Telerehabilitation Guidelines for Patients with Breast Cancer

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Abstract

Thia provides a comprehensive analysis of the current developments in telerehabilitation, focusing on the regulatory and legal frameworks for delivering telerehabilitation services, the clinical manifestations of postmastectomy pain syndrome, and the role and significance of the International Classification of Functioning, Disability, and Health (ICF) in the telerehabilitation of breast cancer (BC) patients. The document also explores telerehabilitation interventions for BC.

A detailed description of the software and hardware tools is provided, including the structural and functional overview of the Telerehabilitation Platform (TRP), software modules such as "Telerehabilitation," "Medical Reports," the Administrative Subsystem, the Information-Analytical Subsystem, which encompass the PM&R physician's digital workspace, the PM&R Expert Subsystem, and the Patient's digital workspace. It also covers existing and prospective scales for evaluating the effectiveness of telerehabilitation, as well as the specifics of working with identified patients in accordance with the eHealth (Electronic Healthcare System of Ukraine) requirements.

The guidelines conclude with organizational and methodological aspects for implementing telerehabilitation programs, including initial and stage-specific rehabilitation assessments, basic ICF sets, and various patient-specific telerehabilitation programs. These include a patient-centered program for the preoperative stage of telerehabilitation and individualized programs for the post-acute and long-term phases. The eight appendices include questionnaires, physical therapy programs, protocols, diaries, and requirements for the equipment and staff of the telerehabilitation/telemedicine office, among other resources.

Keywords: Assessment of Telerehabilitation Effectiveness, Breast Cancer, ICF, Multidisciplinary Rehabilitation Team, Patient-Centered Telerehabilitation Program, Postmastectomy Pain Syndrome, Remote Patient Monitoring, Telemedicine, Telerehabilitation Interventions.

Oncopathology is one of the most pressing medical issues and a leading cause of increasing morbidity and mortality worldwide. According to the World Health Organization (WHO), approximately 450 people are diagnosed with malignant tumors every day (Yefimenko, 2023).

Breast cancer (BC) ranks first among oncological diseases in women, accounting for 31.2% of cases and leading to the highest number of cancer-related deaths (Chhikara & Parang, 2023). Although breast cancer predominantly affects women, men are also at risk. According to the National Cancer Registry of Ukraine, in 2022, BC was diagnosed in 14,170 women and

113 men, with 5,823 deaths recorded (5,774 women and 49 men). Each week, approximately 110 Ukrainians die from BC (*National Cancer Registry of Ukraine*, 2024).

Current BC treatment is based on a comprehensive approach that combines radiation therapy, chemotherapy, hormone therapy, immunotherapy, and surgical interventions, which collectively lead to the development of postmastectomy pain syndrome (PMPS). The care provided to patients with breast cancer is primarily focused on treating the primary disease and continuous monitoring for recurrence.

This approach, however, does not adequately address physical and functional well-being, as surgical and radiation treatments often result in significant physical and functional limitations, including pain, fatigue, upper limb dysfunction, lymphedema, weakness, neuropathy, weight gain, and osteoporosis. Scientific research highlights the necessity for ongoing monitoring of these impairments to effectively manage functional disorders and improve the quality of life at all stages of rehabilitation.

Key issues currently faced include the epidemiology of malignant diseases, their prevalence, early detection, modern diagnostics, principles of surgical treatment and radiation therapy, assessment of functional status and patient potential, rehabilitation plan development, specificity of rehabilitation programs for various malignancies, and treatment during wartime.

Rehabilitation for cancer patients is a significant challenge for specialists in Physical Medicine and Rehabilitation (PM&R). PM&R encompasses medical, psychosocial, and vocational interventions provided to individuals who have experienced certain types of functional impairments. It requires rehabilitation professionals to assess the transition from rehabilitation programs to palliative care. Patient activity may decline due to both the oncological process and its treatment (immobility, cognitive disorders, etc.). Therefore, it is vital to determine how many cancer patients in Ukraine are ready for active rehabilitation.

One-third of patients who undergo surgical treatment for BC require physical rehabilitation, while another third need psychological support. Unmet needs often manifest in psychological, sexual, and financial spheres, as well as inadequate rehabilitation assistance. Given this, oncology care must continually expand its impact through systematic evaluation of patient needs and their integration into the rehabilitation process.

Today, after comprehensive BC treatment, the application of rehabilitation interventions is essential to restore respiratory function, the range of motion in the upper limb on the surgical side, manage lymphedema, correct vertebrogenic disorders, and address hormonal imbalances and psycho-emotional states.

To optimize the treatment and rehabilitation process for patients with postmastectomy pain syndrome, it is advisable to organize patient aftercare and rehabilitation through "rehabilitation at home" using modern telerehabilitation technologies. This approach reduces the number of inpatient bed days, lowers economic costs, and significantly improves psycho-emotional indicators.

In recent years, the provision of rehabilitation assistance using telerehabilitation has become a promising direction (Chaikovsky, Dykhanovskyi, et al., 2023; Malakhov, 2022b, 2023a, 2024a; Palagin, Malakhov, Velychko, & Semykopna, 2022; Velychko et al., 2021). Telerehabilitation, a component of telemedicine, facilitates the provision of rehabilitation services by rehabilitation specialists through teleconsultations, assessments, multidisciplinary rehabilitation team meetings, telemetric monitoring, tele- and video-consultations, remote supervision (remote patient monitoring), and other forms compliant with legal regulations, using Information and Communication Technologies (ICT) (Zub, 2023).

Telerehabilitation should be viewed as a process that includes two key aspects:

1) Rehabilitation at the individual level, involving the diagnosis and attention to the patient's own attitudes.

2) Rehabilitation at the social level, which involves creating favorable conditions for the patient's successful social adaptation and addressing society's negative attitudes towards the patient.

Telerehabilitation can serve as the next step for patients discharged from inpatient rehabilitation, allowing them to continue physical therapy and promote further recovery. Assessments and rehabilitation interventions can be conducted in real-time or through pre-recorded individualized programs. It is important to successfully implement this form of rehabilitation, considering the needs for rehabilitation and the comfort provided by personalized medicine technologies.

Section 1. Current Trends in Telerehabilitation Advancement

1.1. Regulatory and Legal Frameworks for Providing Telerehabilitation Services in Ukraine

To implement state policy in the field of oncology and meet the population's needs for specialized oncological care, an appropriate legislative and regulatory framework has been established (Malakhov, 2023a). The sector-specific regulatory document for the use of telemedicine in Ukraine is the Order of the Ministry of Health (MOH) dated March 26, 2010, No. 261 "On the Implementation of Telemedicine in Healthcare Institutions." The procedure for providing medical care using telemedicine is also defined by MOH Order dated October 19, 2015, No. 681 "On Approval of Regulatory Documents on the Use of Telemedicine in Healthcare" and the Law of Ukraine dated December 3, 2020, No. 1053-IX "On Rehabilitation in Healthcare," Article 19 "Provision of Rehabilitation Assistance Using Telerehabilitation" (Verkhovna Rada of Ukraine, 2020).

The Law of Ukraine dated July 29, 2022, No. 2494-IX "On Amendments to Certain Legislative Acts of Ukraine Regarding the Improvement of Accessibility to Medical and Rehabilitation Assistance During Martial Law" introduced an additional provision in Section V "Final and Transitional Provisions" of the Law of Ukraine "On Rehabilitation in Healthcare," which specifies that "rehabilitation specialists who are foreign nationals (except citizens of the Russian Federation and Belarus) or stateless persons may be involved in providing rehabilitation assistance using telerehabilitation, provided they are registered in the information and communication system that ensures the provision of rehabilitation assistance using telerehabilitation" (Verkhovna Rada of Ukraine, 2022).

According to the Law of Ukraine dated August 9, 2023, "On Amendments to Certain Legislative Acts of Ukraine Regarding the Functioning of Telemedicine," the fundamentals of Ukrainian healthcare legislation expand the definition of telerehabilitation and the conditions for providing telerehabilitation services. Qualified medical and rehabilitation assistance must be provided while adhering to the requirements of maintaining medical confidentiality and confidentiality of health information, in compliance with the Laws of Ukraine "On Information," "On Personal Data Protection," "On Information Security in Information and Communication Systems," and in accordance with the norms of medical ethics and deontology (Verkhovna Rada of Ukraine, 2023).

The preservation of medical confidentiality and confidentiality during the provision of rehabilitation assistance is supported by several legislative requirements for healthcare institutions, their medical and administrative staff, and individual entrepreneurs (IEs) engaged in the provision of rehabilitation services, as defined in the Procedure for Providing Medical Assistance Using Telemedicine, Rehabilitation Assistance Using Telerehabilitation During Martial Law in Ukraine or Certain Localities, approved by the Order of the Ministry of Health of Ukraine No. 1695 dated September 17, 2022 (The Ministry of Health of Ukraine, 2022), and the Law of Ukraine "Fundamentals of Ukrainian Health Legislation" dated November 19, 1992 (Article 35-6) (Verkhovna Rada of Ukraine, 1993):

1) be connected to and registered in telemedicine platforms (systems);

2) ensure the preservation of medical confidentiality, the integrity of medical information about the patient's health status, and compliance with the Law of Ukraine "On Personal Data Protection" (Verkhovna Rada of Ukraine, 2010);

3) use software and hardware that allows for the provision of rehabilitation assistance solely in accordance with the tasks resolved using telemedicine (telerehabilitation) technologies;

4) comply with the legislation on medical confidentiality and confidentiality when recording and storing records (including audio, video, and equipment parameter records) of telemedicine consultations, telemedicine consultations, telemetric data, home teleconsultations, and the performance of medical procedures and operations;

5) designate responsible individuals who will collect and compile the necessary information for using telemedicine platforms (systems) and provide access to doctors or medical personnel who will participate in telemedicine/telerehabilitation consultations on such platforms (systems) (Malakhov, 2022a, 2023a, 2023b, 2024a; Malakhov et al., 2022; Yaremko, 2023).

