{dt} + c_{21}(\square). \end{aligned}$$

Коэффициенты которых для схем на рисунке 1 а)-г) выписаны в таблицу 1.

Таблица 1

**Коэффициенты системы дифференциальных уравнений движений
для различных схем виброизоляции**

b_{ij}	Схема а	Схема б	Схема в	Схема г	c_{ij}	Схема а	Схема б	Схема в	Схема г
b_{00}	$\frac{b_1}{m_0} \rightarrow 0$	0	$\frac{b_1}{m_0} \rightarrow 0$	$\frac{b_1 + b_2}{m_0} \rightarrow 0$	c_{00}	$\frac{c_1}{m_0} \rightarrow 0$	$\frac{c_1}{m_0} \rightarrow 0$	$\frac{c_1}{m_0} \rightarrow 0$	$\frac{c_1 + c_2}{m_0} \rightarrow 0$
b_{01}	$\frac{b_1}{m_0} \rightarrow 0$	0	$\frac{b_1}{m_0} \rightarrow 0$	$\frac{b_2}{m_0} \rightarrow 0$	c_{01}	$\frac{c_1}{m_0} \rightarrow 0$	$\frac{c_1}{m_0} \rightarrow 0$	$\frac{c_1}{m_0} \rightarrow 0$	$\frac{c_2}{m_0} \rightarrow 0$
b_{02}	0	0	0	$\frac{b_1}{m_0} \rightarrow 0$	c_{02}	0	0	0	$\frac{c_1}{m_0} \rightarrow 0$
b_{10}	$\frac{b_1}{m_1}$	0	$\frac{b_1}{m_1}$	$\frac{b_2}{m_1}$	c_{10}	$\frac{c_1}{m_1}$	$\frac{c_1}{m_1}$	$\frac{c_1}{m_1}$	$\frac{c_2}{m_1}$
b_{11}	$\frac{b_1}{m_1}$	$\frac{b_2}{m_1}$	$\frac{b_1 + b_2}{m_1}$	$\frac{2b_2}{m_1}$	c_{11}	$\frac{c_1 + c_2}{m_1}$	$\frac{c_1 + c_2}{m_1}$	$\frac{c_1 + c_2}{m_1}$	$\frac{2c_2}{m_1}$
b_{12}	0	$\frac{b_2}{m_1}$	$\frac{b_2}{m_1}$	$\frac{b_2}{m_1}$	c_{12}	$\frac{c_2}{m_1}$	$\frac{c_2}{m_1}$	$\frac{c_2}{m_1}$	$\frac{c_2}{m_1}$
b_{20}	0	0	0	$\frac{b_1}{M}$	c_{20}	0	0	0	$\frac{c_1}{M}$
b_{21}	0	$\frac{b_2}{M}$	$\frac{b_2}{M}$	$\frac{b_2}{M}$	c_{21}	$\frac{c_2}{M}$	$\frac{c_2}{M}$	$\frac{c_2}{M}$	$\frac{c_2}{M}$
b_{22}	0	$\frac{b_2}{M}$	$\frac{b_2}{M}$	$\frac{b_1 + b_2}{M}$	c_{22}	$\frac{c_2}{M}$	$\frac{c_2}{M}$	$\frac{c_2}{M}$	$\frac{c_1 + c_2}{M}$

II. Расчётная математическая модель устойчивых динамических колебаний

Масса m_0 неограниченно большая, поэтому её влияние на систему выражается в совокупности случайных вибросмещений, виброскоростей и виброускорений, вычисляемых по формулам: $x_0 = -a \cdot \omega^{-2} \cdot \sin(\omega t)$, $\dot{x}_0 = -a \cdot \omega^{-1} \cdot \cos(\omega t)$, $\ddot{x}_0 = a \cdot \sin(\omega t)$, из дифференциального уравнения $m_0 \ddot{x}_0(t) = F(t)$.

