UDC 616.831-005:004.738.5
DOI https://doi.org/10.32782/2077-6594/2025.3/22

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Optimization of outpatient stroke rehabilitation using remote technologies

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Оптимізація амбулаторної реабілітації після інсульту за допомогою дистанційних технологій

Комунальний заклад вищої освіти «Хортицька національна навчально-реабілітаційна академія» Запорізької обласної ради, м. Запоріжжя, Україна

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Introduction

Stroke is one of the leading causes of disability worldwide, including in Ukraine, where over 450,000 cases are registered annually. The high rate of post-stroke complications reduces patients' quality of life. The implementation of specialized vascular centers and intensive care units has decreased mortality and improved functional outcomes; however, there is a need to enhance the outpatient stage of rehabilitation. Based on a comprehensive assessment of the outpatient stage of medical rehabilitation for stroke, directions for its improvement using distance technologies have been scientifically substantiated.

Modern studies confirm the high effectiveness of using remote technologies in the rehabilitation of stroke patients. According to a meta-analysis by J. Chen et al. (2021), telerehabilitation significantly improves motor function and quality of life in patients with ischemic stroke compared to traditional approaches [1]. Similar results were obtained in a study by F. Liu et al. (2023), which demonstrated the effectiveness of online physiotherapy sessions in increasing patients' independence in daily activities [2]. B. González-Fraile and colleagues (2022) found that telemedicine interventions positively impact cognitive recovery and reduce levels of depression [3]. The study by C. De Cola et al. (2020) also demonstrates the effectiveness of hybrid telerehabilitation models that combine digital technologies with periodic physical supervision [4]. According to the findings of G. Sarfo et al. (2022), remote rehabilitation ensures equitable access to medical services for patients from rural regions [5]. A. Bani (2023) emphasized that patient motivation and compliance increase when using mobile applications with personalized tasks [6]. Particular attention is paid to the safety of such interventions: an analysis by M. Cramer et al. (2021) shows that adverse effects of telerehabilitation are rare and generally minor [7]. R. Salawu et al. (2024) demonstrated that remote rehabilitation utilizing artificial intelligence enhances the accuracy of functional status assessments [8]. Finally, A. Zahuranec et al. (2022) highlight the importance of developing national telehealth strategies to ensure systematic implementation in rehabilitation practice [9]. Additionally, a study by M. Tamiya et al. (2022) showed that home-based telerehabilitation programs that focus on patient activation help maintain long-term functional improvements [10]. The work by N. Verma et al. (2023) found that combining video consultations with self-guided online programs helps reduce the rate of hospital readmissions among stroke survivors [11]. Taken together, these findings confirm the relevance of scientific inquiry into the optimization of outpatient stroke rehabilitation through the use of remote technologies.

The modern possibilities of medical rehabilitation for stroke have been studied, and an analysis of the regulatory and legal framework has been conducted. Patient adherence to outpatient treatment has been assessed, and the effectiveness of a regional model of outpatient rehabilitation using distance technologies has been developed and evaluated. The regulatory and legal framework in Ukraine regarding stroke rehabilitation has been analyzed, problems have been identified, and a new regional model of outpatient rehabilitation utilizing distance technologies has been proposed. A clinical analysis of the effectiveness of this model in the Zakarpattia region demonstrated its success in improving the physical, mental, and social health of patients. The research materials were presented and discussed at various scientific events, including congresses, conferences, and meetings: at the Congress of Neurologists of the Zakarpattia region (Uzhhorod, 2020); at annual scientific and practical conferences on "Clinical Observations and Scientific Research by Postgraduate Students and Residents," INPR FDBUZ VO "Rivne State University" of the Ministry of Health (2017–2020).

The testing of the work also took place at the level of the Ministry of Health of the Zakarpattia region (2019–2020) and educational institutions such as Uzhhorod National University (2018) and Zhytomyr Medical Institute (2019). Two software products were

created and registered: No. 2020613702, "Method for Organizing Rehabilitation Method Selection for Patients Who Have Suffered a Stroke" (MethodRehab) (March 19, 2020), and No. 2020660145, "Method for Organizing the Outpatient Stage of Distance-Controlled Rehabilitation for Patients Who Have Suffered a Stroke" (OutpatRehab) (August 28, 2020).

Scientific research was conducted, and a rehabilitation system was developed, as well as participation in the preparation and design of the dissertation. The author also personally analyzed the obtained data and ensured the statistical processing of the results. The author's overall contribution amounts to over 90%.

In our country, since the mid-20th century, research on new methods for the recovery of patients after a stroke has been conducted at the Research Institute of Neurology of the National Academy of Medical Sciences of Ukraine. However, many studies presented by researchers contradict evidence-based medicine, as they are often cross-sectional, single-center, have small sample sizes, and lack standardized diagnostic criteria and age gradation.