When providing medical/rehabilitation services through telemedicine/telerehabilitation, it is essential to remember the criminal liability provided for in Article 132 of the Criminal Code (CC) of Ukraine "Disclosure of Information about Medical Examinations to Detect Human Immunodeficiency Virus (HIV) or Other Incurable Infectious Diseases" and Article 145 of the CC of Ukraine "Unlawful Disclosure of Medical Confidentiality" (Verkhovna Rada of Ukraine, 2001).

Among BC patients, symptoms of depression, anxiety, and distress are common, negatively impacting their quality of life. Given the negative impact of oncological diseases on patients' quality of life, expanding access to rehabilitation measures through intelligent information-analytical systems that support rehabilitation processes is a valuable tool.

It is important to note that telemedicine tools also allow for screening the patient's psychological state, providing psychological interventions and counseling. This ensures patients have constant access to support and a sense that they are not alone and that medical help is always available, which is beneficial for improving their psychological well-being.

The main advantage of telerehabilitation is the simultaneous inclusion of a greater number of patients in outpatient rehabilitation, especially those who are immobile or have limited mobility, as well as those living far from rehabilitation centers, by providing remote rehabilitation services. Additionally, many patients are reluctant to participate in rehabilitation programs due to inconvenient session times, financial costs, or travel time.

Conducting rehabilitation sessions at home is one way to address the above-mentioned issues, as it increases the accessibility of rehabilitation programs and enables direct and continuous interaction between patients and rehabilitation specialists. With the help of modern remote technologies (Kaverinsky & Malakhov, 2023; Malakhov, 2024a; Malakhov et al., 2022; Malakhov & Velychko, 2021; Palagin, Kaverinsky, et al., 2023; Palagin, Malakhov, Velychko, & Semykopna, 2022), it is possible to monitor the performance of exercises and patient workload in real-time, as well as adjust the rehabilitation program based on subjective sensations and the dynamics of the patient's condition (Lahutina, 2020).

1.2. Clinical Manifestations and Course of Postmastectomy Pain Syndrome

BC is the leading oncopathology among the female population not only in Ukraine but also globally (Yefimenko, 2023). In 2022, 14,332 women with BC were registered in oncology institutions, with mortality rates per 100,000 population in the age groups 45-49 years at 28.7; 50-54 years at 40.9; 55-59 years at 52.5; 60-64 years at 69.9; 65-69 years at 84.9; and 70-74 years at 74.8 (Chhikara & Parang, 2023).

The choice of BC treatment method at the current stage is determined by the stage of the tumor process, clinical form, age and general condition of the patients, histological structure of the tumor (degree of malignancy), steroid hormone receptor levels, immunohistochemical indicators, and other factors (R. Lloyd et al., 2016). Treatment of BC patients is based on the use of modern methods: chemotherapy, radiation therapy with various irradiation modes, hormone therapy, immunotherapy, but surgery remains the decisive intervention today (Hernandez Silva et al., 2019).

The extent of the surgical intervention ranges from organ-preserving surgeries to complete removal of the breast and its reconstruction (Galiano-Castillo et al., 2017). Surgical intervention leads to a series of postoperative complications, as in addition to removing the breast, lymph nodes, nerves, and nerve trunks fall within the surgical area, and coarse postoperative scars form. The occurrence of such complications is associated not only with the nature and extent of the surgery but also with the use of radiation therapy, which is an integral component of combined BC treatment, as well as tumor recurrence and metastasis (Garcia-Roca et al., 2022).

Modern radiation therapy using high-energy radiation sources leads, along with an increase in clinical cures, to a rise in radiation reactions and complications. The effects of radiation are not only limited to direct damage to tumor elements but also affect unaffected tissue structures (Mella-Abarca et al., 2020).

Radiation therapy applied to the chest area reduces the adaptive capabilities of the cardiovascular system, evidenced by a significant increase in tachycardia and a decrease in heart rate variability (HRV) (Loubani et al., 2022), as well as negatively impacting the diastolic and systolic function of the left ventricle. Due to radiation, surgical, and toxic tissue damage, followed by the compression of vessels (lymphatic, blood) and nerves by scars, trophic disturbances, innervation issues, and reduced contractility of the chest muscles, shoulder girdle, and upper limb occur, leading to shoulder joint contracture on the surgical side and posture disturbances (Cattaneo et al., 2023).

Patients who undergo axillary lymph node resection and radiation therapy eventually develop lymphedema, with the pathomorphosis of soft tissues manifesting as progressive fibrosis and the development of coarse scar changes (Siegel et al., 2021). Damage to the nerve trunks of the brachial plexus, cerebrovascular complications, significant blood and lymph circulation disorders, phlebitis with subsequent post-thrombotic syndrome, and secondary lymphedema also occur (Giaquinto et al., 2022). The use of modern combined BC treatment methods helps reduce mortality among women from this pathology, but the persistence of functional disorders resulting from the treatment prevents them from fully performing self-care activities (Torres Lacomba et al., 2009).

Today, this pathology remains a significant issue not only for oncologists, as the treatment leads to the development of PMPS, which combines organic, functional, and psychological disorders, and requires a multidisciplinary approach by rehabilitation specialists. PMPS is a complex of functional and organic disorders of the upper limb and adjacent tissues that arise at different times after BC treatment (Keesing et al., 2018).

The course of PMPS is characterized by a variety of clinical symptoms (soft tissue swelling on the surgical side, limited range of active and passive movements in the limb at the shoulder joint, reduced muscle strength, sensory disturbances, vegetative-trophic disorders of the upper limb) and forms: neuropathic, edematous, cerebral, mixed. It has been established that cerebrovascular disorders are a significant clinical component of PMPS, resulting from hypertonicity of the anterior scalene muscle, which leads to impaired blood flow in the vertebral artery system (Smolanka et al., 2020).

Neurological manifestations of PMPS appear as Naftziger, Wright-Mendlovich, and Falconer-Wedell syndromes. Clinically, Naftziger syndrome manifests as paresthesia and hypoesthesia in the ulnar zone of the forearm and hand, neck pain, supraclavicular pain, and pain in the elbow and hand. Wright-Mendlovich syndrome presents with pain in the chest muscles radiating to the shoulder, forearm, and hand, hypoesthesia, and acroparesthesia. Falconer-Wedell syndrome involves paresthesia and pain in the subclavian area and shoulder, which intensifies with shoulder abduction and external rotation.

The occurrence of pain in women with PMPS can be caused by various factors, including brachial plexus plexopathies resulting from ionizing radiation exposure; peripheral neuropathies related to surgical nerve trauma during mastectomy or directly resulting from upper limb lymphedema; and toxic polyneuropathies caused by chemotherapy side effects.

Early signs of PMPS appear immediately after BC surgery and are post-traumatic in nature, including seroma, bleeding, wound infection, post-radiation dermatitis and ulcers, prolonged fever, phantom pain, asthenia, impaired tissue regeneration, wound dehiscence, marginal necrosis of skin flaps, hematomas, prolonged lymphorrhea, and subsequent development of early postmastectomy edema and erysipelas. These complications prolong the postoperative period, delay the timing of other anticancer therapies, and delay patient rehabilitation.

Lymphedema is a chronic progressive condition that can have serious adverse effects on women's quality of life and is one of the most challenging long-term complications of BC treatment. Rehabilitation interventions are considered the cornerstone of lymphedema treatment, with physical therapy being an integral part of such rehabilitation. In the absence of adequate treatment, lymphedema can lead to secondary complications such as cellulitis, lymphangitis, axillary vein thrombosis, severe functional impairments of the upper limb, and even lymphangiosarcoma. Clinically, lymphedema manifests as increased limb volume, a growing sense of heaviness, limited mobility in small and then large joints, significantly worsening the quality of life.

In the development of PMPS, protective myofixation of the shoulder-scapular region and compression of the neurovascular bundle in the area of the upper thoracic aperture occur. After radical surgery, the incidence of clinical syndromes increases: hyperabduction syndrome in 76%; costoclavicular syndrome in 37.5%; scalene syndrome in 32%. Within 12 months after surgery, 99% of women consistently develop and then progress to anterior scalene muscle syndrome, which causes stable compression of the neurovascular bundle of the upper limb. In the long-term period, damage to the nerve trunks of the brachial plexus results from direct radiation exposure and compression by scar tissue, manifested by pain syndrome, impaired function of the shoulder girdle muscles and upper limb, plexitis, leading to a reduction in the range of active movements and decreased efficiency of the muscle vascular pump.

Posture disorders arising after BC surgery vary and depend primarily on the nature and severity of neurological disorders and associated functional and organic impairments of the chest muscles, shoulder girdle, and upper limb. With severe upper limb lymphedema, posture asymmetry typically occurs, characterized by a drooping shoulder on the side of the edema and curvature of the thoracic spine.

In 96% of women after radical BC treatment, biomechanical and myotonic disorders manifest as functional blocking of intervertebral joints in the cervical and thoracic spine, spasm of the anterior scalene and upper trapezius muscles, and scoliosis. Most of these disorders develop 3-5 years after surgery.

The minimum recovery time for range of motion after radical mastectomy, provided early rehabilitation begins, is 105 days; after quadrantectomy, it is 75 days. The presence of PMPS leads to certain difficulties in performing both daily activities and professional duties (Smolanka et al., 2020). Despite these challenges, most women limit upper limb movements on the operated side due to a lack of awareness about potential impairments or the limited effectiveness of current rehabilitation measures for improving upper limb function.

The use of chemotherapy and radiotherapy in cancer treatment negatively affects the psycho-emotional state, gastrointestinal function, leading to vomiting, prolonged diarrhea, reduced metabolism, and cardiovascular function (lowered blood pressure, sinus tachycardia, arrhythmia, chest pain), requiring the development of differentiated rehabilitation

interventions and dietary therapy to reduce the risk of postoperative complications. Thus, telerehabilitation for women with this pathology has a very high priority, and the development of differentiated physical rehabilitation aimed at preventing and eliminating postmastectomy complications is essential (Von Blanckenburg et al., 2014).

