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Evaluation of the effect of kidney transplantation on cardiac activity in patients with chronic heart failure in the outcome of stage 5 chronic kidney disease

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Abstract

The main cause of death in patients with terminal forms of chronic renal failure, on renal replacement therapy, are cardiovascular diseases. Cardiovascular diseases also account for 40 to 60% of all deaths after kidney transplantation.

Objective: in this study, we assessed the effect of kidney transplantation on the functional state of the heart in patients with stage 5 chronic kidney disease complicated by the development of chronic heart failure.

Methods. The study included 13 patients who had undergone kidney transplants. Inclusion criteria: patients over 18 years of age, the presence of informed consent, with the presence of chronic heart failure with a reduced left ventricular ejection fraction < 50%, a high level of final diastolic volume and a high calculated average pressure in the pulmonary artery.

Results. After transplantation, the lowest value of the ejection fraction was 49%, the highest value was 68%, the average value was 56.3%. The calculated average pressure in the pulmonary artery was the lowest value was 10 mmHg. the highest value was 38 mmHg. the average value was 19.69 mmHg. According to the results of the control ultrasound examination after transplantation, positive dynamics was noted in all 13 cases. The average calculated mean pressure in the pulmonary artery decreased from 39.46 mmHg to 19.69 mmHg. a decrease of 50.1%, the ejection fraction increased from 41.46% to 56.43%, an increase of 35.8%.

Conclusion. The research results highlight the significant improvement in both cardiac and pulmonary function in patients with chronic heart failure after kidney transplantation. However, in our study, some parameters, such as an increase in the ejection fraction and a decrease in the calculated average pressure in the pulmonary artery, turned out to be more pronounced, which may indicate the specifics of our patient population and treatment methods.

Keywords: chronic kidney disease, kidney transplantation, chronic heart failure, final diastolic volume, ejection fraction, arterial hypertension.

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Introduction

Chronic kidney disease (CKD) is a persistent decline in kidney function that affects approximately 10% of the global population to some extent [1]. CKD significantly increases the risk of cardiovascular diseases due to fluid and electrolyte imbalances, leading to the development of hypertension and cardiovascular complications. Lipid metabolism disorders, calcium regulation disturbances, and chronic vascular wall inflammation caused by elevated blood creatinine and urea levels contribute to the development of atherosclerosis and cardiovascular diseases [2]. Thus, the primary cause of mortality in patients with end-stage renal disease (ESRD) undergoing renal replacement therapy is cardiovascular disease [3-5]. Additionally, cardiovascular diseases account for 40% to 60% of all deaths following kidney transplantation [5-6].

According to the European Dialysis and Transplant Association, the one-year survival rate for patients with ESRD on renal replacement therapy is 83.5%, the two-

year survival rate is 72.2%, and the five-year survival rate is 42.0%. In comparison, kidney transplant recipients have significantly higher survival rates: one-year survival at 96.8%, two-year survival at 94.9%, and five-year survival at 88.3% [7].

Kidney transplantation remains the only radical treatment for patients with ESRD [8]. The advantages of kidney transplantation over hemodialysis are evident, as it leads to an improved quality of life and higher survival rates. Kidney transplantation not only reduces the burden on the cardiovascular system but also significantly improves the functional state of the heart in patients with varying degrees of chronic heart failure [7].

In this study, we assessed the impact of kidney transplantation on the functional state of the heart in patients with stage 5 chronic kidney disease complicated by the development of chronic heart failure.

Materials and methods

This study is a retrospective, quantitative analysis of data from patients who underwent kidney transplantation.

To assess heart function, the most accessible and informative method, transthoracic echocardiography (TTE), was used as an ultrasound-based cardiac assessment both before and after the transplantation procedure.

The evaluation also included complications associated with CKD and heart failure, such as arterial hypertension, respiratory failure, pleuritis, and pericarditis.

A total of 13 patients who had undergone kidney transplantation were included in the study. The inclusion criteria were: patients over 18 years old, informed consent,

and the presence of chronic heart failure with a reduced left ventricular ejection fraction (LVEF) $\leq 50\%$, high end-diastolic volume (EDV), and elevated estimated mean pulmonary artery pressure (mPAP). The exclusion criterion was the absence of informed consent.

This study was conducted in accordance with the principles of the Helsinki Declaration, and prior to its retrospective analysis, approval was obtained from the local bioethics committee of the "National Scientific Oncology Center".

All calculations were performed using Microsoft Excel, applying mean value calculations.

Results

Between 2021 and 2023, a total of 160 kidney transplants were performed at our clinic from both living and deceased donors. Among these, 13 recipients with chronic heart failure and reduced left ventricular ejection fraction (LVEF) $\leq 50\%$, high end-diastolic volume (EDV), and elevated estimated mean pulmonary artery pressure (mPAP) were included in our study.

The average age of the recipients was 31.76 years, and the mean body mass index (BMI) was 19.36 kg/m². One recipient had grade 2 obesity with a BMI of 32.79. Out of 13 patients, 12 were male and 1 was female. The causes of end-stage CKD were glomerular diseases in 12 patients and diabetic nephropathy in 1 patient. Pleural effusion was detected in 4 cases, and pericardial effusion was found in 6 cases. Before surgery, 8 patients were anuric, while 5 patients had a urine output of 100 to 500 mL of discolored urine per day. The average duration of hemodialysis before transplantation was 28.46 months.

Seven patients had type 1 respiratory failure, experiencing shortness of breath with minimal physical activity, while 5 patients had type 2 respiratory failure, experiencing shortness of breath with moderate physical activity. One patient had dyspnea at rest as a type 3 respiratory failure. Arterial hypertension was classified as a stage 3 hypertension in 10 patients, Stage 2 hypertension in 1 patient, and 2 recipients had stage 1 hypertension.

Echocardiography (ECHO) was performed 1 week to 1 month before kidney transplantation. Before transplantation, the lowest recorded LVEF was 29%, the highest was 48%, and the mean value was 41.46%. The

lowest recorded mPAP was 15 mmHg, the highest was 80 mmHg, and the mean was 39.46 mmHg. The lowest recorded EDV was 94 mL, the highest was 219 mL, and the mean was 144.23 mL.

All recipients underwent a standard, widely accepted kidney transplantation procedure using a living donor, with the transplant placed retroperitoneally in the right iliac fossa.

There were no cases of acute rejection or delayed graft function. The average postoperative hospital stay was 14 days. At discharge, all recipients had satisfactory kidney graft function.

Follow-up echocardiography was performed 1 to 3 months after discharge. Positive dynamics were observed in all 13 recipients.

After transplantation, the lowest recorded LVEF was 49%, the highest was 68%, and the mean was 56.3%. The lowest recorded mPAP was 10 mmHg, the highest was 38 mmHg, and the mean was 19.69 mmHg. The lowest recorded EDV was 80 mL, the highest was 161 mL, and the mean was 108.76 mL.

According to follow-up echocardiography, positive improvements were observed in all 13 cases. The average mPAP decreased from 39.46 mmHg to 19.69 mmHg, a reduction of 50.1%. LVEF increased from 41.46% to 56.3%, an improvement of 35.8%. EDV decreased from 144 mL to 108.76 mL, a reduction of 24.6%.

Table 1 - Clinical parameters of patients before and after transplantation

Clinical parameters	Before transplant	After transplant
Ejection fraction	41,46	56,43
estimated mean pulmonary artery pressure	39,46	19,69
end diastolic volume	144	108,76
Pericarditis	6	0
Pleurisy	4	0
Type 1 respiratory failure	7	2
Type 2 respiratory failure	5	0
Type 3 respiratory failure	1	0
Stage 3 hypertension	10	0
Stage 2 hypertension	1	1
Stage 1 hypertension	2	12

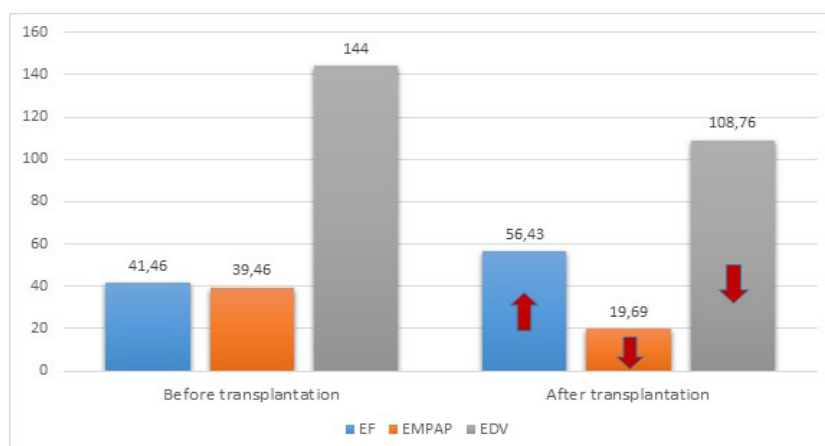


Figure 1 - Average value of EF (ejection fraction), EMPAP (estimated mean pulmonary artery pressure, EDV (end diastolic volume) before and after the kidney transplantation procedure

Type 1 respiratory failure was observed in 2 patients 3 months after transplantation, while the remaining 11 patients had no respiratory failure. Blood pressure normalization occurred in 7 patients without the use of

Discussion

The results of our study demonstrated a significant improvement in cardiovascular status in patients with chronic heart failure after kidney transplantation. The included recipients had pronounced manifestations of heart failure with reduced LVEF, high EDV, and elevated mPAP. It is important to note that this patient population is at high risk for complications associated both with end-stage renal failure and chronic heart failure.

One to three months after transplantation, all recipients showed positive dynamics in heart function indicators. The average increase in LVEF from 41.46% to 56.3% (a 35.8% improvement) indicates a significant improvement in left ventricular pumping function, likely related to the restoration of volume status following kidney transplantation. The reduction in mPAP from 39.46 mmHg to 19.69 mmHg (a 50.1% decrease) confirms the reduction of pulmonary artery pressure and improvement in hemodynamics. This suggests a positive effect of kidney transplantation on systemic circulation and pulmonary hypertension caused by renal failure.

Additionally, the significant reduction in EDV from 144.23 mL to 108.76 mL (a 24.6% decrease) indicates a reduction in left ventricular volume overload. This parameter may serve as an additional marker of improved

antihypertensive medications. In 3 patients, blood pressure improved with the use of antihypertensive drugs, reaching normal levels. Two patients had no arterial hypertension either before or after kidney transplantation.

heart function and the general condition of patients after transplantation.

It is also important to highlight the positive changes in respiratory function. In most patients, respiratory failure either decreased or completely disappeared, indicating correction of metabolic disturbances and improved oxygenation following the normalization of renal function. Moreover, the normalization of blood pressure in most patients without the use of antihypertensive medications underscores systemic improvement.

These results confirm the effectiveness of kidney transplantation in patients with a combination of end-stage renal failure and chronic heart failure, which could have clinical significance for improving the prognosis of this patient group.

The instrumental methods used in our study were similar to those in other studies [9-12]. The obtained results are consistent with the data from other studies demonstrating an improvement in cardiovascular function after kidney transplantation in patients with chronic heart failure (CHF). In the study by Lentine et al. (2012), it was shown that kidney transplantation leads to significant improvement in heart function, including a reduction in

pulmonary hypertension and an increase in left ventricular ejection fraction (LVEF) [13]. However, in our study, the average increase in LVEF (by 35.8%) was higher than in some other studies, where improvement ranged from 15% to 25%. This could be due to the fact that our cohort included patients with more pronounced initial heart function abnormalities, which resulted in a more noticeable improvement after transplantation.

In the study of Kumar et al. (2024) discusses that the impact of kidney transplantation on pulmonary hypertension (PH) and highlights that, in some cases, kidney transplantation can lead to a reduction in mean pulmonary artery pressure (mPAP) [14]. In our study, we observed a more significant reduction - by 50.1%. The difference may be related to the methods of measuring mPAP, as well as differences in the patient cohort. Given the high baseline values of mPAP in our patients, transplantation may have had a more pronounced effect on reducing pulmonary artery pressure.

In the study Eun Jung Kim et al. (2019) analyzed the association between perioperative factors and changes in left ventricular diastolic function in patients with preserved ejection fraction following kidney transplantation. The study found that kidney transplantation was associated with improved diastolic function [15]. In our study, the reduction

in EDV was 24.6%, which is slightly higher compared to the 15-20% observed in other studies. This may indicate a more pronounced post-load correction of heart function in our patients after transplantation, which could also be explained by the specifics of their initial condition.

Several studies discuss that kidney transplantation can lead to better blood pressure control compared to dialysis, attributing this improvement to the restoration of endocrine functions and fluid balance by the transplanted kidney [16,17]. In our study, normalization of blood pressure without the use of antihypertensive medications was achieved in 7 out of 13 patients, which supports these findings. However, in 3 patients, antihypertensive medications were still used to control blood pressure, which is also consistent with other studies indicating that not all patients achieve complete blood pressure normalization after transplantation.

Thus, our results confirm and complement the data from other studies, highlighting significant improvements in both cardiac and pulmonary function in patients with CHF after kidney transplantation [17-19]. However, in our study, some parameters, such as the increase in LVEF and the reduction in mPAP, were more pronounced, which may indicate the specificity of our patient cohort and treatment methods.

Conclusion

Many similar studies confirm the presence of positive dynamics in cardiovascular function, further emphasizing the invaluable role of kidney transplantation as a method that directly impacts the survival of patients with terminal stages of chronic kidney disease. We will continue to collect data from this patient group, incorporating additional criteria that may influence the process of improving cardiovascular function.

Conflict of interest. No.

Acknowledgments. No.

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Түйіндеме

Созылмалы бүйрек жеткіліксіздігінің терминалды формалары бар, бүйректі алмастыратын терапиядағы пациенттер өлімінің негізгі себебі жүрек-қан тамырлары аурулары болып табылады. Сондай-ақ, жүрек-қан тамырлары аурулары бүйрек трансплантациясынан кейінгі барлық өлім-жітімнің 40-60% құрайды.

Зерттеудің мақсаты: Бұл зерттеуде біз созылмалы жүрек жеткіліксіздігінің дамуымен асқынған 5 сатыдағы созылмалы бүйрек ауруы бар науқастарда бүйрек трансплантациясының жүректің функционалды жағдайына қаншалықты әсерін бағаладық.

Әдістері. Зерттеуге бүйрек трансплантациясынан өткен 13 науқас қатысты. Қосу критерийлері: 18 жастан асқан пациенттер, сол жақ қарыншаның шығарылу фракциясы ≤50% төмендеген созылмалы жүрек жеткіліксіздігінің, соңғы диастолалық көлемнің жоғары деңгейінің және жоғары есептелген өкпе артериясындағы орташа қысымның болуымен ақпараттандырылған келісімінің болуы.

Нәтижесі. Шығарылу фракциясы трансплантациясынан кейін ең төменгі көрсеткіш 49% құрады, ең жоғары 68% орташа көрсеткіш 56,3% болды. Өкпе артериясындағы орташа қысымның ең төменгі мәні сынап бағанасы 10 мм. болды, ең жоғары мәні 38 мм. сынап бағанасы, орташа мәні 19,69 мм. сынап бағанасы болды. Трансплантациядан кейінгі бақылау ультрадыбыстық нәтижелері бойынша барлық 13 жағдайда оң динамика байқалды. Өкпе артериясындағы орташа қысымның орташа деңгейі 39,46 мм. сынап бағанасынан 19,69 мм. сынап бағанасына дейін төмендеді. Шығарылу фракциясы 46%-дан 56,43%-ға дейін 35,8%-ға ұлғайды.

Қорытынды. Біздің нәтижелеріміз бүйрек трансплантациясынан кейін созылмалы жүрек жеткіліксіздігі бар науқастарда жүрек және өкпе функциясының айтарлықтай жақсарғанын көрсетті. Дегенмен, біздің зерттеуімізде шығарылу фракциясының жоғарылауы және өкпе артериясындағы орташа қысымның төмендеуі сияқты кейбір параметрлер айқынырақ болды, бұл біздің пациенттер контингентінің және емдеу әдістерінің ерекшелігін көрсетуі мүмкін.

Түйін сөздер: созылмалы бүйрек ауруы, бүйрек трансплантациясы, созылмалы жүрек жеткіліксіздігі, соңғы диастолалық көлем, шығарылу фракциясы, артериялық гипертензия.

Оценка влияния трансплантации почки на сердечную деятельность у пациентов с хронической сердечной недостаточностью в исходе хронической болезни почек 5 стадии

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Резюме

Основной причиной смертности пациентов с терминальными формами хронической почечной недостаточности, на заместительной почечной терапии, являются сердечно-сосудистые заболевания. Также сердечно-сосудистые заболевания составляют от 40 до 60% всех случаев смерти после трансплантации почки.

В этом исследовании мы оценили на сколько влияет трансплантация почки на функциональное состояние сердца у пациентов с хронической болезнью почек 5 стадии осложнившейся развитием хронической сердечной недостаточностью.

Методы. В исследование были включены 13 пациентов которые перенесли трансплантации почек. Критерии включения: пациенты старше 18 лет, наличие информированного согласия, с наличием хронической сердечной недостаточности со сниженной фракцией выброса левого желудочка $\leq 50\%$, высоким уровнем конечного диастолического объема и высоким расчетным средним давлением в легочной артерии.

Результаты. После трансплантации самое низкое значение фракция выброса составило 49% самое высокое значение 68% среднее значение составило 56,3%. Расчетное среднее давление в легочной артерии самое низкое значение составило 10 мм. рт. ст. самое высокое значение 38 мм. рт. ст. среднее значение составило 19,69 мм. рт. ст. По результатам контрольного ультразвукового исследования после трансплантации отмечена положительная динамика во всех 13 случаях. Средний уровень расчетного среднего давления в легочной артерии с 39,46 мм. рт. ст. снизилось до 19,69 мм. рт. ст. снижение на 50,1%, фракция выброса увеличилась с 41,46% до 56,43% увеличение на 35,8%, конечный диастолический объем со снижением со 144 мл. до 108,76 мл. снижение на 24,6%.

Выводы. Результаты исследования подчеркивают значительное улучшение как сердечной, так и легочной функции у пациентов с хронической сердечной недостаточностью после трансплантации почки. Однако в нашем исследовании некоторые параметры, такие как увеличение фракции выброса и снижение расчетного среднего давления в легочной артерии, оказались более выраженными, что может свидетельствовать о специфике нашего пациентского контингента и методов лечения.

Ключевые слова: хроническая болезнь почек, трансплантация почки, хроническая сердечная недостаточность, конечный диастолический объем, фракция выброса, артериальная гипертензия.

Contemporary Methods of Early Diagnosis of Neurological Diseases: International Research Experience

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Abstract

The significant increase in scientific papers reflects growing interest in the early detection of neurological diseases, driven by advances in neuroimaging, artificial intelligence and biomarker research.

The overarching goal is to identify key trends and innovative methods that improve diagnostic accuracy and timeliness, thereby optimizing patient outcomes in the early stages of neurological diseases.

This study analyzes 6132 publications in the Scopus database (1946-2024) related to the keywords "diagnosis" and "neurology". The rapid growth in scientific output underscores an emerging focus on early detection of neurological disorders, facilitated by advancements in neuroimaging, artificial intelligence, and biomarker research.

Research-oriented articles were selected based on the keywords "Diagnostics" and "Neurology," and as a result, the 6132 selected scientific publications underwent statistical analysis using the SPSS program. The descriptive statistics method was used to study the dynamics of publications by year, leading countries, leading organizations, and major research areas.

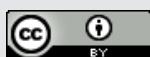
Analysis reveals a substantial rise in publications over the last decade, particularly in the fields of medicine, engineering, and computer science. The United States leads in overall output, followed by the United Kingdom and Germany. Collaborative, multidisciplinary research has contributed to emerging technologies ranging from advanced imaging modalities to AI-driven diagnostic tools that are increasingly crucial in detecting neurodegenerative and cognitive disorders at preclinical stages.

A systematic review of publication activity highlights the growing global emphasis on early neurological diagnosis. Despite cost and accessibility challenges, integrating neuroimaging, AI systems, and biomarker technologies holds great promise for refining diagnostic precision, fostering international collaboration, and expanding the frontiers of neurological research.

Keywords: neurology, early diagnosis, neuroimaging, biomarkers, Scopus, statistical analysis.

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Introduction

Contemporary methods of early diagnosis of neurological diseases acquire particular importance in light of the increasing prevalence of these pathologies and their serious impact on patients' quality of life. Early diagnosis allows diseases to be identified in a timely manner, minimizes their consequences, and substantially reduces the economic burden on healthcare. Rapid technological development in international practice, including neuroimaging, biomarkers, and artificial intelligence, is opening new horizons for detecting neurological disorders in their early stages. However, despite these advances, the need to adapt such methods in different countries, consider regional specificities, and develop universal approaches remains relevant, highlighting the significance of the present study.

Early diagnosis of neurological diseases plays a decisive role in timely intervention and the management of conditions such as Alzheimer's disease (AD) and autism spectrum disorders (ASD), since there are still no definitive treatments for many of them [1,2]. Against the backdrop of rapid progress in artificial intelligence (AI), neuroimaging, and genetic sequencing, particular attention is being paid to quantitative electroencephalography (QEEG), which makes it possible to evaluate cognitive impairments in a wide range of patients and, specifically, to detect concentration disorders among professional pilots [3]. In addition, AI technologies can process large volumes of data and reveal patterns that can elude clinicians, thus significantly increasing diagnostic accuracy [1,2]. The use of genetic methods remains an important area, among which clinical (CES) and whole-exome sequencing (WES) are facilitating the identification of new gene variants in idiopathic neurodevelopmental disorders [4]. In the context of imaging methods, the use of functional magnetic resonance imaging (fMRI) in combination with the graph canonical correlation analysis (GATE) algorithm is promising, as it improves the detection accuracy of pathological patterns of brain activity [5]. At the same time, there is an ongoing issue of misinterpreting symptoms when functional neurological disorders (FND) are often mistaken for organic pathologies [6]. A multidisciplinary approach involving neurologists, psychiatrists, and other specialists makes it possible to expand diagnostic capabilities and combat patient stigmatization [7]. Special attention should be given to predicting neurological disorders in pediatric

Materials and Methodology

This study is based on the evaluation of 6132 publications indexed between 1946 and 2024, using the keywords "diagnosis" and "neurology." Such a time range was selected to cover the broadest possible spectrum of works related to identifying and studying neurological conditions. The majority of the sources retrieved are articles (4040), indicating a prevalence of original research, empirical observations, and detailed experiments. A substantial number of conference materials (897) reflects the innovative nature of the field, as findings are often presented at specialized scientific forums. Reviews (685) occupy a separate position, providing a systematic overview of key concepts, theoretical approaches, and clinical practice trends. Less common but nonetheless crucial for understanding scientific progress over time are editorial articles (148), notes (103), letters (88), book chapters (68), and short surveys (44).

Among other document types, corrections and retractions (Erratum and Retracted) also appear, along with rare instances like Data Paper (1), reflecting the diversity of the scientific landscape. The study's comprehensiveness

practice, where machine learning techniques demonstrate high effectiveness in detecting early signs and, consequently, increase the likelihood of timely correction [8].

Based on an analysis of publication activity from 1946 to 2024 using the keywords "diagnosis" and "neurology" in the Scopus database, 6132 scientific works were identified, underscoring the sustained interest of researchers in this topic. The United States has the largest number of publications (1781), followed by the United Kingdom (633), Germany (487), China (387), and India (346), reflecting the global involvement of countries with varying levels of scientific and technological development. Italy (272), France (255), and Canada (244) also make significant contributions, continuing to shape a multinational research landscape. Notably, even countries with a relatively small number of publications, such as the Russian Federation (113), Kazakhstan (5), or Malaysia (37), further develop this field and confirm its international scope. Thus, a broad range of authors worldwide underscores the multifaceted nature and importance of research related to diagnosis in neurology, as well as the need for interdisciplinary and multicultural collaboration among specialists.

Our study, "Contemporary Methods of Early Diagnosis of Neurological Diseases: International Research Experience," aims at a comprehensive analysis of scientific publications selected by the keywords "diagnosis" and "neurology" and indexed in the Scopus database for the period from 1946 to 2024. The primary goal is to identify and consolidate leading trends, innovative approaches, and methodological solutions applied in the early diagnosis of neurological diseases. In pursuit of this goal, we plan to conduct a quantitative analysis of publication activity dynamics, determine the geographical distribution of research, and identify the most notable scientific teams and journals shaping the research agenda in this field. A detailed review of key technologies will also be carried out, including neuroimaging, artificial intelligence, and biomarkers that are actively used in international early diagnostic practices. Such an approach will allow us to systematize contemporary methods and outline future avenues for research that contribute to more effective detection and treatment of neurological diseases on a global scale.

is further strengthened by examining leading academic editions with a well-established tradition of publishing on neurological topics. Among the most frequently encountered are BMJ Case Reports (434), Neurology (108), as well as the Annual International Conference Of The IEEE Engineering In Medicine And Biology Proceedings (95). Their presence in various journals and conference series, including Lecture Notes In Computer Science and IEEE Transactions On Biomedical Engineering, underscores the multidisciplinary nature of the field. Papers in Journal Of Neurology (44), Archives Of Neurology (42), European Journal Of Radiology (39), and several others provide a thorough view of methodological diversity, geographical coverage, and a focus on particular diagnostic and clinical observation aspects.

The inclusion of research from a wide range of countries illustrates the high significance of these issues, further supported by the extensive use of technologies from traditional neuroimaging to the most advanced computer-based methods. Such a selection of sources enables taking into account both the applied and the fundamental components necessary for a comprehensive analysis of

existing achievements and identifying areas that require more in-depth study.

The primary task was to determine and systematize the collected data array, necessitating tools capable of handling and analyzing large volumes of information. SPSS was chosen for statistical analysis, having proven itself in the academic arena thanks to a wide array of procedures, including descriptive statistics, correlation studies, regression analysis, and visualization tools. By employing SPSS, it is possible to discern hidden patterns, distributions, and interrelationships within the data structure, as well as assess the statistical significance of the results obtained.

This tool ensures a comprehensive approach: from basic descriptive operations and frequency table construction to algorithmic trend identification using artificial intelligence methods. Such a broad range of technical solutions aims to produce highly reliable and reproducible results, allowing for the determination of key factors influencing the efficiency of early neurological diagnosis and for comparing and integrating data from diverse sources and regions.

The initial step involved forming a sample through a detailed search of scholarly publications based on specified keywords in the database, along with recording parameters such as year of publication, document type, and assignment to a particular journal or conference edition. After selection, duplicate entries were removed and irrelevant results inconsistent with the research subject were excluded. The publications were then systematized in an electronic database suitable for subsequent statistical and content analysis. At the first stage, descriptive statistics were evaluated using SPSS: determining the average number of publications per year, identifying periods of most intense

Results

In recent years, brain imaging has been rapidly evolving, enabling a significant increase in accuracy and timeliness when diagnosing diseases associated with neurodegeneration and cognitive impairments. Various methods, including MRI, PET, and DTI, make it possible to detect structural and functional changes that can appear long before clinical symptoms arise, which is particularly valuable when suspecting Alzheimer's disease (AD) and other forms of dementia [9-11]. A major breakthrough has been the use of fMRI and PET, as they allow for the detection of early metabolic shifts and cerebral blood flow anomalies [12]. At the same time, combining neuroimaging and cerebrospinal fluid biomarkers yields higher sensitivity and specificity in diagnosing MCI and AD [13], while the use of machine learning algorithms helps identify subtle data patterns, increasing diagnostic accuracy [10,14]. In pediatrics, DTI has greatly simplified the localization of epileptogenic foci, which is especially important in cases of treatment-resistant epilepsy [15], and assessing malignant neoplasms in childhood has become more detailed and timely [16]. Despite advancements, questions remain regarding the accessibility and high costs of technologies, as well as the risk of false positives, complicating clinical decision-making [17]. Nonetheless, the further integration of nanotechnology and artificial intelligence into image analysis [18,9,10,14] promises even earlier detection of neurological pathologies and more effective monitoring of their progression in the context of contemporary early diagnostic methods.