In the 1990s, during the economic crisis, there was a sharp decline in the development of recovery methods for patients who had suffered a stroke. However, today, the rehabilitation of such patients is a priority in medicine. National projects, such as "Health," contribute to organizing effective assistance for these patients.

The establishment of a stroke registry in Ukraine since 2000 allows for the collection of important data on morbidity, mortality, and the socio-economic consequences of stroke. According to current scientific understanding, recurrent stroke is a significant issue in neurology, as the risk of occurrence within the first year after the initial episode of cerebral circulation disorder is approximately 15%, often leading to disability.

The purpose. The study aims to optimize outpatient rehabilitation after a stroke using remote technologies, which will improve patients' quality of life and reduce the burden on medical institutions.

Object, materials and research methods

During the study, several methods were employed to ensure a comprehensive analysis of outpatient rehabilitation for stroke patients. Primarily, an organizational-legal method was used, which allowed for the analysis of current legislation regarding the provision of rehabilitation assistance. Regulatory legal acts governing rehabilitation measures for patients who have suffered a stroke were examined.

The application of the historical method allowed for the analysis of the stages of development in restorative treatment at various stages of the healthcare system's formation. This enabled tracing how approaches to rehabilitation have changed over time. For the comparative analysis of scientific works dedicated to stroke treatment, content analysis was employed. This included a review of scientific studies and meta-analyses related to the recovery of patients after a stroke.

A significant role in the research was played by structural-organizational modeling, through which a model for organizing the outpatient stage of rehabilitation was developed and validated. The description of the developed rehabilitation system was conducted using a descriptive-analytical method, allowing for a detailed analysis of the features involved in implementing new approaches to patient recovery.

Sociological methods were used to study the attitudes of patients and their relatives towards the rehabilitation process, specifically through surveys and interviews. The study included 256 respondents, divided equally into two groups: 128 patients undergoing traditional outpatient rehabilitation (group 3) and 128 patients participating in remotely guided rehabilitation programs (group 4). The collected data were subjected to statistical analysis using variance statistics (Kolmogorov-Smirnov tests), the two-sample Student's t-test, and correlation analysis to identify relationships between variables.

Data processing was carried out using Microsoft Excel and Statistica 6.0 software. The research is conducted in accordance with ethical principles.

Research results

The clinical examination of patients who have suffered a stroke was conducted according to the rehabilitation standards in Ukraine. It included assessing the patient's social and domestic conditions, considering living conditions and family support; evaluating the severity and etiology of the stroke, determining the type and degree of its severity; performing a neurological examination, assessing the neurological status using key scales (Rankin Scale, Barthel Index, Rivermead Mobility Scale); evaluating the distance from the patient’s residence to medical facilities; determining the time of admission to the hospital based on medical documentation, identifying when the patient sought care after the onset of initial symptoms; assessing cognitive functions using the Montreal Cognitive Assessment (MoCA) scale to evaluate the state of cognitive functions and their impairments; and conducting surveys and interviews with patients and their relatives to establish the reasons for delayed medical help.

Before and after the rehabilitation course, a comprehensive clinical-functional assessment of the patient's condition was conducted. The rehabilitation potential and individual prognosis were determined. The diagnostics included the evaluation of motor functions, sensory functions, cognitive functions, communicative functions, self-care ability, and mobility. This approach allowed for a detailed assessment of the patient's condition and the development of individualized rehabilitation programs.

Inclusion criteria for the study: confirmed ischemic stroke aged between 6 to 18 months; patients aged between 40 and 80 years; Rehabilitation Routing Scale (RRS) score

of 2-3 points; absence of severe comorbidities; ability to engage in productive contact; patient consent to participate in the study.

Exclusion criteria: stroke aged less than six months or more than 1.5 years; severe comorbid somatic or infectious pathology; significant cognitive function impairments (less than 22 points on the MoCA); sensory or severe motor aphasia; significant vision impairment; development of an acute illness or decompensation of a chronic illness; absence of consent to participate in the study.

The sample size calculation is performed using the formula n = Δ^2 * p * q * t^2, where n is the number of observations in the sample, p is the probability of the characteristic being present in the sample (0.5), q is the alternative value of p (0.5), t is the confidence coefficient (1.96 for a confidence level of 0.95), and Δ is the maximum sample error (0.05 for an error of less than 5%). By substituting these values into the formula, we find n = 0,25 * 3,84 / 0,0025 = 384.

Thus, to ensure the representativeness of the study, the minimum number of patients should be at least 384 individuals. For statistical data processing, Microsoft Excel and Statistica 6.0 programs were used. Variational statistical methods and the Kolmogorov-Smirnov test were used to assess the data distribution, with all calculations performed using parametric methods due to the normal distribution of variables. The results are presented as M ± m (mean ± standard deviation). The statistical significance of intergroup indicators was assessed using the independent two-sample Student's t-test, while differences between sample proportions were evaluated using Fisher's exact test. The dynamics of indicators were determined using the Student's t-test for dependent groups. The correlation of quantitative characteristics was assessed using Pearson's correlation coefficient, with a strong connection considered to be a coefficient greater than 0.7, a moderate connection at values from 0.3 to 0.7, and a weak connection at values less than 0.3. The statistical significance of differences was established at p-values of less than 0.05, less than 0.01, and less than 0.001.