1.3. Role and Impact of the International Classification of Functioning, Disability, and Health in the Telerehabilitation of Breast Cancer Patients

Telerehabilitation for patients who have undergone treatment for BC is aimed at preventing disability, reducing the consequences and symptoms, and enhancing participation and reintegration into society to achieve maximum possible independence and improve quality of life. Telerehabilitation interventions should begin as early as the preoperative stage to maintain functional capacity, reduce the risk of losing essential abilities or independence, and should be individualized according to the disease phase, functional deficits, personal needs, and specific goals (Amatya et al., 2017).

Detailed information about the needs of such patients allows for more effective and targeted telerehabilitation interventions. Therefore, a comprehensive assessment of various health domains for patients who have undergone BC treatment is necessary, using a standardized system and common language to describe the impact of the disease at different levels.

This can be achieved by using the core sets of the International Classification of Functioning, Disability, and Health (ICF). According to the ICF (*ICF (in Ukrainian)*, 2022; Stucki & Melvin, 2007; WHO, 2024), approved by the WHO in 2001, cancer and its specific treatment affect the body structures, impact functions, activities, and participation, as well as environmental factors. Specific full and short ICF core sets have been developed for BC, which describe functions and disabilities (Brach et al., 2004).

The ICF model integrates diagnosis and subsequent functional impairments within the context of limitations related to environmental and personal factors. Environmental factors interact with all aspects of life (physical, social, and psychological), while personal factors (e.g., influences or characteristics such as self-efficacy) contribute to adaptation. It is important to understand the terms used in this model. Body functions refer to the physiological functions of the body, while structures refer to anatomical parts involved in the process. Activity limitation is defined as difficulty in performing a task, whereas participation restriction refers to problems engaging in a life situation.

Unlike the International Classification of Diseases (ICD) (WHO, 2022), the ICF does not define criteria for making diagnostic decisions based on the presence or absence of a disease or disorder. Instead, functioning and disability are viewed as a continuum: "Functioning is a general term for body functions, body structures, activities, and participation, representing the positive aspects of the interaction between a person (with a health condition) and their contextual factors (environmental factors and personal factors)."

The ICF model includes the perspectives of clinicians on managing complex and interacting symptoms in patients who have undergone BC treatment, the views of physical therapists on managing changes in functional status in daily life, and the perspectives of the women themselves who have undergone BC treatment. The ICF model explains how deficits at the level of body functions and structures can negatively impact activity levels and ultimately lead to participation restrictions. Participation restrictions may include difficulties in performing routine household tasks, work-related duties, and engaging in social or physical activities. In this context, BC-related impairments, such as limited upper limb range of motion or reduced muscle strength, can limit a woman's ability to perform self-care, reach, or lift objects. These limitations, in turn, may lead to participation restrictions, such as the inability to engage in recreational activities. Environmental factors may include the inability to access adequate rehabilitation services, or personal factors, such as low self-esteem, which can also affect a woman's ability to participate in recreational activities.

The use of the ICF model in psychological rehabilitation allows for the description of both medical and non-medical issues that impact patients' functioning and the overall course of rehabilitation. For example, if a patient is not inclined toward rehabilitation interventions, has a negative attitude, and is unwilling to engage with the multidisciplinary team, providing rehabilitation assistance will be challenging. The reasons may include personal issues as well as environmental factors. Based on the identified ICF domains, the psychologist not only restores lost mental functions and develops patient learning skills but also begins to work on their attitudes, motivation, and the development of cooperation and trust with other professionals.

The selection of specific domains for psychological rehabilitation describes the individual characteristics of the patient in a specific life situation at a particular stage of recovery. This allows for a diagnostic assessment of the patient's condition and the

setting of psychocorrectional, psychotherapeutic, and consultative goals. Quantitative assessment of the domains at the start of working with the patient and at the current moment allows for the evaluation of progress in the patient's psychological rehabilitation. Thus, the use of the ICF tool is sufficient to ensure the practical work of a psychologist in the rehabilitation field.

ICF categories used in the work of a clinical psychologist include: in the section "Body Functions" – global mental functions (b110-b139), specific mental functions (b140-b189); in the section "Activity and Participation" – learning and applying knowledge: purposeful use of sensory organs (d110-d129), basic learning skills (d130-d159), applying knowledge (d160-d179), general tasks and demands (d210; d220; d230; d240; d298), interpersonal interactions and relationships: general interpersonal interactions (d710-d729), specific interpersonal relationships (d730-d779), major life areas (d910; d920; d930), community life (d940; d950; d998); in the section "Environmental Factors" – support and relationships (e310; e315; e320; e325; e330; e335; e340; e350; e355; e360) (Yang et al., 2019).

The ICF model can be used to assess the outcomes of telerehabilitation interventions. It allows for a broad quantitative assessment of functioning and methods for documenting progress in patients with oncological diseases. Understanding and documenting how structural or anatomical defects limit activities (self-care, dressing, childcare) and participation (attending public events, reduced work expectations) provide a broader understanding of the patient's capabilities. Rehabilitation specialists should have a clear understanding of the goals of their telerehabilitation interventions and use appropriate tools to assess the effectiveness of these interventions.

1.4. Control Functions in Telerehabilitation

1.4.1. Traditional Methods of Control

A key aspect in developing telerehabilitation measures to improve function in women after BC treatment is identifying measurement tools that can capture functional limitations for decision-making in treatment and the development of telerehabilitation programs. Assessment metrics must be sensitive to the unique challenges faced by women post-BC treatment (e.g., shoulder range of motion after mastectomy) and responsive to changes in patients' conditions.

The frequency, severity, and impact of pain on the quality of life of oncology patients are critical factors that must be considered when planning telerehabilitation interventions. Cancer-related pain may arise from the tumor itself or as a side effect of specific treatments. Pain is influenced by emotional and subjective factors and can be affected by psychological and behavioral interventions. Common upper limb disorders associated with BC, often accompanied by pain, include cervical radiculopathy, brachial plexopathy, neuropathy, rotator cuff injury, tendinitis, adhesive capsulitis, lateral epicondylitis, PMPS, edema, and metastases in the hand. Pain significantly impacts mobility, and some researchers have even established threshold values for moderate and severe pain based on its effect on daily activities.

Pain assessment is essential for patients who have undergone BC treatment. Tools like the Visual Analog Scale and the Numeric Pain Rating Scale measure pain intensity, while other scales are multidimensional. For instance, the Brief Pain Inventory (*Brief Pain Inventory*, 2024; Cleeland, 2009) allows for the assessment of pain severity and its impact on key aspects of patients' quality of life – daily activities, mobility, ability to perform household chores, relationships with others, mood, sleep, and ability to experience pleasure (Kozlova et al., 2021).

Patients who have undergone surgery, chemotherapy, or radiation therapy for BC may experience a limited range of motion in the shoulder joint. This deficit may result from scar tissue formation post-surgery, joint hypomobility after chemotherapy or surgery, or radiation-induced fibrosis. A reduction in shoulder range of motion can occur during treatment or after its completion. Less invasive surgeries (e.g., lumpectomy compared to mastectomy) may reduce shoulder range of motion as much as more invasive procedures (Pinto et al., 2022). Therefore, goniometry is a necessary examination for patients who have undergone BC treatment.

Muscle strength reduction in oncology patients may occur due to inflammatory byproducts produced by the tumor, leading to muscle wasting (cachexia) through catabolism. Surgical interventions can also damage muscle groups and peripheral nerves, resulting in muscle strength loss. Radiation and chemotherapy may reduce strength by damaging muscle tissue or peripheral nerves. Moreover, pain, fear, and fatigue lead to reduced activity, causing further muscle strength and aerobic capacity loss. Manual muscle testing and hand dynamometry are used to measure muscle strength.

To assess the impact of disease on upper limb function in individuals who have undergone BC treatment, the DASH questionnaire (Disabilities of the Arm, Shoulder, and Hand) is commonly used. This tool measures upper limb function related to pain and examines symptoms such as pain, weakness, and numbness, as well as the degree of disability related to work

and recreational activities. The Functional Assessment of Cancer Therapy – Breast (FACT-B+4) and DASH questionnaires are highly recommended for use in patients who have undergone BC treatment due to their psychometric properties and clinical utility (Serlin et al., 1995).

Vital signs measurement (heart rate, blood pressure, respiratory rate, and oxygen saturation) provides insight into the cardiorespiratory status of oncology patients. Cardiorespiratory status impairment may manifest only under increased load. For this reason, the 6-minute walk test or a similar aerobic capacity test is conducted. Discrepancies from normal values of these assessment tools indicate cardiovascular and respiratory dysfunction. Patient reports of breathlessness (using the dyspnea scale) and excessive exertion during physical activity (using the Borg scale) during the 6-minute walk test allow for the planning of physical activity appropriate to the patient's condition.

The 6-minute walk test is used as an indirect measure of aerobic capacity in individuals who have undergone BC treatment. It records the distance a person can quickly walk on a flat, hard surface in 6 minutes and is used to assess submaximal functional capacity. Functional mobility indicators from the "Timed Up and Go" test have recently been linked to health outcomes and survival from all causes in older adults and cancer survivors (Gilchrist et al., 2009).