In addition to neuroimaging, the application of AI systems capable of analyzing large volumes of heterogeneous medical data significantly influences improvements in

growth, and analyzing various types of works in terms of their contribution to the data set. Concurrently, the distribution by journals and conference materials was studied to identify the outlets most frequently publishing results on neurology and diagnosis. Subsequently, an in-depth analysis was carried out: frequency tables were compiled, and regression models were constructed to trace changes in the scientific landscape. Where necessary, qualitative analysis of texts was applied to refine the findings and unveil thematic patterns.

In this process, keywords, phrases, and contextual indicators were coded, enabling a more precise definition of scientific directions, approaches, and methodological features. Visualization of results, including the creation of informative charts and graphs, facilitated interpretation and synthesis of the core findings. Ultimately, based on the analysis, a synthesized report was prepared, integrating all collected and examined data to form the basis of the scientific article.

Hence, the chosen approach encompassing thorough screening and systematization of materials, the use of multipurpose analytical tools, and a step-by-step data processing procedure ensures the comprehensiveness and reliability of the outcomes. Each phase, from sample formation to integrated analysis in SPSS and detailed study of textual sources, is oriented toward constructing the most accurate picture of the key aspects of early neurological diagnosis. This methodology guarantees reproducibility and a high level of scientific validity, while also opening up broad prospects for further in-depth research and the development of new strategies, ultimately contributing to enhancing early diagnostic practices and improving the quality of patient care.

diagnostic quality and speed. These solutions extend not only to oncology or cardiology [19,20] but also to dentistry [21] and emergency medicine, where machine learning helps detect critical conditions such as acute appendicitis [22]. Furthermore, deep neural networks and CNNs have proven effective in processing brain images, facilitating more accurate determination of tumor characteristics and staging [23]. However, these innovations face challenges including insufficient standardization of algorithms and limited reliability of certain results [24,25]. It is also crucial for clinicians to understand the logic behind neural network decisions, prompting growing interest in the concepts of explainable artificial intelligence [26]. It is worth emphasizing that in situations requiring a rapid response, intelligent systems can significantly reduce the time needed to make a diagnosis, and therefore initiate therapy earlier [27]. Although the requirement for large data volumes and privacy concerns remain unresolved [28], the potential for AI integration into the diagnostic process looks promising, especially given the increasing number of studies on early detection of oncological and neurological pathologies [29].

Thus, the combination of modern imaging methods, AI systems, and biomarker technologies provides a comprehensive basis for more accurate and timely diagnosis of neurological diseases, ensuring early detection of pathological processes and a personalized approach to treatment. Uniting these methods not only expands clinical practice capabilities but also optimizes patient routing, thereby increasing the effectiveness of therapeutic interventions. Despite existing constraints, including access to high-tech equipment, specialist training issues, and regulatory aspects, continued progress in this area

opens up new horizons for fundamental research and the implementation of innovations on a global scale.

A multifaceted analysis demonstrated the importance of a comprehensive approach encompassing an assessment of publication activity by year, a comparative review of scientific contributions from various countries, and an examination of the knowledge domains in which research is actively developing. Particular attention was devoted to the work of leading organizations and the identification of key journals, whose pages host the most significant studies. Further exploration of publication titles by keywords allowed for formulating the main directions of development and highlighting dominant thematic focuses, while citation analysis pinpointed works with the greatest authority and influence on the scientific discourse. The sum of the data obtained reflects characteristic trends and

consolidates promising avenues for future research and the practical application of findings.

An examination of the number of publications per year, starting from 1946 up to 2024, points to a gradual yet uneven evolution of interest in the subject matter. In the early period (1946-1970), the number of works was minimal, explained by both the limited volume of scientific research and the difficulties in accessing diagnostic technology at that time. Steady growth has been observed since the 1970s, but a notably sharp increase has occurred in more recent periods. For example, between 2005 and 2015, overall interest remained relatively stable, whereas from 2016 onward, it began to rise, reaching its highest values in 2024 (535 publications). This dynamic may reflect the emergence of new neuroimaging technologies and the improvement of AI tools for early diagnostics (Figure 1).

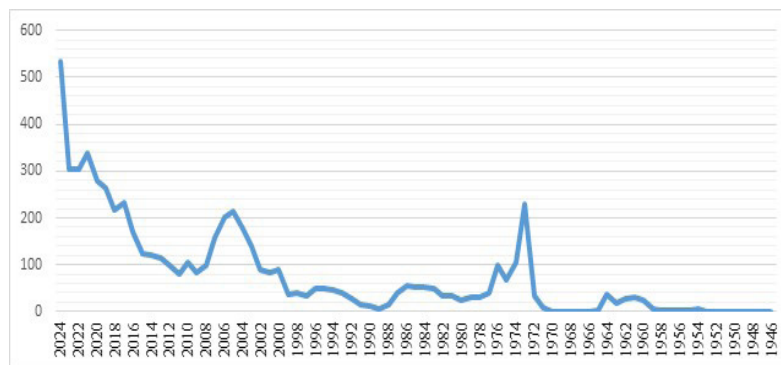


Figure 1 - Dynamics of publication activity on contemporary methods of early diagnosis of neurological diseases (1946–2024) (Source: Authors' calculations based on Scopus-indexed publication data)

Since 2020, when many studies began emphasizing interdisciplinary approaches and the integration of genetic, biomarker, and IT technologies, the number of publications has grown even more rapidly. The shift toward new diagnostic standards and the increase in multinational projects likely played a key role in reaching the peak values in 2023 (303) and 2024 (535). These trends confirm the growing recognition of the importance of early detection of neurological pathologies, fueling further advances in optimizing diagnostics, refining instruments, and expanding the evidence base.

A comparative assessment of scientific activity by country reveals substantial differences in the number of publications. The United States leads with 1781, followed by the United Kingdom (633) and Germany (487). China's significant contribution (387) highlights the rising role of the Asian region in contemporary scientific research. India (346) and Italy (272) also show high levels of interest, reflecting these countries' significant involvement in addressing issues related to early detection and monitoring. France (255), Canada (244), Japan (208), and Australia (194) round out the top ten, forming a picture of global scientific collaboration (Figure 2).

A comparative assessment of scientific activity by

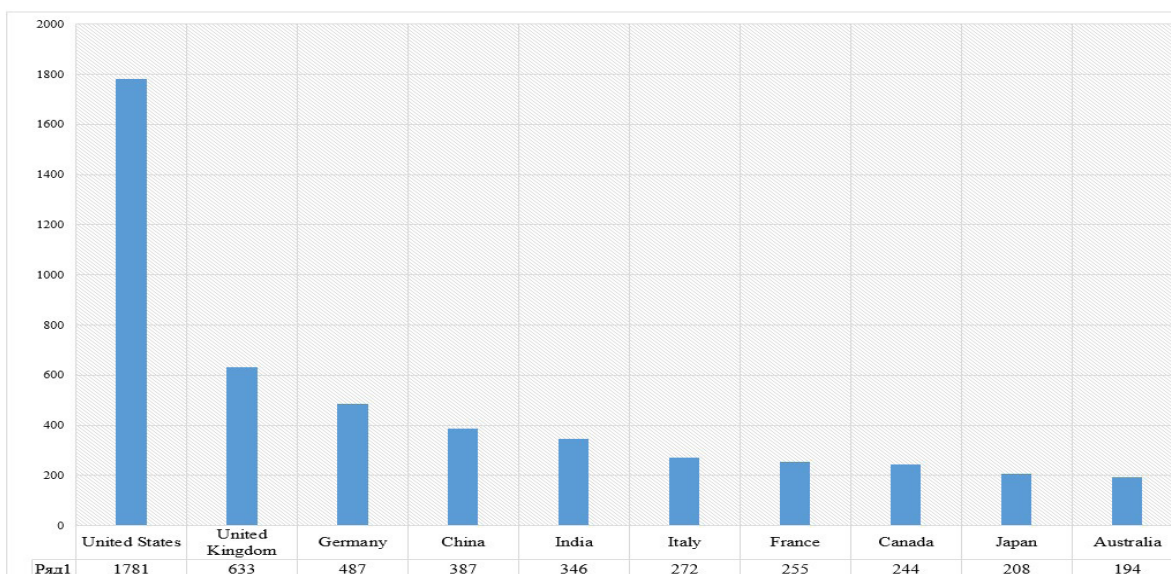


Figure 2 - Top 10 countries by number of publications on contemporary methods of early diagnosis of neurological diseases: analysis of Scopus data (Source: Authors' calculations based on Scopus-indexed publication data)

Next comes a range of countries with fewer studies, such as the Russian Federation (113), Turkey (119), and Brazil (99). Their contributions demonstrate the expansion of the international research field and highlight the importance of a multidisciplinary approach that takes into account regional aspects and healthcare resources. The geographic spread underscores broad recognition of the problem and confirms the considerable potential for further interstate exchange of experience and joint developments.

A preliminary distribution of publications by field of knowledge shows a clear dominance of medicine (4536), indicating the fundamental role of clinical and epidemiological research in this scientific domain. Following

are engineering (1067), computer science (1010), and neuroscience (838), whose high activity may be explained by the growing use of technologies, machine learning methods, and neuroimaging in the diagnostic process. Biochemistry, genetics and molecular biology (450), alongside the health professions (370), also demonstrate substantial academic interest, encompassing comprehensive approaches to early detection of diseases. Lesser but still notable attention is directed to the exact and natural sciences, including physics and astronomy (309), mathematics (270), and materials science (204), where computational models, statistical methods, and cutting-edge diagnostic materials are increasingly being employed (Figure 3).

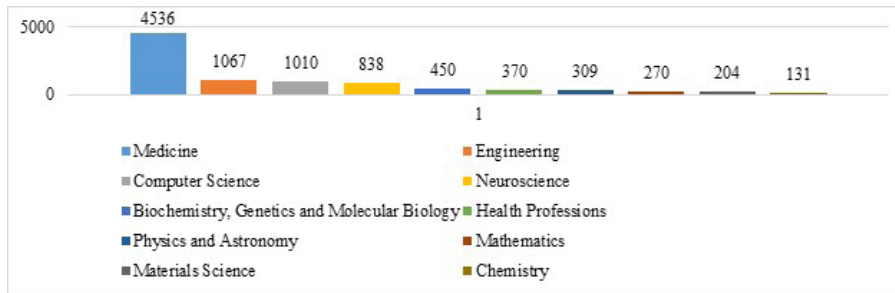


Figure 3 - Top 10 knowledge domains by number of scientific publications on contemporary methods of early diagnosis of neurological diseases: analysis of Scopus data
(Source: Authors' calculations based on Scopus-indexed publication data)

In a second cluster of fields, chemistry (131) and chemical engineering (106) stand out, reflecting the contribution of analytical and technological solutions, including the development of contrast agents and biosensors. The arts and humanities, as well as psychology (89 each) and the social sciences (79), though fewer in number, point to an interest in the ethical, cultural, and behavioral aspects of diagnosis. Moreover, economic factors (Business, Management and Accounting, 11), environmental considerations (Environmental Science, 44), and even veterinary medicine (Veterinary, 53) are increasingly taken into account in solving diagnostic challenges, underscoring the potential for multidisciplinary collaboration to improve the quality and timeliness of detection.

A comparison of research activities by different organizations shows a notable lead by Harvard Medical School (109 publications), followed by Massachusetts

General Hospital (108). The University of California, San Francisco (63) and the Mayo Clinic (60) play a significant role in shaping the scientific agenda, collectively reflecting a high level of expertise and professional standards in clinical research. Also included in the top ten most productive institutions are the UCL Queen Square Institute of Neurology (56) and University College London (55), confirming the international recognition of London-based research centers. Leading positions of the University of Toronto (53), along with the parallel success of Ludwig-Maximilians-Universität München (45) and UCSF School of Medicine (45), attest to broad geographic coverage and the substantial role of multinational projects in early diagnostics. Johns Hopkins University School of Medicine (43) and King's College London (43) complete the top group, representing prominent academic institutions with longstanding traditions of scientific discovery (Figure 4).

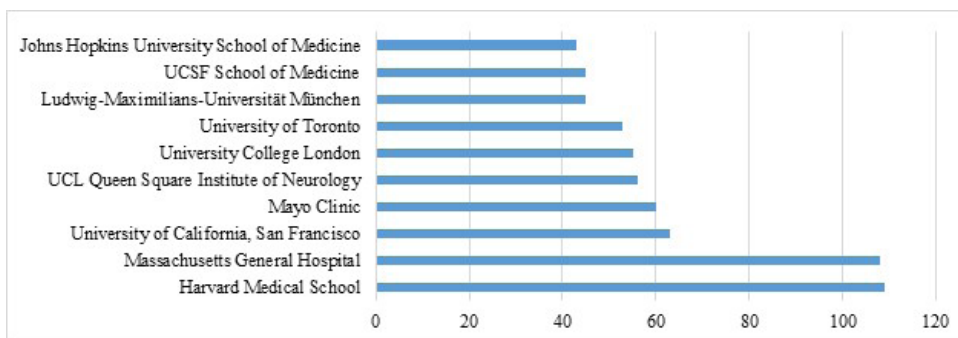


Figure 4 - Top 10 organizations by number of scientific publications on contemporary methods of early diagnosis of neurological diseases: analysis of Scopus data
(Source: Authors' calculations based on Scopus-indexed publication data)

Further analysis reveals active participation by the University of Pennsylvania (39), the VA Medical Center (38), and several medical schools such as UT Southwestern Medical Center (33) and Northwestern University Feinberg School of Medicine (32), indicating numerous clinical and laboratory studies. Concurrently, large research centers in Europe and

Asia Inserm (36), Brigham and Women's Hospital (36), the Chinese Academy of Sciences (24), and Capital Medical University (23) show a high level of engagement.

This trend underscores a rising interest in interdisciplinary collaboration and multinational projects aimed at developing and implementing more effective early detection methods for neurological disorders.

An analysis of scientific journals publishing works related to this topic indicates a clear dominance of BMJ Case Reports (434 publications). Neurology (108) also shows high figures, reflecting its leading role in discussing clinical and fundamental issues. Substantial venues for presenting research results include the Annual International Conference Of The IEEE Engineering In Medicine And Biology Proceedings (95), as well as the Lecture Notes In Computer

Science series (82), including subseries on artificial intelligence and bioinformatics. Among those consistently publishing relevant content are IEEE Transactions On Biomedical Engineering (71), Journal Of Neurology Neurosurgery And Psychiatry (57), Journal Of Neurology (44), and Archives Of Neurology (42), emphasizing a strong interest in specialized diagnostic issues. Other journals that occupy top positions include European Journal Of Radiology (39) and Progress In Biomedical Optics And Imaging Proceedings Of SPIE (39), demonstrating the major contribution of imaging technologies to research efforts (Figure 5).

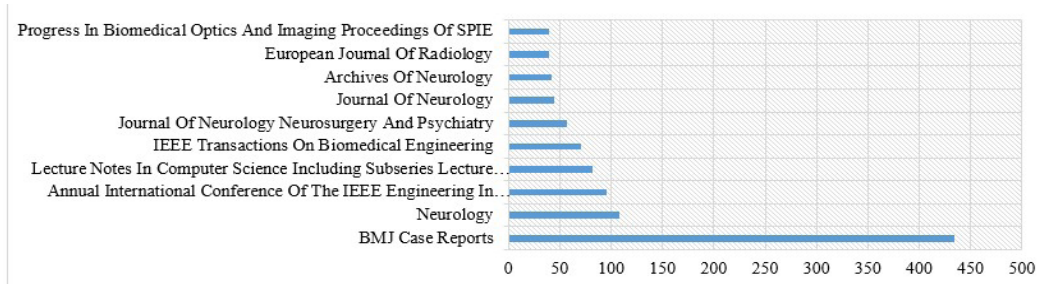


Figure 5 - Top 10 scientific journals by number of publications on contemporary methods of early diagnosis of neurological diseases: analysis of Scopus data (Source: Authors' calculations based on Scopus-indexed publication data)

The second wave of journals consists of those oriented toward innovative approaches and interdisciplinary research, such as Computers In Biology And Medicine (36), Journal Of Neural Engineering (35), and Optometry And Vision Science (35). The presence of IEEE Transactions On Medical Imaging (32), Computer Methods And Programs In Biomedicine (24), and Frontiers In Neurology (23) highlights the growing role of integrating computer algorithms, biomedical computing methods, and clinical data for early pathology detection. Publications in Meditsina Truda I Promyshlennaya Ekologiya (26) and Journal Of The Neurological Sciences (25) point to a multi-faceted research landscape that takes into account occupational factors and broadens the range of clinical scenarios. Such diversity in journals reflects both the deep specialization of individual areas and the drive toward interdisciplinary cooperation to optimize diagnostic strategies.

An analysis of the keywords found in the titles of scientific articles shows that the term "diagnosis" (650 mentions) ranks as one of the most frequently used, underscoring the priority placed on accurate and timely identification of pathologies. The terms "neurological" (545) and "neurology" (516) point to a clear focus on neurology, whereas "disease" (406) and "brain" (406) indicate researchers' concentration on specific mechanisms and clinical manifestations. The presence of words such as "clinical" (383), "epilepsy" (354), and "patients" (305) underscores the close link between theoretical models and practice, emphasizing the clinically oriented nature of the research. Equally significant are "analysis" (304) and "using" (397), which reflect the active application of analytical and computational methods in the processing of medical data (Table 1).

Table 1 - Top 20 keywords found in the titles of scientific publications on contemporary methods of early diagnosis of neurological diseases: analysis of Scopus data (Source: Authors' calculations based on the database of indexed articles in Scopus)

Keywords	Number of Keywords	Keywords	Number of Keywords
diagnosis	650	disorders	283
neurological	545	system	259
neurology	516	case	256
disease	406	eeg	248
brain	406	detection	242
using	397	syndrome	241
clinical	383	study	229
epilepsy	354	based	211
patients	305	diagnostic	208
analysis	304	imaging	197

Citation trends of the most authoritative works in the field of early diagnosis of neurological diseases clearly demonstrate that the leading publications receive broad recognition in the scientific community. At the top, "Heart rate variability: A review" (Acharya, U.R., Joseph, K.P., Kannathal, N., Lim, C.M., Suri, J.S., 2006) has 2092 mentions, followed by "Prediction of central nervous system embryonal tumour outcome based on gene expression"

(Pomeroy, S.L., Tamayo, P., Gaasenbeek, M., ... Lander, E.S., Golub, T.R., 2002) with 2051 citations. These figures indicate high demand for the results of both fundamental and clinical studies related to heart rate variability assessment and molecular-genetic approaches in diagnosing oncological pathologies of the central nervous system. Classic studies, such as "A continuous performance test of brain damage" (Rosvold, H.E., Mirsky, A.F., Sarason, I. et al., 1956) with

1770 citations, and work on developing diagnostic criteria for paraneoplastic neurological syndromes (Graus, F,

Delattre, J.Y., Antoine, J.C. et al., 2004) with 1383 references, underscore long-standing interest in cognitive function.

Table 2 - Top 10 most cited works in the field of contemporary methods of early diagnosis of neurological diseases: analysis of Scopus data from 1946 to 2024 (Source: Authors' calculations based on the database of indexed articles in Scopus; Export Date: 26 December 2024)

Title of the Work	Authors	Source	Year	Citations
Heart rate variability: A review	Acharya, U.R., Joseph, K.P, Kannathal, N., Lim, C.M., Suri, J.S.	Medical and Biological Engineering and Computing, 44(12), 1031–1051. https://doi.org/10.1007/s11517-006-0119-0	2006	2 092
Prediction of central nervous system embryonal tumour outcome based on gene expression	Pomeroy, S.L., Tamayo, P., Gaasenbeek, M., ... Lander, E.S., Golub, T.R.	Nature, 415(6870), 436–442. https://doi.org/10.1038/415436a	2002	2 051
A continuous performance test of brain damage	Rosvold, H.E., Mirsky, A.F., Sarason, I., Bransome Jr., E.D., Beck, L.H.	Journal of Consulting Psychology, 20(5), 343–350. https://doi.org/10.1037/h0043220	1956	1 770
Recommended diagnostic criteria for paraneoplastic neurological syndromes	Graus, F., Delattre, J.Y., Antoine, J.C., ... Vincent, A., Voltz, R.	Journal of Neurology, Neurosurgery and Psychiatry, 75(8), 1135–1140. https://doi.org/10.1136/jnnp.2003.034447	2004	1 383
The relation of the Trail Making Test to organic brain damage	Reitan, R.M.	Journal of Consulting Psychology, 19(5), 393–394. https://doi.org/10.1037/h0044509	1955	1 380
Deep convolutional neural network for the automated detection and diagnosis of seizure using EEG signals	Acharya, U.R., Oh, S.L., Hagiwara, Y., Tan, J.H., Adeli, H.	Computers in Biology and Medicine, 100, 270–278. https://doi.org/10.1016/j.combiomed.2017.09.017	2018	1 242
Early, accurate diagnosis and early intervention in cerebral palsy: Advances in diagnosis and treatment	Novak, I., Morgan, C., Adde, L., ... White, R., Badawi, N.	JAMA Pediatrics, 171(9), 897–907. https://doi.org/10.1001/jamapediatrics.2017.1689	2017	1 072
An essay on the shaking palsy. 1817.	Parkinson, J.	The Journal of neuropsychiatry and clinical neurosciences, 14(2), 223–236. https://doi.org/10.1176/jnp.14.2.223	2002	1 007
A brain-computer interface using electrocorticographic signals in humans	Leuthardt, E.C., Schalk, G., Wolpaw, J.R., Ojemann, J.G., Moran, D.W.	Journal of Neural Engineering, 1(2), 63–71. https://doi.org/10.1088/1741-2560/1/2/001	2004	938
Wernicke's encephalopathy: new clinical settings and recent advances in diagnosis and management	Sechi, G., Serra, A.	Lancet Neurology, 6(5), 442–455. https://doi.org/10.1016/S1474-4422(07)70104-7	2007	913

A second tier of significant research focuses on implementing groundbreaking technologies and innovations into the diagnostic process. Among these, “Deep convolutional neural network for the automated detection and diagnosis of seizure using EEG signals” (Acharya, U.R., Oh, S.L., Hagiwara, Y. et al., 2018) with 1242 citations underlines the strategic importance of machine learning in EEG analysis. Equally notable attention is given to works on the early detection of cerebral palsy (Novak, I., Morgan, C., Adde, L. et al., 2017) and the historical foundations of neurology, such as “An essay on the shaking palsy. 1817.” (Parkinson, J., 2002). The final positions in the top ten are occupied by studies on brain-computer interface technology (Leuthardt, E.C., Schalk, G., Wolpaw, J.R. et al., 2004) and the diagnosis of encephalopathies (Sechi, G., Serra, A., 2007), highlighting the interdisciplinary nature of research and the particular relevance of improving diagnostic methods in neurology.

Thus, the overall analysis shows that interest in the early diagnosis of neurological diseases is increasing both

Discussion

The aim was to conduct a multifaceted analysis of publications focusing on the early diagnosis of neurological diseases and to identify the key trends, active research areas, and the most influential scientific teams and journals. To achieve this goal, a series of tasks was undertaken to gather and systematize data spanning temporal, geographical, and thematic dimensions, along with analyses of journals, organizations, keywords, and the most frequently cited works.

The results indicate a significant increase in publication activity over recent years, pointing to intensifying interest in enhancing methods for early detection of neurological disorders. The most active entities

quantitatively and qualitatively, covering a wide range of scientific fields and organizations worldwide. The revealed trends underscore a high level of international cooperation, the active introduction of cutting-edge technologies such as neuroimaging and AI, and the rising role of multidisciplinary approaches in research strategies. Special attention is paid to integrating biomarkers, neurophysiological methods, and computer algorithms for more accurate and timely detection of pathologies. The structure of publication activity, the geographic distribution of authors and key organizations, as well as an analysis of the most cited works, reveal a growing consensus in the scientific community regarding the importance and promise of improving diagnostic methods. This dynamic opens up extensive opportunities for continued research and the development of innovative methodological solutions that can substantially increase diagnostic efficiency and enhance patient outcomes.

turned out to be research groups in the United States, the United Kingdom, and several European countries, as well as universities and medical centers that adopt a multidisciplinary approach. This trend is driven by both the development of technological solutions, including neuroimaging and digital algorithms, and increased attention to neurodegenerative diseases and the search for effective prevention strategies.

An analysis of the fields to which publications belong shows sustained interest in medicine, engineering, computer science, and neurobiology. Although research in the humanities and socioeconomic areas is present in smaller volumes, it emphasizes the need for a holistic

examination of early diagnosis issues, encompassing not only clinical and technical factors but also social, cultural, and ethical considerations. Moreover, highly cited works often concentrate on the development and implementation of biomarkers, machine learning for processing electrophysiological signals, and the standardization of screening protocols.

A key outcome of the conducted analysis is the realization that despite evident progress in the creation and application of various early diagnostic methods, a number of major obstacles persist regarding their universal adoption. On the one hand, advanced tools, including neuroimaging, computational methods, and AI-based algorithms, indeed demonstrate high efficiency and flexibility in clinical practice, allowing specialists to identify potential neurological disorders more accurately and swiftly. On the other hand, such technologies typically require expensive equipment, qualified personnel, and a well-established infrastructure, limiting their widespread use particularly in regions with limited resources and uneven access to medical care. Meanwhile, growing international collaboration reveals opportunities for sharing best practices and leveling the playing field between medical facilities and research teams across different countries. Joint efforts and the establishment of a unified research platform not only improve diagnostic quality and accelerate the exchange of methodologies but also boost overall scientific potential: attracting specialists from various disciplines and regions of the world fosters diversity of perspectives and stimulates

Conclusion

This study has made it possible to identify a set of key regularities and trends associated with implementing contemporary methods of early diagnosis of neurological diseases. The analysis showed that a combination of technological solutions from neuroimaging and genetic sequencing to machine learning algorithms constitutes a robust foundation for more accurate and timely identification of pathologies. Consideration of publication activity, the geographical distribution of research, and the most frequently cited works has made it possible to outline the most promising directions and emphasize the role of a multidisciplinary approach in shaping a suite of diagnostic tools.

The findings confirm a growing interest in integrating innovative technologies into routine clinical practice. A notable achievement is the formation of an international collaborative network where scientific teams from different countries and disciplines contribute to developing and testing new methodologies.

This provides access to a wide range of resources and expertise, facilitating rapid adaptation and improvement of existing diagnostic protocols. At the same time, significant challenges remain regarding the standardization of clinical guidelines, expansion of infrastructure, and training specialists who can effectively apply new tools.

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new ideas to enhance diagnostic algorithms, standards, and protocols.

Moving forward, special attention should be paid to the synthesis of comprehensive interdisciplinary approaches, in which the integration of advanced technologies (neuroimaging, machine learning, biomarker analysis) and clinical protocols adapted to regional and economic realities plays a central role. Plans call for creating data-sharing platforms capable of unifying the results of diverse research efforts, thereby helping to standardize diagnostic criteria and increase predictive accuracy. In education and workforce training, it is essential to develop programs aimed at building competencies in computational, biomedical, and clinical disciplines, as well as proficiency in using contemporary data analysis tools.