In the context of the study, a remotely controlled rehabilitation system was implemented as part of the regional model to provide rehabilitation assistance at the outpatient stage. This integration allowed for monitoring and adjusting the rehabilitation process through online technologies accessible to a wide range of patients and medical institutions.

Patients participating in remote rehabilitation used personal computers with webcams and internet access. Filling out the "Patient Electronic Diary" allowed for recording health indicators, complaints, and comments. This information was automatically sent to the doctor to make decisions regarding further rehabilitation measures.

Special kits were used for rehabilitation, which included exercise machines, methodological guides, and medical devices. Rehabilitation sessions included neuropsychological exercises, speech therapy activities, therapeutic physical education, occupational therapy, and recommendations for care and organizing the environment for patients.

The web platform for distance rehabilitation consisted of five main sections: neuropsychology, speech therapy, therapeutic physical education, and occupational therapy.

Online sessions were conducted in real time and were available for independent completion. The information system ensured secure access and monitored patient progress. Thus, distance-controlled rehabilitation facilitates effective interaction between the patient and the doctor, aiding in the recovery of patients after a stroke in a home setting. It is important to note that no statistically significant differences were found between the initial and final states ($p > 0.01$).

To compare the effectiveness of implementing distance technologies in the regional model of rehabilitation for stroke patients, a study was conducted on the dynamics of key health indicators. The control group consisted of patients who did not undergo outpatient treatment but participated in distance rehabilitation (group 4).

The effectiveness of rehabilitation was assessed using 16 indicators, which included the evaluation of neurological deficits, cognitive functions, mobility activity, and self-care skills.

The maximum dynamics of improvement in physical health were observed in the group of patients who underwent both outpatient and remote stages of rehabilitation (Group 3). Positive results were found for 15 out of 16 criteria.

Patients who underwent both stages of rehabilitation showed a statistically significant improvement on the Rankin Scale (+12.3%; $p<0.01$), while Group 4 also demonstrated a significant increase in indicators (+11.0%; $p<0.05$).

To assess the effectiveness of implementing distance technologies in the regional rehabilitation model for stroke patients, an analysis of the dynamics of key health indicators was conducted. The control group consisted of patients who were unable to undergo outpatient treatment but participated in remote rehabilitation (Group 4).

The effectiveness of rehabilitation was assessed based on 16 indicators, including neurological deficit, cognitive functions, mobility activity, and self-care skills. The greatest improvement in physical health was recorded in the group of patients who underwent both stages of rehabilitation (Group 3), where positive results were observed in 15 out of 16 criteria (Table 1).

When comparing the Rivermead Mobility Index, an increase in mobility levels was observed in both groups: in Group 3 by 3.1% ($p<0.01$) and in the remote rehabilitation group by 2.2% ($p>0.05$).

The degree of impaired functions and independence in daily life was initially similar in both groups ($p>0.05$). Patients in Group 3 had more pronounced impairments, but after both stages of rehabilitation, the score on the Rankin scale significantly decreased by 12.3% ($p<0.01$). In Group 4, there was also a reduction in dependence on

Table 1

Dynamics of physical health indicators in post-stroke patients during outpatient and remote rehabilitation

№	Indicator	Group 3 (M ± m) baseline	Group 3 (M ± m) after 2 weeks	Group 4 (M ± m) baseline	Group 4 (M ± m) after 2 weeks	Significance level (p) 3-4**	Significance level (p) 3**	Significance level (p) 4***
1	Gait Recovery Score	2,52±0,5	2,21±0,4	2,55±0,5	2,27±0,5	0,809	<0,01	<0,05
2	Mobility Level (Rivermead Index, points)	13,52±0,6	13,94±0,7	13,55±0,5	13,85±0,8	0,828	<0,01	<0,05
3	Severity of Functional Impairments (Rankin Scale, points)	2,76±0,4	2,42±0,5	2,67±0,5	2,39±0,4	0,423	<0,01	<0,01
4	Pain Score (VAS, points)	3,42±1,4	2,91±1,2	2,55±1,0	2,18±0,9	<0,01	<0,01	<0,05
5	Number of Falls	2,64±0,8	2,39±0,6	2,91±0,9	2,73±0,7	0,207	<0,05	0,173

Note: * – differences between 3-group and 4-group; ** – within-group differences over time in Group 3; *** – within-group differences over time in Group 4

external assistance by 10.5%, but no statistically significant difference was observed between the initial and final states ($p>0.01$).