Динамическая система (1) позволяет разделить дифференциальные уравнения по соответствующим переменным $x_1(t)$ и $x_2(t)$:

$$L_1(L_2(x_i)) - d_{12}(d_{21}(x_i)) = \frac{d^4 x_i}{dt^4} + (b_{11} + b_{22}) \frac{d^3 x_i}{dt^3} + (c_{11} + c_{22} + b_{11}b_{22} - b_{12}b_{21}) \frac{d^2 x_i}{dt^2} + (c_{11}b_{22} + c_{22}b_{11} - c_{12}b_{21} - c_{21}b_{12}) \frac{dx_i}{dt} + (c_{11}c_{22} - c_{12}c_{21})x_i, \quad i = 1, 2. \quad (2)$$

На основании этой системы составляется характеристическое уравнение:

$$\lambda^4 + a_3 \lambda^3 + a_2 \lambda^2 + a_1 \lambda + a_0 = 0. \quad (3)$$

В этом случае устойчивыми быстро затухающими движениями рассматриваемых динамических схем на рисунке 1 и математической модели (1) будут решения вида:

$$x_i(t) = e^{-\lambda_1 t} (C_{i1} \sin(\lambda_2 t) + C_{i2} \cos(\lambda_2 t)) + e^{-\lambda_3 t} (C_{i3} \sin(\lambda_4 t) + C_{i4} \cos(\lambda_4 t)) + C_{i5} \sin(\omega t) + C_{i6} \cos(\omega t), \quad (i = 1, 2), \quad (4)$$

при положительных значениях $\lambda_1 > 0$ и $\lambda_3 > 0$. Незвестные произвольные постоянные C_{ij} , ($i = 1, 2, j = \overline{1, 6}$) подлежат определению из решений однородных систем дифференциальных уравнений с учётом известных начальных условий и неоднородных систем со специальными правыми частями (1). Первые четыре слагаемые обеспечивают быстрое стремление графиков собственных законов движений $x_1(t)$ и $x_2(t)$ к своему состоянию покоя $x_1(t) \rightarrow 0$ и $x_2(t) \rightarrow 0$ при $\lambda_1 > 0$ и $\lambda_3 > 0$. Это приводит к быстрому их гашению с асимптотическим убыванием амплитуд до нуля. При этом вынужденные колебания и их амплитуды C_{i5} и C_{i6} должны иметь минимальные значения. Для этих целей используем алгебраические критерии устойчивости В.С. Воронова [2] и исследуем стабильность динамической системы на основании выведенных известных соотношений между коэффициентами характеристического полинома (3): $a_0 = c_{11}c_{22} - c_{12}c_{21}$; $a_1 = c_{11}b_{22} + c_{22}b_{11} - c_{12}b_{21} - c_{21}b_{12}$; $a_2 = c_{11} + c_{22} + b_{11}b_{22} - b_{12}b_{21}$; $a_3 = b_{11} + b_{22}$; $a_4 = 1$.

Необходимым условием устойчивости динамической системы будут выполнения неравенств $\frac{a_{k-2}}{a_k} < \frac{a_{k-1}}{a_{k+1}} < \dots, (k = \overline{2, n-1})$. Достаточные условия устойчивости связаны ограничениями вида: $\Omega_k = \frac{a_k^2}{a_{k-1}a_{k+1}} > \sqrt{2.148}, (k = \overline{1, n-1})$. Условиями устойчивости с запасом являются требования: $W_k = \frac{a_k a_{k+1}}{a_{k-1} a_{k+2}} > 3, (k = \overline{1, n-2})$. Условия устойчивости, сформированное по показателям качества динамической системы, должны удовлетворять неравенствам: $\Omega_k > \sqrt{3}, (k = \overline{1, n-1})$.