Further, collaboration between universities, medical organizations, and industry sectors should be strengthened to speed the implementation of innovative technologies in practice and optimize costs. Expanding the availability of diagnostic technologies via telemedicine and mobile solutions, as well as creating cloud services for large-scale data analysis, has the potential to substantially reduce disparities in healthcare delivery. Such a comprehensive approach helps form a global scientific and practical network capable of providing more rapid and accurate detection of neurological diseases, thereby improving prognosis and quality of life for patients worldwide.

Ultimately, the analysis supports the argument that a holistic solution comprising technological innovations, well-structured research programs, expanded educational initiatives, and the creation of a unified information framework is needed. Overcoming barriers related to funding, accessibility, and standardization appears feasible through the expansion of international consortia, open databases, and the active deployment of telemedicine services.

This strategy not only advances the quality of early neurological disease detection but also promises to improve overall healthcare levels, thus presenting opportunities for further progress in understanding brain processes and refining therapeutic strategies.

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Author contribution. All stages of the study, including conceptualization, conducting the research, methodology development, data collection, original draft preparation, visualization, project administration, editing, and final supervision, were carried out by a single author – N.K.

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Неврологиялық ауруларды ерте диагностикалаудың заманауи әдістері: Халықаралық зерттеу тәжірибесі

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Түйіндеме

Ғылыми зерттеулердің едәуір өсуі нейромагинг, жасанды интеллект, биомаркерлерді зерттеу саласындағы жетістіктер ықпал еткен неврологиялық ауруларды ерте анықтауға қызығушылықтың артқанын көрсетеді.

Шолудың мақсаты диагноз қоюдың дәлдігі мен уақтылылығын арттыратын негізгі үрдістер мен инновациялық тәсілдерді анықтау, сондай-ақ неврологиялық бұзылулардың бастапқы сатысындағы пациенттер үшін болжамды жақсарту болып табылады.

Әдістері. Зерттеу бағытындағы мақалалар «Диагностика» және «Неврология» түйін сөздері бойынша таңдап алынып, нәтижесінде іріктелген 6132 ғылыми басылым SPSS бағдарламасын пайдалану арқылы статистикалық талдаудан өтті. Жылдар бойынша жарияланымдардың динамикасын зерттеу үшін жетекші елдер, жетекші ұйымдар мен негізгі ғылыми бағыттар бойынша сипаттау статистикасының әдісі қолданылды.

Нәтижелері. Талдау нәтижелері соңғы он жылдықта, әсіресе медицинада, машина жасауда, информатика саласында зерттеу еңбектері санының айтарлықтай өскенін анықтады. АҚШ бұл бағыттағы басылымдар саны бойынша жетекші орындарды иеленеді, одан кейін Ұлыбритания мен Германия. Көп салалы зерттеулер қазіргі заманғы нейромагинг тәсілдерінен бастап, клиникаға дейінгі кезеңде нейродегенеративті және танымдық бұзылуларды анықтау үшін қолданылатын жасанды интеллект алгоритмдеріне дейінгі инновациялық технологиялардың пайда болуына ықпал етті.

Қорытынды. Ғылыми зерттеулер белсенділігіне жүйелі шолу неврологиялық ауруларды ерте диагностикалауға жаһандық қызығушылықтың артып келе жатқанын растайды. Технологиялардың жоғары құны және қолжетімділігі сияқты кедергілерге қарамастан, нейромагинг, жасанды интеллект жүйелері мен биомаркерлердің интеграциясы диагностиканың дәлдігін арттыруға, халықаралық ынтымақтастықты дамытуға және неврология саласындағы ғылыми мүмкіндіктерді кеңейтуге зор әлеуетке ие.

Түйін сөздер: неврология, ерте диагностика, нейромагинг, биомаркерлер, Scopus, статистикалық талдау.

Современные методы ранней диагностики неврологических заболеваний: Международный опыт исследований

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Резюме

Значительный рост научных работ свидетельствует об усилении интереса к раннему выявлению неврологических заболеваний, чему способствуют прогресс в нейровизуализации, искусственном интеллекте и исследованиях биомаркеров.

Цель обзора – выявить основные тенденции и инновационные подходы, повышающие точность и своевременность диагностики, а также улучшающие прогноз для пациентов на ранних стадиях неврологических нарушений.

Методы. Исследовательские статьи были отобраны по ключевым словам «Диагностика» и «Неврология», в результате чего отобранные 6132 научные публикации прошли статистический анализ с использованием программы SPSS. Для изучения динамики публикаций по годам применялся метод описательной статистики с учетом ведущих стран, ведущих организаций и основных научных направлений.

Результаты. Анализ показал существенный рост числа работ за последнее десятилетие, особенно в медицине, инженерии и компьютерных науках. Лидирующие позиции по количеству научных публикаций занимают США, за которыми следуют Великобритания и Германия. Мультидисциплинарные исследования способствовали появлению инновационных технологий от современных методов нейровизуализации до алгоритмов искусственного интеллекта, применяемых для обнаружения нейродегенеративных и когнитивных расстройств на доклинических стадиях.

Выводы. Системный обзор научной активности подтверждает рост мирового интереса к ранней диагностике неврологических заболеваний. Несмотря на существующие барьеры в виде высокой стоимости и доступности технологий, интеграция нейровизуализации, систем искусственного интеллекта и биомаркеров обладает большим потенциалом для повышения точности диагностики, развития международного сотрудничества и расширения научных горизонтов в неврологии.

Ключевые слова: неврология, ранняя диагностика, нейровизуализация, биомаркеры, Scopus, статистический анализ.

Application of Artificial Intelligence in National Mandatory Health Insurance Systems: Review of Opportunities and Payment Practices

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Abstract

Issues of reimbursement for medical care are gaining increasing importance due to the expansion of national guarantee programs, an aging population, and the prolonged treatment of costly diseases. This document systematizes international experiences of incorporating artificial intelligence technologies into health insurance systems and proposes best practices.

The aim: The integration of artificial intelligence (AI) in healthcare systems has catalyzed the evolution of various payment models for AI-driven medical services. This article aims to present a comprehensive review of the diverse payment models implemented across different countries, with a focus on promoting technological advancement, maintaining healthcare system standards, and ensuring guaranteed clinical outcomes.

Methods: This study employs a systematic review methodology, analyzing existing literature on AI-driven healthcare service payment models. The analysis includes categorization of these models into three main types with potential hybrid variations. Sources were selected based on relevance, peer-review status, and contribution to the understanding of AI reimbursement in healthcare. Data was extracted and synthesized to identify patterns and gaps in current payment practices.

Results: The review identifies three primary categories of AI-enabled healthcare service payment models: fee-for-service, bundled payments, and value-based payments. Hybrid models combining elements of these categories are also discussed. Key findings highlight the strengths and limitations of each model in terms of promoting innovation and achieving clinical outcomes. Despite the rapid advancements in AI technologies, the study reveals a scarcity of systematic research comparing the effectiveness of different reimbursement schemes.

Conclusion: This article underscores the critical need for further studies to navigate the evolving technological landscape and international regulatory frameworks. Significant directions in the development of reimbursement models for AI in healthcare are explored, including the adaptation of Software as a Service (SaaS) payment models, the implementation of anticipatory funding mechanisms, and the differentiation between AI registration and its inclusion in insurance reimbursement programs as a distinct service. These insights are essential for policymakers, healthcare providers, and technology developers to optimize payment strategies and enhance the integration of AI in healthcare.

Keywords: artificial intelligence, healthcare, payment models, reimbursement, technology, clinical outcomes, regulatory activities.

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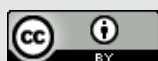
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Introduction

(i) Issues related to reimbursement for healthcare services occupy a central place in current healthcare discussions. The rapid expansion of national healthcare guarantee programs, an aging population, and an increasing number of patients requiring long-term and costly treatments are putting substantial pressure on the financial sustainability of healthcare systems [1-3].

(ii) In this context, it is important to explore the potential of artificial intelligence (AI), including computer vision technologies, as tools for reducing healthcare costs and optimizing the financial burdens of illness. There is a

Materials and Methods

A narrative analysis of medical literature in peer-reviewed journals was conducted, focusing on issues related to the organization of insurance reimbursement for services provided with the help of artificial intelligence in national healthcare systems. Due to the lack of systematized data on the application of insurance programs involving AI, the high

Results. Geography of AI Application in National Healthcare Systems

Currently, AI is included in reimbursement programs involved in Russia, Germany, France, the United Kingdom, the Netherlands, Belgium, Spain, Greece, the United States, Canada, Japan, [5-7]. Despite the active promotion of the AI agenda, the registration of hundreds of medical products using it, and the presence of special mechanisms for pre-registration reimbursement of breakthrough technologies, only a small portion of AI solutions receive insurance reimbursement [5].

United States of America

In the USA, there are stable mechanisms for reimbursing of AI in inpatient and outpatient care settings. They are regulated by provisions developed by the Centers for Medicare and Medicaid Services (CMS) as part of a comprehensive strategy aimed at encouraging the use of innovative technologies by healthcare organizations that do not fit into more conservative "permanent" tariff systems [6]. These provisions are of a short-term nature (up to 4 years) and allow motivating healthcare organizations to implement such systems, evaluate their clinical and population effectiveness, determine the costs associated with their widespread implementation, regulate pricing for AI services, and attract competitors of the first registered company to enter the market.

In the inpatient segment, such functionality is implemented through the New Technology Add-on Payment (NTAP) system. New payment systems are also being developed, such as Medical Coverage of Innovative Technology (MCIT), which, among other things, allow for the earlier introduction of "breakthrough" treatment methods into clinical practice [8].

In the USA, medical services are grouped into diagnosis-related groups (DRGs) based on the conditions of care and diagnosis. DRG represents a list of allowable procedures and their maximum price within a specific clinical situation. NTAP allows for the inclusion of an additional parameter (e.g., AI application) in certain DRGs, with the possibility of increasing the maximum cost of the tariff itself [9].

As of 2023, the total number of registered medical products for which reimbursement is provided as a separate line within insurance mechanisms was only 2 out of more than 200 approved for use [5].

need to systematize international experience and develop recommendations for best practices in this area.

(iii) The aim of this study is to analyze and systematize the potential of artificial intelligence, including computer vision technologies, to reduce healthcare costs and enhance the financial sustainability of healthcare systems through insights from international experiences and recommendations for best practices.

pace of AI integration into clinical practice, and the absence of specific questions that would allow for structured scientific information, a narrative research design was chosen. This approach made it possible to synthesize a significant and diverse body of material regarding the funding methods for AI technologies in national insurance systems worldwide.

Russian Federation

In the Russian Federation, three payment circuits for medical care using artificial intelligence (AI) technologies have been formed. The first and earliest circuit is represented by an experiment conducted under the auspices of the Scientific and Practical Clinical Center of the Moscow Department of Information Technology and is aimed at stimulating the mass use of AI through free connections for medical organizations to an online library of services, the payment for which in the "fee-for-service" format is made by the Department of Information Technology [10].

The second payment circuit was formed by a Decree, making it mandatory for all subjects of the Russian Federation in 2023 to apply at least three AI technologies in the healthcare system; funds for their purchase are sought by the regions independently. Finally, since 2023, the first services for radiological AI have appeared, directly included in the compulsory medical insurance (CMI) as an independent payment unit.

In the CMI system of the Russian Federation, there are two payment principles - for medical service and for attachment in outpatient organizations. The first type includes both individual types of visits, examinations, and procedures (for example, an oncologist's examination or CT of the chest), and services requiring hospitalization in day or round-the-clock hospitals. The per capita part of the CMI tariff currently does not mention the use of artificial intelligence.

In hospitals, medical services are paid in the form of clinical-statistical groups (hereinafter referred to as CSGs). The formation of CSGs is based on medical services included in a single federal nomenclature. All medical services that can be provided under the CMI system are listed in a single list. Groups of medical services with similarity in clinical tasks, conditions of provision, and approximate costs are assigned a unifying code of a clinical-statistical group.

Clinical-statistical groups are standardized groups for assessing the costliness of treatment. In addition to the code of the medical service, they may include other parameters, some of which are mandatory, and some may be used as additional modifiers affecting the final tariff. Such modifiers include, for example, the ICD disease code (which, in some cases, affects the possibility of setting the tariff, and

in some cases, determines its cost), the number of bed-days, or the application of specific technologies, including AI.

The structure of CSGs is determined by the Methodological Recommendations on Methods of Payment for Medical Care from the CMI Funds, developed by the Federal State Budgetary Institution "Center for Expertise and Quality Control of Medical Care" of the Ministry of Health of Russia and approved by the Ministry of Health of the Russian Federation and the Federal Compulsory Medical Insurance Fund on an annual basis depending on the annual content of the State Guarantees Program.

The addition of a new functional feature to the tariff can be carried out at the level of any region or the Russian Federation as a whole. For this purpose, there is a number of mechanisms, including but not limited to:

- creation of a new CSG code;
- reorganization of the clinical-statistical group (formation of a specific subgroup with special financial and organizational properties within the higher technology - for example, allocation from the CSG for drug therapy in oncology of separate groups for more expensive or cheaper drugs);

- addition of enhancing coefficients of the clinical-statistical group depending on the application of a specific technology (for example, the use of certain types of robotic therapy in rehabilitation);

- formation of the institution's level coefficient in relation to institutions with a specific type of technology [11].

So-called "simple services" (procedures, interventions, and outpatient visits, paid for each service separately) are not federally standardized and are established by each region independently depending on its financial provision and organizational needs. The first AI circuit in the CMI is currently launched in Moscow, where since 2023, the outpatient service of mammography is evaluated using AI. This service is invoiced similarly to any other service, and the basis for its provision is the presence of a medical organization's connection to the corresponding software [12].

A summary of the existing insurance regimes in the United States and Russia is presented in Table 1.

Table 1 - Comparison of Characteristics

	USA	Russia
Structural payment element in inpatient care	Diagnosis-related group	Clinical-statistical group
Expenses within the structural element	Decomposed each time and submitted separately for each treatment case	Averaged, calculated only when forming a new tariff
Authorities responsible for forming the structure of expenses in inpatient care	Centers of Medical Services for Medicare and Medicaid	Center for Medical Care Expertise and Quality Control, Federal Fund of Compulsory Medical Insurance, Ministry of Health of the Russian Federation
Authorities entitled to adjust coefficients at the regional level	Centers of Medical Services for Medicare and Medicaid	Territorial Fund of Compulsory Medical Insurance (TF-CMI), executive bodies of the subjects of the Federation
Implemented technological solutions at the inpatient level in the Compulsory Medical Insurance (CMI)	VIZ.AI, Rapid ASPECTS	Medical systems "Cels", "Third Opinion" (CT of the chest and upper abdomen)
Implemented technological solutions at the outpatient clinic level in the Compulsory Medical Insurance (CMI)	IDx-DR, Optellum Lung Cancer Prediction (LCP), HeartFlow	Description and interpretation of mammographic study data using artificial intelligence
Implemented technological solutions at any level with non-insurance providers	Individual solutions at the level of research-oriented hospitals	The Research and Development Center Program (with over 50 providers and over 100 solutions for CT of the chest and upper abdomen, MRI of the pelvis and kidneys, CT of the lower abdomen and pelvis, MRI of the brain and other modalities)

France

In France, the evaluation of market entry strategies and cost compensation for AI-supported medical devices is carried out by the National Health Directorate. Pricing for such devices is negotiated with the Ministry of Health, and the amount of compensation depends on the classification system, which establishes the level of device cost reimbursement. In 2023, a new reimbursement mechanism for AI-managed medical devices was introduced [13]. Additionally, there are special regulatory mechanisms that expedite the reimbursement process for such devices:

1. The Innovation Package, which provides preliminary funding for clinical trials of medical products, existing in various forms.
2. Pre-insurance, allowing the use of the product for a year before applying for its inclusion in the national insurance system.
3. Early support program, providing early

reimbursement of expenses before official approval based on proven clinical effectiveness and safety [14].

Once the price of a digital medical solution is determined, it is added to the list of reimbursable products, and the National Health Union sets the reimbursement rate for the next five years. The amount of reimbursement is directly related to the assessment of the clinical effectiveness of the digital solution, which is carried out jointly with the supplier [15, 16].

In 2023, the French Ministry of Health and Prevention introduced an innovative mechanism for early access to cost reimbursement for advanced digital medical devices, including mobile health applications, through the PECANd program. This initiative provides temporary, one-year special financial coverage within the French national healthcare system. The funding methodology allows manufacturers to receive reimbursement while they complete the process of confirming the clinical or organizational effectiveness of their developments [17].

United Kingdom

In the United Kingdom, reimbursement of costs for medical devices based on artificial intelligence is carried out by the National Health Service (NHS) after approval by the National Institute for Health and Care Excellence [18]. Products meeting the criteria for digital technology assessment can be included in the NHS catalog, but this does not necessarily mean automatic reimbursement of their costs. The government allocates funds to support the National Institute for Health Research and the NHS Innovation Accelerator. Access to innovative medical technologies, including AI-based technologies, is provided through a specialized route. Funding for the implementation of such devices is provided through the Innovation and Technology Financing Program and the Technology Mandate [19].

The main object of payment in the United Kingdom is the financing of individual medical services using AI (Software as a Service, SaaS model) [20].

Japan

While Japan remains the second-largest market for medical devices in the world after the United States, the process of regulatory adaptation of any products, including AI, to the peculiarities of the healthcare system, is lengthy and complex [14]. One possible reason is the highly cautious and thorough analysis of the capabilities and risks of AI by the professional community in Japan [21].

By 2020, Japan had already registered 11 products that utilize artificial intelligence in their operations. While 6 of them were understandably related to radiology, 5 were intended for patients with gastrointestinal profiles [22].

Germany

According to the provisions of mandatory health insurance, digital health applications may be reimbursed

Discussion

Globally, several non-exclusive models and vectors of payment for healthcare services involving artificial intelligence (AI) have emerged. These payment models can be divided into two primary categories based on their purpose:

- Payment aimed at ensuring technological advancement and maintaining the technological level of the healthcare system.

- Payment intended to guarantee clinical outcomes.

In some countries, such as the United Kingdom and France, the distinction between these two purposes is blurred, with many models encompassing elements of both.

Regarding the scope of payment (or insurance reimbursement) for AI-assisted services, three main classes can be identified, with intermediate, mixed options possible:

Payment for a distinct AI service, which exists in several forms:

Conclusions

Currently, the insurance medical systems of the world's most developed economies are implementing, in one form or another, payments for healthcare technologies associated with artificial intelligence (AI). The methodological diversity of healthcare systems, along with the relatively recent introduction of these technologies, does not yet allow for the identification of the most effective payment methods or the overall assessment of the appropriateness of such payments. The most significant and

if they have been approved by the Federal Institute for Drugs and Medical Devices and have been registered in the national digital health registry [23]. The cost calculation for such applications is based on a pay-per-service model [24].

For the first 12 months of an application being placed in the digital medical applications registry, the manufacturer is granted the right to independently set the selling price and choose the pricing model. After this period, the price is determined through negotiations between the manufacturer and the National Association of Health Insurance Funds [23].

Before initiating price discussions, the manufacturer of a medical device sends the following information to the regulator:

1. Confirmation of compliance with general requirements and evidence of positive health impact.
2. Results of studies conducted during the potential trial phase.
3. Information on costs for self-paying individuals.
4. Pricing information from other European countries.
5. A full report from the Federal Institute for Drugs and Medical Devices on the inclusion of the application in the national registry.
6. The number of activation codes or prescriptions used for the application since its registration in the registry up to five days before submitting the application.

Developers of digital health applications may qualify for financial support from Germany's Innovation Fund, funded by the German statutory health insurance company (Gesetzliche Krankenversicherung).

- Payment for the use of AI as an integral or optional component of a comprehensive healthcare service.

- Payment based on the integration of AI within a healthcare organization's system for specific service types.

Currently, however, there is a lack of comparative studies in the literature assessing the effectiveness of different reimbursement models. Existing publications fall short of systematically capturing both the technological boom driven by machine learning in healthcare and the accompanying global regulatory activities. The most comprehensive systematic review on AI reimbursement, published in April 2024, identified only 40 publications on this topic within the European Union — regions traditionally noted for their academic focus on financial policy in healthcare [25].

well-developed vectors for the advancement of insurance reimbursement for AI in healthcare are:

- Adaptation of the Software as a Service (SaaS) payment model for medical solutions that incorporate artificial intelligence.

- Implementation of "advanced financing" technologies, including various experimental-legal regimes, where certain financial support for AI initiatives is provided even before their registration as medical devices.

• Delineation of the concepts of registration of medical devices utilizing artificial intelligence with the inclusion of artificial intelligence in insurance reimbursement programs as a separate service.

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Міндетті әлеуметтік медициналық сақтандыру жүйелерінде жасанды интеллект қолдану: Мүмкіндіктерді шолу және төлем тәжірибелері

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Түйіндеме

Медициналық көмекті өтеу мәселелері ұлттық кепілдік бағдарламаларының кеңеюіне, тұрғындардың қартаюуына және шығынды ауруларды ұзақ уақыт емдеуге байланысты маңызды бола түсуде. Бұл мақалада жасанды интеллект (ЖИ) технологияларын денсаулық сақтау жүйелеріне енгізу жөніндегі халықаралық тәжірибе жүйелендіріліп, ең үздік тәжірибелер ұсынылған.

Зерттеудің мақсаты: ЖИ-тің денсаулық сақтау жүйелеріне интеграциясы ЖИ негізіндегі медициналық қызметтерге арналған әртүрлі төлем модельдерінің дамуына ықпал етті. Яғни, мақаланың мақсаты - әртүрлі елдерде жүзеге асырылған төлем модельдерінің жан-жақты шолуын ұсыну, технологиялық прогресті ілгерілетуге, денсаулық сақтау жүйесінің стандарттарын сақтауға және кепілдендірілген клиникалық нәтижелерге қол жеткізуге назар аудару.

Әдістері. Бұл зерттеу жүйелі шолу әдістемесін қолданады, ЖИ негізіндегі медициналық қызметтерге арналған төлем модельдері бойынша қолданыстағы әдебиеттерді талдайды. Талдау осы модельдерді негізгі 3 түрге және мүмкін болатын аралас вариацияларға жіктеуді қамтиды. Деректер таңдалған дереккөздердің релеванттығына, рецензиялау мәртебесіне және денсаулық сақтау саласындағы ЖИ үшін өтемақы алуды түсінуге қосқан үлесіне негізделген. Деректер алынып, төлемнің қазіргі тәжірибелеріндегі үлгілер мен олқылықтарды анықтау үшін синтезделді.

Нәтижелері. Шолу ЖИ мүмкіндіктері бар медициналық қызметтердің төлем модельдерінің 3 негізгі санатын анықтайды: қызмет көрсету үшін төлем, топтамалық төлемдер және құндылыққа негізделген төлемдер. Осы санаттардың элементтерін біріктіретін аралас модельдер де талқыланады. Негізгі қорытындылар әрбір модельдің инновацияларды дамытудағы және клиникалық нәтижелерге қол жеткізудегі күшті және әлсіз жақтарын көрсетеді. ЖИ технологияларының тез дамуына қарамастан, зерттеу әртүрлі өтемақы схемаларының тиімділігін салыстыратын жүйелі зерттеулердің жеткіліксіздігін көрсетеді.

Қорытынды. Бұл шолу дамып келе жатқан технологиялық ландшафт пен халықаралық нормативтік базаларда бағдарлау үшін қосымша зерттеулердің қажеттілігін көрсетеді. Денсаулық сақтаудағы ЖИ үшін өтемақы алу үлгілерін әзірлеудегі маңызды бағыттар, соның ішінде қызмет ретінде бағдарламалық қамтамасыз ету (SaaS) төлем модельдерін бейімдеу, қаржыландыру механизмдерін алдын ала жүзеге асыру және ЖИ тіркеуі мен оны жеке қызмет ретінде сақтандыру өтемақы бағдарламаларына

енгізу арасындағы айырмашылық зерттеледі. Бұл түсініктер саясаткерлер, денсаулық сақтау қызметтерін жеткізушілер және технология әзірлеушілер үшін төлем стратегияларын оңтайландыру және денсаулық сақтауда ЖИ интеграциясын жақсарту үшін маңызды.

Түйін сөздер: жасанды интеллект, денсаулық сақтау, төлем модельдері, өтемақы, технологиялар, клиникалық нәтижелер, нормативтік қызмет.

Применение искусственного интеллекта в национальных системах обязательного медицинского страхования: Обзор возможностей и практик оплаты

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Резюме

Вопросы организации возмещения за оказанную медицинскую помощь приобретают все большее значение из-за роста программ национальных гарантий, старения населения и длительного лечения дорогостоящих заболеваний. В данном исследовании систематизирован международный опыт включения технологий искусственного интеллекта (ИИ) в системы медицинского страхования и предложены наилучшие практики.

Цель исследования: Интеграция ИИ в системы здравоохранения привела к эволюции различных моделей оплаты за медицинские услуги на основе ИИ. Цель данной статьи - представить всесторонний обзор разнообразных моделей оплаты, реализованных в разных странах, с акцентом на продвижение технологического прогресса, поддержание стандартов системы здравоохранения и обеспечение гарантированных клинических результатов.

Методы. Исследование использует метод систематического обзора, анализируя существующую литературу по моделям оплаты медицинских услуг на основе ИИ. Анализ включает классификацию этих моделей на 3 основных типа с возможными гибридными вариациями. Источники отбирались на основе релевантности, статуса рецензирования и вклада в понимание возмещения за ИИ в здравоохранении. Данные извлекались и синтезировались для выявления закономерностей и пробелов в текущих практиках оплаты.

Результаты. Обзор выявляет три основные категории моделей оплаты за медицинские услуги на основе ИИ: оплата за услугу, пакетные платежи и оплата на основе ценности. Также обсуждаются гибридные модели, сочетающие элементы этих категорий. Ключевые результаты подчеркивают сильные и слабые стороны каждой модели в плане продвижения инноваций и достижения клинических результатов. Несмотря на быстрый прогресс в технологиях ИИ, исследование выявляет нехватку систематических исследований, сравнивающих эффективность различных схем возмещения.

Выводы. Обзор подчеркивает необходимость дальнейших исследований для навигации в развивающемся технологическом ландшафте и международных нормативных рамках. Исследуются значительные направления в разработке моделей возмещения за ИИ в здравоохранении, включая адаптацию моделей оплаты за программное обеспечение как услугу (SaaS), внедрение механизмов предвосхищения финансирования и различие между регистрацией ИИ и его включением в программы страхового возмещения как отдельной услуги. Эти выводы важны для политиков, поставщиков медицинских услуг и разработчиков технологий для оптимизации стратегий оплаты и улучшения интеграции ИИ в здравоохранении.

Ключевые слова: искусственный интеллект, здравоохранение, модели оплаты, возмещение, технологии, клинические результаты, нормативная деятельность.

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Оригинальная статья

Рост *Escherichia coli* при диарее у детей во время прорезывания зубов

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Резюме

В период прорезывания зубов у детей могут наблюдаться такие симптомы, как диарея, различные кожные высыпания, снижение или потеря аппетита, слюнотечение, нарушение сна, раздражительность. Это может затруднять дифференциальную диагностику и приводить к неправильному лечению детей в инфекционных стационарах с диагнозом «Эшерихиоз».

Цель исследования: определить количественный и качественный состав *Escherichia coli* у детей раннего возраста с диареей в период прорезывания зубов.

Методы. С 2021 по 2024 год проведено бактериологическое исследование эшерихий, выделенных из фекалий у детей в возрасте от 6 до 30 месяцев.