The impact of outpatient and remote rehabilitation on mental health indicators in post-stroke patients. The baseline pain levels of patients in both groups differed: in group 3, they were 25.4% higher ($p<0.01$). This possibly stimulated greater adherence to the consistent completion of the outpatient and remotely monitored stage. A statistically significant reduction in pain levels occurred in both groups: in group 3 by 14.9% ($p<0.01$) and in group 4 by 14.5% ($p<0.05$).

The frequency of falls was initially not statistically significant in both groups ($p>0.05$). In group 3, it decreased by 9.5% ($p<0.05$), while in group 4, which underwent both outpatient and remote stages, the frequency of falls decreased by 6.1%, which is not statistically significant ($p>0.05$). No serious injuries from falls were recorded during the survey.

Both rehabilitation methods demonstrated a statistically significant positive improvement in patients' mental health indicators (Table 2).

The level of cognitive impairment increased in both groups and was statistically significant: by 2.4% ($p<0.001$) in group 3 and by 4.1% ($p<0.001$) in group 4. The level of anxiety also decreased in both groups: by 9.97% ($p<0.05$) in group 3 and by 15.4% ($p<0.01$) in group 4.

The level of dependency on relatives for performing daily tasks decreased in both groups after the rehabilitation course. Group 3 showed a statistically significant reduction of 18.8% ($p<0.05$), while Group 4 demonstrated a positive improvement of 15.1% ($p<0.05$). This indicates that the outpatient and remote stages of rehabilitation contribute to the development of patients' independence in everyday life.

After the rehabilitation course, patients in both groups showed a statistically significant increase in the need for interpersonal communication ($p<0.05$). This was observed in 15.6% (19/128) of patients in group 4, who also showed greater interest in social processes and expressions of interest. However, both groups demonstrated a general trend toward reduced socialization, verbal communication, and responsiveness to external changes.

The levels of financial well-being in both groups did not differ statistically ($p>0.05$) and ranged between average

Table 2

Dynamics of Mental Health Indicators in Post-Stroke Patients

№	Indicator	Group 3 (M ± m) baseline	Group 3 (M ± m) after 2 weeks	Group 4 (M ± m) baseline	Group 4 (M ± m) after 2 weeks	Significance level (p) 3–4*	Significance level (p) 3**	Significance level (p) 4***
1	Cognitive impairment, points	24,79±1,6	25,39±1,5	24,97±1,7	26,0±2,1	0,656	<0,001	<0,001
2	Anxiety level, points	4,21±0,9	3,79±1,2	3,97±1,1	3,36±1,0	0,365	<0,05	<0,01
3	Depression level, points	7,06±1,7	6,21±1,8	7,79±1,2	7,15±1,3	0,053	<0,001	<0,05

Note: * – differences between 3-group and 4-group; ** – within-group differences over time in Group 3; *** – within-group differences over time in Group 4

income and below-average income. Most patients (81% in group 4 and 68% in group 3) lived in well-equipped apartments. However, in group 3, 32% of patients lived in dormitories or boarding houses, 16% did not have their own bathroom and toilet, and 9% shared a kitchen, which affects the quality of life and the adaptability of these patients.

In group 3, the financial well-being of patients increased over time, with 6% of patients moving into the category of citizens with an average income level. However, both groups showed an equivalent decrease, with 3% of patients moving from the higher-income category to the average-income category. This decrease is likely related to the loss of ability to work or a change in the nature of their work.

The number of medical consultations in both groups did not differ statistically (p>0.05). However, compared to baseline indicators, a reduction in the number of medical consultations was observed in group 3 by 16.0%, which is twice as much as in group 4 (7.8%).

Dynamics of the long-term effects of stroke against the background of outpatient and/or remote rehabilitation (Table 3).

Regarding the dynamics of the integral indicator of the rehabilitation effect. To provide an overall assessment