In the ICF, the function of lymphatic vessels and nodes is classified as an immunological function. Impairments may be related to obstruction or tumor in lymphatic vessels but more commonly develop due to surgical resection of lymph nodes or radiation-induced fibrotic changes in lymphatic vessels. In either case, regional lymphatic drainage decreases, leading to the accumulation of lymphatic fluid and regional edema. Such edema poses a threat to the skin, increasing the likelihood of inflammation, infection, skin damage, reduced range of motion in joints, and decreased ability to move the affected limb. Localized swelling is the most common sign of lymphedema, so the primary focus in assessing this impairment is on determining limb volume. Patients are taught how to measure the circumference of the upper limb and calculate its volume using a measuring tape, following the anatomical landmarks provided on the Cleveland Clinic's website: Breast Cancer – Arm Volume Calculator (Harrington et al., 2015). A difference of more than 2.0 cm at any of the four measurement points indicates the need for lymphedema treatment. It is important to pay attention to symptoms of heaviness, stiffness, or swelling in the affected limb.

Volume measurement is just one method used to describe the severity of lymphatic impairments and thermal toxicity (ICF subdomain "Skin and Related Structures"). There are scales for assessing the severity of skin color changes, lymph leakage, lymphocele, fibrosis, and phlebostatic cords. These scales provide a standardized language for describing lymphatic tissue and skin changes, which can be clinically useful, particularly for setting long-term goals and exchanging information among colleagues (Klepin et al., 2010).

Cancer-related fatigue, also known as cancer fatigue, is a prevalent long-term side effect among those who have undergone BC treatment. This complex and multifactorial condition is clinically characterized by a persistent sense of physical, emotional, and/or cognitive rigidity, leading to a significant decline in quality of life. The primary indicator for assessing fatigue is the Brief Fatigue Inventory (BFI), a multidimensional self-assessment scale that measures the impact of fatigue on quality of life. This questionnaire consists of 2 parts and 9 questions, rated on a scale from 0 to 10. Specifically, the first three questions assess the current, usual, and worst levels of fatigue over the past 24 hours, while the remaining six questions address the impact of fatigue on activity, mood, mobility, work, relationships, and life satisfaction. The overall BFI score is calculated as the arithmetic mean of the 9 scores, with scores of 1-3 indicating mild fatigue, 4-6 indicating moderate fatigue, and 7-10 indicating severe fatigue. The BFI is a reliable tool that allows for quick assessment of fatigue levels in oncology patients and identifies patients with severe fatigue (Mendoza et al., 1999).

Quality of life assessment has become one of the most important components of oncology care. Often, decisions to start, avoid, or discontinue specific treatments can be based on discussions of the patient's quality of life. Furthermore, quality of life has become an important indicator of the effectiveness of rehabilitation care. One of the most widely used quality-of-life scales in oncology is the EORTC QLQ-C30 questionnaire, which consists of 30 questions and includes 5 functional scales (physical functioning, role functioning, emotional functioning, cognitive functioning, and social functioning), 3 symptom scales (fatigue, nausea, and pain), and 6 additional criteria: sleep disturbance, appetite loss, constipation, diarrhea, dyspnea, and financial difficulties (Boing et al., 2019).

Strength, balance, mobility, and endurance are some of the key indicators that rehabilitation specialists aim to assess thoroughly in their patients. Oncology rehabilitation specialists typically require a comprehensive assessment of these indicators to better characterize functional capabilities, risk stratification, mortality prediction, and quality of life.

BC patients experience numerous concomitant psychological symptoms. Despite the good prognostic outlook of modern BC treatment methods, a cancer diagnosis is threatening and exposes women to many additional stressors, such as treatment and its side effects. Anxiety is one of the most common psychological symptoms in BC patients, occurring at a rate of 10% to

30%. Patients may experience anxiety symptoms due to expectations of negative outcomes, concerns about recurrence, and treatment side effects. Distress is a broad construct that encompasses a wide range of emotions related to symptoms of depression, anxiety, and adjustment disorders that arise with varying intensity throughout the course of the disease. Distress may be related to fatigue, family relationships, weight, fears, worries, pain, and more. The prevalence of depression in BC patients has been estimated to range from 10% to 30%, depending on the study population and study design. Depression negatively affects women's treatment regimens, quality of life, self-care, and reduces immunity and survival chances (Yeh et al., 2014).

Both anxiety and depression have a significant impact on BC patients. Screening for anxiety, distress, depression, early detection, and psychological interventions are important for maintaining mental well-being and improving the quality of life for BC patients. The most appropriate, sensitive, and concise tools for screening and monitoring anxiety-depressive disorders in cancer patients are the Center for Epidemiologic Studies Depression Scale (CES-D) and the Hospital Anxiety and Depression Scale (HADS). An analysis of the discriminant validity of HADS demonstrated its superiority over other psychometric scales. HADS includes two subscales for assessing anxiety and depression symptoms, each containing 7 items. The total symptom severity scores range from 0 to 21 points. A cumulative score (on the subscales) of 8 to 10 points indicates the presence of subclinical manifestations of anxiety or depression, while scores above 10 suggest clinically significant anxiety and depression. HADS is the most convenient self-report tool for screening affective and anxiety disorders in somatic patients (Ng et al., 2017).

The Distress Thermometer is a validated tool for rapid psychological distress screening and has been endorsed by the National Comprehensive Cancer Network NCCN's distress management guidelines panel. It assesses the level of distress patients have experienced over the past week. Patients are asked to choose a number from 0 to 10 to indicate their level of distress, where "0" represents no distress and "10" represents extreme distress. Most studies have shown that a score of 4 is used as a threshold for high levels of distress, with optimal sensitivity and specificity relative to established criteria (Ng et al., 2017).

1.4.2. Prospective Scales Based on Electrocardiograms and Heart Rate Variability

Rehabilitation specialists often face the challenge of assessing a patient's rehabilitation potential to determine appropriate care pathways, predict recovery outcomes, and monitor the effectiveness of ongoing rehabilitation interventions. This assessment forms the basis for developing a tailored rehabilitation plan, including setting timelines for achieving specific goals. Patients with high rehabilitation potential particularly benefit from a clear, consistent program throughout all stages of rehabilitation, maximizing their recovery opportunities. Conversely, other patients may be better suited for transfer to social care facilities for education and adaptation to life with existing limitations, thereby optimizing their time in each rehabilitation phase.

Numerous functional assessment scales exist to evaluate rehabilitation potential, with the most comprehensive database compiled by specialists at *Shirley Ryan AbilityLab* (USA) (Ryan, 2024). This database includes several hundred scales of various natures for assessing function across all areas of rehabilitation.

However, upon analyzing this database, it becomes evident that there is a lack of scales suitable for home use based on objective data obtained through portable functional diagnostic tools.

In recent years, the V.M. Glushkov Institute of Cybernetics of the National Academy of Sciences of Ukraine has developed an innovative methodology (Universal Scoring System) for scaling electrocardiograms (ECG) and HRV. This methodology allows for the assessment and monitoring of overall rehabilitation potential, which is critical for rehabilitating diseases of any origin (Chaykovskyy et al., 2019; Kurhaiev et al., 2022). The method is particularly well-suited for telemedicine applications (Malakhov, 2024a; Palagin, Malakhov, Velychko, Semykopna, et al., 2022; Palagin, Semykopna, et al., 2020).

The methodology involves a comprehensive evaluation of the heart muscle, autonomic nervous system, and psycho-emotional state through mathematical analysis of HRV and an extended ECG analysis (including minor myocardial changes) in one or six leads. This approach uses the heart as a "mirror," through autonomic regulation of heart rhythm, to assess the functional state, activity level of functional systems, life processes, and overall work capacity of the body.

In particular, the methodology serves as a tool for assessing functional reserve and the efficiency of adaptation systems, especially the resource-energy and psycho-emotional components. The scientific basis for assessing the psycho-emotional component of adaptation using HRV data is further elaborated in (Chaikovsky, Dykhanovskyi, et al., 2023; Malakhov, 2022a).

This scoring method is designed for practical applications, featuring a user-friendly interface based on a "traffic light" logic, making information easily accessible to both rehabilitation team members and patients. This technology is widely used in Ukraine and abroad to address a range of tasks across various fields of clinical medicine, military medicine, and more.

Notably, this method has been successfully employed for objective monitoring of the rehabilitation process in military personnel with post-traumatic stress disorder (PTSD), post-concussion syndrome, emotional burnout, and other disorders caused by the specific conditions of military service (Chaikovsky, Primin, et al., 2023; Malakhov, 2024b).

An example of a development optimized for home use within the framework of telemedicine technology is the domestic monitoring system "Telecardian." This system is designed for remote ECG recording in manual and/or automatic modes, with subsequent transmission to the physician's digital workspace, email, a receiving station on a personal computer (PC), or the cloud (Google Cloud Computing Services, Amazon Web Services).

The system includes portable recorders (8 models, capable of recording 1 to 12 ECG channels with an operational duration ranging from 24 hours to 1 year), smartphone applications compatible with Android 5+, and software that can be installed on Windows 7, 10, and 11 PCs using wireless technology. Bluetooth / Bluetooth Low Energy protocols are used for communication with the communicator (smartphone or PC) and data exchange over the Internet.

1.5. Telerehabilitation Interventions for Breast Cancer

Rehabilitation interventions consist of expert multidisciplinary assessments that evaluate patient outcomes using functional goal-oriented approaches to prioritize patient needs. Existing evidence on various specific rehabilitation interventions for patients' post-breast cancer surgery is summarized in Table 1.1, following the study design and evidence hierarchy. Priority is given to high-quality systematic reviews, meta-analyses, and randomized controlled trials.

A meta-analysis (De Lazzari et al., 2021; Shin et al., 2017) demonstrated that multifactorial physical therapy, specifically stretching exercises and active exercises, effectively treat postoperative pain and limited shoulder joint range of motion following specific BC treatments. Most rehabilitation programs include the following types of exercises: exercises to increase the range of motion in upper limb joints, shoulder muscle stretching exercises, and upper limb strengthening exercises. Typically, these programs consist of 2-5 different types of exercises.

A review (Schmitz et al., 2019) highlighted the heterogeneity and broad range of conservative interventions and clinical outcome measures used in physical rehabilitation for patients with BC who have undergone or are scheduled to undergo mastectomy (see Figure 1.1). Several studies have shown that maintaining physical activity can prevent some side effects associated with specific cancer treatments.