Результаты. При изучении количества *Escherichia coli*, выделенных из кала детей, у которых в период до прорезывания зубов наблюдались признаки диареи, установлено, что у 6 детей их количество варьировало от 10^7 до 10^8 , у 5 детей - от $1,1 \times 10^8$ до $3,0 \times 10^8$, у 7 детей - от $3,1 \times 10^8$, у 4 детей - от $5,1 \times 10^8$ до 10^9 , у 5 детей - от $1,5 \times 10^9$ до $2,0 \times 10^9$. Гемолитические *E. coli* были выделены в указанных количествах. У 9 детей негемолитические *Escherichia coli* также были выделены в количестве от 10^7 до 10^8 , у 6 детей - от $1,1 \times 10^8$ до $2,0 \times 10^8$, а у 4 детей - от $2,1 \times 10^8$ до $4,0 \times 10^8$.

У детей с явными симптомами диареи среднее количество выделенных гемолитических *Escherichia coli* составило $5,6 \times 10^8$ КОЕ/г, что составило 67,8% от всех исследованных колоний, тогда как количество негемолитических *Escherichia coli* составило $2,6 \times 10^7$ КОЕ/г, что составило 32,2% от всех исследованных колоний. У 33,4% детей гемолитические *Escherichia coli* не были выделены. У 66,6% пациентов среднее количество выделенных гемолитических *Escherichia coli* составило $8,2 \times 10^6$ КОЕ/г на 1 г фекалий, что составило $29,0 \pm 0,04\%$ от всех исследованных колоний.

Выводы. У детей, имевших признаки диареи в период прорезывания зубов, количество *Escherichia coli*, особенно гемолитических *Escherichia coli*, значительно увеличивалось, в некоторых случаях до двух раз по сравнению с детьми, у которых уже прорезались зубы (в основном за счет гемолитических вариантов).

Ключевые слова: прорезывание зубов, диарея, *Escherichia coli*, эшерихиоз.

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Введение

Прорезывание зубов – это естественный физиологический процесс, который проходит каждый ребенок. Обычно он длится около двух лет и начинается в возрасте от 6 до 30 месяцев. Однако, тот факт, что различные заболевания могут сопровождаться схожими симптомами, часто вызывает беспокойство у родителей и медицинских работников.

Часто прорезывание зубов сопровождается такими симптомами, как: повышенная температура, диарея, различные кожные высыпания, снижение или потеря аппетита, обильное слюноотечение, нарушения сна и раздражительность [1,2].

Исторически сложилось мнение, что дети, легко перенесшие период прорезывания зубов, обладали более крепким здоровьем. В прошлые века детская смертность была очень высока, особенно в возрасте от 6 месяцев до 4 лет, что совпадало с периодом прорезывания первых зубов [3-5]. Поэтому неудивительно, что прорезывание зубов часто связывали с различными заболеваниями, в том числе и со смертельными исходами [6-9].

Несмотря на распространенное мнение, научные данные о связи между прорезыванием зубов и серьезными системными изменениями в организме ребенка ограничены. Приписывать все недомогания ребенка исключительно этому процессу не всегда корректно. Стремясь успокоить обеспокоенных родителей, медицинские специалисты порой назначают препараты, эффективность которых при прорезывании зубов не доказана [6,7].

Материалы и методы

Исследование проводилось в период с марта 2021 года по сентябрь 2024 года. В исследование были включены 79 пар «Мать-ребенок» в возрасте от 20 до 40 лет и от 0 до 30 месяцев соответственно. Критериями включения служили: наличие у ребенка прорезывающихся или прорезавшихся зубов, отсутствие истории соматических и хронических заболеваний.

Материалом исследования служил бактериологический анализ кала. У детей с диареей на фоне прорезывания зубов отбирали по 1 грамму кала для посева на среду Эндо. Образцы подвергали десятикратному последовательному разведению от 10^{-2} до 10^{-12} . Подсчет колоний проводили стандартным методом.

Результаты

Результаты исследования количества кишечной палочки, выделенной из фекалий детей с диареей, представлены в таблице 1. Было выявлено, что у 6 детей количество гемолитических *Escherichia coli* составляло от 10^7 до 10^8 КОЕ/г, у 5 детей – от $1,1 \times 10^8$ до $3,0 \times 10^8$ КОЕ/г, у 7 детей – $3,1 \times 10^8$ КОЕ/г, у 4 детей – от

Например, широко применяемые гели для прорезывания зубов, содержащие бензокаин, могут вызывать серьезные побочные эффекты у детей младше двух лет, вплоть до метгемоглобинемии. Кроме того, они способны нарушать важные рефлекс, такие как глотание и рвота, что создает риск асфиксии [10-12].

Часто у детей раннего возраста на фоне прорезывания зубов наблюдаются тяжелые проявления, такие как диарея, высокая температура и обезвоживание, что требует госпитализации.

Прорезывание зубов может оказывать влияние на различные системы организма, в том числе на желудочно-кишечный тракт. В этот период повышается вероятность развития колиэнтеритов, вызванных условно-патогенными микроорганизмами, такими как *Escherichia coli*.

Исследования показали, что стресс, сопровождающий прорезывание зубов, стимулирует выработку норадреналина – нейромедиатора, способного изменять состав кишечной микробиоты. *In vitro* эксперименты продемонстрировали, что норадреналин стимулирует рост как патогенных, так и непатогенных штаммов кишечной палочки [9].

Цель исследования: определить количественный и качественный состав кишечной палочки у детей раннего возраста с диареей в период прорезывания зубов.

Для сбора анамнестических данных была разработана анкета, включающая вопросы о возрасте ребенка и порядке рождения, возрасте матери, образовании, профессии, количестве детей в семье, симптомах, сопровождающих прорезывание зубов. От каждой матери было получено информированное добровольное согласие на участие в исследовании.

Протокол данного исследования и информированное согласие для участвующих были рассмотрены и одобрены на заседании комиссии по биоэтике Ташкентской медицинской академии в 2024 году, протокол №7.

$5,1 \times 10^8$ до 10^9 КОЕ/г, и у 5 детей – от $1,5 \times 10^9$ до $2,0 \times 10^9$ КОЕ/г. У 9 детей было выделено от 10^7 до 10^8 КОЕ/г, у 6 детей – от $1,1 \times 10^8$ до $2,0 \times 10^8$ КОЕ/г, и у 4 детей – от $2,1 \times 10^8$ до $4,0 \times 10^8$ КОЕ/г негемолитических кишечных палочек.

Таблица 1 - Количество кишечной палочки, выделенной из фекалий детей с диареей

Количество зарегистрированных случаев	гемолитические <i>E. coli</i>		негемолитические <i>E. coli</i>	
	абс (КОЕ/г)	%	абс (КОЕ/г)	%
16-20 случаев	$5,6 \times 10^8$	$67,8 \pm 0,005$	$2,6 \times 10^7$	$32,2 \pm 0,005$
11-15 случаев	$8,2 \times 10^6$	$29,0 \pm 0,04$	$6,7 \times 10^7$	$71,0 \pm 0,04$
6-10 случаев	7×10^4	$1,8 \pm 0,05$	$3,8 \times 10^8$	$98,2 \pm 0,05$
1-5 случаев	-	-	$4,6 \times 10^8$	$100 \pm 0,005$

При проведении исследования у детей с выраженными симптомами диареи было выявлено, что средняя концентрация гемолитических штаммов *Escherichia coli* в кале составила $5,6 \times 10^8$ КОЕ на грамм и составляла 67,8% от общего количества исследованных колоний. Типичные кишечные палочки были обнаружены в меньшем количестве – $2,6 \times 10^7$ КОЕ/г (32,2%). У 33,4% детей гемолитические *Escherichia coli* не были выделены. У остальных пациентов их средняя концентрация достигала $8,2 \times 10^6$ КОЕ/г на 1 г кала и составляла $29,0 \pm 0,04\%$ от общего количества исследованных колоний. При этом количество типичных кишечных палочек увеличивалось до $6,7 \times 10^7$ КОЕ/г на 1 гр кала (71,0%).

При анализе кала у здоровых детей обычно обнаруживается небольшое количество *Escherichia coli*. В норме это составляет до $7,0 \times 10^4$ КОЕ типичных *Escherichia coli* на грамм кала.

У детей нашей группы количество типичной *Escherichia coli* было значительно выше нормы и

достигло $3,8 \times 10^6$ КОЕ/г, что составило 98,2% от всех выявленных бактерий (Таблица 2).

Анализ микрофлоры кишечника показал, что у детей, страдающих диареей на фоне прорезывания зубов, наблюдалось многократное увеличение количества гемолитических штаммов *Escherichia coli* по сравнению с детьми без подобных симптомов. В частности, общее количество *Escherichia coli*, преимущественно патогенных гемолитических вариантов, у детей с диареей было несколько раз выше.

Все опрошенные матери (100%) отметили наличие как минимум одного симптома, связанного с прорезыванием зубов. Наиболее часто респонденты указывали на лихорадку (70%), диарею (68,5%) и нарушения сна (63,5%). Кожная сыпь была отмечена как наименее частый симптом (6%) (Таблица 2).

Таблица 2 - Частота наблюдения матерями симптомов, связанных с прорезыванием зубов

Симптомы	Количество случаев	%
Повышение температуры тела	55	69,6
Понос, жидкий стул	54	68,4
Потеря аппетита	44	55,7
Нарушение сна	50	63,3
Увеличение выделения слюны	41	51,9
Кожная сыпь	5	6,3
Риниты	8	10,1

Обсуждение

Таким образом, наши результаты показали, что при прорезывании первых зубов у детей часто наблюдается повышенное беспокойство, повышение температуры и снижение аппетита (в 55,7-69,6% случаев). Также согласно данным опроса, 68,5% матерей отметили наличие диареи у детей во время прорезывания зубов.

Небольшое повышение температуры тела может сопровождать прорезывание зубов, однако высокая температура, как правило, свидетельствует о наличии инфекции [14,15].

Прорезывание молочных зубов связано с местными и системными проявлениями. По результатам двух мета-анализов [15,16], где были проанализированы результаты опроса родителей о симптомах, которые встречаются у детей в возрасте

от 0 до 36 месяцев были желание кусать, оральная регидратация, повышение температуры тела. Диарея встречалась реже. Понимание распространенности и характеристики проявления необходимо для формулирования стандартных рекомендаций по лечению

Ограничения исследования. Следует учитывать, что ограниченный размер выборки и географический охват исследования могут влиять на обобщаемость полученных результатов. Для повышения надежности данных и разработки более эффективных образовательных программ рекомендуется проведение дополнительных исследований в более крупных населенных пунктах, охватывающих как городские, так и сельские районы с различным социально-экономическим статусом.

Выводы

Исследование показало, что у детей в период прорезывания зубов, сопровождающийся диареей, наблюдается значительное увеличение количества кишечной палочки, особенно гемолитической *Escherichia coli*, в кале (почти вдвое) по сравнению с детьми, у которых этот процесс уже завершен.

Сочетание таких симптомов, как повышенная температура и диарея, на фоне прорезывания зубов может затруднить диагностику других заболеваний. Поэтому важно, чтобы медицинские работники и родители правильно интерпретировали этот физиологический процесс.

Необходимо расширить и упростить

информационную поддержку медицинских работников первичного звена и родителей по вопросам здоровья детей в период прорезывания зубов.

Конфликт интересов. Авторы заявляют об отсутствии конфликта интересов, требующего раскрытия в данной статье.

Финансирование. Данное исследование является инициативной работой авторов и не имеет источников финансирования.

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Тісі шығып жатқан балалардағы диарея кезінде Escherichia coli өсуі

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Түйіндеме

Тіс шығару кезінде балаларда іш өту, әртүрлі тері бөртпелері, тәбетінің төмендеуі немесе болмауы, сілекей ағу, ұйқының бұзылуы, ашушандық сияқты белгілер болуы мүмкін. Бұл дифференциалды диагностиканы қиындатып, жұқпалы аурулар ауруханаларында балаларды «Эшерихиоз» диагнозымен дұрыс емдемеуге әкелуі мүмкін.

Зерттеудің мақсаты: Тіс шығару кезінде іші өткен жас балаларда ішек таяқшасының сандық және сапалық құрамын анықтау.

Әдістері. 2021-2024 жылдар аралығында 6 айдан 30 айға дейінгі балаларда нәжістен бөлінген эшерихия бактериологиялық зерттелді.

Нәтижелері. Тіс шығаруға дейінгі кезеңде диарея белгілері байқалған балалардың нәжісінен бөлінген ішек таяқшаларының санын зерттегенде 6 балада олардың саны 10^7 -ден 10^8 дейін, 5 балада $1,1 \times 10^8$ -тан $3,0 \times 10^8$ дейін өзгеретіні анықталды. 10^8 , 7 балада – $3,1 \times 10^8$, 4 балада – $5,1 \times 10^8$ -ден 10^9 -ге дейін, ал 5 балада – $1,5 \times 10^9$ -ден $2,0 \times 10^9$ -ге дейін. Көрсетілген мөлшерде гемолитикалық ішек таяқшалары бөлініп алынды. Сондай-ақ 9 балада гемолитикалық емес ішек таяқшасы 10^7 -ден 10^8 дейін, 6 балада – $1,1 \times 10^8$ -ден $2,0 \times 10^8$ -ке дейін, 4 балада – $2,1 \times 10^8$ -ден $4,0 \times 10^8$ -ке дейін мөлшерде оқшауланған.

Диареяның айқын белгілері бар балаларда оқшауланған гемолитикалық ішек таяқшаларының орташа саны $5,6 \times 10^8$ КҚБ/г құрады, бұл барлық зерттелген колониялардың 67,8% құрады, ал гемолитикалық емес ішек таяқшасының саны $2,6 \times 10^7$ КҚБ/г, бұл барлық зерттелген колониялардың 32,2% құрады. Балалардың 33,4%-да гемолитикалық ішек таяқшасы оқшауланбаған. Пациенттердің 66,6%-да оқшауланған гемолитикалық *Escherichia coli* орташа саны 1 г нәжіске $8,2 \times 10^6$ КҚБ/г құрады, бұл барлық зерттелген колониялардың $29,0 \pm 0,04\%$ құрады.

Қорытынды. Тіс шығу кезінде диарея белгілері бар балаларда *Escherichia coli*-дің, әсіресе гемолитикалық ішек таяқшаларының саны тістері шығып кеткен балалармен салыстырғанда (негізінен гемолитикалық нұсқаларға байланысты) кейбір жағдайларда екі есеге дейін өсті.

Түйін сөздер: тіс шығу, диарея, *Escherichia coli*, эшерихиоз.

Growth of *Escherichia coli* in diarrhea in children during teething

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Abstract

During teething, children may experience symptoms such as diarrhea, various skin rashes, decreased or loss of appetite, salivation, sleep disturbances, and irritability. This can complicate differential diagnosis and lead to improper treatment of children in infectious disease hospitals under the diagnosis of "Escherichiosis".

Objective: To determine the quantitative and qualitative composition of *Escherichia coli* in young children with diarrhea during teething.

Methods. From 2021 to 2024, *Escherichia coli* isolated from feces in children aged 6 to 30 months were bacteriologically examined.

Results. When studying the number of *Escherichia coli* isolated from the stool of children who showed signs of diarrhea during the period before teething, it was found that in 6 children their number varied from 10^7 to 10^8 , in 5 children - from 1.1×10^8 to 3.0×10^8 , in 7 children - 3.1×10^8 , in 4 children - from 5.1×10^8 to 10^9 , and in 5 children - from 1.5×10^9 to 2.0×10^9 . Hemolytic *Escherichia coli* were isolated in the indicated quantities. In 9 children, non-hemolytic *E. coli* were also isolated in amounts from 10^7 to 10^8 , in 6 children - from 1.1×10^8 to 2.0×10^8 , and in 4 children - from 2.1×10^8 to 4.0×10^8 .

In children with obvious symptoms of diarrhea, the average number of isolated hemolytic *E. coli* was 5.6×10^8 CFU/g, which was 67.8% of all colonies examined, while the number of non-hemolytic *Escherichia coli* was 2.6×10^7 CFU/g, which was 32.2% of all colonies examined. In 33.4% of children, hemolytic *Escherichia coli* were not isolated. In 66.6% of patients, the average number of isolated hemolytic *Escherichia coli* was 8.2×10^6 CFU/g per 1 g of feces, which was $29.0 \pm 0.04\%$ of all studied colonies.

Conclusion. In children who had signs of diarrhea during the teething period, the number of *Escherichia coli*, especially hemolytic *E. coli*, increased significantly, in some cases up to two times compared to children whose teeth had already erupted (mainly due to hemolytic variants).

Keywords: teething, diarrhea, *Escherichia coli*, escherichiosis, childhood diseases.

Analysis of public policy on healthcare-associated infections: A Kazakhstan and United Kingdom

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Abstract

The problem of healthcare-associated infections (HAIs) prevention in Kazakhstan is still not sufficiently understood. There are no opportunities for documenting, analyzing and drawing lessons from the accumulated negative and positive experience, there is no methodology for identifying HAIs and evaluating the effectiveness of infection control measures, there are no unified schemes for collecting reliable information about the real scale of HAIs, lack of a unified national comprehensive strategy or program for the prevention and control of HAIs.

The aim of this study was to analyze the main documents underlying the development of public policy in the field of prevention and control of HAIs in two countries. Kazakhstan and the United Kingdom (UK) were selected as both have healthcare systems informed by the social insurance model, involving government funding of healthcare services, financed by general taxation.

The UK experience analysis highlights several potentially useful lessons for health systems that have not yet reached the Monitoring and Evaluation phase. Among them are the need to treat HAIs as a public health issue, the consistent dissemination of evidence-based guidelines, the incorporation of scientific updates into clinical practice, the development of guidance for various types of healthcare settings, and the monitoring of epidemiologically relevant pathogens. Finally, citizen participation in HAIs policy development is highly desirable.

Key words: public policy, healthcare-associated infections, HAIs, infection control.

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Introduction

Health care-associated infections (HAIs) are widespread worldwide. So according to World Health Organizations (WHO) 8.9 million HAIs occur every year in acute and long-term care facilities, 6 most common HAI = 2X the total burden of disability-adjusted life years of all other 32 communicable diseases combined. Health care-associated infections and antimicrobial resistance - 75% of HAIs [1-2]. HAIs are contaminations individuals get while they are getting medical services for another condition. HAIs can occur in any medical services office, including emergency clinics, mobile careful focuses, end-stage renal sickness offices, and long haul care offices. HAIs are infections that first appear 48 hours or more after hospitalization or within 30 days after having received health care [3-5]. These HAIs incorporate focal line-related circulation system contaminations, catheter-related urinary parcel diseases, and ventilator-related pneumonia. Diseases may likewise happen at medical procedure destinations, known as careful site contaminations. Centers for Disease Control and Prevention (CDC) attempts to screen and forestall these diseases since they are a significant danger to patient wellbeing [6-7].

Unfortunately, the problem of HAIs prevention in Kazakhstan is still not sufficiently understood. There are no opportunities for documenting, analyzing and drawing

Material and methods of research

Research Design

The study utilizes a systematic review approach to analyze the development and implementation of Healthcare-Associated Infection Programs (HAIPs) in Kazakhstan and the United Kingdom (UK). Systematic reviews are a rigorous method used to synthesize and analyze available literature, ensuring comprehensive coverage of existing knowledge while minimizing bias. The review aimed to identify the key phases of HAIP development in both countries, including a historical overview of public policy and regulatory frameworks.

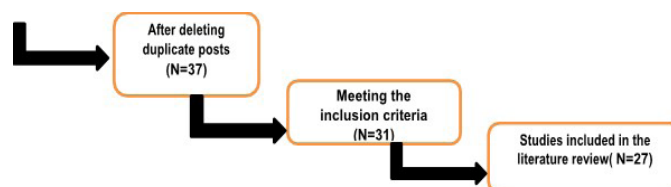


Figure 1 - Strategy search literature

Search Strategy

The search included articles and documents published between 1990 and 2023, in English, Russian, and Kazakh languages. The following key terms were used for the search: "Healthcare-associated infections", "HAI prevention programs", "Infection control policy", "Kazakhstan health system", "UK infection control measures", "Antimicrobial resistance", "HAIP implementation strategies", "National healthcare safety guidelines".

Inclusion Criteria

Articles and reports specifically addressing the development and implementation of HAIP in Kazakhstan and the UK. Documents detailing national policies, infection prevention techniques, and standardization of procedures at healthcare facilities. Studies that describe the effectiveness of HAIP strategies, including monitoring, evaluation, and patient safety outcomes. Historical policy documents that

outline the formation and regulatory evolution of HAIP in both countries.

Exclusion Criteria

Articles focused solely on HAIs in other countries without reference to Kazakhstan or the UK. Studies not addressing national-level HAIP policies or their practical implementation in healthcare systems. Duplicate studies or reports that did not provide original findings or insights.

Data Extraction

Once the literature was reviewed and identified, key data points were extracted, including: The timeline of policy development in Kazakhstan and the UK. The nature of national and local HAIP initiatives, including governmental or regulatory bodies involved. The main infection prevention and control measures adopted at different phases. Evaluation metrics used to measure the success of HAIP strategies (e.g., reduction of HAI incidence, antimicrobial

resistance). Challenges in the adoption and standardization of HAIP in healthcare settings.

Data Analysis

The extracted data was then organized according to four key phases of HAIP development identified through the literature:

Formation: Initial development of infection prevention techniques and practices in healthcare settings.

Standardization: Consolidation of HAIP strategies and establishment of national regulations and guidelines.

Results

United Kingdom

The primary distinction between infection control measures in the UK and those in other countries is that infection control in the United Kingdom is based on the discipline of medical microbiology. Medical microbiologists who have received training in the laboratory identification of infectious agents as well as the diagnosis and treatment of infectious diseases [10-11] primarily pioneer it.

Formation. By the end of WWII, the National Health Service had been established as an integrated, state-funded healthcare service. The establishment of the NHS marked the beginning of the UK government taking responsibility for HAI prevention and control.

Consolidation. The spread of Staphylococcal infections across the UK prompted organizations to take preventative measures. One such measure was the appointment of an Infection Control Nurse as a full-time position to control patient cross infections. It went into effect in April 1959, with the appointment of the first ICN. This indicates that Britain was at the forefront of infection control development. In 1970, the Infection Control Association was founded.

Standardization. The formation of the Infection Prevention Society was the first step toward a more holistic approach to HAI prevention. By including any healthcare professionals involved in infection control and prevention, the society aimed to target infection control at all levels of healthcare.

Monitoring and Evaluation. After the 1970s, the formation of organizations such as the Infection Prevention Society, the Hospital Infection Society, and the Central Sterilizing Club became common. Together with the interested governmental agencies, they contributed to the introduction of recommendations for screening and isolation programs. From then on, much of the emphasis was on identifying and containing an increasing number of antibiotic-resistant bacteria.

Because multiple-resistant gram-negative bacteria only caused local outbreaks, they were not prioritized as much as bacteria such as *S. aureus* and *Clostridium difficile* when developing specific control policies. Currently, the national HAI surveillance program includes *Escherichia coli*, *Staphylococcus aureus*, *Clostridium difficile*, patients with urinary catheters, and surgical site infections, with annual reports generated. Healthcare professionals in all healthcare settings are given operational guidance for HAI prevention and management. According to surveys, all HAI control measures have resulted in a decrease in the number of nosocomial infections reported [10-19].

Kazakhstan

Formation. Stages of the infection control system implementation in the Republic of Kazakhstan includes

Monitoring and Evaluation: The implementation of national-level HAIP measures with a focus on quality improvement, patient safety, and cost savings.

Sustainability and Improvement: Continuous adaptation and scaling of HAIP, with an emphasis on addressing emerging issues like antimicrobial resistance.

The two countries' trajectories in developing HAIP were then compared based on these phases, and similarities and differences were identified.

Implementation of the Infection Control System in pilot projects in a number of healthcare organizations with AIHA support (1995). Creation of the regulatory and methodological framework (1998-1999). Implementation of the Infection Control System in healthcare organizations nationwide (since 2000) [20].

Standardization. Regulatory documents: On approval of the Rules of Infection Control in Medical organizations, On approval of Sanitary Rules "Sanitary and epidemiological requirements for the implementation of production control" On approval of the Sanitary Rules "Sanitary and epidemiological requirements for the organization and conduct of disinfection, disinfection and deratization" On approval of Sanitary Rules "Sanitary and epidemiological requirements for health facilities" On approval of the Sanitary Rules "Sanitary and epidemiological requirements for the organization and conduct of sanitary and anti-epidemic, sanitary and preventive measures for acute respiratory viral infections, influenza and their complications (pneumonia), meningococcal infection, COVID-19 coronavirus infection, chickenpox and scarlet fever".

Monitoring and Evaluation. Organization of infection prevention and control system in the Republic of Kazakhstan. Kazakhstan has an effective system of HAI surveillance, which at the same time requires at the national level and at the level of healthcare organizations. On 2018, an IPC coordinator has been appointed with WHO support self-assessment of implementation of the main IPC components in 6 emergency medical care facilities were conducted in 2019.

This year the research determination of one stage prevalence of healthcare associated infections and use of antimicrobials in four healthcare organizations providing 24-hour inpatient care in the republic of Kazakhstan for 2021-2022 was conducted in pilot mode jointly with the WHO.

The IPC methodological guidelines were developed taking into account the WHO's and CDC's. Infection Prevention and Control System Improvement Plan for 2022-2027 was developed.

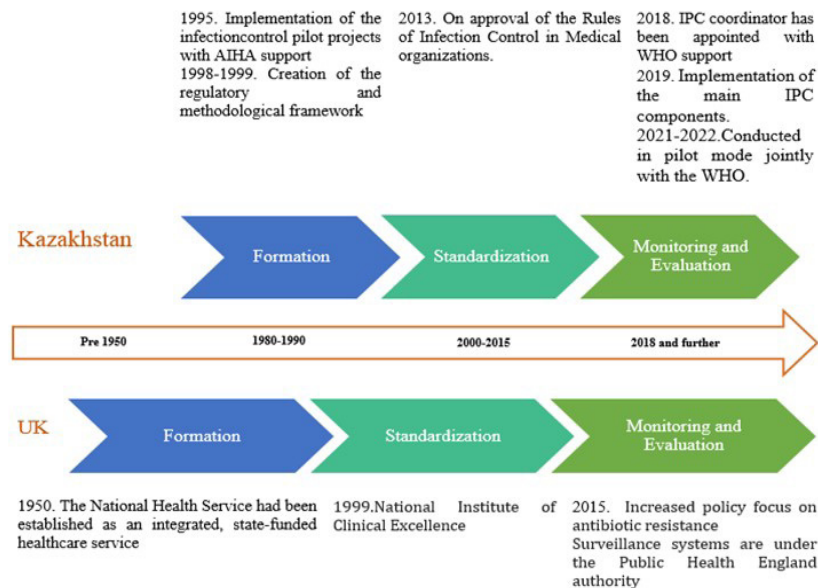


Figure 2 - Evolution of HAIs prevention and control in the United Kingdom and Kazakhstan

Discussion

The main difference between the two countries is that in Kazakhstan, along with the guaranteed volume of free medical care at the expense of budgetary funds, compulsory social health insurance is practiced. Whereas, the United Kingdom has a free, publicly funded healthcare system known as the National Health Service (NHS). Apart from the fact that it is funded through taxation rather than health insurance, the NHS is unique among healthcare systems [21]. When comparing the policies of the two countries in the development of HAI public policy, the baseline of each phase in Kazakhstan occurred much later than in the UK. Other factors, however, may have influenced the focus on HAI. Since the beginning, there have been significant differences in the two countries' profitable, undefined, and political geography. Other multinational trends may have influenced HAI public policy developments, according to the findings. In both countries, there has been an increase in public and political awareness of the issue [22].