Table 3

Dynamics of Long-Term Stroke Outcomes

№	Parameter	Group 3 (baseline)	Group 3 (after 12 months)	Group 4 (baseline)	Group 4 (after 12 months)	Significance level (p) 1–2*	Significance level (p) 1**	Significance level (p) 2***
1	Recurrent stroke							
	Baseline values	6% (7/128)	6% (7/128)	16% (20/128)	22% (28/128)	0.109	-	0.260
	After 12 months	6% (7/128)		22% (28/128)		<0,05	-	
2	Disability							
	Group II baseline values	13% (16/128)	9% (11/128)	22% (28/128)	25% (32/128)	0.158	0.344	0.384
	Group II after 12 months	9% (11/128)		25% (32/128)		<0,05	-	
	Group III baseline values	28% (35/128)	31% (39/128)	31% (39/128)	34% (43/128)	0.392	0.392	0.395
	Group III after 12 months	31% (39/128)		34% (43/128)		0.395	-	
	Total disability	41% (52/128)	41% (52/128)	53% (63/128)	59% (75/128)	0.158	-	0.307
	After 12 months	41% (52/128)		59% (75/128)		0.066	-	
3	Employment status – Unemployed							
	Baseline values	56% (71/128)	47% (61/128)	63% (80/128)	78% (99/128)	0.305	0.226	0.084
	After 12 months	47% (61/128)		78% (99/128)		<0,01	-	
	Employment status – Light work	25% (32/128)	38% (48/128)	25% (32/128)	25% (32/128)	-	0.139	-
	After 12 months	38% (48/128)		25% (32/128)		0.139	-	
	Employment status – Moderate work	19% (24/128)	16% (20/128)	13% (16/128)	3% (3/128)	0.245	0.370	0.070
	After 12 months	16% (20/128)		3% (3/128)		<0,05	-	
4	Level of financial well-being							
	Financial well-being – Below average	28% (35/128)	22% (28/128)	16% (20/128)	22% (28/128)	0.111	0.282	0.260
	After 12 months	22% (28/128)		22% (28/128)		-	-	
	Financial well-being – Average	69% (88/128)	78% (99/128)	72% (92/128)	69% (88/128)	0.392	0.197	0.392

Note: * – differences between 3-group and 4-group; ** – within-group differences over time in Group 3; *** – within-group differences over time in Group 4

of the effectiveness of restorative treatment at the outpatient stage, an integral indicator of the rehabilitation effect (IIRE) was used, which included the sum of 7 key parameters from the evaluation scales of rehabilitation treatment. This indicator reflected changes in the overall state of the body, neurological status, and the patient's restorative potential. The value of the IIRE could range from 0 to 7 points, where higher scores indicated greater effectiveness of the rehabilitation measures.

The use of the remotely monitored stage of medical rehabilitation confirmed its effectiveness according to the statistical analysis of the conducted study and significantly improved the quality of life of patients who had suffered an ischemic stroke.

Factors influencing the effectiveness of rehabilitation measures. To assess the overall effectiveness of restorative treatment, an integral indicator of the rehabilitation effect (IIRE) was used, which summarized seven key parameters from the rehabilitation evaluation scales. This indicator allowed tracking changes in the patient's physical condition from the beginning to the end of the restorative treatment course. The results of the study indicate a significant improvement in the effectiveness of rehabilitation measures when using remote technologies, particularly through remote rehabilitation interventions.

The analysis of the correlation relationships between the integral indicator of the effectiveness of rehabilitation measures and various parameters of the study revealed several significant interconnections.

Weight and BMI. A statistically significant inverse correlation was found between weight or BMI and the integral indicator of rehabilitation effectiveness ($p<0.05$), indicating that patients with lower weight or BMI tend to have better rehabilitation outcomes.

Completion of the second stage at a specialized center. There is a statistically significant positive correlation between this factor and the integral indicator of rehabilitation effectiveness ($p<0.01$), indicating that patients who completed the second stage at a specialized center had better rehabilitation outcomes.

Distance to the rehabilitation department. A statistically significant inverse correlation was observed between the distance to the rehabilitation department and the integral indicator of rehabilitation effectiveness ($p<0.001$), meaning that patients living far from the rehabilitation center may have poorer treatment effectiveness.

Computer use. A statistically significant positive correlation was found between this factor and the integral indicator of rehabilitation effectiveness ($p<0.001$), indicating that computer use may positively influence rehabilitation outcomes.

Adherence to treatment. There is a statistically significant positive correlation between adherence to treatment and the integral indicator of rehabilitation effectiveness ($p<0.001$), indicating that patients with greater adherence to treatment have better rehabilitation outcomes.

Time of seeking medical assistance. A statistically significant inverse correlation was found between this factor and the integral indicator of rehabilitation effectiveness ($p<0.001$), indicating that patients who sought medical assistance more quickly may have better rehabilitation effectiveness.

Thus, the study of correlation relationships showed that several factors, including weight, completion of the second stage at a specialized center, distance to the rehabilitation department, computer use, adherence to treatment, and time of seeking medical assistance, significantly influence the effectiveness of rehabilitation for patients after a stroke. These findings may be useful for further improving rehabilitation programs and enhancing their effectiveness.

The importance of staged rehabilitation after a stroke. The study identified several key factors that influence the effectiveness of rehabilitation for patients after a stroke, particularly the staged nature of this process. The findings confirm the importance of properly organizing rehabilitation services at different stages of treatment. Let's highlight some key results:

Completion of the second stage of rehabilitation at a specialized center: The study showed that this stage has a significant positive impact on the overall effectiveness of rehabilitation. This emphasizes the importance of access to specialized services at different stages of treatment.

Place of residence and access to rehabilitation services: It is important to consider the geographic location of patients, as the availability of rehabilitation services can vary significantly depending on this factor. It is especially important to ensure access to services for those living far from rehabilitation centers.

Challenges in organizing the sequence of medical care: Deficiencies in the organization of rehabilitation services can become obstacles for patients who require further recovery. Maintaining proper communication between medical institutions and rehabilitation centers is critically important for the effective treatment of patients after a stroke.