The 2018 consensus statement from the International Multidisciplinary Roundtable indicated that individuals who have undergone cancer treatment should engage in 150 minutes of moderate-intensity aerobic exercise (at least three times a week, each session lasting no less than 30 minutes) or 75 minutes of high-intensity aerobic exercise twice a week, as well as resistance and flexibility exercises (Vanderbyl et al., 2017).

Rehabilitation strategies for lymphedema typically involve complex decongestive therapy, which usually includes manual lymphatic drainage (a massage technique that stimulates the contractility of lymphatic pathways), skin care, multi-layer limb bandaging, and physical exercises (moderate, repetitive muscle contractions). Patients typically undergo 15-30 sessions over 4-6 weeks. After achieving optimal limb volume, patients may transition to self-care exercises.

It is essential to educate and encourage women with lymphedema to adopt long-term and consistent use of compression garments. Compression garments should be worn from morning until evening and removed before bed. Patients must be informed that lymphedema is a lifelong condition, requiring daily use of compression garments. Patients can expect stabilization and/or moderate improvement in lymphedema with consistent use of compression garments.

Patients with a higher body mass index (BMI) are advised to follow weight loss and maintenance strategies. Although there is no conclusive evidence linking high BMI with secondary lymphedema after cancer treatment, maintaining a healthy body weight is recommended for cancer survivors due to other associated health benefits.

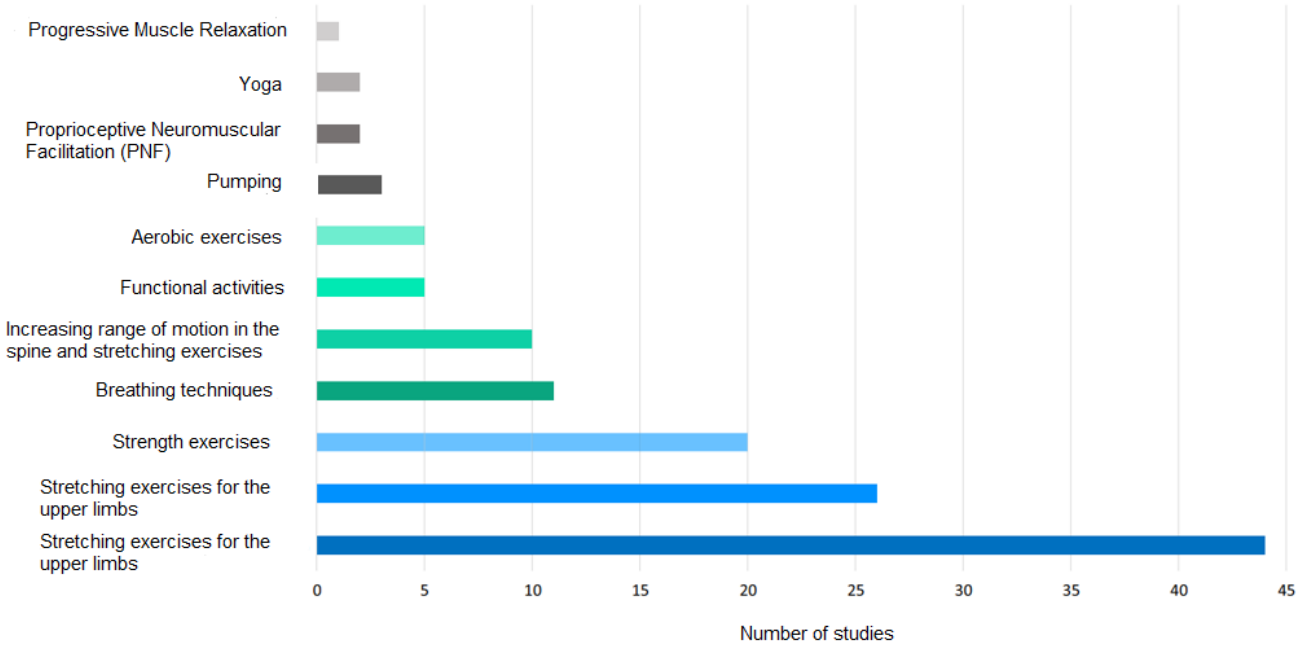
Fatigue related to BC is common among those who have undergone surgery, particularly after radiation or chemotherapy. It is estimated that 28-91% of cancer survivors experience fatigue (Runowicz et al., 2016). Expertise in energy conservation allows occupational therapists to analyze a cancer survivor's desired activities and modify those activities or the environment to enable patient participation despite varying levels of fatigue. Occupational therapists may prescribe individual energy conservation methods to enhance participation in current life roles, increase work engagement, and improve productivity (Gradishar et al., 2020; Harris et al., 2012).

Table 1.1 Rehabilitation Interventions for Breast Cancer

Interventions	Positive Effects	Level of Evidence
Multidisciplinary rehabilitation	Improvement of short-term (up to 12 months) disability (range of motion in the shoulder joint), activity (adaptation to shoulder joint movements), participation (psychosocial adaptation), and quality of life	I
Therapeutic exercises	Reduction in disability, improvement in mobility, maintenance of range of motion, reduction in fatigue, and enhancement of quality of life; no impact on the incidence of postoperative lymphedema.	I
Strength training	Improvement in muscle strength, mobility, and quality of life; preservation of bone mineral density, improvement in psychological symptoms	I
Endurance training, aerobic training	Improvement in aerobic indicators, muscle strength, and reduction in fatigue	I
Compression bandaging of the limb	Reduction in the volume of lymphedema	II
Occupational therapy, educational programs	Improvement in activities of daily living, reduction in the impact of fatigue, and increase in self-esteem	I

Figure 1.1

Types of Physical Exercises



Section 2. Information and Technology Resources for Telerehabilitation

2.1. Introduction

Each stage in the evolution of healthcare and medicine is marked by the emergence of new integrated fields of knowledge that embody fundamental scientific principles, such as medical cybernetics, health economics, management, marketing, and others. One of the most urgent needs for the rapid integration of information technologies is within the critical area of patient rehabilitation (Chaikovsky, Dykhanovskyi, et al., 2023; Malakhov et al., 2022; Velychko et al., 2021, 2022). Rehabilitation is increasingly recognized by the global medical community as an essential response to the inadequacies of clinical medicine in restoring and compensating for the physiological functions lost during illness (D. V. Vakulenko, 2023; D. V. Vakulenko et al., 2023; D. V. Vakulenko & Martseniuk, 2015; L. O. Vakulenko et al., 2005, 2018; L. O. Vakulenko & Mysuly, 2005; Verkhovna Rada of Ukraine, 2020, 2023). According to WHO data, the portion of Ukraine's population that falls within the "safe" health zone has steadily declined from 8% twenty years ago to just 1% today, with the ongoing war in Ukraine significantly increasing the number of patients requiring rehabilitation.

The development of an effective medical rehabilitation system, considering the current state of public health, undoubtedly ranks among the most important medical and social challenges in modern healthcare. In Ukraine, significant attention to medical rehabilitation is reflected in the "Fundamentals of Health Legislation" (Malakhov, 2023a) and the comprehensive Intersectoral Program "Health of the Nation."

The hybrid cloud platform developed and the telerehabilitation information technology built upon it serve a wide range of PM&R specialists in the "Telerehabilitation of Oncology Patients" sector (Kaverinsky & Malakhov, 2023; Malakhov, 2023b, 2024a; Palagin, Kaverinsky, et al., 2023; D. V. Vakulenko & Martseniuk, 2015).

A distinguishing feature of the proposed technology is the combination of artificial intelligence methods with precise mathematical optimization techniques (Malakhov, 2023b): the development of mathematical models for discrete and nonsmooth optimization problems, subgradient space transformation algorithms (for minimizing nonsmooth functions with thousands of variables), and the method of global equilibrium search, among others.

All planned tasks are focused on predicting the current and overall condition of patients, strategies for intervention in the rehabilitation process, clustering of oncology patients, allocation of funds for treatment, etc. The technological platform of interactive knowledge (Litvin et al., 2023; Palagin, Kaverinskiy, et al., 2023, 2024; Palagin, Petrenko, et al., 2024; Palagin, Velychko, et al., 2020; Petrenko et al., 2023) is implemented as a component ensemble of services (Galiano-Castillo et al., 2017; Hernandez Silva et al., 2019; Malakhov, 2024a; Malakhov et al., 2024; Palagin, Kaverinsky, et al., 2023). Each service provides dynamic functionality through an ontology-driven service-oriented architecture (Palagin et al., 2014; Palagin, Petrenko, et al., 2023, 2024; Palagin & Petrenko, 2018). The cognitive services of the basic information technology enable the implementation of information-analytical platforms (Palagin et al., 2018; Velychko et al., 2021), capable of processing all information generated in spatially distributed network sources in an integrated manner and making it continuously available to all relevant specialists participating in rehabilitation activities (Palagin, Kaverinskiy, et al., 2023; Romaniv et al., 2023; Stetsyuk et al., 2023; D. V. Vakulenko, 2024; D. V. Vakulenko & Vakulenko, 2024).

The rapid increase in information volume, along with the development of IT and artificial intelligence algorithms, presents new challenges in forming a patient-centered rehabilitation ecosystem (Palagin, Malakhov, Velychko, & Semykopna, 2022). The functions of the technological platform are centered around several user groups*:*

Patients: the central figure in the rehabilitation system, receiving medical and rehabilitation services. Patients actively collaborate with specialized medical professionals to achieve the best outcomes in their treatment.

Providers of specialized medical care: These include rehabilitation departments, centers, or institutions offering various forms of patient care—whether inpatient, outpatient, or remote. They provide the medical and physical infrastructure necessary for rehabilitation procedures and patient care. PM&R specialists, including PM&R physicians, psychotherapists, occupational therapists, and other professionals, develop and implement individualized rehabilitation programs for patients, offering medical consultations and support throughout the recovery process.