We discovered similarities in the phases of HAI public policy in both countries; however, when compared to the UK, Kazakhstan began each phase around 40 years later. Notable, our analysis covered the data on HAIs control in sovereign Kazakhstan.

The NHS began in the UK in 1948, while in Kazakhstan; the MH was not fully developed until the 1990s. The influence of international organizations such as the WHO may have aided in the advancement of the HAI topic, particularly in developing countries. Patient safety has been

Conclusion

The UK experience analysis highlights several potentially useful lessons for health systems that have not yet reached the Monitoring and Evaluation phase. Among them are the need to treat HAIs as a public health issue, the consistent dissemination of evidence-based guidelines, the incorporation of scientific updates into clinical practice, the development of guidance for various types of healthcare settings, and the monitoring of epidemiologically relevant

pathogens. Finally, citizen participation in HAIs policy development is highly desirable.

retropective analysis of the literature data showed that in Kazakhstan the most critical gaps and problems for the prevention of healthcare associated infections (PHAIs) system at the national level are: the absence of a single national comprehensive strategy or program for the prevention and control of HAIs; lack of an effective epidemiological surveillance system based on effective tools for collecting and analyzing data on cases of HAIs and risk factors; lack of practical guidelines and algorithms for PHAIs activities for most stakeholders; lack of opportunity to gain in-depth knowledge, corresponding to modern ideas and evidence-based workshops on the problems of HAIs and PHAIs, as well as related branches of knowledge, for almost all interested parties; the absence of a monitoring system for activities implemented within the framework of the PHAIs.

Safer care can be viewed as a shared goal in high and middle-income countries, and our research identifies areas of common development in HAIP in the United Kingdom and Kazakhstan [25-27]. Nonetheless, significant differences exist between the two countries. In comparison, Kazakhstan must overcome numerous political and economic obstacles in order to advance universal healthcare provision [25]. The challenge for healthcare systems around the world is to strike a good balance between healthcare access, economic sustainability, and patient safety.

pathogens. Finally, citizen participation in HAIs policy development is highly desirable.

Conflict of Interest Statement. The authors declare no conflict of interest.

Author Contributions. A.C. contributed to conceptualizing and editing of the manuscript, writing the original draft. K.D. and A.M. contributed to the methodology. A.C., K.D. and A.M. contributed to data collection.

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Медициналық көмекті көрсетумен байланысты инфекциялар бойынша мемлекеттік саясатты саралау: Қазақстан мен Ұлыбритания

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Түйіндеме

Қазақстанда Медициналық көмекті көрсетумен байланысты инфекциялардың (МКБИ) алдын алу және бақылау мәселелері әлі де өзекті болып отыр. Жинақталған теріс және оң тәжірибеден құжаттау, талдау және сабақ алу үшін мүмкіндіктер жоқ, инфекциялық бақылау шараларының тиімділігін бағалау әдістемесі жоқ, МКБИ нақты ауқымы туралы дәйекті ақпарат жинаудың бірыңғай схемалары жоқ, МКБИ алдын алу және бақылау жөніндегі бірыңғай ұлттық кешенді стратегия немесе бағдарламалар жоқ.

Бұл зерттеудің мақсаты екі елде МКБИ алдын алу және оған қарсы күрес саласындағы мемлекеттік саясатты әзірлеу негізінде жатқан негізгі құжаттарды талдау болды. Қазақстан мен Ұлыбритания таңдалды. Себебі екі елде де денсаулық сақтау жүйелері жалпы салық салу есебінен қаржыландырылатын медициналық қызметтерді мемлекеттік қаржыландыруды көздейтін әлеуметтік сақтандыру моделіне негізделген.

Ұлыбритания тәжірибесін талдау, бақылау және бағалау кезеңіне әлі де болса жетпеген денсаулық сақтау жүйелері үшін пайдалы бірнеше тұстарды көрсетеді. Оларға МКБИ-ны қоғамдық денсаулық мәселесі ретінде қарастыру қажеттілігі, дәлелді нұсқауларды дәйекті түрде тарату, клиникалық тәжірибеге ғылыми жаңартуларды енгізу, денсаулық сақтау мекемелерінің әртүрлі түрлеріне арналған нұсқаулықтарды әзірлеу және эпидемиологиялық маңызды патогендердің мониторингі кіреді. Сонымен қатар, МКБИ басқару саясатын әзірлеуге тұрғындардың қатысуы өте қажет.

Түйін сөздер: мемлекеттік саясат, медициналық көмек көрсетуге байланысты инфекциялар, МКБИ, инфекциялық бақылау.

Анализ государственной политики в отношении инфекций, связанных с оказанием медицинской помощи: Казахстан и Великобритания

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Резюме

Проблемы профилактики и контроля за инфекциями, связанными с оказанием медицинской помощи (ИСМП) в Казахстане все еще остаются актуальной. Отсутствуют возможности для документирования, анализа и извлечения уроков из накопленного негативного и положительного опыта, отсутствует методология оценки эффективности мер инфекционного контроля, отсутствуют унифицированные схемы сбора достоверной информации о реальных масштабах ИСМП, отсутствует единая национальная комплексная стратегия или программы по профилактике и контролю ИСМП.

Целью данного исследования был анализ основных документов, лежащих в основе разработки государственной политики в области профилактики и борьбы с ИСМП в двух странах. Казахстан и Соединенное Королевство (Великобритания) были выбраны, поскольку в обоих странах системы здравоохранения основаны на модели социального страхования, предполагающей государственное финансирование медицинских услуг, финансируемых за счет общего налогообложения.

Анализ опыта Великобритании выделяет несколько потенциально полезных уроков для систем здравоохранения, которые еще не достигли фазы мониторинга и оценки. Среди них — необходимость рассматривать ИСМП как проблему общественного здравоохранения, последовательное распространение руководств, основанных на фактических данных, включение результатов научных исследований в клиническую практику, разработка руководств для различных типов медицинских учреждений и мониторинг эпидемиологически значимых патогенов. Наконец, участие граждан в разработке политики ИСМП крайне желательно.

Ключевые слова: государственная политика; инфекции, связанные с оказанием медицинской помощи, ИСМП, инфекционный контроль.

Комплексный анализ кишечной микробиоты при хронической сердечной недостаточности: Интеграция метагеномных данных и метаболических путей в контексте патофизиологии заболевания

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Резюме

Хроническая сердечная недостаточность (ХСН) является глобальной проблемой здравоохранения, связанной со значительной заболеваемостью и смертностью. Недавние исследования указывают на потенциальную роль кишечной микробиоты в здоровье сердца.

Целью данного исследования было изучение связей между микробными процессами в кишечнике и клиническими проявлениями ХСН.

Методы. В проспективном обсервационном когортном исследовании участвовали пациенты старше 18 лет с верифицированным диагнозом ХСН. Пациенты были стратифицированы на основе эхокардиографических данных. Анализ кишечного микробиома проводился с использованием высокопроизводительного секвенирования и биоинформатических инструментов.

Результаты выявили значительные изменения в составе кишечной микрофлоры у пациентов с ХСН по сравнению со здоровым контролем. Наблюдалось снижение альфа-разнообразия и изменения в бета-разнообразии, указывающие на нарушение баланса микрофлоры. У пациентов с ХСН отмечалось значительное снижение соотношения Firmicutes/Bacteroidetes. На уровне семейств и родов были обнаружены значимые изменения, включая увеличение относительной численности Sutterellaceae, Synergistaceae и ряда условно-патогенных бактерий. Наблюдалось уменьшение относительной численности Bifidobacteriaceae и Coriobacteriaceae, известных своими потенциальными кардиопротективными свойствами.

Выводы. Анализ метаболических путей показал увеличение активности бактерий, связанных с расщеплением белков, и уменьшение активности бактерий, участвующих в переработке углеводов. Это может приводить к образованию потенциально вредных веществ в кишечнике. Результаты исследования открывают новые перспективы для диагностики и лечения ХСН. Анализ состава кишечных бактерий может стать дополнительным инструментом в оценке состояния пациентов с ХСН, а коррекция состава кишечной микрофлоры может быть рассмотрена как часть комплексного лечения.

Ключевые слова: хроническая сердечная недостаточность, метагеномика, микробиом, метаболиты.

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Введение

Хроническая сердечная недостаточность (ХСН) является глобальной проблемой здравоохранения, связанной со значительной заболеваемостью и смертностью [1-4]. В то время как традиционные факторы риска, такие как гипертония, диабет и ожирение, способствуют развитию и прогрессированию сердечной недостаточности, недавние исследования пролили свет на потенциальное участие кишечной микробиоты в здоровье сердца [5]. Вопреки прогрессу, достигнутому в современных подходах к лечению ХСН, мы сталкиваемся с увеличением частоты госпитализаций и летальности. За последние десятилетия открытия в области патофизиологии, фармакотерапии и метаболомики позволили улучшить показатели выживаемости и смертности от сердечной недостаточности.

Материалы и методы

Дизайн исследования представляет собой проспективное обсервационное когортное исследование. В исследование включаются пациенты старше 18 лет с верифицированным диагнозом ХСН согласно критериям Европейского общества кардиологов и группу здорового контроля (CNTRL).

Для анализа кишечного микробиома фекальные образцы были собраны в пробирки Zymo Research R1101 и хранились при температуре +4°C до момента выделения ДНК. Экстракцию тотальной микробной ДНК проводили с использованием набора ZymoBIOMICS DNA Miniprep Kit (Zymo Research, D4300). Качество выделенной ДНК оценивали спектрофотометрически (соотношение OD₂₆₀/280) с помощью Nanodrop и электрофоретически в 1% агарозном геле. Концентрацию и чистоту образцов ДНК определяли флуориметрически на приборе Invitrogen Qubit 3.0 (Invitrogen, Карлсбад, Калифорния, США). Высокопроизводительное секвенирование выполняли на платформе Illumina NovaSeq 6000 согласно стандартным протоколам производителя.

Анализ данных секвенирования проводили с использованием комплекса биоинформатических инструментов bioBakery 3, включающего методы таксономического, деформационного, функционального и филогенетического профилирования метагеномов. Относительная

Результаты

Наше исследование выявило важные изменения в составе кишечной микрофлоры у пациентов с ХСН по сравнению со здоровым контролем.

Во-первых, мы обнаружили значительное снижение разнообразия бактерий (альфа-разнообразие), что указывает на нарушение баланса микрофлоры (Рисунок 1). Кроме того, мы наблюдали существенные изменения в структуре микробного сообщества (бета-разнообразие) у пациентов с ХСН. Это свидетельствует о том, что ХСН связана не только с уменьшением разнообразия бактерий, но и с изменением их соотношения.

Интересно отметить, что у пациентов с ХСН наблюдалось значительное снижение соотношения Firmicutes/Bacteroidetes (F/B ratio), двух основных типов бактерий в кишечнике (Рисунок 1). При этом представители типа Firmicutes преобладали в группе ХСН.

Недавние исследования убедительно демонстрируют, что изменения в микробиоме кишечника могут играть роль в развитии сердечно-сосудистых патологий, включая ХСН [5-7]. Микробиом взаимодействует с организмом через продуцируемые метаболиты, которые оказывают влияние на развитие сердечно-сосудистых заболеваний.

Цель настоящего исследования: изучить связи между микробными процессами в кишечнике и клиническими проявлениями ХСН.

Численность микробных таксонов оценивали с помощью алгоритма MetaPhlan 4. Профилирование генов, метаболических путей и модулей осуществляли с использованием HUMAnN 3 на основе аннотаций UniRef90.

Для межгруппового сравнения применяли U-критерий Манна-Уитни. Бета-разнообразие оценивали с использованием индексов Брея-Кертиса (количественный) и Жаккара (качественный). Ординацию выполняли методом анализа главных координат (PCoA) с последующим применением тестов ANOSIM и PERMANOVA (999 пермутаций).

Анализ разнообразия, ординацию и статистические тесты реализованы на Python 3 с использованием пакетов Scikit-Bio 0.5.6, Scikit-Learn 1.2.0 и SciPy 1.7.0. Для визуализации применяли библиотеку Matplotlib 3.7.0. Выявление значимых функциональных особенностей между группами осуществляли с помощью STAMP 2.1.3. Дифференциальный анализ таксономического состава проводили методом LEfSe.

На уровне семейств и родов бактерий мы обнаружили ряд значимых изменений. Так, мы наблюдаем увеличение относительной численности бактерий семейств Sutterellaceae ($q < 0.009$); Synergistaceae ($q < 0.03$), важно отметить увеличение относительной численности представителей условно-патогенной флоры Anaerotruncus ($q < 0.006$); Dysosmobacter ($q < 0.011$); Enterocloster ($q < 0.002$); Flavonifractor ($q < 0.01$); Hungatella ($q < 0.009$); Parasutterella ($q < 0.001$).

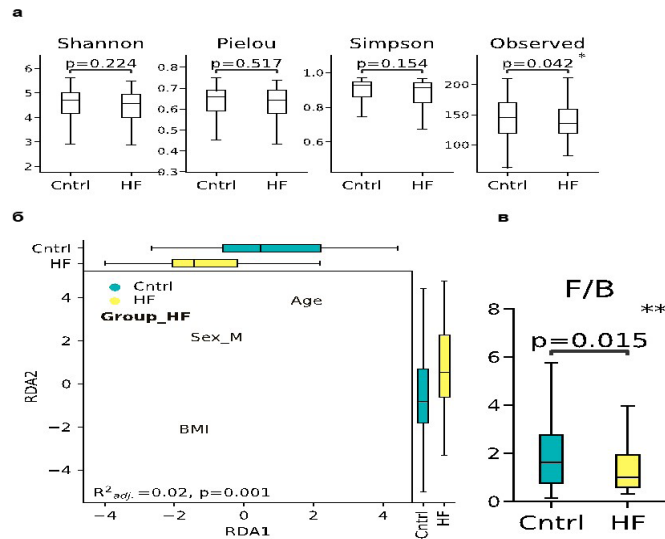


Рисунок 1 - Микробное разнообразие и композиционный анализ; а) α -разнообразие для индексов Shannon, Pielou, Simpson, and Observed; б) Redundancy Analysis (RDA); в) соотношение Firmicutes/Bacteroidetes между двумя группами HF и контроль

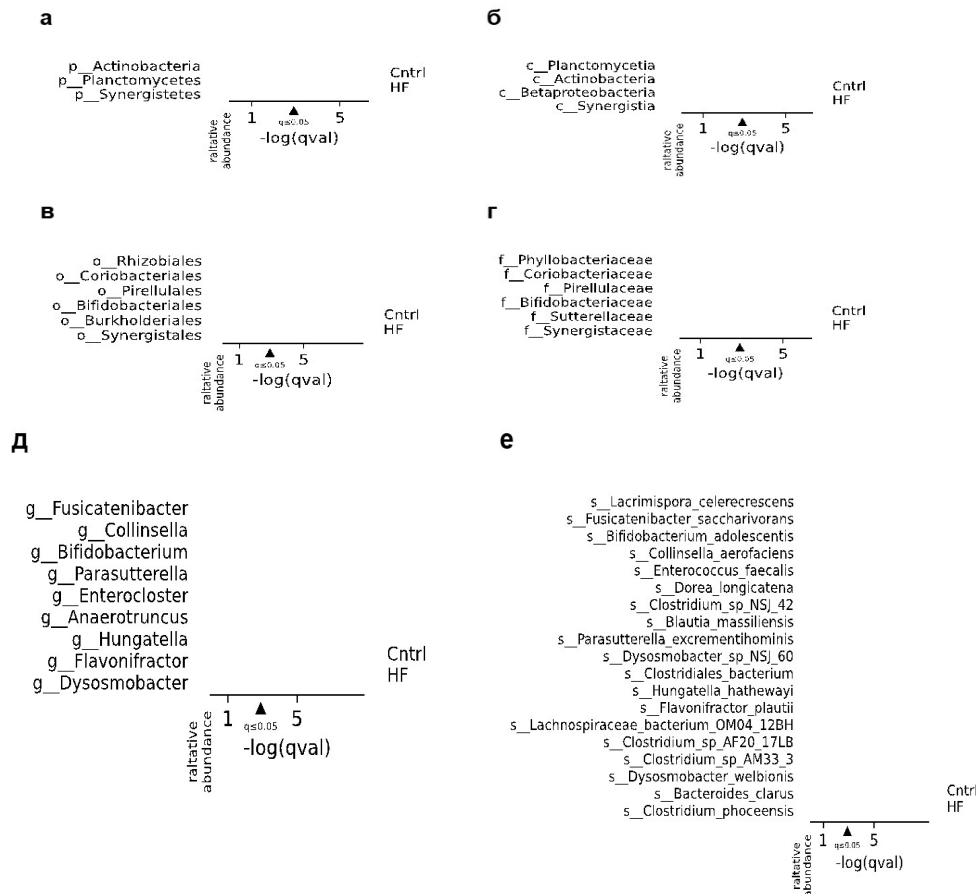


Рисунок 2 - Дифференциальный анализ бактериальных таксонов в контрольной группе и группе с ХСН методом LefSe. а) на уровне типов; б) на уровне классов; в) на уровне порядков; г) на уровне семейств; д) на уровне родов; е) на уровне видов

Также следует отметить уменьшение относительной численности представителей семейств Bifidobacteriaceae ($q < 0.012$), Coriobacteriaceae ($q < 0.006$). Известно, что некоторые штаммы Bifidobacterium могут производить γ -аминомасляную кислоту (ГАМК), которая обладает гипотензивным эффектом [6]. Представители Bifidobacteria могут снижать уровень общего холестерина и липопротеинов низкой плотности (ЛПНП) в крови, потенциально уменьшая риск атеросклероза. Bifidobacteria способствуют производству противовоспалительных цитокинов,

что может снижать системное воспаление, связанное с сердечно-сосудистыми заболеваниями [7]. Исследования показывают, что некоторые штаммы Bifidobacterium могут улучшать функцию эндотелия, что важно для здоровья сосудов [8]. Coriobacteriaceae участвуют в метаболизме желчных кислот, которые играют роль в регуляции уровня холестерина и триглицеридов [9].

Комплексный анализ композиционного состава кишечного микробиома на разных таксономических уровнях демонстрирует увеличение количества

бактерий, связанных с расщеплением белков, и уменьшение бактерий, участвующих в переработке углеводов. Это может приводить к образованию потенциально вредных веществ в кишечнике, таких как аммиак, фенолы и сульфиды. В частности, наблюдалось снижение активности путей, отвечающих за накопление и расщепление гликогена; образование сахарозы;

Обсуждение

Настоящее исследование выявило значительные изменения в составе кишечной микробиоты у пациентов с ХСН по сравнению со здоровым контролем. Полученные результаты согласуются с растущим объемом доказательств, указывающих на важную роль кишечного микробиома в патофизиологии сердечно-сосудистых заболеваний [10].

Luedde et al. (2017) отмечали снижение микробного разнообразия при ХСН [11], что приводит к нарушению важных функций кишечной микробиоты, включая метаболизм питательных веществ и поддержание барьерной функции кишечника [12]. Данные изменения могут способствовать транслокации бактерий и их метаболитов в кровоток, вызывая системное воспаление и оксидативный стресс, что, в свою очередь, может усугублять течение ХСН [11].

Значительное снижение соотношения Firmicutes/Bacteroidetes у пациентов с ХСН представляет особый интерес, влияя на метаболизм короткоцепочечных жирных кислот (КЦЖК), играющих важную роль в регуляции воспаления и функции кардиомиоцитов [13]. Изменения метаболизма КЦЖК, желчных кислот и других метаболитов, что может приводить к дислипидемии и нарушению энергетического обмена в миокарде. Cui et al. (2018) также наблюдали снижение соотношения Firmicutes/Bacteroidetes при ХСН [14], однако Kamo et al. (2017),

Выводы

Эти результаты открывают новые перспективы для диагностики и лечения ХСН. В будущем анализ состава кишечных бактерий может стать дополнительным инструментом в оценке состояния пациентов с ХСН. Возможно, коррекция состава кишечной микрофлоры может стать частью комплексного лечения ХСН. Необходимы дальнейшие исследования для разработки конкретных рекомендаций по модификации кишечной микрофлоры у пациентов с ХСН.

Эти результаты подчеркивают важность комплексного подхода к лечению ХСН, учитывающего не только состояние сердечно-сосудистой системы, но и особенности кишечной микрофлоры пациента.

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расщепление сложных сахаров (стахиозы) и синтез аминокислоты орнитина. Такие представители, как *Blautia massiliensis*, *Dorea longicatena* и *Fusicatenibacter saccharivorans*, показали сильную связь со всеми изученными метаболическими путями. Это указывает на их потенциально важную роль в изменении обмена веществ при ХСН.

обнаружили противоположный результат [12]. Эти различия могут быть связаны с особенностями популяции пациентов или стадией заболевания.

Рядом авторов показан сдвиг кишечной флоры в сторону условно-патогенной, что способствует продукции триметиламин (ТМА), который в печени превращается в триметиламин-N-оксид (ТМАО) [15,16]. ТМАО связан с повышенным риском сердечно-сосудистых заболеваний и может способствовать прогрессированию ХСН через усиление воспаления и фиброза миокарда [16].

Наблюдаемое увеличение активности бактерий, связанных с расщеплением белков, и уменьшение активности бактерий, участвующих в переработке углеводов, согласуется с концепцией "уремического миллионера", предполагающей накопление токсичных метаболитов при ХСН [17]. Данные изменения могут способствовать накоплению уремических токсинов, таких как p-крезил сульфат и индоксил сульфат, может усиливать оксидативный стресс, способствуя повреждению кардиомиоцитов и эндотелиальной дисфункции [18].

Эти потенциальные механизмы могут образовывать порочный круг, где изменения в микробиоте способствуют прогрессированию ХСН. ХСН, в свою очередь, влияет на состав кишечной микробиоты.

Конфликт интересов отсутствует.

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Созылмалы жүрек жеткіліксіздігі кезіндегі ішек микробиотасының кешенді талдауы: Аурудың патофизиологиясы контекстіндегі метагеномдық деректер мен метаболикалық жолдардың интеграциясы

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Түйіндеме

Созылмалы жүрек жетіспеушілігі (СЖЖ) айтарлықтай аурушаңдық пен өлім-жітімге байланысты жағандық денсаулық сақтау мәселесі болып табылады. Соңғы зерттеулер ішек микробиотасының жүрек денсаулығында әлеуетті рөлін көрсетеді.

Бұл зерттеудің мақсаты ішектегі микробтық процестер мен созылмалы жүрек жетіспеушілігінің клиникалық көріністері арасындағы байланысты зерттеу болды.

Әдістері. Бұл проспективті бақылау когорттық зерттеуге СЖЖ диагнозы расталған 18 жастан асқан науқастар қатысты. Науқастар эхокардиографиялық деректер негізінде стратификацияланды. Ішек микробиомын талдау жоғары өнімді секвенциялау және биоинформатикалық құралдарды қолдану арқылы жүргізілді.

Нәтижелер. СЖЖ бар науқастарда дені сау бақылау тобымен салыстырғанда ішек микрофлорасының құрамында айтарлықтай өзгерістерді анықтады. Альфа әртүрлілігінің төмендеуі және бета әртүрлілігінің өзгеруі байқалды, бұл микробтық тепе-теңдіктің бұзылуын көрсетеді. СЖЖ бар науқастарда Firmicutes/Bacteroidetes қатынасының айтарлықтай төмендеуі байқалды. Тұқымдас және туыс деңгейінде айтарлықтай өзгерістер, соның ішінде Sutterellaceae, Synergistaceae және бірнеше оппортунистік бактериялардың салыстырмалы мөлшерінің артуы анықталды. Әлеуметті кардиопротекторлық қасиеттері бар Bifidobacteriaceae және Coriobacteriaceae-нің салыстырмалы мөлшерінің азаюы байқалды.

Қорытынды. Метаболикалық жолдарды талдау ақуыздардың ыдырауымен байланысты бактериялардың белсенділігінің жоғарылауын және көмірсулардың метаболизміне қатысатын бактериялардың белсенділігінің төмендеуін көрсетті. Бұл ішекте әлеуметті зиянды заттардың түзілуіне әкелуі мүмкін. Зерттеу нәтижелері СЖЖ-ін диагностикалау мен емдеудің жаңа перспективаларын ашады. Ішек бактерияларының құрамын талдау СЖЖ бар науқастардың жағдайын бағалаудың қосымша құралына айналуы мүмкін, ал ішек микрофлорасының құрамын түзету кешенді емдеудің бір бөлігі ретінде қарастырылуы мүмкін.

Түйінді сөздер: созылмалы жүрек жетіспеушілігі, метагеномика, микробиом, метаболиттер.

Comprehensive Analysis of Gut Microbiota in Chronic Heart Failure: Integration of Metagenomic Data and Metabolic Pathways in the Context of Disease Pathophysiology

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Abstract

Chronic Heart Failure (CHF) represents a global health concern associated with significant morbidity and mortality. Recent studies suggest a potential role of the gut microbiota in cardiac health.

The objective of this investigation was to examine the associations between microbial processes in the intestine and the clinical manifestations of CHF.

Methods. This prospective observational cohort study included patients over 18 years of age with a verified diagnosis of CHF. Patients were stratified based on echocardiographic data. Gut microbiome analysis was conducted using high-throughput sequencing and bioinformatic tools.

The results revealed significant alterations in the composition of the intestinal microflora in patients with CHF compared to healthy controls. A reduction in alpha diversity and changes in beta diversity were observed, indicating a disruption in the microbial balance. Patients with CHF exhibited a significant decrease in the Firmicutes/Bacteroidetes ratio. At the family and genus levels, significant changes were detected, including an increase in the relative abundance of Sutterellaceae, Synergistaceae, and several opportunistic bacteria. A decrease in the relative abundance of Bifidobacteriaceae and Coriobacteriaceae, known for their potential cardioprotective properties, was observed.

Conclusions. Analysis of metabolic pathways demonstrated an increase in the activity of bacteria associated with protein degradation and a decrease in the activity of bacteria involved in carbohydrate metabolism. This may lead to the formation of potentially harmful substances in the intestine. The study results open new perspectives for the diagnosis and treatment of CHF. Analysis of the intestinal bacterial composition may become an additional tool in assessing the condition of patients with CHF, and modulation of the gut microflora composition may be considered as part of a comprehensive treatment approach.

Keywords: chronic heart failure, metagenomics, microbiome, metabolites.

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Brief ecen

Мейіргерлік қарқынды күтім хаттамасын жасау және оны анестезиология-реанимация қарқынды емдеу бөлімінің тәжірибесіне енгізу арқылы медициналық көмек сапасын жақсарту

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Түйіндеме

Зерттеудің мақсаты: мейіргерлік қарқынды күтім хаттамасын жасау және оны анестезиология-реанимация және қарқынды емдеу бөлімінің тәжірибесіне енгізу арқылы медициналық қызмет сапасын жақсарту.

Әдістері. Хаттама жасау және енгізу процесі келесі кезеңдерден тұрды: науқастарды қарқынды емдеу кезіндегі шаралар мен мәселені ескере отырып хаттама құрастырылды. Хаттама талқыға салынып, қажетті өзгертулер мен толықтырулар енгізіліп, күнделікті тәжірибеге енгізілген соң, хаттама қолданыста болған кезеңде бөлім жұмысының сапасына талдау жасалды. Сапа көрсеткіші ретінде жыл бойында емделген ауыр науқастар саны, төсек жараның кездесу жиілігі, катетер себебінен болатын инфекциялық асқынулар жиілігі, ауруханаішілік инфекциялардың кездесу жиілігі, жасанды тыныс алу аппаратымен байланысты пневмония жиілігі, мейірбикелер жұмысы сапасына дәрігерлер тарапынан жасалған шағымдар саны алынып, көрсетілген медициналық көмекке қанағаттану дәрежесін білу мақсатында 50 науқасқа сауалнама жүргізілді.