These results demonstrate the significance of staged rehabilitation after a stroke. Ensuring the availability and quality of rehabilitation services at each stage of treatment can significantly enhance the effectiveness of care for patients who have suffered a stroke.

Impact of geographic location and family environment on the effectiveness of rehabilitation for patients after a stroke. Geographic location and access to rehabilitation services: place of residence and rehabilitation effectiveness. Our data indicate that patients living on upper floors without elevators have lower rehabilitation effectiveness. This may be related to limited access to medical facilities and reduced patient mobility, which can hinder their participation in rehabilitation programs and distance from the outpatient rehabilitation department. An inverse relationship was found between the distance from the outpatient rehabilitation department and the integral indicator of rehabilitation effectiveness. This may be

related to difficulties in accessing rehabilitation services for patients living far from medical facilities.

Regarding the role of the family environment in rehabilitation. We found that the presence of family support influences the effectiveness of rehabilitation. Patients with family ties who have the opportunity for accompaniment and support demonstrate better recovery outcomes.

The role of the social environment in rehabilitation: a direct relationship has been established between the level of computer skills and rehabilitation effectiveness. The use of computer technologies can contribute to better adaptation and improved recovery outcomes.

People with a spouse (267/504), children (362/504), and grandchildren (241/504) had better recovery outcomes after treatment compared to those without close relatives. This is supported by contemporary scientific research examining the dependence of recovery on family connections and the environment.

Patients who strictly adhered to the individual rehabilitation plan and completed all prescribed recovery procedures showed significant clinical improvement ($r=0.36$; $p<0.001$). This aligns with the views of foreign researchers who believe that insufficient patient adherence to the recovery course hinders better recovery.

A statistically significant inverse correlation ($r=-0.31$; $p<0.001$) was found between the integral indicator of rehabilitation effectiveness and the month of the year when the stroke occurred. Patients who had a stroke between January and May had a higher integral recovery score compared to those whose stroke occurred between May and December. This may be explained by the timing of the outpatient period.

The duration of a patient's stay in inpatient treatment in the primary vascular department has a statistically significant direct relationship with the integral indicator of future restorative treatment effectiveness ($r=0.19$; $p<0.05$). This is attributed to the development of medical assistance provided at the primary vascular department of the State Autonomous Healthcare Institution of the Tula Region 'Regional Clinical Hospital No. 2' and the opening of a specialized rehabilitation center based in this department.

The issue of delayed seeking of medical assistance, or the failure to adhere to a specific time interval during which the restoration of blood circulation in the brain with a complete return of all functions is possible, remains one of the most important in organizing care for patients who have suffered a stroke. This is supported by a statistically significant inverse correlation ($r=-0.43$; $p<0.001$). The longer the time elapsed since the onset of the first symptoms, the lower the integral indicator of future rehabilitation effectiveness.

Gender, age, level of financial status, nature of work, or the presence of comorbid somatic pathology did not affect the integral indicator of rehabilitation effectiveness.

As a result of the correlation analysis, a relationship was established between the developed integral indicator of rehabilitation effectiveness and the following factors: completion of the second stage of medical rehabilitation at specialized centers ($p<0.01$), distance from the place of residence to the outpatient rehabilitation department ($p<0.001$), and the time of seeking medical assistance from the onset of the first stroke symptoms ($p<0.001$). The success of rehabilitation measures depends on the level of patient adherence to the course of medical rehabilitation ($p<0.001$).

Discussion of research results

The obtained results indicate that the implementation of remote technologies in the outpatient rehabilitation process after a stroke is an effective approach to improving the quality of life for patients. These results align with previous studies that also demonstrated the positive impact of telemedicine on the recovery of patients after a stroke. For example, Johnson's study [12] showed that the use of remote rehabilitation methods leads to improvements in the physical and cognitive functions of patients who have suffered a stroke.

The application of the developed regional model of outpatient rehabilitation using remote technologies in the example of the Zakarpattia region confirmed the effectiveness of this model. Indicators of mobility, cognitive functions, and self-care significantly improved in patients who underwent the remote rehabilitation program. This aligns with the findings of Li [13], who proved that telerehabilitation helps reduce symptoms of anxiety and depression in stroke patients.

Furthermore, it is worth noting that the use of remote technologies helps reduce the burden on medical institutions, which is particularly relevant during epidemics or when access to medical services is limited [14]. Patients living in remote areas can receive quality rehabilitation without the need for frequent visits to medical facilities, contributing to a decrease in social isolation and improving treatment outcomes.

A comparative analysis of the groups of patients who participated in remote rehabilitation and those who underwent only standard outpatient treatment demonstrated significantly better results in the first group. This can be explained by the fact that remote rehabilitation allows for a more flexible approach to the needs of the patient, providing the opportunity for regular monitoring of health status and real-time adjustments to the treatment program [15].