Collaboration among these participants helps create an effective and efficient rehabilitation system aimed at improved outcomes for patients requiring rehabilitation. Each group has its unique functions and contributions to the rehabilitation process, but all are united by a common goal: improving patients' quality of life and helping them return to full life after injury, illness, or surgery. Interaction with the patient at various stages of rehabilitation should be supportive, motivational, and informative, helping the patient adapt to their new condition and return to normal physical and psychological well-being.

To optimize the patient's rehabilitation trajectory, a rehabilitation trajectory algorithm is needed, with further addition of the developed optimization and ontolinguistic models (Palagin, Kaverinskiy, et al., 2024; Palagin, Velychko, et al., 2020) in specific modules such as the "Decision Support Expert System," "Information-Analytical Subsystem," and other modules developed within the Telerehabilitation Platform (TRP) (Malakhov, 2023b).

The TRP is primarily designed with full support for the Ukrainian language, ensuring comprehensive functionality and usability for Ukrainian-speaking users. At the current stage of TRP development, there is partial beta support for English localization. This means that while many of the core features and interface elements have been translated into English, users may still encounter some components that are not yet fully localized. The ongoing development aims to enhance the English language support, with full localization planned in future updates to better serve a broader audience.

2.2. Algorithmization of the Rehabilitation Process

The process of moderating a rehabilitation program is entrusted to the PM&R physician, who, based on communication with the patient, considers the patient's initial condition, rehabilitation goals, functional capabilities, and specific temporal, financial, psychological, and social factors. Figure 2.1 illustrates the algorithm for determining a patient's rehabilitation trajectory.

The PM&R physician assesses and aligns the plan with the capabilities and workload of the rehabilitation center specialists. The next step involves selecting the optimal multidisciplinary team from the available specialists, taking into account the patient's rehabilitation goals, limitations, and potential. This selection is coordinated with the patient and planned in a schedule visible to all participants in the rehabilitation program.

During the execution of the planned rehabilitation program, ongoing communication is maintained with the patient and the multidisciplinary team through filled-in diaries and verbal communication. This continuous interaction allows for the rehabilitation program to be adjusted as needed or concluded if necessary. An essential stage of the rehabilitation program is the evaluation of its effectiveness at an interim stage or upon completion, which informs either the program's adjustment or the development of a personalized rehabilitation plan for the patient.

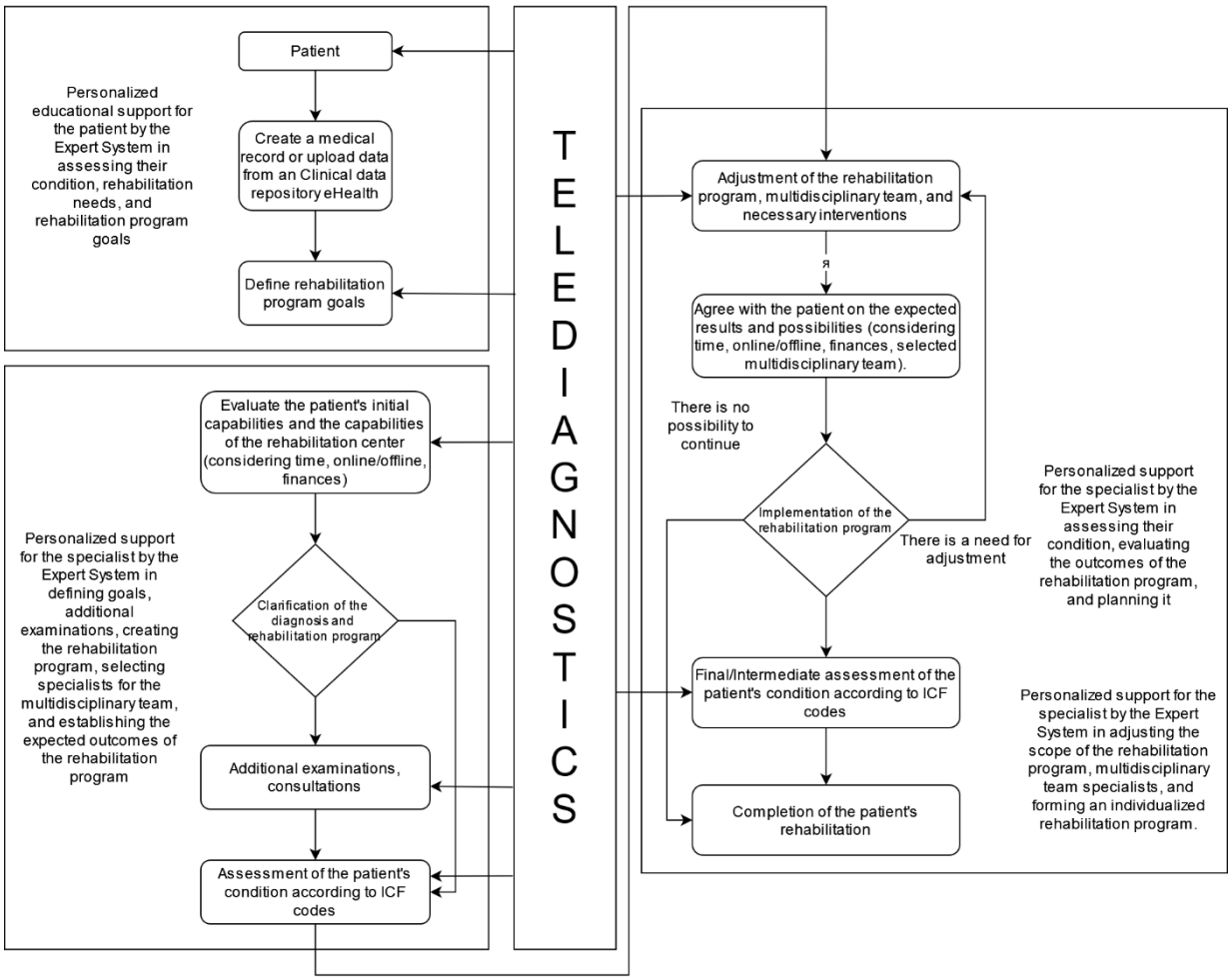
A significant role in ensuring the maximum effectiveness of the rehabilitation trajectory for both the patient and the specialist is played by educational and informational support. The component that provides this support is the Information-Analytical Subsystem (Module) of the Expert System. Figure 2.1 presents the educational and informational tasks at each stage of rehabilitation. At the beginning of the program, it is important to help the patient assess their condition, rehabilitation needs, and goals in an accessible way. At the subsequent stages of forming and implementing the rehabilitation program, personalized support from the Expert System is needed to evaluate their condition, assess the results of the rehabilitation program, participate in the program, and plan future individualized rehabilitation programs (IRP).

In the work of PM&R physicians and other rehabilitation specialists, it is necessary to ensure personalized support from the Expert System in setting goals, determining additional examinations, selecting ICF codes and their weighted assessment, developing the rehabilitation program, selecting specialists for the multidisciplinary team, and forming the expected outcomes of the rehabilitation program. During the following stages of implementation, adjustment, effectiveness evaluation, and IRP development, the presence of personalized support from the Expert System remains important.

Given the significant workload on the PM&R physician in planning, conducting, and evaluating the effectiveness of the rehabilitation program, optimization tasks are essential for saving time and resources for participants in the rehabilitation process while enhancing its effectiveness. For this purpose, optimization tasks can be addressed at each stage of the patient's rehabilitation trajectory. Telediagnostics is a key component for monitoring the patient's condition throughout all stages of the rehabilitation process.

Figure 2.1

Algorithm for Defining a Patient's Rehabilitation Trajectory



2.3. Structural and Functional Description of the TRP

The structural diagram of the TRP with its modules is presented in Figure 2.2. The initial login page graphical user interface (GUI) for users to access the Cloud Platform for Patient-Centered Telerehabilitation of Oncology Patients is available at the following link: https://his.e-rehab.pp.ua/sign-in.

The TRP includes modules that manage patient transitions, personal information, emergency contacts, and details about a trusted person. The Rehabilitation module encompasses the history of previous assessments and rehabilitation programs and the setting of rehabilitation program goals. It allows for the determination of personalized goals based on the patient's condition and needs. If necessary, the submodule allows for scheduling additional assessments, consultations, functional tests, and surveys. The list of submodules is displayed in the menu under the PM&R Physician's Digital Workspace.

A demo button is available for test login under the PM&R Physician's profile, and the home page GUI after logging into the TRP is shown in Figure 2.3.