III. Пример реализации разработанной методики гашения колебаний

Для обеспечения асимптотически устойчивых быстро затухающих колебаний потребуем выполнения совокупности всех последних неравенств. Подстановка формул из таблицы 1 в совокупность всех алгебраических критериев устойчивости приведёт к нелинейным многопараметрическим соотношениям, разрешить которые в общем случае достаточно сложно. Например, для схемы б рисунка 1 представлено одно из возможных решений быстро затухающих, асимптотически убывающих свободных колебаний на рисунке 2 с весьма малыми амплитудами вынужденных случайных колебаний при следующих физических параметрах $M = 150.0$ кг, $m_2 = 1.0$ кг, $b_2 = 0.42$ н·с/м, $c_1 = 3500.0$ н/м, $c_2 = 35.0$ н/м.

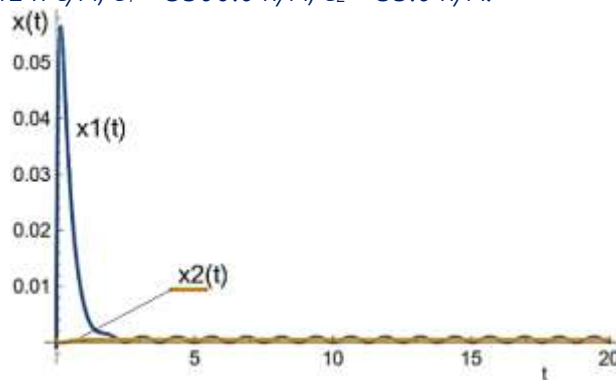


Рисунок 2 – Законы движений $x_1(t)$ инерционной массы m_1 и $x_2(t)$ виброизолируемой массы M для схемы б

Заключение

Получены программные продукты, позволяющие оценить степень качественной устойчивости двухкаскадной виброизоляции и выбрать наиболее оптимальные физические параметры инженерных конструкций. Исследованы приведенные частотные уравнения с относительными безразмерными коэффициентами. Выведены зависимости между физическими параметрами виброизолирующих модулей и виброизолируемой конструкцией для полного гашения вредных колебаний мобильной техники. Показана их хорошая адаптивность к динамическим процессам в технических устройствах. Разработана методика выбора физических параметров механических модулей волновых гасителей на основании асимптотически устойчивых быстро затухающих колебаний для обеспечения оптимальной настройки виброизоляции. Представлены численные расчёты по разработанной методике выбора пропорциональных коэффициентов между физическими характеристиками одинаковой размерности. Получены формулы для влияния на процесс снижения амплитуды вынужденных колебаний, их закономерности представлены в виде графических зависимостей.

По выведенным критериям, которые накладываются на физические параметры, для приведенных схем двухкаскадной виброизоляции можно сделать вывод о том, что схема на рисунке 1 а ни при каких физических параметрах не приведёт к асимптотической устойчивости виброизолируемого тела с массой M . Схема виброизоляции на рисунке 1 б может иметь затухающую качественную устойчивость. Схема виброизоляции на рисунке 1 в может иметь затухающую качественную устойчивость и быстро затухающую асимптотическую устойчивость с запасом. Схема на рисунке 1 г обладает асимптотической устойчивостью с запасом для собственных динамических режимов, но не способна в должной мере обеспечить устойчивость вынужденных случайных колебаний. Применение второго каскада для неё не

приводит к перераспределению и затуханию высоких уровней кинетической энергии. Аналитически показано, что система виброизоляции на схеме 1 г не может при всех допустимых значениях демпфирующих параметров b_2 существенно уменьшить амплитуду колебаний объекта с массой M до её предельных уровней.

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LEVERAGING DIGITAL TECHNOLOGIES TO STRENGTHEN ANTI-CORRUPTION EFFORTS

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Abstract

This article explores Kazakhstan's progress in leveraging digital technologies to strengthen anti-corruption efforts, focusing on the integration of ICT tools such as e-government platforms, real-time procurement transparency systems, risk mapping applications, and citizen feedback mechanisms. The research highlights the country's shift from punitive to preventive approaches through digitalization and outlines how initiatives like the "Corruption Risks Map," the "Open Government" portal, and the "Kun Jarygy" platform have improved institutional transparency and accountability. Drawing on domestic experiences and international comparisons—including Estonia and China—the study evaluates how digital tools reduce discretionary power, foster civic engagement, and facilitate early detection of corruption risks. The paper concludes that while technology provides transformative potential in combating corruption, its success depends on strong political will, digital literacy, and integrated strategic planning. Kazakhstan's case demonstrates a shift toward a digitally empowered governance system that prioritizes openness, efficiency, and anti-corruption culture.