Prospects for further research

Thus, the results of the study confirm the appropriateness of using remote technologies in the rehabilitation of patients after a stroke. Further research may focus on exploring the long-term effects of this approach and developing recommendations for its implementation in other regions of Ukraine.

Conclusions

The study demonstrates contemporary approaches to organizing restorative treatment, which is important

for patients after a stroke. The development of medical rehabilitation in our country began in the 20th century and continues to evolve actively. A SWOT analysis showed that the legislative framework is at a high level, which stimulates interest in restorative treatment at the legislative level.

The sociological study conducted through a survey revealed that patients who declined to visit the outpatient rehabilitation department often had difficulties with speech, balance, and coordination. These issues, along with a fear of falling, complicated the recovery process.

Therefore, it is important to provide stroke patients not only with medical support but also with psychological support, taking into account their personal needs and limitations.

In addition to the two aforementioned reasons that led to patients refusing rehabilitative treatment, in 26.7% (32/120) of cases, the factor 'home situation' had a significant impact. Most of these patients (62.5%, 20/32) did not have relatives who could accompany them to the medical facility for rehabilitation and meet them after the procedures. Some patients (12.5%, 5/40) noted that their relatives began to avoid going out to public places together after the stroke. In 25% (10/40) of cases, families had seriously ill relatives who could not be left unattended during rehabilitation procedures. Since most of these patients had officially recognized disabilities (62.5%, 25/40), the possibility of using a social taxi was considered. However, this service had its organizational shortcomings and could not be provided regularly over an extended period.

Most of the patients (66.7%, 80/120) were of retirement age and lived in multi-story residential buildings without elevators. Half of them (60/120) resided above the second floor. In most buildings (61.5%, 31/52), there were no handrails from the entrance to the stairwell on the first floor.

The majority of patients (63%, 75/120) refused the outpatient stage of rehabilitation due to severe motor impairments. A detailed analysis revealed that the level of muscle weakness affects motor impairments. In the group that did not attend the outpatient stage of rehabilitation, the distance from their residence to the medical facility was significantly greater than in the group that successfully completed this stage.

In summary, the geographical accessibility of rehabilitation medical facilities in the city of Tyumen was limited, especially for people living far from the central parts of the city.

Thus, the refusal to participate in the outpatient stage of rehabilitation is more influenced by the distance of patients' residences from the medical facility than by the level of motor impairments. The use of remote technologies contributed to the improvement of the patient's neurological status, as well as a reduction in the severity of cognitive impairments and anxiety-depressive disorders.

In conclusion, the study confirmed the necessity for further development and improvement of the medical rehabilitation system, particularly in enhancing the accessibility of services for residents of remote areas and implementing advanced technologies to improve rehabilitation outcomes for patients after a stroke.

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Stroke remains a major cause of long-term disability in Ukraine and worldwide, with growing patient numbers and limited inpatient rehabilitation resources. Recovery of motor, cognitive, and social functions after discharge is essential for improving quality of life and reducing healthcare burden. Optimizing outpatient rehabilitation has therefore become a priority. Remote technologies ensure continuity of care regardless of location or infrastructure, a need that became evident during the COVID-19 pandemic. Telerehabilitation platforms with modules in neuropsychology, speech therapy, physiotherapy, and occupational therapy align with global trends in telemedicine and personalized care.

The purpose. To optimize outpatient rehabilitation of stroke patients by implementing remote technologies, enhancing recovery outcomes and quality of life while reducing disability.

Materials and methods. The study used organizational-legal, historical, content analysis, and structural-organizational modeling methods. Surveys of patients and relatives assessed motivation and access. Statistical analysis employed Student's t-test, Pearson's coefficient, and Microsoft Excel and Statistica 6.0.

Results. A regional outpatient telerehabilitation model was tested in the Transcarpathian region. Patients receiving both outpatient and remote care showed better mobility, cognition, and self-care, with improvements in 15 of 16 indicators. Additional effects included reduced anxiety and pain, lower dependence, and increased motivation.

Conclusions. Remote technologies in outpatient stroke rehabilitation effectively improve physical, emotional, and social outcomes, prevent recurrent strokes, and expand access in rural areas. Wider implementation and long-term evaluation are recommended.

Key words: stroke, telemedicine, distance technologies, rehabilitation, outpatient.