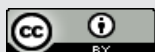
Нәтижесі. Хаттама қолданыста болған кезеңдерге жасалған талдау нәтижесі бойынша қарқынды күтім қажет еткен науқастар санының жыл санап артуына қарамастан, ауруханаішілік инфекциялардың және катетерге байланысты инфекциялар санының, төсек жаралардың азайғаны анықталды. Жасанды тыныс алу аппаратын қолдану салдарынан болған өкпе қабынулары 0,54 тен 0,26%-ға азайып отыр. Мейірбикелердің жұмыс сапасына жасалған шағымдар саны өспеген. Сауалнама жүргізілген науқастардың 90% анестезиология-реанимация және қарқынды емдеу бөлімінде жүргізілген медициналық көмек сапасына толық қанағаттанғанын көрсетті.

Қорытынды. Мейіргерлік күтім хаттамасын құрастыру және оны тәжірибеге енгізу - емдеу шараларының нәтижесін жақсарту мен көрсетілетін медициналық көмек сапасын арттыру жолындағы маңызды қадамдардың бірі. Ұсынылып отырған мейіргерлік күтім хаттамасы науқастарды анестезиология-реанимация және қарқынды емдеу бөлімінде емдеу нәтижелерін жақсартуға бағытталған тиімді құралдардың бірі болып табылады.

Түйін сөздер: мейірбикелік қарқынды күтім хаттамасы, медициналық қызмет сапасы, қарқынды емдеу.

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Кіріспе

Негізгі мақсаты – ағзаның өмірлік маңызы бар қызметтерін қалпына келтіру мен оны жақсарту болып табылатын, анестезиология-реаниматология және қарқынды емдеу (АРҚЕ) бөлімінің науқастарды кешенді емдеу барысында алатын орны ерекше [1]. Оның ішінде орта буын қызметкерлері, яғни мейіргерлер маңызды рөл атқарады. Емдеу нәтижесіне тікелей әсер ететін жағдайдың бірі науқастарға күтім жасау мен кешенді қарқынды емдеу шараларын жүзеге асыруға орта медициналық қызметкерлерде ат салысады. Сондықтан бұл қызмет сапасы, өз кезегінде, осы қызметкерлердің жұмысының сапасы мен қабілетіне тікелей байланысты [2].

Жаңа әрі ыңғайлы тәжірибелік шешімдерді мейірбике қызметіне енгізе отырып, олардың тиімділігі мен қызметінің сапасын арттыруға болады. Бұл жолда, алдымен күнделікті тәжірибедегі қиындықтар мен мәселелерді анықтап, оларды шешу жолдарын табу қажет, яғни тиімді тәжірибелік хаттама болуы керек [2, 3]. Осы орайда, қолданыста бар хаттамаларды зерттеп, сол хаттаманың күнделікті тәжірибе талаптарына сәйкес келетінін анықтап алған дұрыс. Мұндағы негізгі мақсат науқастарға сапалы қызмет көрсетіп, емдеу шараларының әрбір науқастың қажеттілігіне сәйкес болуын қамтамасыз ету болып табылады [4].

Ғылыми дәлелденген тәжірибелік шараларды науқас күтімі хаттамасына енгізу арқылы медициналық көмек сапасын жақсартуға болады. Мұндай бағыттың дұрыстығын соңғы кезде жасалып жатқан кең ауқымды зерттеулер дәлелдеп отыр [5, 6]. Яғни, дәлелді медициналық көзқарасты күнделікті жұмыс барысына енгізу көрсетілетін көмек сапасын жақсартып қана қоймай, науқастардың қауіпсіздігін де қамтамасыз етеді алады.

Әрбір медициналық ұйымның ерекшелігі мен көрсететін медициналық қызмет түрін, сол ұйымның емдеу нәтижелерін ескере отырып, жақсартуды қажет ететін бағыттар мен мейіргерлік күтім шараларын анықтауға болады. Осы жерде, назар аударатын бағыттарды атап айтар болсақ, олар: ауырсынуды тиімді бағалау және ауырсынуды басу, науқас пен

Зерттеу әдісі мен құралдары

Мейірбикелік қарқынды күтім хаттамасын құрастыру және оны тәжірибеге енгізу барысы Қазақстан Республикасы Президентінің Іс басқармасы Медициналық орталығы ауруханасының анестезиология-реаниматология және қарқынды емдеу бөлімінде жүргізілді.

Анестезиология-реаниматология және қарқынды емдеу бөлімі: 6 төсек орынды жалпы хирургиялық бекет, 7 төсек орынды кардиохирургиялық бекет, 8 төсек орынды қарқынды емдеу блогы мен 12 төсекті ояну палатасынан тұрады. Бөлім көпбейінді салада қызмет етеді. Қызметкерлер құрамы 29 дәрігер анестезиолог-реаниматолог, 48 мейірбике мен 18 кіші буын қызметкерлерінен құралған.

Жоғарыда көрсетілген мақсатқа сәйкес, мейірбикелік күтім хаттамасын жасау және оны күнделікті тәжірибеге енгізу үдерісі келесі кезеңдерден тұрды:

- тиісті әдебиеттерге шолу жасалып, қолданыстағы басқа хаттамалар және күнделікті тәжірибе ескеріліп, мейірбикелік қарқынды күтім хаттамасы әзірленді;

медициналық қызметкерлер арасындағы қарым-қатынас, көрсетілген медициналық қызметке науқастардың қанағаттануы. Мұндай кешенді көзқарас арқылы, біз сәйкесінше жақсартуды қажет ететін бағыттарды айқындай аламыз [1-7].

Анестезиология-реанимация және қарқынды емдеу бөлімі қызметкерлерінің жеке көзқарастары мен ұсыныстарын да ескере отырып, тәжірибелік мәселелер мен шешуді қажет ететін сұрақтарды анықтау маңызды. Дәрігерлер мен мейірбикелер, бөлім қызметкерлері бірлесе отырып, кешенді түрде талқылау арқылы, жаңа хаттамалар мен ұсыныстарға қол жеткізе алады. Өйткені, бөлім қызметкерлерінің тәжірибелік дағдылары және қабілеттері - тиімді әрі қолайлы хаттама жасауға қажетті маңызды көрсеткіштер [8,9].

Мейірбикенің науқастарға жасайтын қарқынды күтімі мен емдік шаралары, өмірлік маңызы бар жүйелердің қызметін қалпына келтіру және емдеу барысында ерекше орын алады. Қазіргі кезде, анестезиология-реанимация және қарқынды емдеу бөлімі мейірбикелері науқас күтімінен бөлек, уақыт пен сәйкес ресурстарды қажет ететін көптеген медициналық құжаттарды толтыруға мәжбүр. Сондықтан, күнделікті жұмыс барысында медициналық қызмет сапасы мен қауіпсіздігіне кері әсерін тигізбейтін, уақыт пен жұмсалатын күшті үнемдеп, сәйкес деңгейде медициналық күтім мен көмек көрсетуге мүмкіндік беретін хаттамаға сұраныс артып отыр [7-9].

Тиісті әдебиеттерге, мақалаларға шолу жасай отырып, біз клиникадағы тәжірибе мен жұмыс барысына талдау жасай келе, анестезиология-реаниматология және қарқынды емдеу бөлімі мейірбикелерінің уақыты мен күшін үнемдейтін, қызмет сапасын, қауіпсіздігін арттыратын қарқынды күтім хаттамасының қажеттігін анықтадық.

Зерттеудің мақсаты: мейірбикелік қарқынды күтім хаттамасын жасау және оны анестезиология-реанимация және қарқынды емдеу бөлімінің тәжірибесіне енгізу арқылы медициналық қызмет сапасын жақсарту.

-құрастырылған хаттама бөлім қызметкерлері арасында талқыланып, сауалнама арқылы қажетті түзетулер мен толықтырулар енгізілді;

-хаттама бөлім қызметкерлері мен аурухананың сапа бөлімінің сараптамасынан өтіп, күнделікті тәжірибеге енгізілді.

Хаттаманың соңғы түпнұсқасы А4 форматты 4 беттер тұрады және тәулік бойында (24 сағат) дәрігер тағайындаумен қатар жүргізіледі және құрамы төмендегідей бірнеше бөлімдерден тұрады.

Бірінші бетте берілген мәліметтер:

-құжаттық бөлім: науқастың аты-жөні, стационарлық карта номері, бөлімге түскен күні мен уақыты, жату тәртібі (жалпы немесе изоляция);

-гигиеналық іс-шаралар бөлімі мен науқасты белсендіру;

-интубациялық түтік, трахеостома күтімі, қақырық сипаты, дренаждар мен басқа түіктердің сипаты.

Екінші бетте тіркелетін мәліметтер:
-неврологиялық статусты бағалау: Глазго кома шкаласы бойынша;

-Браден шкаласы бойынша (Braden scale) төсек жара пайда болу қаупін анықтау [10];

-мұрын-асқазандық зонд мониторингі және тамақтандыру уақыты.

Үшінші бетте тіркелетін мәліметтер:

-вербальды шкала бойынша ауырсыну түрі мен орналасуын бағалау, сәйкес көмек түрі [11, 12];

- тамыршілік катетер мониторингі;

-уретральды катетер мониторингі;

-жасанды тыныс алу (ЖТА) аппаратында жатқан науқасты бақылау. Фибробронхоскопия, бронхолаваж және сынама алу туралы мәліметтер.

Төртінші бетте тіркелетін мәліметтер:

-Ричмонд шкаласы бойынша ажитация мен седация дәрежесін бағалау [12];

-науқасты бекіту (фиксация). Бекіту уақыты, бекітілген аймағы, бекіту кезінде және кейінгі тері жамылғысы, науқастың психикалық жағдайы [13];

-ұзақ эпидуралды катетеризация мониторингі. Орналасқан жері. Қойылған және алып тасталған күні. Пункция жасалған жері мен катетер маңындағы тері жамылғысы. Катетердің функциональдық жағдайы.

Хаттамаға мәліметтер тәулік барысында

Нәтижелері

Мейіргерлік күтім хаттамасы анестезиология-реаниматология және қарқынды емдеу бөлімінің күнделікті тәжірибесінде қолданыста болған кезеңге жасалған талдау нәтижелеріне келер болсақ, 2020-2023 жылдар аралығында анестезиология-реаниматология және қарқынды емдеу бөлімінде жатқан науқастар саны (1-ші кесте) жыл санап біршама артқаны байқалды және мұндағы алғашқы жылдарда науқас

тіркеліп, кезекшілік соңында кезекші мейірбике мен кезекші дәрігердің қолымен расталады.

Мейірбикелік күтім хаттамасы тәжірибеге енгізіліп күнделікті қолданыста болған кезеңде анестезиология-реаниматология және қарқынды емдеу бөлімінің жұмысының сапасына талдау жасалды.

Талдау барысында сапа көрсеткішін бағалау мақсатында келесі мәліметтер тіркелді: жыл бойында анестезиология-реанимация және қарқынды емдеу бөлімінде емделген науқастар саны, оның ішінде қарқынды күтімді қажет ететін 3 және 10 тәуліктен артық жатқан науқастардың үлесі, төсек жараның кездесу жиілігі, катетер себебінен болатын инфекциялық асқынулар жиілігі, ауруханаішілік инфекциялардың кездесу жиілігі, ЖТА аппаратымен байланысты пневмония жиілігі, мейірбикелер жұмысы сапасына дәрігерлер тарапынан жасалған шағымдар саны.

Науқастардың анестезиология-реанимация және қарқынды емдеу бөлімінде көрсетілген медициналық көмекке қанағаттану дәрежесін білу мақсатында соңғы 2023 жыл барысында 3 тәуліктен артық жатқан 50 науқасқа сауалнама жүргізілді және ондағы бағалау деңгейлері: 0 - қанағаттанарлық емес, 1 - толық қанағаттанбадым, 2 - қанағаттанарлық, 3 - бағалай алмаймын немесе жауап беруге қиналамын.

Алынған мәліметтерге сәйкес статистикалық талдау SPSS 20 бағдарламасында талдау жасалды.

санының аз болуының бір себебі COVID-19 пандемиясы болып саналады (бұл инфекция бар науқастар арнайы стационарда ем қабылдаған). Ауруханаға түскен науқастар санының жыл санап артуына байланысты анестезиология-реаниматология және қарқынды емдеу бөлімінде қарқынды емдеу шараларына мұқтаж, ауыр науқастардың саны да артқан.

1-ші кесте - Анестезиология-реанимация және қарқынды емдеу бөлімінен өткен науқастардың саны

	2020 жыл	2021 жыл	2022 жыл	2023 жыл
Анестезиология-реанимация және қарқынды емдеу бөлімі арқылы емделіп өткен науқастардың жалпы саны	3132	4293	4821	6779
Анестезиология-реанимация және қарқынды емдеу бөлімінде жатып емделген ауыр науқастардың саны	368	519	617	756
Науқастардың жату ұзақтығы (төсек-күн)	4,3	4,06	3,09	3,7

Науқастардың анестезиология-реаниматология және қарқынды емдеу бөлімінде жату ұзақтығына клиникалық, демографиялық факторлармен қатар, медициналық көмекті ұйымдастыру және жүзеге асыру жолдары да әсер етеді. Медициналық көмекті ұйымдастыру қатарына, дәрігерлер мен мейірбикелер арасындағы тиімді қарым-қатынасты да жатқызуға болады.

Мейірбикелік қарқынды күтім хаттамасын қолданысқа енгізгеннен соң, анестезиология-реанимация және қарқынды емдеу бөлімі мейірбикелер жұмысының сапасын сипаттайтын мәліметтерді 2-ші кестеден көруге болады.

Жоғарыда айтылғандай, емдеу және күтім барысында науқастың неврологиялық статусын бағалау, вербальды шкала арқылы ауырсыну белгілерін анықтау және бағалау шаралары біршама оң нәтижелерге қол жеткізуге себепші болды. 2-ші кестеде

көрсетілгендей, жыл санап 3 және 10 тәуліктен артық жатқан ауыр науқастар санының артуына қарамастан, анестезиология-реанимация және қарқынды емдеу бөлімінде жатудың орташа ұзақтығы 2021 мен 2023 жыл аралығында орташа есеппен 3,9 төсек-күнге азайған.

Мейірбикенің қарқынды күтім жасауы барысында қызмет сапасына себепші болатын көрсеткіштердің бірі - төсек жаралар жиілігі. Хаттамаға енгізілген Браден шкаласы бойынша төсек жара даму қаупін бағалау шарасы оң нәтиже көрсетіп отыр. Талдау барысында, соңғы 2022-2023 аралығында төсек жаралардың болмағаны анықталды.

Бұл көрсеткіш алдыңғы 2 жылда (2020-2021 жж.) 0,27 және 0,19% аралығында болған. Мұндай көрсеткіштің орын алуына тағы бір фактор ретінде науқасты бекіту (фиксация) шараларының қатаң бақылануын айтуға болады. Клиникалық

көрсеткіштерге (делирий, ажитация) қарай бекітуді қажет еткен науқастарда, бекітілген аймақ (аяқ, қол және кеуде) терісінің түсі, температурасы, бекіту уақыты мен ұзақтығы, сонымен қатар науқастың психикалық статусы әрбір сағатта тексеріліп, хаттамаға тіркеледі. Осындай тиянақты бақылау нәтижесінде

төсек жаралары мен науқастың өз-өзіне жасайтын жарақаттар орын алмаған.

Науқаста седацияны қажет ететін жағдай орын алғанда, хаттамаға сәйкес Ричмонд шкаласы қолданылды. Яғни, науқасқа қажетті седация немесе бекіту шаралары өз уақытында жасалады.

Кесте 2 - Талдау кезеңіндегі сана көрсеткіштері

Көрсеткіш	2020 жыл	2021 жыл	2022 жыл	2023 жыл
Анестезиология-реанимация және қарқынды емдеу бөлімінде жатып емделген ауыр науқастардың саны	368	519	617	756
Жату ұзақтығы (төсек-күн)	36,3	21,9	17,7	18,2
3 тәуліктен артық жатқан науқастар саны	90	122	124	215
	24,5%	23,5%	20,1%	28,4%
10 тәуліктен артық жатқан науқастардың саны	10	32	25	30
	2,7%	6,2%	4,1%	3,9%
Тамырішілік катетерге байланысты инфекция	1	0	0	1
	0,27%	0	0	0,13%
Уретралды катетерге байланысты инфекция	1	0	1	1
	0,27%	0	0,16%	0,13%
Жасанды тыныс алу аппаратымен байланысты пневмония	2	3	2	2
	0,54%	0,58%	0,32%	0,26%
Төсек жаралар	1	1	0	0
	0,27%	0,19%	0	0
Мейірбике жұмысы сапасына жасалған шағымдар саны (дәрігерлер тарапынан)	9	9	6	8

Күтім хаттамасының бір тармағы - тамырішілік катетерлер мен уретралды катетерлерге жасалатын күтім шаралары.

Хаттамаға сәйкес дер кезінде және тиянақты бақылау барысында, тамырішілік катетер мен уретралды катетерге байланысты болатын инфекциялар жиілігі де 0,27% дан 0,13%-ға дейін азайған (2-ші кесте).

Мейірбикелік күтім хаттамасына енгізілген тағы бір маңызды бөлім - жасанды тыныс алу аппараты мен сол аппарат қосылған науқастарға жасалатын күтім шаралары. Мейірбикенің науқасты күту

барысында интубациялық түтік пен ауыз қуысының тазалығы назардан тыс қалмайды және белгелі бір уақыт аралығында гигиеналық тазалық өткізіледі. Анестезиология-реанимация және қарқынды емдеу бөлімінде ЖТА аппаратына қосылған науқастарда жиі кездесетін асқынулардың бірі ЖТА аппаратымен байланысты пневмониялар жиілігі болып табылады. 2020 және 2021 жылмен салыстырғанда соңғы 2 жылда (2022-2023 ж.) ЖТА байланысты пневмония жиілігі орташа есеппен 0,27% төмендеген.



1-ші сурет - Науқастардың көрсетілген көмекке қанағаттану дәрежесі

Науқасты емдеу және оған күтім жасау барысында мультидисциплинарлық көзқарас пен дұрыс қарым-қатынас маңызды орын алады. Бұл ретте әрбір қызметкердің өзіне жүктелген міндетті дұрыс немесе бұрыс атқаруы, емдеу шараларының сапасы мен нәтижесіне тікелей әсер етеді. Мейірбикелік күтім хаттамасы осы орайда да өз орнын атқарды. Стандартты іс-шаралар мен хаттаманы қолдану барысында мейірбикелердің жұмысына деген ұқыптылығы артады. Мәселеге осы қырынан қарар болсақ, хаттаманы кеңінен қолданған жылдарда, мейірбикелердің жұмысына бөлім дәрігерлері тарапынан жасалған шағымдар саны да соңғы 2 жылда 11,2%-дан 33,3%-ға азайған (2-ші кесте).

Анестезиология-реанимация және қарқынды емдеу бөлімінде көрсетілген медициналық көмекке науқастардың берген бағасын анықтау мақсатында жасалған сауалнама нәтижесі 1-ші суретте беріліп отыр. Көріп тұрғандай, сауалнамаға жауап берген 50 науқастың 45-і (яғни, 90%) қанағаттанғанын айтып, 1 ғана науқас (2%) қанағаттанарлық көмек алмағанын белгіледі. Сауалнама қорытындысы бойынша науқастар тарапынан анестезиология-реанимация және қарқынды емдеу бөлімі жұмысына жалпы жақсы баға беріліп отырғанын анықтадық.

Талқылау

Күнделікті тәжірибелік мәселелерді шешу барысында бөлім қызметкерлерінің көзқарасын, тәжірибелік дағдыларын ескеру орындалатын істің сапасын арттыратыны сөзсіз. Жасалатын және енгізілетін хаттаманы талқылау барысында көп деңгейлі топтың болуы, яғни дәрігерлер мен орта буын медициналық қызметкерлерінің бірлесе отырып талқылауы қарқынды күтім хаттамасының тиімділігін арттырмақ [9-14].

Әдебиеттерде ұсынылған, кейбір қарқынды күтім хаттамаларын кез-келген аурухана немесе медициналық ұйымға тікелей енгізу мүмкін емес, себебі әрбір бөлімнің ерекшеліктері мен атқаратын міндеттері сәйкес бола бермейді [15, 16]. Сондықтан, біз мейірбикелік қарқынды күтім хаттамасын жасап, оны енгізу барысын жеткілікті уақыт аралығында тәжірибелік сынақтан өткізіп, үш кезеңдік жетілдіру мен талдау елегінен өткіздік және хаттама мейлінше ыңғайлы әрі жүйелі болуына назар аудардық. Хаттаманың орындалуына үнемі мониторинг жасау және оның жұмыс нәтижесіне оң әсерін бағалау хаттама тиімділігі мен сапасын арттыру жолының бірі болып табылады. Сәйкесінше, сандық және сапалық бағалау нәтижесіне назар аударар болсақ, біз қолданысқа енгізіп отырған мейірбикелік қарқынды күтім хаттамасы анестезиология-реанимация және қарқынды емдеу бөлімінде көрсетілген медициналық қызмет сапасына айтарлықтай септігін тигізіп отырғанын көреміз.

Отандық және шетелдік басылымдар мен әдебиеттерге шолу барысында мейірбикелік күтім хаттамаларына зерттеу және ғылыми талдау жасаған жұмыстарды кездестіре алмадық. Көпшілік жағдайда, тек хаттаманың құрылымы мен қолдану ерекшеліктеріне сипаттама жазылған, ал қолдану барысында жеткен жетістіктер мен қол жеткізген нәтижелерге талдау жазылмаған [14-19].

Анестезиология-реанимация және қарқынды емдеу бөлімінде, қарқынды мейірбикелік күтім хаттамасына деген қажеттіліктің себебін айтар болсақ, алдымыздан шешімін табуы қажет ететін күнделікті тәжірибелік мәселелер шығатыны сөзсіз. Күнделікті күтім барысына ғылыми дәлелденген тәжірибені енгізу маңызды рөл атқарады. Соның бірі - науқаста ауырсыну белгілерін анықтау, оны бағалау және сәйкес емдік іс-шараларды жасау, сонымен қатар төсек жараның алдын алу және даму қаупі дәрежесін жүйелі түрде бағалау [10]. Бұлардың бірі науқастың медициналық көмекке қанағаттануын арттырса, екіншісі ауруханаішілік инфекциялық асқынулардың алдын алуға себепші болмақ.

Қорытынды

Мейірбикелік күтім хаттамасын құрастыру және оны тәжірибеге енгізу - емдеу шараларының нәтижесін жақсарту мен көрсетілетін медициналық көмек сапасын арттыру жолындағы маңызды қадамдардың бірі. Ұсынылып отырған мейірбикелік күтім хаттамасы науқастарды анестезиология-реанимация және қарқынды емдеу бөлімінде қарқынды емдеу нәтижелерін жақсартуға бағытталған тиімді құралдардың бірі болып табылады.

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Енгізіліп отырған хаттамада гигиеналық іс-шараларға да ерекше орын беріліп отыр. Сонымен қатар, хаттама мейірбикенің назарын науқастың есі мен психологиялық жағдайына да аударады және сәйкес сынама көмегімен бағалауға мүмкіндік береді. Мейірбикелік тәжірибеде, бұл хаттама ауруханаішілік инфекциялардың алдын алуға да көмек береді. Яғни тамыршілік, уретральды катетерлердің күтіміне де назар аудартады. Бұған қосымша дәлел ретінде біздің анестезиология-реанимация және қарқынды емдеу бөлімінде бөлімінде кездесетін инфекциялық асқынулар деңгейінің азайуын айтуға болады. Қарқынды күтім кезінде, хаттама ЖТА-на қосылған науқастардың жағдайына мейірбикенің назарын аударып, көмек көрсетуіне себепші болады. Мұндай шараларды, соңғы 3 жылдық тәжірибе нәтижесінде ЖТА байланысты болатын пневмонияның біздің бөлімшеде азайуына септігін тигізген жағымды факторлардың бірі деп есептейміз. Анестезиология-реанимация және қарқынды емдеу бөлімінде кейбір науқастарда ауру себебі мен ерекшеліктеріне қарай психомоторлық қозу болып, седация жасалуы мүмкін. Сондықтан хаттамада бұл мәселеге де жеке орын беріліп отыр. Кейбір авторлардың мәліметі бойынша науқасты бекіту хаттамаларын енгізу, оны орынсыз қолдануды 30–50% азайтқан [20].

Біз ұсынып отырған мейірбикелік қарқынды күтім хаттамасының тағы бір артықшылығы ретінде, науқастардың көрсетілген медициналық көмекке қанағаттану деңгейінің артуын айтуға болады.

Сонымен қатар, хаттама күнделікті жұмыс барысында күтім жоспарын жасауға, жүйелі және уақытында әрекет етіп, қателіктердің алдын алуға мүмкіндік береді.

Құрастырылған мейірбикелік қарқынды күтім хаттамасына, тәжірибе барысында түзетулер, толықтырулар мен өзгертулер енгізуге болады. Бұл, өз кезегінде хаттаманың үнемі өзекті, әрі уақыт пен талапқа сәйкес болуын қамтамасыз етеді. Хаттаманы электрондық, ақпараттық жүйелерге де енгізуге болады. Әзірленген мейірбикелік күтім хаттамасына 2024 жылдың 22-қаңтарында № 42243 авторлық құқық куәлігі алынды.

Хаттаманың кейбір шектеулері де бар, ол сәйкес ұқыптылық пен толтыруға уақыт қажет етеді. Барлық анестезиология-реанимация және қарқынды емдеу бөлімдеріне сай әмбебап болмауы мүмкін. Хаттаманы белгілі бір кезеңдерде қайта қарап, бағалап, сәйкесінше өзгертіп ыңғайластыруға болады.

Мүдделер қақтығысы: жоқ.

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Повышение качества медицинской помощи путем разработки и внедрения протокола интенсивного сестринского ухода в практику отделения анестезиологии-реанимации и интенсивной терапии

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Резюме

Цель исследования: повышение качества и безопасности медицинских услуг путем создания протокола интенсивного сестринского ухода и внедрения его в практику отделений анестезиологии-реанимации и интенсивной терапии.

Методы. Процесс создания и внедрения протокола состоял из следующих этапов: протокол разрабатывался с учетом проводимых мероприятий и особенностей интенсивной терапии. Разработанный протокол обсуждался, вносились необходимые изменения, дополнения, после протокол внедрен в ежедневную практику. Проанализировано качество работы отделения за период применения данного протокола. Критерием качества интенсивного ухода было: частота пролежней; частота инфекционных осложнений, вызванных катетерами; частота внутрибольничных инфекций; частота вентилятор-ассоциированных пневмоний; количество жалоб со стороны врачей на качество работы медицинских сестер. С целью определения степени удовлетворенности пациентов было проведено анкетирование 50 пациентов.

Результаты. По результатам оценки периодов применения протокола, несмотря на увеличение количества тяжелых пациентов, снизилось количество внутрибольничных инфекционных и катетер-ассоциированных инфекций и пролежней. Пневмония, связанная с аппаратом искусственного дыхания снизилась с 0,54 до 0,26%. Жалобы на качество работы медицинских сестер было меньше. Всего 90% опрошенных пациентов остались полностью удовлетворены качеством оказываемых медицинских услуг в отделении анестезиологии-реанимации и интенсивной терапии.

Выводы. Разработка и внедрение протокола сестринского ухода является одним из важнейших этапов улучшения результатов лечения и повышения качества медицинской помощи. Представленный протокол интенсивного сестринского ухода является одним из эффективных инструментов, направленных на улучшение результатов лечения пациентов в отделении анестезиологии-реанимации и интенсивной терапии.