Keywords: *Kazakhstan, anti-corruption, digital technologies, e-government, ICT, transparency, accountability, corruption risk map, open government, digital transformation, public sector innovation, citizen engagement.*

Corruption remains one of the most pressing socio-political problems of the modern world, acting as a significant barrier to sustainable development, the rule of law, and institutional trust. It undermines economic growth, distorts the functioning of public institutions, and erodes public confidence in justice and equity. In Kazakhstan, as in many other countries, combating corruption is a strategic priority for ensuring good governance and achieving national development goals.

While legislative frameworks, institutional control mechanisms, and punitive measures are traditionally employed in the fight against corruption, their effectiveness is increasingly dependent on adaptation to the rapidly changing technological landscape. In this context, the integration of modern information and communication technologies (ICT) into anti-corruption strategies emerges as a pivotal factor in improving transparency, accountability, and public engagement [1].

The digitalization of public administration through e-government platforms, big data analytics, blockchain technology, and interactive feedback systems has demonstrated its potential in minimizing discretionary power, eliminating non-transparent procedures, and reducing opportunities for corrupt behavior. Such tools enable real-time monitoring, enhance access to public services, and create digital traces that facilitate the detection and prevention of unethical practices.

Kazakhstan has significantly enhanced its anti-corruption framework in recent years by integrating advanced digital tools and platforms to promote transparency, accountability, and public oversight. Since 2022, the Anti-Corruption Agency's online Portal has provided real-time access to corruption risk maps by region and state bodies, online integrity assessments, e-learning modules, feedback forms, and volunteer engagement, fostering citizen participation in oversight. The launch of the "Corruption Risks Map" has enabled identification of vulnerable roles and regions, guiding targeted prevention measures. Procurement reform has been bolstered by the "Kun Jarygy" coalition (est. 2022), which uses open-data monitoring on the e-procurement portal to curb single-source contracts—from 48.6 % in 2020 down to just 19.1 % in 2023. Additionally, under the 2022–2026 Anti-Corruption Policy Concept, methodologies for risk mapping, conflict-of-interest checks, financial declarations, and digital case management have been institutionalized across public and quasi-public sectors. These innovations—spanning real-time e-procurement transparency, AI-enhanced risk mapping, and citizen-driven reporting—have collectively

improved preventive controls, reduced discretionary power, and empowered public scrutiny, marking a substantive modernization of Kazakhstan's anti-corruption efforts.

Furthermore, the active involvement of civil society in monitoring government activities through digital platforms strengthens social oversight and fosters a culture of integrity. Therefore, the effective deployment of information technologies is not merely a supplementary instrument but a fundamental component of a systemic and preventive approach to combating corruption in the 21st century.

This article will consider the role of modern information technologies in anti-corruption policy and their potential, evaluate their effectiveness on the basis of specific examples and experiences, assess the potential of anti-corruption digitalization on the basis of domestic and international experience, and study the prospects of anti-corruption policy in the context of digital transformation in Kazakhstan.

Kazakhstan has demonstrated significant progress in integrating modern information and communication technologies (ICT) into its public administration system as a strategic measure to combat corruption. One of the most notable achievements is the country's advancement in e-government, which has become a central pillar in addressing petty corruption through the digitization of public services.

According to the United Nations E-Government Development Index (EGDI) 2022, Kazakhstan ranked 28th among 193 countries, entering the group of nations with a high level of e-government development (UN E-Government Survey, 2022). This achievement largely stems from the government's sustained efforts to enhance public engagement through the Open Government Portal. The portal ensures citizens' access to vital public information and offers feedback mechanisms in five key areas: open data, open regulations, open budgets, performance evaluation of public agencies, and open dialogue. In particular, the open dialogue platform enables direct interaction between citizens and government officials, including ministers and regional governors, through blog posts, public comments on policy issues, online surveys, and a dedicated complaints registration system [2].