Figure 2.2

Structural Diagram of the TRP with Modules

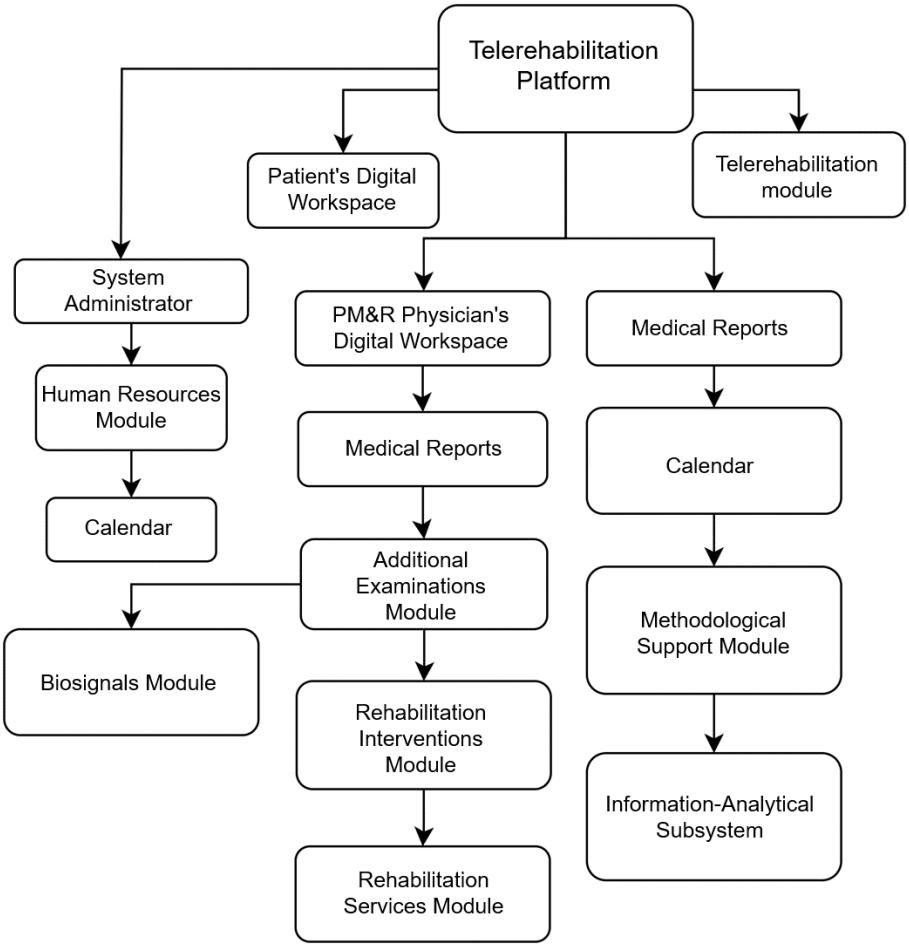
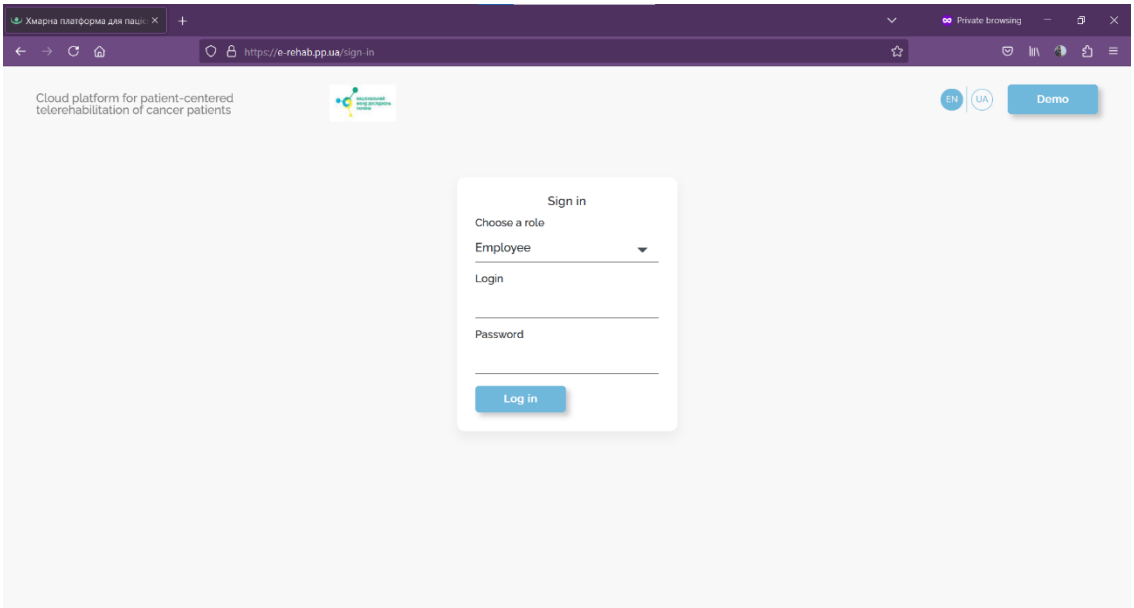


Figure 2.3

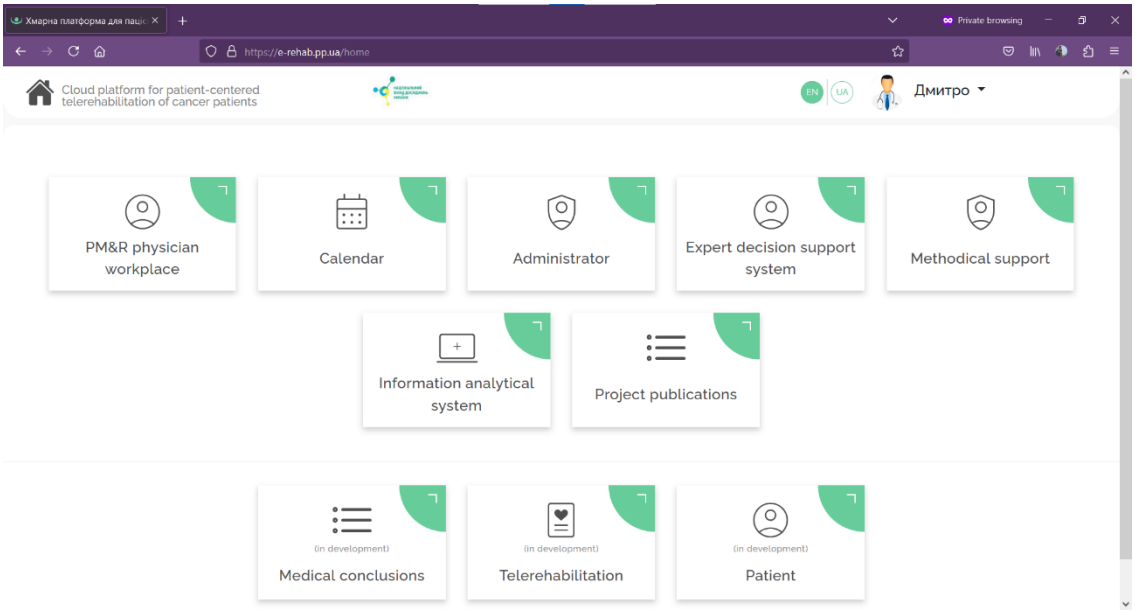
Initial Login Page GUI for Users in the Telerehabilitation Platform (TRP)



The home page GUI after logging into the TRP under the PM&R physician's profile is shown in Figure 2.4.

Figure 2.4

The GUI of the PM&R Physician's Digital Workspace with the Available TRP Modules



2.4. PM&R Physician's Digital Workspace

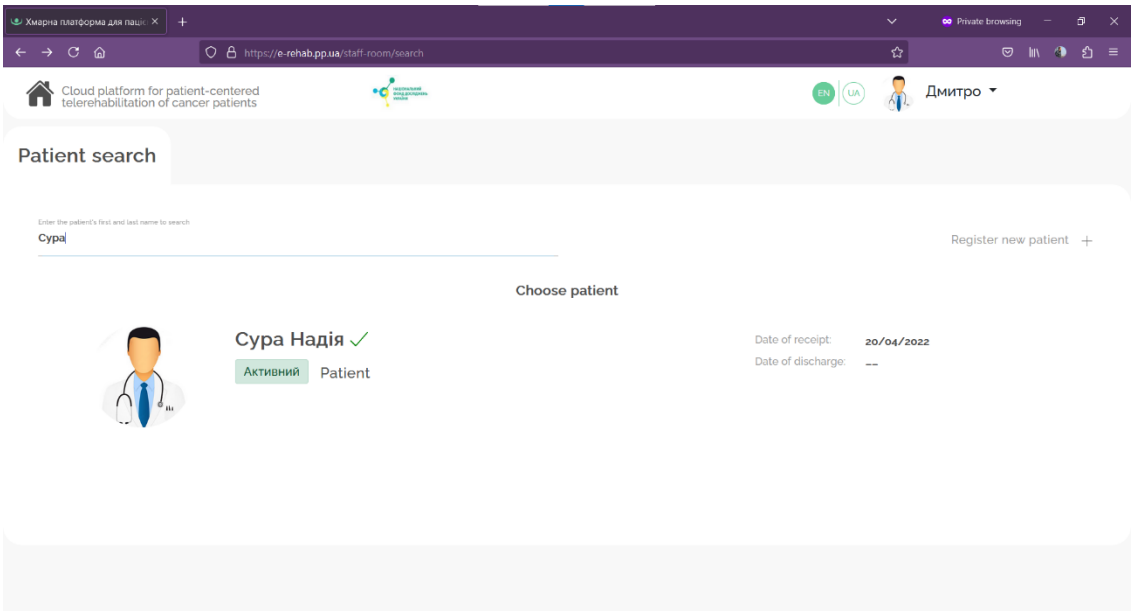
The "PM&R Physician's Digital Workspace" module includes various tools and functions designed to support the telerehabilitation process for patients. The system allows for the selection of a patient and the use of saved rehabilitation program models.

The PM&R physician's interaction with a patient begins with searching for the patient in the database, as illustrated in Figure 2.5, showing the GUI window. When selecting the patient search by referral, the next window, shown in Figure 2.6, will be accessible.

The system provides the capability for the patient to register their personal workspace independently and for the PM&R physician to register the patient in the PM&R Physician's Digital Workspace. The GUI window for patient registration in the PM&R Physician's personal workspace is shown in Figure 2.7.

Figure 2.5

The GUI Window of the TRP for Searching a Patient in the Database by Last Name and Referral Number



After selecting a patient, the PM&R Physician's Digital Workspace tab, within the sub-menu of the PM&R Physician's Digital Workspace, displays the GUI window as shown in Figure 2.8.

Access to the Patient's Profile, including Personal Information, Emergency Contacts, and Information on a Trusted Person, is available. The Rehabilitation Module includes the history of previous assessments and rehabilitation programs, as well as the ability to work with the rehabilitation program goals. This module allows the determination of specific rehabilitation goals for each patient, which can be individualized according to the patient's condition and needs. If necessary, the Submodule allows for planning additional Assessments, Consultations, Functional Tests, and Surveys. The GUI of the PM&R Physician's Digital Workspace module, with the submodules Rehabilitation, Additional Assessments, and Rehabilitation Services in the TRP, is presented in Figure 2.9.