Ключевые слова: протокол интенсивного сестринского ухода, качество медицинской помощи, интенсивная терапия.

Improving the quality of medical care through the development and implementation of an intensive nursing care protocol in the practice of the department of anesthesiology, resuscitation and intensive care

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Abstract

Objective. To improve the quality and safety of medical services by developing an intensive nursing care protocol and implementing it in the practice of anesthesiology, resuscitation, and intensive care units.

Methods. The process of developing and implementing the protocol consisted of the following stages: the protocol was designed taking into account the procedures performed and the specifics of intensive care. The developed protocol was discussed, necessary changes and additions were made, and it was integrated into daily practice. The quality of the department's work during the period of protocol application was analyzed. The criteria for the quality of intensive care included: the incidence of pressure ulcers, the frequency of catheter-related infectious complications, the rate of hospital-acquired infections, the rate of ventilator-associated pneumonia, and the number of complaints from physicians regarding the quality of nurses' work. To assess patient satisfaction, a survey of 50 patients was conducted.

Results. Based on the evaluation of the periods during which the protocol was applied, despite an increase in the number of critically ill patients, there was a reduction in hospital-acquired infections, catheter-associated infections, and pressure ulcers. Ventilator-associated pneumonia decreased from 0.54% to 0.26%. Complaints about the quality of nurses' work decreased. 90% of the surveyed patients were fully satisfied with the quality of medical services provided in the anesthesiology, resuscitation, and intensive care unit.

Conclusion. The development and implementation of a nursing care protocol is one of the most important steps in improving treatment outcomes and enhancing the quality of medical care. The presented intensive nursing care protocol is an effective tool aimed at improving patient outcomes in the anesthesiology, resuscitation, and intensive care unit.

Keywords: intensive nursing care protocol, quality of medical care, intensive care.

Enhancing online learning experiences: A cross-sectional study on medical students engagement and challenges

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Abstract

Background. Digital learning tools have become integral to higher education, offering students enhanced accessibility, flexibility, and engagement. However, their effectiveness depends on usability, reliability, and alignment with academic needs. Limited research has explored students' experiences with these tools across diverse educational systems. This study examines the frequency of use, perceived benefits, and challenges of digital learning tools among university and college students in multiple countries.

Methods. A cross-sectional survey was conducted among 103 Kazakhstan, Russia, South Korea, Turkey, Germany, the USA, and Canada medical students. A structured questionnaire assessed demographic characteristics, usage patterns, and perceptions of digital learning tools. Responses were measured using a fivepoint Likert scale, and statistical analyses, including correlation analysis, were performed to identify key factors influencing student satisfaction and engagement.

Results. The study revealed a high engagement rate with digital learning tools, with 73.1% of students frequently utilizing online resources. Despite this, students reported significant challenges: 57.2% struggled to find reliable information, 62.8% questioned content accuracy, and 71.5% found tools lacking interactivity. Correlation analysis indicated that perceived reliability and usability strongly influenced student satisfaction and motivation.

Conclusions. Findings highlight the need for improvements in digital learning tools to enhance accuracy, engagement, and personalization. Addressing these challenges can optimize student learning experiences and contribute to more effective, student-centered educational strategies. Future research should explore interventions that enhance content credibility and interactive learning features.

Keywords: Digital learning tools; student engagement; online education; higher education; usability; content reliability.

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Introduction

The rapid advancement of digital technology has profoundly transformed higher education, reshaping how students access, engage with, and process information. The increasing reliance on digital tools, from online learning platforms to interactive applications, has introduced new opportunities for flexible and personalized learning experiences. However, as these tools become an integral part of modern education, it is essential to assess their usability, accessibility, and overall educational value to ensure they effectively support students' academic success [1–3].

Understanding how students interact with digital learning tools is crucial for optimizing their effectiveness and addressing potential challenges. Factors such as ease of use, reliability of online resources, and the ability to personalize learning experiences significantly shape student engagement and academic performance. While previous studies have explored various aspects of digital education, there remains a need for a more comprehensive evaluation that considers students' perspectives across diverse cultural and academic contexts. Educational experiences vary by

region and institution, making cross-national analyses useful for identifying universal and specific trends [4,5].

Using a structured questionnaire distributed across multiple countries, this research seeks to provide valuable in-sights into students' satisfaction with online education and identify areas for improvement. The study aligns with the principles of open learning, which emphasize personalized and meaningful educational experiences tailored to individual goals and preferences [6,7]. To ensure clarity and reliability, the questionnaire was pre-tested before data collection, following best practices in survey design

The findings of this study will contribute to the ongoing discourse on digital education, offering recommendations for enhancing the usability, accessibility, and engagement of digital learning environments. Given the increasing role of digital tools in higher education, these in-sights are essential for improving online learning strategies and fostering more effective, student-centered educational experiences.

Materials and Methods

Study Setting, Period, and Design

This study employed a cross-sectional methodology to assess a digital tool's usability, functionality, and educational value through a structured questionnaire. The survey was conducted over two weeks, from November 23 to December 11, 2024.

Participants

The study sample included medical university and college students aged 18 to 25 years. A total of 103 respondents participated in the survey. Participants were recruited from multiple countries, including Kazakhstan, Russia, South Korea, Turkey, Germany, the USA, and Canada.

Data Collection Tools

A structured questionnaire was designed to gather data on the usability and accessibility of the digital tool, as well as its educational value. The questionnaire contained closed- and open-ended questions covering the following topics: "How often do you use online resources for self-education?" "Do educational platforms meet your individual needs and preferences?". "Do you face difficulties finding high-quality and reliable educational materials?". "What challenges do you encounter in self-learning?". "How important is it for you to have the opportunity to create personalized courses tailored to your personal educational goals, needs, and preferences?"

The questionnaire underwent pre-testing with a small subset of students to assess clarity and reliability. Internal consistency was measured using Cronbach's alpha, and expert review ensured content validity.

Results

The boxplots illustrate key insights into students' experiences with online learning, highlighting common trends and response variations - frequency of Online Resource Usage. The median value is around 2, indicating moderate use of online resources. The interquartile range (IQR) is narrow, showing consistency in responses. Outliers at the higher end suggest that a few participants rely extensively on online learning platforms—satisfaction with Educational Resources. The median response is close to 2, indicating moderate satisfaction. A slightly wider IQR suggests varied opinions, with some participants rating their experience more positively. A few outliers reflect

Sample Size Determination

The study included a convenience sample of 103 participants. Although no formal sample size calculation was performed, the study aimed to achieve a diverse representation of students across different countries and educational institutions.

Data Collection and Procedures

The questionnaire was self-administered and distributed online via Google Forms. Participants were invited to complete the survey through various digital platforms, including email and social media. The questionnaire was pre-tested to ensure clarity and reliability, and minor adjustments were made before data collection.

Statistical Analysis

Data were analyzed using SPSS software version 27.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics, including frequencies, proportions, means, and standard deviations, were calculated to summarize digital learning tools' demographic characteristics and usage patterns. Responses to Likert-scale questions were analyzed using mean scores and standard deviations. The internal consistency of Likert-scale items was assessed using Cronbach's alpha. Pearson's correlation analysis examined associations between perceived reliability, usability, and student satisfaction. Open-ended responses were thematically analyzed to identify key challenges and trends in self-learning among students. A p-value of <0.05 was considered statistically significant for all analyses.

higher satisfaction levels and difficulties in finding reliable information. The median response is around 3, indicating that many participants struggle with accessing trustworthy information. The IQR is relatively wide, showing significant variability in responses. Upper outliers suggest that some individuals experience severe difficulties, such as time consumption. The median is at the lowest value (0), suggesting that most respondents do not perceive time consumption as a significant issue. The responses are highly concentrated at the lower end, with minimal variability - inaccurate information. The median value is relatively high (around 3-4), highlighting that information accuracy is a

significant concern. The IQR is wide, indicating differing perceptions of inaccuracy. Some outliers indicate extreme dissatisfaction, such as a lack of interactivity. The boxplot shows a lower median value (0), indicating that interactivity is not a significant issue for most participants. Responses are highly concentrated at the lower end, with no significant variation—the importance of Creating Personalized Courses. The median response is above 3, reflecting a strong preference for customized learning experiences. A wider IQR suggests that most participants recognize the value of

personalized courses—loss of Motivation. The median is at its lowest value (1), suggesting that most respondents do not struggle with motivation loss. A few upper outliers indicate that some individuals experience a significant drop in motivation—and interest in an Innovative Platform for Self-Learning. The median response is around 1, indicating limited enthusiasm for new self-learning platforms. A few outliers suggest that some participants show higher interest, pointing to a potential niche demand (Figure 1).

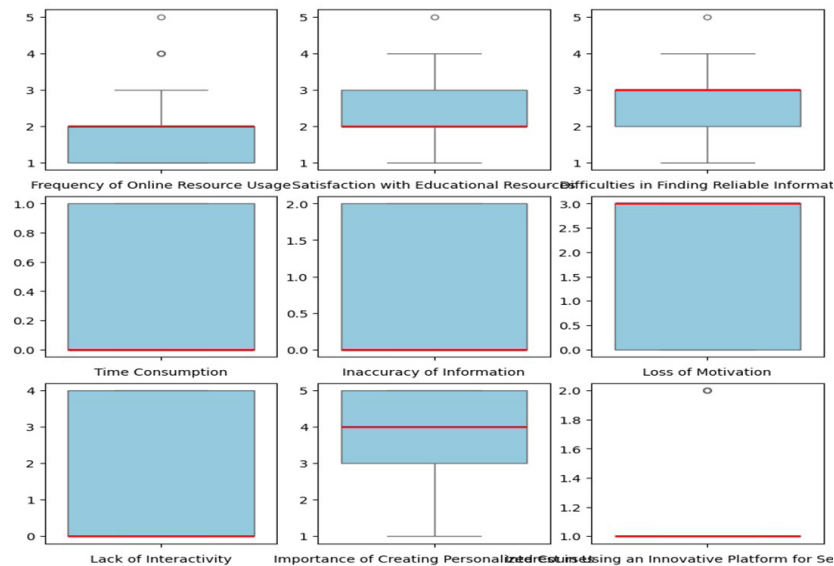


Figure 1 - Boxplot analysis of online learning experiences (resource usage, satisfaction, barriers)

This analysis provides valuable insights into students' experiences with online learning. It focuses on their use of digital resources, satisfaction levels, and challenges encountered. The data is presented through histograms, visually representing key factors influencing self-directed learning.

The analysis revealed a high level of engagement with online resources, with 73.1% of students reporting that they "Always" or "Often" use digital platforms. In contrast, only a tiny proportion reported infrequent or no usage. Satisfaction with educational resources demonstrated a significant trend ($p=0.021$), with 69.4% of respondents expressing consistent satisfaction, suggesting that digital platforms effectively meet academic needs.

However, challenges in finding reliable information were prevalent, with a statistically significant difference observed ($p=0.036$); 57.2% of students reported experiencing difficulties "Often" or "Sometimes." Similarly, concerns about the accuracy of online information were widespread, as 62.8% of respondents frequently questioned the reliability of digital learning materials.

A notable finding related to self-learning motivation ($p=0.041$), with 58.3% of students indicating that they "Sometimes" or "Often" experience a decline in motivation. Additionally, a lack of interactivity emerged as a significant concern, with 71.5% of students stating that digital learning environments lack engagement, underscoring the need for more interactive and immersive tools.

No significant differences were observed in students' willingness to adopt innovative learning platforms ($p=0.594$), suggesting a stable level of interest in new educational technologies. Similarly, while the importance of

personalized courses was widely acknowledged ($p=0.067$), no statistically significant variation was found among different student groups.

Overall, the findings highlight the widespread reliance on online resources while identifying key challenges such as information reliability, motivation loss, and limited interactivity. Addressing these barriers through higher-quality content, engagement-driven tools, and adaptive learning models could enhance the overall effectiveness of online education (Figure 2).

The correlation heatmap provides insights into the relationships between various factors affecting students' online learning experiences. Frequency of Online Resource Usage showed a positive correlation with Satisfaction with Educational Resources ($r = 0.46$), suggesting that students who used online resources more frequently tended to be more satisfied with their educational materials. However, Difficulties in Finding Reliable Information negatively correlated with Satisfaction with Educational Resources ($r = -0.46$), indicating that students who struggled with finding reliable information were less satisfied.

Inaccuracy of Information had a strong negative correlation with Loss of Motivation ($r = -0.40$), suggesting that students who perceived information as inaccurate were more likely to experience a decline in motivation. Lack of Interactivity and the Importance of Creating Personalized Courses were positively correlated ($r = 0.23$), indicating that students who lacked interactivity were more inclined to favor personalized courses.

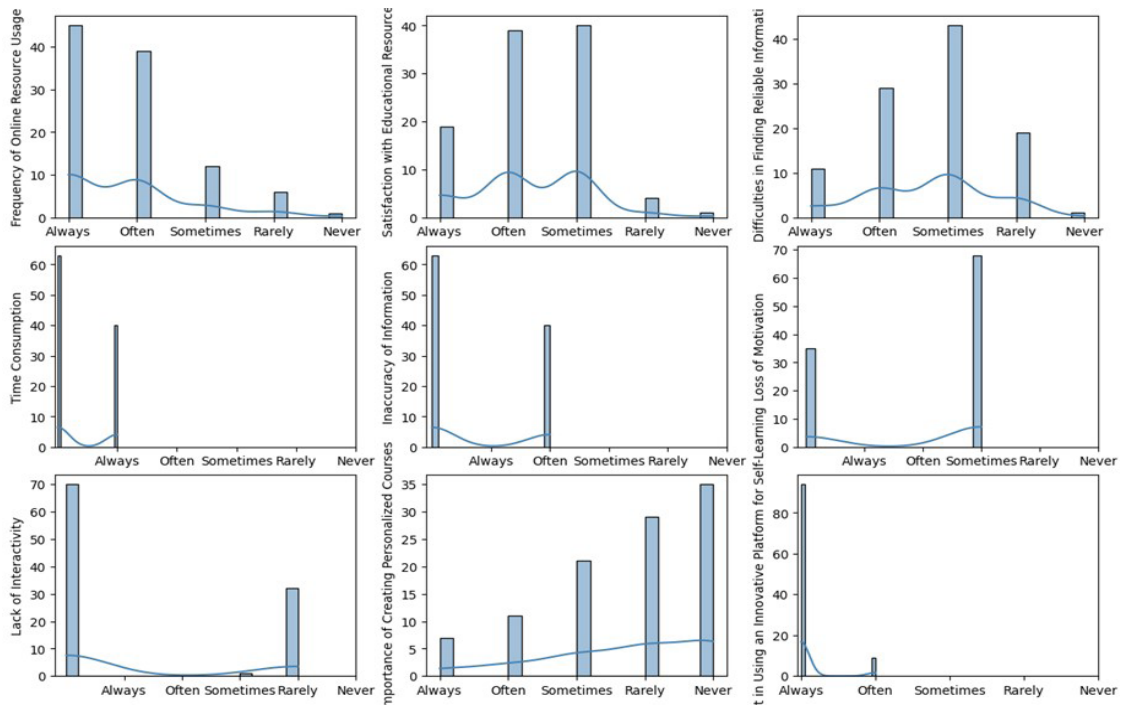


Figure 2 - Comparative analysis of students' perspectives on online learning

Interest in Using an Innovative Platform for Self-Learning was negatively correlated with the Importance of Creating Personalized Courses ($r = -0.27$), implying that students who valued personalized learning experiences were less interested in using innovative self-learning platforms. Time Consumption did not correlate strongly with other variables, suggesting that it was not a significant

barrier to online learning.

These findings highlight the importance of addressing information accuracy, interactivity, and personalized learning options to enhance students' online learning experiences (figure 3).

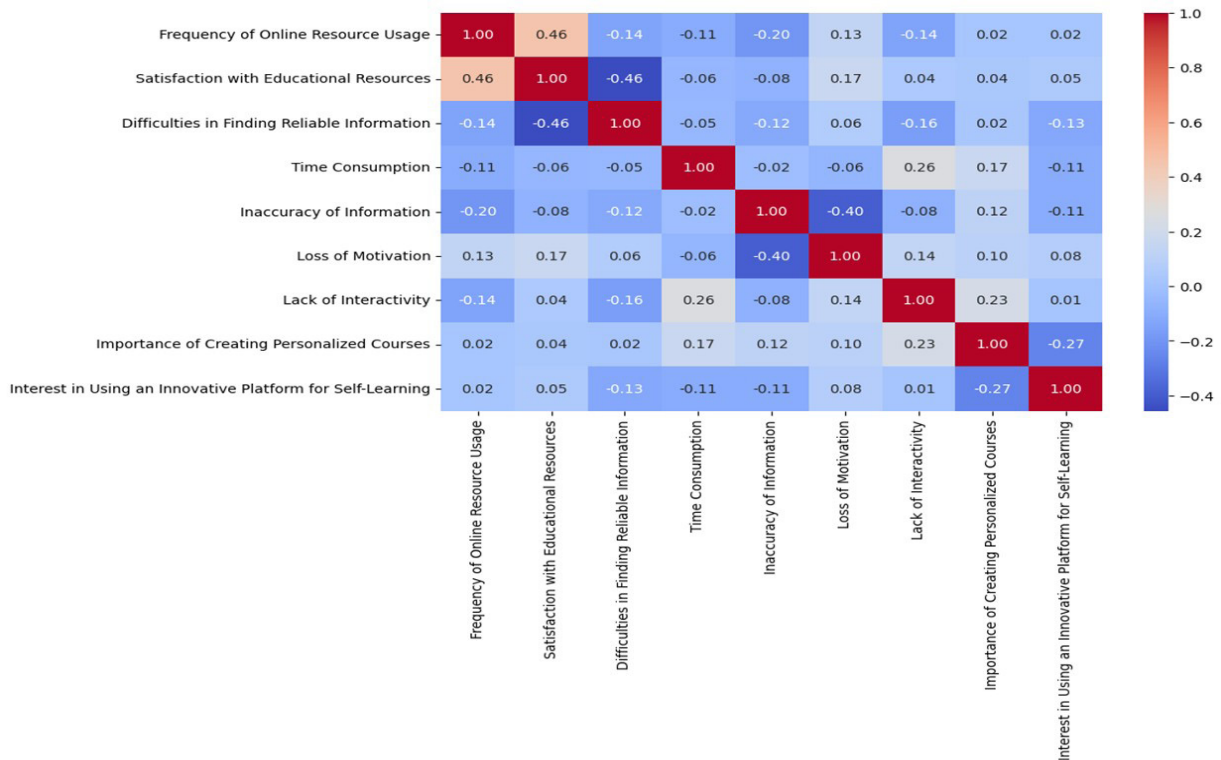


Figure 3 - Correlation heatmap of factors influencing online learning outcomes

Discussion

The findings of this study provide valuable insights into students' experiences with online learning, highlighting

both the benefits and challenges associated with digital education. The results indicate a high level of engagement

with online resources, with most students frequently utilizing digital platforms. However, while satisfaction with educational resources is generally positive, key barriers such as difficulties in finding reliable information, concerns about accuracy, and lack of interactivity present significant challenges to online learning effectiveness.

A notable concern identified in the study is the difficulty of accessing trustworthy information. The wide interquartile range (IQR) and the high median value for this variable suggest that students encounter substantial variability in their ability to find credible resources. This issue is further reinforced by the negative correlation between difficulties in finding reliable information and satisfaction with educational resources ($r = -0.46$). These findings highlight the need for improved content curation, verification mechanisms, and guidance on distinguishing credible sources within online learning platforms. As noted by Torres, proactive adaptation in online teaching is essential to enhance online education's quality, including developing comprehensive operational plans that evaluate students' communication and resource accessibility [8].

Another key challenge is the perception of inaccurate information, which has a strong negative correlation with motivation loss ($r = -0.40$). Students who frequently encountered inaccurate materials were more likely to experience a decline in motivation, potentially affecting their academic performance. Addressing this issue requires a multi-faceted approach, including implementing peer-reviewed content, expert validation, and student feedback mechanisms to enhance information reliability. Research by McKenna et al. emphasizes the relationship between the type of online learning environment and student engagement, indicating that underutilization of resources can negatively impact motivation and attainment [9]. Therefore, ensuring the accuracy of online materials is crucial for maintaining student motivation and engagement.

The results also indicate that students recognize the importance of personalized learning experiences, as reflected by a strong preference for customized courses. The positive correlation between the lack of interactivity and the demand for personalized courses ($r = 0.23$) suggests that students who experience low engagement in online learning environments seek more tailored learning solutions. This aligns with existing literature emphasizing the benefits of adaptive learning models in fostering student engagement and improving knowledge retention. Lawrence et al. and Quigley et al. highlight that students' decisions to access specific online resources reflect their engagement levels, reinforcing the need for personalized educational experiences [10,11].

Interestingly, while students acknowledge the value of innovative self-learning platforms, the median

Conclusion

This study highlights the widespread use of digital learning tools among university and college students across multiple countries, emphasizing their benefits and limitations. While 73.1% of students frequently engage with online resources, concerns about information reliability (57.2%), content accuracy (62.8%), and interactivity (71.5%) persist. Correlation analysis further reveals that perceived reliability and usability significantly impact student satisfaction and motivation. Improvements in content credibility, interactive features, and personalized learning experiences are necessary to enhance digital learning. Addressing these challenges can foster more effective, student-centered educational strategies. Future

research should explore innovative solutions, such as adaptive learning models and AI-driven content verification, to optimize the online learning experience.

response suggests limited enthusiasm for adopting new technologies. The lack of significant response variation ($p = 0.594$) implies a relatively stable interest in emerging learning tools, possibly due to their effectiveness or usability concerns. Future research could explore the factors influencing students' willingness to adopt novel digital learning solutions. As noted by Davis et al., engaging students as co-designers in developing online resources can enhance usability and effectiveness, addressing their needs and preferences more effectively [12].

Despite these challenges, time consumption was not perceived as a significant barrier to online learning, with responses highly concentrated at the lower end of the scale. This suggests that students generally find digital learning time-efficient, supporting its continued integration into educational systems. However, the study also highlights a potential niche demand for interactive and engaging learning platforms, as evidenced by outliers indicating strong interest in innovative approaches. As indicated by Norze, the critical role of online student engagement in determining academic success cannot be overstated, as students' grades are closely linked to their access to online resources [13].

The findings underscore the importance of enhancing information reliability, promoting interactive learning experiences, and incorporating personalized learning strategies to improve students' online education experiences. Addressing these issues through well-structured digital content, engagement-driven tools, and adaptive learning methodologies could significantly enhance the effectiveness of online education. Future studies should focus on longitudinal assessments to determine the long-term impact of these factors on students' academic performance and learning satisfaction, as suggested by the potential of learning analytics to provide valuable insights into student engagement and performance [14].

Limitations of the Study

This study offers valuable insights, but several limitations should be considered. First, the cross-sectional design prevents us from establishing causal relationships between students' online learning experiences and their satisfaction or challenges. Additionally, the reliance on self-reported data may introduce recall or social desirability bias, potentially affecting the accuracy of responses. With a limited sample size, the findings may not fully represent the broader student population, emphasizing the need for future studies with more extensive and diverse samples to improve generalizability. Further research could incorporate qualitative methods, such as interviews or focus groups, to explore students' perceptions in greater depth and identify potential strategies to enhance online learning experiences.

research should explore innovative solutions, such as adaptive learning models and AI-driven content verification, to optimize the online learning experience.

Authorship contribution. V. K.: Writing – review & editing, Writing – original draft, Validation, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. O.T.: Writing – review & editing, Supervision, Project administration, Methodology, Conceptualization. A.M.: Writing – review & editing, Supervision, Formal analysis. A.M.: Writing – review & editing, Supervision, Formal analysis. O.T.: Writing – original draft, Formal analysis.

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Онлайн оқыту тәжірибесін жақсарту: Медициналық оқу орны студенттерін тарту және пайда болатын мәселелердің көлденең зерттеуі

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Түйіндеме

Цифрлық білім беру құралдары жоғары білім берудің ажырамас бөлігіне айналды. Студенттерге қолжетімділікті, икемділікті және тартылуды арттырады. Дегенмен, олардың тиімділігі пайдаланудың қарапайымдылығына, сенімділігіне және академиялық қажеттіліктерге сәйкестігіне байланысты. Бұл құралдарды әртүрлі білім беру жүйелерінде қолдану тәжірибесіне арналған зерттеулер саны шектеулі. Бұл зерттеу университеттер мен колледждердің студенттері арасында сандық білім беру құралдарын пайдалану жиілігін, қабылданған артықшылықтарды және туындаған мәселелерді зерттейді.

Әдістері. Қазақстан, Ресей, Оңтүстік Корея, Түркия, Германия, АҚШ және Канададан 103 медик-студент арасында көлденең сауалнама жүргізілді. Құрылымдық сауалнама демографиялық сипаттамаларды, үлгілерді пайдалану және сандық білім беру құралдарын қабылдауды бағалауға мүмкіндік берді. Жауаптар Лайкерттің бес баллдық шкаласы бойынша өлшенді, сондай-ақ студенттердің қанағаттануына және тартылуына әсер ететін негізгі факторларды анықтау үшін корреляциялық талдау

жүргізілді.

Нәтижелер. Зерттеу жоғары деңгейдегі қатысуды анықтады: студенттердің 73,1% онлайн ресурстарды үнемі пайдаланады. Осыған қарамастан, студенттер айтарлықтай мәселелерді атап өтті: 57,2% сенімді ақпаратты табуда қиындықтарға тап болды, 62,8% ұсынылған мазмұнның дәлдігіне күмән келтірді, ал 71,5% құралдарды жеткілікті интерактивті емес деп санады. Корреляциялық талдау қабылданған сенімділік пен пайдалану қарапайымдылығы студенттердің қанағаттануына және уәждемесіне айтарлықтай әсер ететінін көрсетті.

Қорытынды. Алынған нәтижелер студенттерді тарту және жекелендірудің дәлдігін арттыру үшін сандық білім беру құралдарын жетілдіру қажеттілігін көрсетеді. Табылған мәселелерді шешу студенттердің білім беру тәжірибесін оңтайландырып, студентке бағытталған тиімдірек білім беру стратегияларын әзірлеуге ықпал етуі мүмкін. Бұдан әрі мазмұнның сенімділігін және оқытудың интерактивтілігін арттыру шараларын енгізуге бағытталған зерттеулер жүргізу қажет.

Түйін сөздер: цифрлық білім беру құралдары, студенттердің қатысуы, онлайн білім, жоғары білім, пайдаланудың қарапайымдылығы, мазмұнның сенімділігі.

Повышение качества онлайн-обучения: Поперечное исследование вовлеченности студентов-медиков и возникающих трудностей

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Резюме

Цифровые образовательные инструменты стали неотъемлемой частью высшего образования, обеспечивая студентам широкий доступ к учебным материалам, гибкость и вовлеченность. Однако их эффективность зависит от удобства использования, надежности и соответствия академическим потребностям. Ограниченное количество исследований посвящено изучению опыта студентов в применении данных инструментов в различных образовательных системах. Данное исследование анализирует частоту использования, воспринимаемые преимущества и сложности, с которыми сталкиваются обучающиеся университетов и колледжей в некоторых странах.

Методы. Было проведено поперечное исследование среди 103 студентов-медиков из Казахстана, России, Южной Кореи, Турции, Германии, США и Канады. Структурированная анкета включала вопросы о демографических характеристиках, паттернах использования и восприятии цифровых образовательных инструментов. Ответы оценивались по пятибалльной шкале Ликерта. Для выявления ключевых факторов, влияющих на удовлетворенность и вовлеченность студентов, использовался корреляционный анализ.