E-government has played a pivotal role in reducing corruption risks by minimizing face-to-face interactions between officials and service recipients—often considered breeding grounds for informal payments. The transition to digital services significantly curtails opportunities for discretionary decision-making and enhances transparency in service delivery.

Moreover, informal platforms such as social media—particularly Facebook and Twitter—have emerged as supplementary tools for public scrutiny and communication, further strengthening digital transparency and accountability.

Kazakhstan launched its e-government initiative in 2004 with three key objectives: to provide faster access to public services, to improve efficiency in state service delivery through the use of IT solutions, and to reduce direct interactions between citizens and government officials to mitigate corruption risks (Knox & Janenova, 2019). Among post-Soviet countries, excluding the Baltic states, Kazakhstan is widely recognized as a regional leader in e-government development. Scholars attribute this success to a combination of traditional top-down administrative control, central government funding, and directive-based implementation mechanisms. As Kassen (2016) noted, Kazakhstan has achieved "impressive outcomes in this domain, making it a model worthy of consideration by other post-Soviet states."

Currently, the Kazakh government continues to accelerate the digitalization of public services and integration of state databases as part of its broader vision to build a service-oriented state. This effort is driven by the national program "Digital Kazakhstan," which aims to create an efficient digital ecosystem across all sectors of governance. Notably, the integration of government services into the unified e-government platform has increased substantially [3].

As of recent years, over 90% of public services (compared to 71% in 2017) are delivered electronically or through the State Corporation "Government for Citizens," resulting in a more than two-thirds reduction in petty corruption related to public service delivery. The remaining services are provided through the "one-stop-shop" principle, with the ultimate objective being a complete digital transformation of public service provision.

Additionally, anti-corruption initiatives in Kazakhstan extend to the protection of the business sector. Special attention has been given to safeguarding entrepreneurs and investors from undue interference by corrupt officials. Digital tools have been developed to facilitate this protection. For instance, the National Chamber of Entrepreneurs "Atameken" operates the "Entrepreneur's Personal Cabinet" portal, a dedicated digital platform tailored to the needs of small and micro-businesses. Through this portal, registered users can access a wide range of services and essential business-related information in a streamlined and secure manner [4].

This comprehensive digital infrastructure not only enhances transparency and citizen participation but also reinforces institutional integrity, demonstrating how strategic implementation of ICT can serve as a transformative force in anti-corruption governance.

In China, research into the use of artificial intelligence in the judicial system has been underway since 2014, and during that time, hundreds of millions of data from court cases were digitized, either entirely or partially used for artificial intelligence software. In December 2020, 16 lawyers competed in the analysis of legal contracts with artificial intelligence systems. As a result, the artificial intelligence system examined five documents in one minute and found in the documents the threats that court officials were unable to identify in 30 minutes. Since April 2020, in ten courts in Shanghai, the artificial intelligence system has replaced living assistants and has committed to transcribing audio recordings of trials, providing evidence digitally and searching for required pages and links in documents [5].

The experience of Estonia, a world leader in digital management and operational compatibility, shows that the country's success is largely due to the introduction of the X-Road platform. X-Road is a level of decentralized and secure data exchange that allows different information systems to interact. The main anti-corruption mechanism in Estonia is to ensure full access to the Internet. Estonia is one of the most advanced countries of the European Union in the field of IT-technologies. The country is fully equipped with free Wi-Fi, and 98% of the territory has wireless Internet access. Thus, the widespread use of the Internet will have an additional impact on the level of public perception of corruption. At the same time, an effective government has the opportunity to use access to information on the Internet to its advantage, that is, to hesitate to use the information in its own way [6]. It can be argued that such information technologies can provide significant assistance in the fight against corruption.