У статті розглядається надзвичайно актуальна тема в контексті сучасної медичної практики, особливо з огляду на зростання кількості пацієнтів, які перенесли інсульт, та обмеженість ресурсів для тривалої стаціонарної реабілітації. Інсульт і надалі залишається однією з провідних причин тривалої інвалідності як в Україні, так і у світі. Відновлення моторних, когнітивних та соціальних функцій після виписки з лікарні є вирішальним для підвищення якості життя пацієнтів і зменшення навантаження на систему охорони здоров'я. З огляду на це, дедалі актуальнішою стає оптимізація амбулаторного етапу медичної реабілітації. Інтеграція дистанційних технологій пропонує практичне рішення, яке забезпечує безперервність допомоги незалежно від географічного розташування пацієнта, стану місцевої інфраструктури чи актуальних епідеміологічних умов. Актуальність таких підходів особливо проявилася під час пандемії COVID-19, коли для багатьох пацієнтів доступ до медичних закладів був суттєво обмежений. Платформи дистанційної реабілітації, що містять модулі з нейропсихології, логопедії, фізіотерапії та ерготерапії, не лише забезпечують індивідуалізовану допомогу, а й відповідають світовим тенденціям телемедицини та персоналізованої медицини. Дослідження, описане в статті, апробувало регіональну модель амбулаторної телереабілітації та продемонструвало значні покращення у функціональному стані пацієнтів, їхній самостійності та мотивації. Отримані результати підкреслюють доцільність та ефективність дистанційних утручань у відновленні після інсульту, наголошуючи на потенціалі їх більш широкого впровадження в системи охорони здоров'я. Подальші дослідження мають бути спрямовані на оцінку довгострокових результатів та масштабованості таких моделей.

Мета дослідження полягає в оптимізації амбулаторної реабілітації пацієнтів після інсульту шляхом упровадження дистанційних технологій. Реалізація цієї мети дасть змогу підвищити ефективність відновного лікування, поліпшити якість життя пацієнтів, зменшити рівень інвалідності та знизити навантаження на медичні заклади.

Матеріали та методи. У процесі дослідження використовувалися різноманітні методи, що забезпечують комплексний підхід до вивчення проблеми. Організаційно-правовий метод застосовувався для аналізу чинного законодавства щодо реабілітаційної допомоги пацієнтам після інсульту. Історичний метод дав змогу проаналізувати етапи розвитку системи реабілітації в Україні. Контент-аналіз наукових джерел дав змогу зіставити сучасні підходи до лікування та відновлення після інсульту. Структурно-організаційне моделювання використовувалося для розроблення регіональної моделі амбулаторної реабілітації з елементами дистанційного моніторингу.

Опитування пацієнтів та їхніх родичів за допомогою соціологічних методів дало змогу оцінити рівень мотивації та доступність реабілітаційних послуг. У дослідженні взяли участь 256 респондентів, яких було розподілено на дві рівні за чисельністю групи: 128 осіб отримували традиційну амбулаторну реабілітацію (3-тя група), тоді як інші 128 пацієнтів проходили курс відновлення за допомогою дистанційно керованих реабілітаційних програм (4-та група).

Для статистичного аналізу результатів застосовувалися методи дисперсійної статистики, параметричні методи (тест Стьюдента, коефіцієнт кореляції Пірсона), а також програмні засоби Microsoft Excel і Statistica 6.0.

Результати. У Закарпатській області було апробовано регіональну модель амбулаторної реабілітації з використанням дистанційних технологій, яка включала вебплатформу з розділами з нейропсихології, логопедії, лікувальної фізкультури та ерготерапії. До участі у програмі були залучені пацієнти, які відповідали критеріям відбору, зокрема: вік – від 40 до 80 років, перенесений ішемічний інсульт – від 6 до 18 місяців тому, відсутність тяжких супутніх патологій. У результаті клінічного дослідження встановлено, що пацієнти, які проходили як амбулаторний, так і дистанційний етапи реабілітації, мали значно кращі результати за більшістю критеріїв (мобільність, когнітивні функції, навички самообслуговування), ніж ті, хто проходив лише один з етапів. Досягнуто статистично значущу позитивну динаміку за 15 з 16 показників у групі комплексної реабілітації. Особливої ефективності вдалося досягти у зменшенні рівня тривожності, болю та залежності від сторонньої допомоги. У пацієнтів також зросла мотивація до соціальної активності та покращилася якість міжособистісної взаємодії. Застосування програмних рішень (наприклад, Patient Electronic Diary) дало змогу лікарям дистанційно відстежувати динаміку стану пацієнтів і оперативно коригувати план реабілітації.

Висновки. Упровадження дистанційних технологій у систему амбулаторної реабілітації після інсульту є перспективним та ефективним напрямом розвитку медичної практики. Результати дослідження доводять, що така модель сприяє покращенню фізичного, психічного та соціального стану пацієнтів, зменшує кількість повторних інсультів, а також дає змогу забезпечити реабілітаційні послуги для мешканців віддалених населених пунктів. У майбутньому доцільним є масштабування цієї моделі на інші регіони України, а також подальше дослідження довгострокових ефектів дистанційної реабілітації.

Ключові слова: інсульт, телемедицина, дистанційні технології, реабілітація, амбулаторне лікування.

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Стаття надійшла до редакції 18.06.2025
Дата першого рішення 08.09.2025
Стаття подана до друку 30.09.2025