Результаты исследования показали высокий уровень вовлеченности обучающихся в использование цифровых образовательных инструментов, 73,1% респондентов регулярно обращаются к онлайн-ресурсам. Однако были выявлены значительные трудности: 57,2% студентов испытывают сложности с поиском достоверной информации, 62,8% сомневаются в точности представленного контента, а 71,5% отмечают недостаточную интерактивность инструментов. Корреляционный анализ показал, что восприятие надежности и удобства использования существенно влияет на удовлетворенность и мотивацию студентов.

Выводы. Полученные данные подчеркивают необходимость совершенствования цифровых образовательных инструментов с целью повышения точности, интерактивности и персонализации. Устранение выявленных проблем может способствовать оптимизации образовательного процесса и развитию более эффективных, ориентированных на студентов, образовательных стратегий. Будущие исследования должны быть направлены на изучение методов повышения достоверности контента и улучшения интерактивных функций обучения.

Ключевые слова: цифровые образовательные инструменты, вовлеченность студентов, онлайн-образование, высшее образование, удобство использования, достоверность контента.

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Original article

Isolation of new strains of Agaricales and medicinal fungi distributed in Burabay and Kokshetau national parks

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Abstract

In Kazakhstan, agaric mushrooms remain an understudied group despite their ecological and nutritional significance. This study is the first to investigate the species composition of edible agaric mushrooms in the Burabay and Kokshetau National Parks, their morphometric characteristics, and the creation of a strain collection.

The purpose of this research: to determine the species diversity of edible agaric mushrooms, analyze their morphometric characteristics, and establish a strain collection by isolating new samples for further biological studies and potential applications.

Methods. Macromycetes were collected using a route method, sorted, dried (45–50°C, 30–40 min), and stored. Morphological characteristics were examined visually, and microscopic structures were analyzed using a Mikmed-1 microscope and cameras. Young specimens were cultivated on nutrient media (Czapek-Dox, Murashige-Skoog, potato-glucose agar) for strain isolation and further study.

Results. Over 80 mushroom samples were collected, identifying 71 species from two classes (Basidiomycetes and Ascomycetes), four orders (Aphyllphorales, Agaricales, Lycoperdales, Pezizales), 11 families, and 26 genera. The isolated strains hold potential for further ecological research and artificial cultivation.

Conclusion. The current sample size is limited. Further collection and analysis using additional methods are planned to refine knowledge of agaric mushroom diversity in Kazakhstan.

Keywords: mushroom, macromycetes, strains, cap, stipe, spore, agaric mushrooms.

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Introduction

In Kazakhstan, agaric fungi remain an understudied group of macrofungi despite their significant ecological role and nutritional value. Systematic studies of their species diversity in the country's national parks have been conducted only rarely. Edible agaric fungi play an important role in forest ecosystems by participating in the decomposition of organic matter and forming symbiotic relationships that contribute to nutrient cycling and soil structure improvement. Furthermore, many species have economic significance due to their nutritional and potential medicinal properties [1].

Until now, comprehensive studies of edible agaric fungi in Kazakhstan's national parks have not been conducted. This study is the first to focus on identifying the species composition of edible agaric fungi growing in the Burabay and Kokshetau National Parks, their morphometric characteristics, and the creation of a strain collection for further research and possible practical applications. The aim of this study is to determine the species diversity of edible agaric fungi, provide their morphometric characterization, and isolate new strains for the creation of a collection. This will allow for the study of their biological characteristics and potential applications in biotechnology, agriculture, and medicine [2].

Mushrooms are a highly valuable food product. They are rich in proteins, various vitamins essential for the human body, and trace elements such as iron, calcium, zinc, iodine, potassium, and phosphorus. Due to their nutritional properties, mushrooms are considered a gerontological product. They do not contain harmful substances such as cholesterol, nitrates, or nitrites. Currently, mushrooms are consumed fried, boiled, salted, pickled, as well as in the form of powder, paste, and as a seasoning for various dishes. The protein content in mushrooms, in terms of dry matter, ranges from 21% to 30%, which is significantly higher than that of meat or wheat. One hectare of land can yield 110 tons of mushrooms containing approximately 330 kg of protein. For comparison, one hectare of land can produce 30 tons of potatoes with only 3 kg of protein and an average of 3 tons of grain crops containing only 5 kg of protein [3].

The Burabay State National Nature Park, under the jurisdiction of the Administration of the President of the Republic of Kazakhstan, was established on August 12, 2000. The total area of the park is 129,299 hectares, of which 47.4 thousand hectares are covered by forests. Water bodies occupy 8,493.5 hectares. The flora of the park includes 754 plant species, while the fauna comprises 469 animal species. The national park encompasses the Burabay mountain-forest massif, located in the eastern part of the Kokshetau Upland in the northwestern part of the Kazakh Uplands (Saryarka). The park includes eutrophic lakes such as Burabay, Zerendi, Ulken and Kishi Shabakty, and Shchuchye. The lakes in this region mainly contain

Materials and methods

The object of the study is cap fungi in the Burabay State National Natural Park (SNNP) in the Akmola region, including edible mushrooms, as well as the creation of a valuable strain collection from natural populations. During the expedition, the territories of the Burabay and Kokshetau State National Natural Parks were studied from July 15 to July 28.

A total of three groups of mycologists and algologists participated in the comprehensive expedition:

- Scientists from L.N. Gumilyov Eurasian National

freshwater. Additionally, the park features small rivers and streams. The Burabay forest massif has preserved coniferous and mixed deciduous forests dating back to the Pleistocene epoch [1-3].

Currently, the national park is a state organization and is part of the system of specially protected natural areas of republican significance. The Burabay State National Nature Park consists of seven forest management units: Akylbai, Burabay, Katar-Kol, Zolotobor, Barmash, Mirnoye, and Priozornoye. The park also includes facilities that support operational activities. The entire park is divided into 15 economic units and 56 protected zones. The climate of the region where the national park is located is continental, with cold, long winters and short, hot summers. The average temperature in January is -16.7°C , while in July, it is $+18.6^{\circ}\text{C}$ [4].

The national park has preserved relict plant and animal species characteristic of northern Kazakhstan. The park contains 757 plant species, 95 of which are rare or endangered. Among them are the large-flowered lady's slipper orchid, black alder, reindeer lichens, Fuchs' sedge, and others. The dominant tree species in the forested areas is pine, while aspen, willow, honeysuckle, spirea, wild rose, hawthorn, black currant, and other species are also present. Relict species include ferns, horsetails, clubmosses, sedges, cranberries, and other plants. The flora of the park also includes medicinal, edible, and ornamental plant species. Some small lakes have preserved relict peat bogs [5].

The fauna of the national park is also diverse, with 305 species of vertebrates, 87 of which are rare. The park is home to noble deer and their hybrids from the Askania-Nova reserve. Lynxes, ermines, white-backed woodpeckers, and forest martens inhabit the forests. The park's water bodies host six species of fish, three species of amphibians, six species of reptiles, and more than 200 bird species, including those listed in Kazakhstan's Red Book, such as the white-tailed eagle, black kite, and Eurasian eagle-owl. The invertebrate fauna is not fully studied, but protected insect species such as the beautiful horsefly, Serville's grasshopper, steppe scolia wasp, and carmine Polish beetle can be found in the park [6].

Local residents and tourists admire the picturesque natural landscapes of the park, often referring to it as the "Kazakh Switzerland." As a result of weathering and wind erosion, unique rock formations have been shaped here, including "Okzhetpes," "Sleeping Warrior," "Eagle," "Camel," "Kudyr," and "Sphinx" [6].

The objective of the study is to determine the species composition of edible agaric fungi identified in the Burabay and Kokshetau State National Natural Parks (SNNP), provide a morphometric description, and create a strain collection by obtaining new strains.

University (M.A. Ashikbayeva, S. Abiev, R.Z. Asylkhanova).

- Scientists from the Institute of Botany and Phytointroduction of the Ministry of Education and Science (two mycologists and two algologists).

All seven forest districts of the national park were studied: Akylbay, Burabay, Katar-Kol, Zolotobor, Barmashyn, Mirny, and Priozerny. The weather conditions were highly favorable for the mass emergence of macromycetes.

Macromycetes were collected using the route method during an expedition to the Burabay and Kokshetau

SNNP. The collection, sorting, drying, packaging, and transportation of the gathered material were carried out in accordance with mycological and botanical methodologies. For disinfection, the collected samples were dried and heated in a hot-air oven at a temperature of 45–50°C for 30–40 minutes. Each processed specimen was stored in a specially designed box, labeled with the date, location, time of collection, and herbarium number.

The external morphological characteristics of the fungal fruiting bodies were determined through visual observation. The microscopic structure and spore characteristics were analyzed using a Mikmed-1 microscope, along with Exilim-S880, SAMSUNG-ES65, and Canon-PC1474 cameras for documentation. For tissue isolation from the fruiting bodies, only fresh, nutrient-rich, and non-darkened specimens were used. Pre-cleaned fruiting bodies were cut into cube-shaped or triangular pyramid-shaped

tissue samples using a scalpel. These tissue samples were then inoculated onto a nutrient medium (slant agar) using an inoculation needle. The isolation process was conducted on different parts of the fruiting body: the cap, the stipe, and the transition zone between the cap and the stipe.

The growth and development of the isolated pure culture depended on the composition of the nutrient medium. Various nutrient media were used, including Czapek-Dox, Murashige-Skoog, and potato-glucose agar [7–9].

During the expedition, more than 130 mushroom samples were collected. Morphometric analysis of these collected fungi revealed 71 species of cap fungi, classified into two classes (Basidiomycetes and Ascomycetes), four orders (Aphyllorphales, Agaricales, Lycoperdales, Pezizales), 11 families, and 26 genera (Table 1).

Results

Macromycetes belonging to one family (Polyporaceae), four genera, and six species from the order Aphyllorphales were identified. The edibility of one species

(*Coriolus zonatus*) remains unknown, while the remaining species are edible.

Table 1 – Fungal Species Identified in Burabay and Kokshetau SNNP

Nº	Latin Name of the Fungus	Herbarium No.	Edibility
Order: Aphyllorphales			
Family: Polyporaceae			
1.	<i>Coriolus vericolor</i> (Fr.) Quel.	19	Edibility unknown
	<i>Coriolus zonatus</i> (Fr.) Quel	28	Edibility unknown
2.	(<i>Trametes</i>) <i>Hizschioporus pergamentus</i> Fr.	38	Inedible
3.	<i>Fomitopsis rosea</i> (Fr.) Karst.	51	Inedible
4.	<i>Fomitopsis penicola</i> (Sw.ex. Fr.), Karst.	71	Inedible
5.	<i>Fomes fomentarius</i> Fr.	65	Inedible
Order: Agaricales			
Family: Agaricaceae			
1.	<i>Agaricus arvensis</i> Schaeff.ex. Secr.	1	Edible
2.	<i>Agaricus bisporus</i> Lange	3	Edible
3.	<i>Agaricus silvaticus</i> Schaeff.ex. Secr.	8	Edible
4.	<i>Agaricus silvicolus</i> (Vitt.) Sacc., Syll.	2	Edible
5.	<i>Lepiota alba</i> (Bres.) Sacc.	14	Edible
6.	<i>Macrolepiota campestris</i> Samg.	72	Edibility unknown
Family: Russulaceae			
1.	<i>Russula aeruginea</i> Lindbl.	37	Edible
2.	<i>Russula flava</i> Rom. in Lonnegren.	55	Edible
3.	<i>Russula integra</i> (Fr.) Epicr.	21	Edible
4.	<i>Russula rosacea</i> (Fr.) Epicr.	4	Edible
5.	<i>Russula pulchella</i> Borszczow	35	Edible
6.	<i>Russula sardonica</i> (Fr.) Epicr.	24	Edible
7.	<i>Russula verescens</i> (Schaeff. ex Zanedschi) Fr.	12	Edible
8.	<i>Russula xerampelina</i> (Schaeff. ex Secr.)	5	Edible
9.	<i>Lactarius necator</i> (Fr.) Karst.	49	Edible
10.	<i>Lactarius scrobiculatus</i> (Fr.) Epicr.	31	Edible
11.	<i>Lactarius trivialis</i> (Fr.) Epicr.	41	Edible
Family: Tricholomataceae			
1	<i>Armiliariella mellea</i> (Fr.) Karst.	53	Edible
2	<i>Clitocybe gibba</i> (Fr.) Kumm.	6	Edible
3	<i>Clitocybe gilva</i> (Fr.) Kumm.	50	Edibility unknown
4	<i>Clitocybe inversa</i> (Fr.), Quel.	13	Edible

Table 1 (Continuation) – Fungal Species Identified in Burabay and Kokshetau SNNP

5	<i>Clitocybe odora</i> (Fr.), Kumm.	10	Edible
6	<i>Clitocybe vibecina</i> (Fr.), Quel.	58	Edible
7	<i>Marasmius oreades</i> (Fr.) Epicr.	36	Edible
8	<i>Mycena poliadelpha</i> (Lasch.), Kuhner.	60	Edibility unknown
9	<i>Omphalina ericetorum</i> (Fr.), M. Lge.	7	Inedible
Family: Strophariaceae			
1	<i>Hhypholoma sullaterium</i> (Fr.) Quel., Champ., Jura Vosg.	54	Poisonous
2	<i>Pholiota squarrosa</i> (Fr.) Kumm.	16	Edible
Family : Comphidaceae			
1	<i>Chroogomphus rutilus</i> (Fr.), O. K. Miller, Canad., J. Bot.	69	Edible
Family: Amanitaceae			
1	<i>Amanita fulva</i> (Schaeff. Ex Pers.) Fr.	20	Edible
2	<i>Amanita muscaria</i> (Fr.) Hook.	17	Inedible
3	<i>Pluteus pellitus</i> (Fr.) Kumm.	42	Edible
Family: Boletaceae			
1	<i>Leccinum scabrum</i> (Fr.) S.F. Gray	40	Edible
2	<i>Suillus granulatus</i> (Fr.) Kuntze	39	Edible
3	<i>Suillus luteus</i> (Fr.) S.F.Gray	18	Edible
Family: Cortinariaceae			
1	<i>Cortinarius cinnamomeoluteus</i> P. D. Orton	27	Inedible
2	<i>Cortinarius mucosus</i> (Fr.), Kickx.	46	Edible
3	<i>Cortinarius varius</i> (Fr.), Fr., Epicr.	9	Edibility unknown
4	<i>Hebeloma mesophaeum</i> (Fr.) Quel.	45	Inedible
5	<i>Hebeloma strophosum</i> (Fr.) Sacc.	29	Inedible
Family: Paxillaceae			
1	<i>Paxillus involutus</i> (Fr.) Epicr.	23	Edible
2	<i>Paxillus pannuoides</i> (Fr.), Fr., Epicr.	61	Inedible
Order: Lycoperdales			
Family: Lycoperdaceae			
1	<i>Langermania gigantea</i> (Pers.), Rostk.	30	A young specimen Edible
2	<i>Lycoperdon perlatum</i> Pers. Syn. . Fung.	15	A young specimen Edible
3	<i>Lycoperdon piriforme</i> (Pers.) Schaef.	25	A young specimen Edible
4	<i>Lycoperdon pusillum</i> Pers.	26	Edibility unknown
Class: Ascomycetes			
Order: Pezizales			
Family: Helvellaceae			
1	<i>Helvella lacunose</i> Fr.	57	Edibility unknown

From the order Agaricales, macromycetes belonging to eight families, 18 genera, and 40 species were identified. Among them, six species from three genera of the Agaricaceae family and 11 species from two genera of the Russulaceae family were found to be edible.

In the Tricholomataceae family, one species (*Omphalina ericetorum*) from five genera and nine species was found to be inedible, while the edibility of another species (*Mycena poliadelpha*) remains uncertain. The remaining seven species from three genera are edible.

None of the macromycetes belonging to the Cortinariaceae family (two genera, five species) were found to be edible.

All identified species from the Boletaceae family (three species) and Gomphidaceae family (one species) were edible.

Two species were identified from the Strophariaceae family, of which one (*Pholiota squarrosa*) was edible, while the other (*Hypholoma sublateritium*) was toxic.

In the Amanitaceae family, one species (*Amanita*

muscaria) was toxic, while the remaining two species (*Amanita fulva* and *Pluteus pellitus*) were edible.

Two species from the Paxillaceae family were described: one (*Paxillus involutus*) was edible, while the other (*Paxillus pannuoides*) was inedible.

From the order Lycoperdales, macromycetes belonging to one family, two genera, and four species were identified. The edibility of one species (*Lycoperdon pusillum*) is uncertain, while the remaining three species were found to be edible.

Macromycetes are widely distributed in Burabay National Park. Research was conducted to identify their species composition, provide morphometric descriptions, and obtain new strains. As a result of the study, a total of 26 macromycete species belonging to four orders and 11 families were identified.

Edible mushrooms were collected during their peak fruiting period. New strains were isolated on the same day of collection or within one to three days, stored in polyethylene bags in a refrigerator.

For isolation, fresh, firm, and non-infected carpophores were selected. Before isolation, the fruiting bodies were cleaned of adhered plant debris and soil, washed briefly with running and sterilized water (to prevent excessive absorption), and dried with filter paper. The dried fruiting bodies were wiped with 96% ethanol.

Using these preliminary cleaning methods, small

tissue fragments in the shape of cubes or triangular pyramids were cut from the fruiting bodies with a scalpel and inoculated onto nutrient media (slant agar) using an inoculation needle. The samples were taken from different parts of the fruiting body: the cap, stipe, and the transition zone between the cap and stipe (Figure 1).

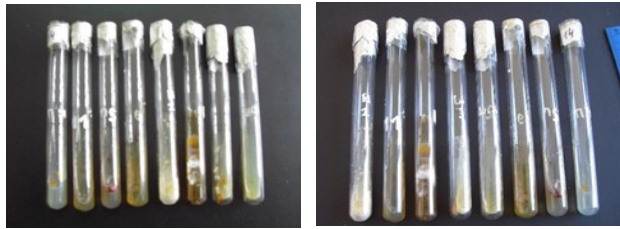


Figure 1 - Tissue fragments of the mushroom placed on slant agar

To evaluate the morphological and cultural characteristics of the mycelium and growth parameters, we used 25 strains of saprotrophic and xylotrophic basidiomycetes isolated through the tissue culture method. These included *Suillus granulatus* (Fr.) Kuntze, *Lyophyllum connatum* (Fr.) Sing., *Pholiota squarrosa* (Fr.) Kumm., and

Kuehneromyces mutabilis (Fr.) Sing.

Table 2 presents the growth dynamics and colony formation characteristics of 11 actively growing mycelial strains on solid agar medium in Petri dishes (Figure 2).

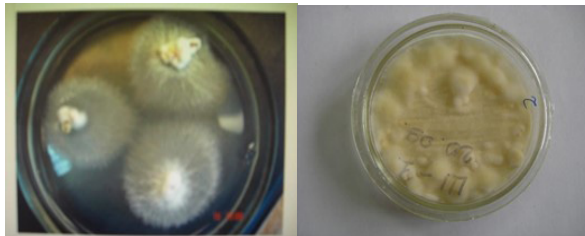


Figure 2 - Growth of strain colonies in Petri dishes

Table 2 - Growth characteristics and colony formation dynamics of different mycelial strains

Strains	Cultivation Time, Days				
	Mycelial Network Formation	Mycelial Density	Formation of Dense Nodules in Mycelium	Pigmentation of Mycelial Colony	Mycelial Colony Covered with a Membrane
Sg-1	8	23	29	33	45
Sg-23	10	22	27	35	43
Sg-8	8	16	22	34	39
Lc-1	11	20	25	43	52
Lc-15	11	22	24	37	50
Lc-18	9	16	20	33	48
Phs-3	18	25	31	39	57
Phs-15	14	24	33	39	54
Phs-10	17	28	35	42	58
Km-25	10	23	33	35	45
Km-34	12	23	30	34	45

Note* Sg - *Suillus granulatus*, Lc - *Lyophyllum connatum*, Phs - *Pholiota squarrosa*, Km - *Kuehneromyces mutabilis*; numbers indicate strain identifiers

According to A.S. Bukhalo's classification, the growth rate of basidiomycete mycelial colonies is divided into three groups: Group I - Fast-growing (Growth Coefficient, GC* > 100); Group II - Moderately growing (GC = 50-100); Group III - Slow-growing (GC < 50).

All of the strains studied in our research had a growth coefficient below 50, categorizing them as slow-growing mycelial colonies. Their mycelium was initially reticulated and powdery, later forming a felt-like structure spreading over the substrate surface. On average, complete colonization of the nutrient medium in Petri dishes took

about one month.

Mycelial densification occurred between the 16th and 23rd days, while fully compacted cotton-like mycelial nodules formed approximately one month after inoculation.

The fastest-growing strains were Sg-1, Sg-8, Lc-18, Sg-23, and Km-25, reaching notable growth within 8-10 days. In contrast, Phs-3 and Phs-10 exhibited the slowest growth, requiring 17-18 days to develop. Full mycelial densification was observed 4 to 4.5 weeks after the start of cultivation.

Discussion

The conducted study provided valuable insights into the diversity and morphological characteristics of Agaricales mushrooms in Burabay and Kokshetau National Parks. The identification of 42 species from 26 genera and 11 families highlights the rich fungal biodiversity in these regions. The compiled species catalog serves as an important reference for future research and conservation efforts [10].

One of the key findings of this study is the differentiation of mushroom species based on their edibility and toxicity. The discovery of one toxic species underlines the importance of accurate identification to prevent potential health hazards. Meanwhile, the presence of 31 edible species suggests significant potential for their sustainable use in local communities, while the 10 inedible species contribute to the overall ecological balance of the forest ecosystem [11].

Compared to previous studies in similar temperate forest regions, our findings align with existing fungal biodiversity assessments but also expand the known distribution of certain species. The use of morphometric characteristics and specialized identification keys allowed for precise species classification, reinforcing the reliability of traditional taxonomic approaches in mycological research.

Conclusion

Based on the conducted research, the following conclusions were made:

1. Morphological descriptions of mushroom structures were provided;
2. Spores were isolated, their micrometric characteristics were analyzed, and photographic documentation was performed;
3. Using the obtained morphometric characteristics and specialized identification keys, the species of the mushrooms were determined.

The study of all collected mushrooms in Burabay and Kokshetau National Parks identified 42 species from 26 genera and 11 families of the order Agaricales. Among them: 1 species was toxic; 31 species were edible; 10 species were inedible.

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Despite the comprehensive nature of this study, certain limitations should be acknowledged. Environmental factors such as seasonal variations and microhabitat specificity may have influenced species diversity. Additionally, some cryptic species might require molecular analysis for more accurate identification. Future research could integrate DNA-based methods to complement morphological descriptions and provide deeper insights into species phylogeny.

The findings of this study contribute not only to mycology but also to conservation biology. Understanding the fungal diversity in protected areas aids in the development of sustainable resource management strategies. Given the ecological role of fungi in nutrient cycling and forest health, further monitoring of Agaricales species could help assess the impact of environmental changes on fungal populations [12,13].

In conclusion, this study enhances the knowledge of Agaricales diversity in Burabay and Kokshetau National Parks, providing a foundation for further ecological and conservation studies. Future research should aim at exploring additional regions, incorporating molecular techniques, and assessing the potential socio-economic applications of edible species.

4. A species catalog of Agaricales mushrooms from Burabay and Kokshetau National Parks was compiled;

5. The collected data and findings hold significant value for the sustainable use and conservation of natural resources.

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Authors' Contributions.

Conceptualization: A.S. and A.M.A.; Draft writing: A.M.A.; Writing and editing: A.S., A.M.A., A.N.Z.; Data collection and analysis: A.M.A., S.A.

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Бурабай және Көкшетау ұлттық парктөрінде таралған Agaricales саңырауқұлақтарының жаңа штаммдарын алу

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Түйіндеме

Қазақстанда агарикті саңырауқұлақтар экологиялық және тағамдық маңыздылығына қарамастан аз зерттелген. Бұл зерттеу Бурабай және Көкшетау ұлттық парктөрінде кездесетін жеуге жарамды агарикті саңырауқұлақтардың түрлік құрамын, морфометриялық сипаттамаларын және штаммдар коллекциясын жасауды алғаш рет қарастырады.

Зерттеу мақсаты: жеуге жарамды агарикті саңырауқұлақтардың түрлік әртүрлілігін анықтау, олардың морфометриялық сипаттамаларын зерттеу және жаңа үлгілерді бөліп алу арқылы штаммдар коллекциясын құру. Бұл олардың биологиялық ерекшеліктерін әрі қарай зерттеуге және қолдану мүмкіндіктерін айқындауға мүмкіндік береді.

Әдістері. Макромицеттер маршруттық әдіспен жиналып, сұрыпталып, кептіріліп (45–50°C, 30–40 мин) сақталды. Морфологиялық сипаттамалар визуалды түрде, микроскопиялық құрылымы *Микмед-1* микроскопы және фотокамералар көмегімен зерттелді. Жас үлгілер қоректік орталарға (*Чанек-Докс, Мурасиге-Скуз, картон-глюкоза агары*) көшіріліп, штаммдар бөліп алынды.

Нәтижелері. 80-ден астам саңырауқұлақ үлгісі жиналып, олардың 71 түрі анықталды. Бұл түрлер екі класқа (базидиомицеттер және аскомицеттер), төрт қатарға (*Arhyllorhiales, Agaricales, Lycoperdales, Pezizales*), 11 тұқымдасқа және 26 туысқа жатады. Бөлініп алынған штаммдар экологиялық зерттеулер мен жасанды өсіру үшін перспективалы.

Қорытынды. Үлгі көлемі әлі де шектеулі. Агарикті саңырауқұлақтардың түрлік әртүрлілігін нақтылау үшін қосымша әдістерді қолдана отырып, әрі қарай үлгілер жинау және талдау жоспарлануда.

Түйін сөздер: саңырауқұлақ, макромицеттер, штаммдар, қалпақша, сабақ, спора, агарикті саңырауқұлақтар.

Получение новых штаммов грибов порядка Agaricales, распространенных в национальных парках Бурабай и Кокшетау

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Резюме

В Казахстане агариковые грибы остаются малоизученными, несмотря на их экологическую и пищевую значимость. Настоящая работа – первое исследование видового состава съедобных агариковых грибов в национальных парках Бурабай и Кокшетау, их морфометрической характеристики и создание коллекции штаммов.

Целью данного исследования является определение видового разнообразия съедобных агариковых грибов, их морфометрическая характеристика и создание коллекции штаммов за счет выделения новых образцов, что позволит в дальнейшем изучить их биологические особенности и потенциальное применение.

Методы. Сбор макромицетов осуществлялся маршрутным методом, образцы сортировали, высушивали и хранили. Морфологические характеристики изучались визуально и микроскопически. Молодые экземпляры культивировали на питательных средах для выделения штаммов.

Результаты. Собрано более 80 образцов, идентифицирован 71 вид, относящийся к двум классам, четырем порядкам, 11 семействам и 26 родам. Выделенные штаммы могут быть использованы для дальнейшего изучения и культивирования.

Выводы. Выборка пока ограничена, планируется дальнейший сбор и анализ образцов с применением дополнительных методов для уточнения видового разнообразия агариковых грибов Казахстана.

Ключевые слова: гриб, макромицеты, штаммы, шляпка, ножка, спора, агариковые грибы.

МАЗМҰНЫ

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Новикова С.П., Даниярова Г.Д., Шайсултанова С.Т., Баянова М.Ф., Пя Ю.В.

Оценка влияния трансплантации почки на сердечную деятельность у пациентов с хронической сердечной недостаточностью в исходе хронической болезни почек 5 стадии 4

Косжанов Н.

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