Today, Kazakhstan is changing its attitude towards the fight against corruption. The country is implementing a new system of values, such as fairness, honesty and trust. Kazakhstan is actively using the methods and tools that have proven itself in world practice, aiming to join the ranks of low-level countries. As a result of digitalization and automation of public services, the level of corruption in this area has decreased significantly—almost fourfold. The opportunities for citizens to get justice have been increased, and the system of public administration has been cleared of despised officials. At the same time, the number of corruption offenses is gradually decreasing. The society's attitude towards corruption has changed, and the focus is now on the formation of an anti-corruption culture, monitoring, identifying and eliminating risks and widespread involvement of the population in this process. Thus, consolidation of efforts of the state, business, non-governmental organizations and civil society plays a crucial role in the radical elimination of corruption.

Recent empirical research on Kazakhstan underscores a complex and heterogeneous relationship between corruption and regional socio-economic development, revealing substantial disparities across oblasts in terms of industrial output, investment attractiveness, consumer spending, and foreign trade turnover. For example, strong inverse correlations between registered corruption crimes and per capita expenditures in regions such as Kostanay (−0.9), Akmola (−0.9), and East Kazakhstan + Abay (−0.89) suggest that corruption directly undermines consumer welfare and economic resilience. Likewise, trade potential subindices show sharp contrasts: while Kostanay and Akmola exhibit strong negative correlations (−0.95), cities like Shymkent demonstrate a counterintuitive positive relationship (+0.85), indicating that digital transparency tools may not yet be fully operational or equally effective nationwide. These variations highlight the urgent need for an individual or cluster-based approach to regional anti-corruption strategies, integrating socio-economic structures, sectoral vulnerabilities, and local governance capacity. Leveraging digital platforms—such as e-procurement monitoring systems, corruption risk maps, and AI-based analytics—tailored to the institutional profiles of each region, can enhance policy responsiveness and accountability. Moreover, regions like East Kazakhstan and Akmola, which benefit from stronger digital infrastructure and proximity to national oversight mechanisms, may serve as benchmarks for best practices. In contrast, regions with weak or inconsistent correlations—such as Mangistau, Atyrau, and Almaty + Zhetysu—require deeper investigation through mixed-methods research to uncover latent variables or unreported forms of corruption. Ultimately, integrating quantitative data with qualitative insights (e.g., interviews with local stakeholders) will allow Kazakhstan to design nuanced, regionally adaptive digital anti-corruption frameworks that reflect its vast territorial, administrative, and cultural diversity [8].

Currently, digital technologies are an important ally in the fight against corruption. New technologies and open data will allow anti-corruption experts to detect, prevent and even predict corruption activities hidden behind the document darkness in the past period [7].

Digitalization has become a reliable partner for a government focused on fighting corruption, as digital technologies combined with political will make it possible to change the public service delivery process.

Digital transformation will allow the government to create effective anti-corruption bodies, work in accordance with the requirements of the digital society and achieve sustainable development goals.

In conclusion, the integration of information and communication technologies holds substantial potential in curbing corruption, particularly when supported by key success factors such as a robust e-government infrastructure, unrestricted access to open data, and widespread technological availability. However, in the absence of these foundational elements, digital reforms may yield limited or even adverse outcomes. Additional challenges—such as low levels of digital literacy and weak civic engagement—can significantly undermine the effectiveness of ICT-based anti-corruption measures.

Most importantly, the presence of strong political will remains a decisive factor. Without genuine commitment from political leadership, even the most well-designed transparency and accountability initiatives may fail to deliver results, including in democratically governed systems. Therefore, the design and implementation of digital anti-corruption strategies must be grounded in comprehensive analysis and consider the broader socio-political context.

It is also increasingly evident that technology-driven anti-corruption mechanisms—when effectively integrated—offer more promising results in restraining corrupt practices within the public sector than conventional enforcement-based approaches. To ensure impact, digital solutions must be supported by strategic planning, citizen empowerment, and institutional readiness.

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