The GUI window of the PM&R Physician's Digital Workspace in the TRP, specifically the submodule for working with rehabilitation program goals, is shown in Figure 2.10.

Figure 2.6

The GUI Window of the TRP for Patient Search by Referral Number

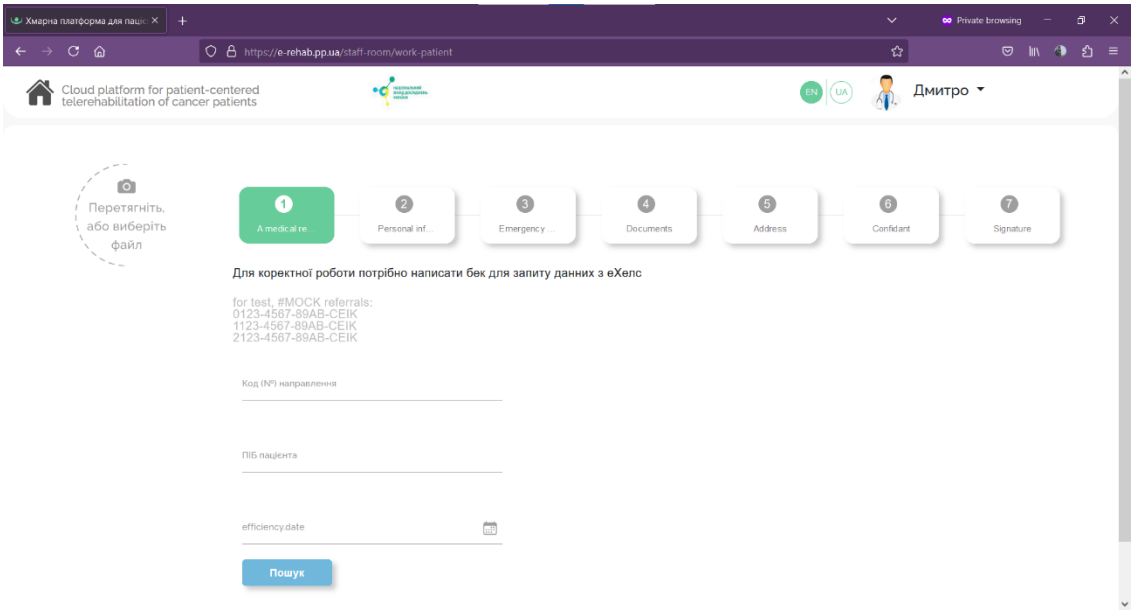


Figure 2.7

The GUI Window for the Patient Registration in the PM&R Physician's Personal Digital Workspace

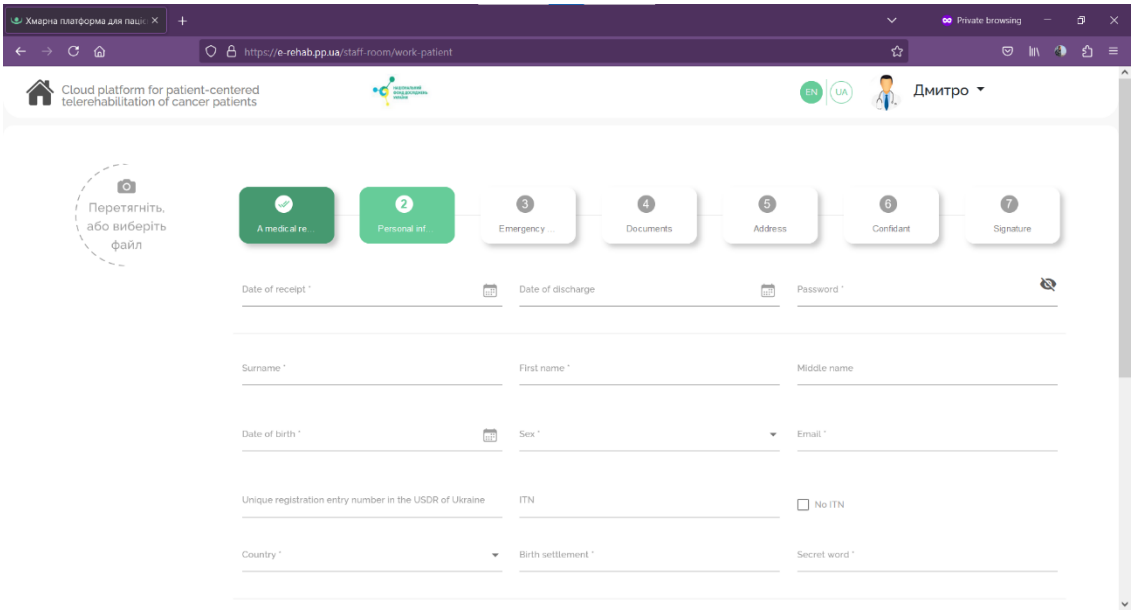


Figure 2.8

The PM&R Physician's Digital Workspace GUI in the TRP

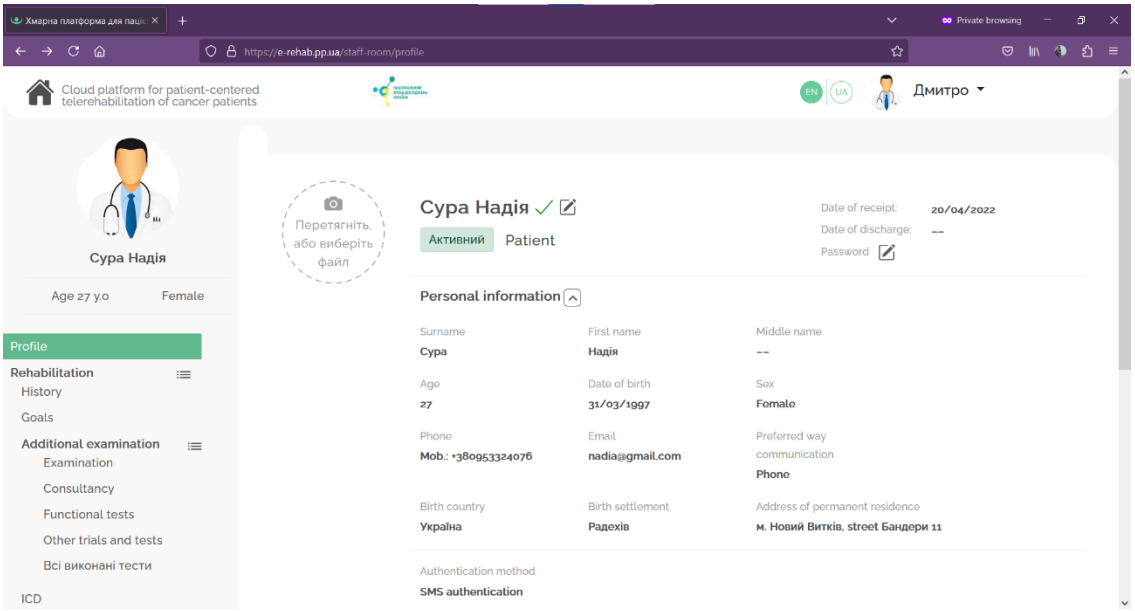


Figure 2.9

The GUI Window of the PM&R Physician's Digital Workspace in the TRP – Patient Profile Submodule

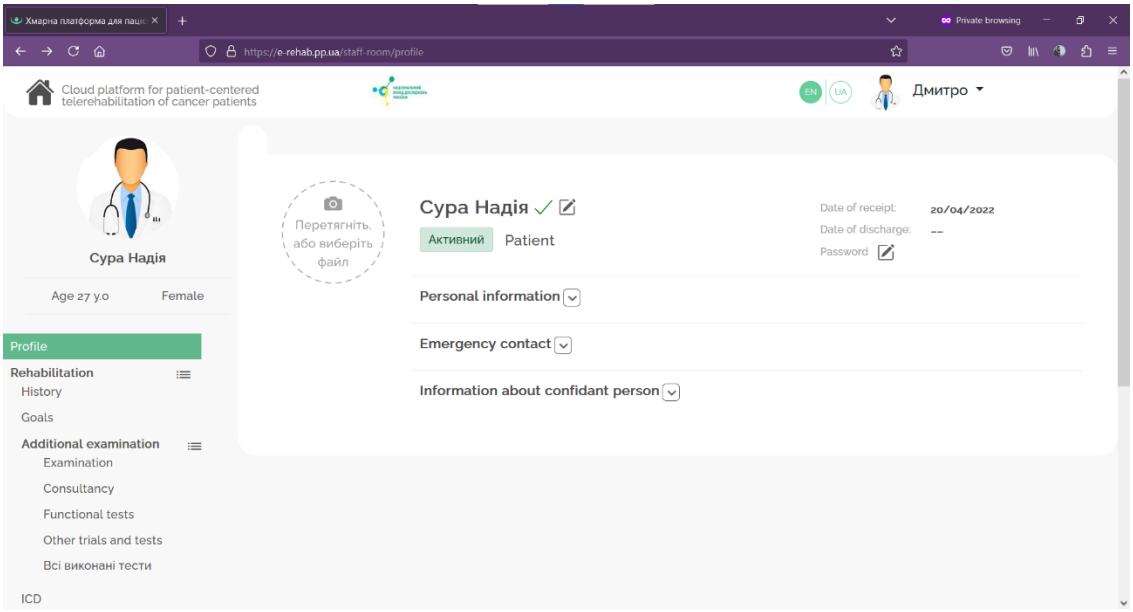


Figure 2.10

The GUI Window of the PM&R Physician's Digital Workspace in the TRP – Rehabilitation Program Goals Submodule

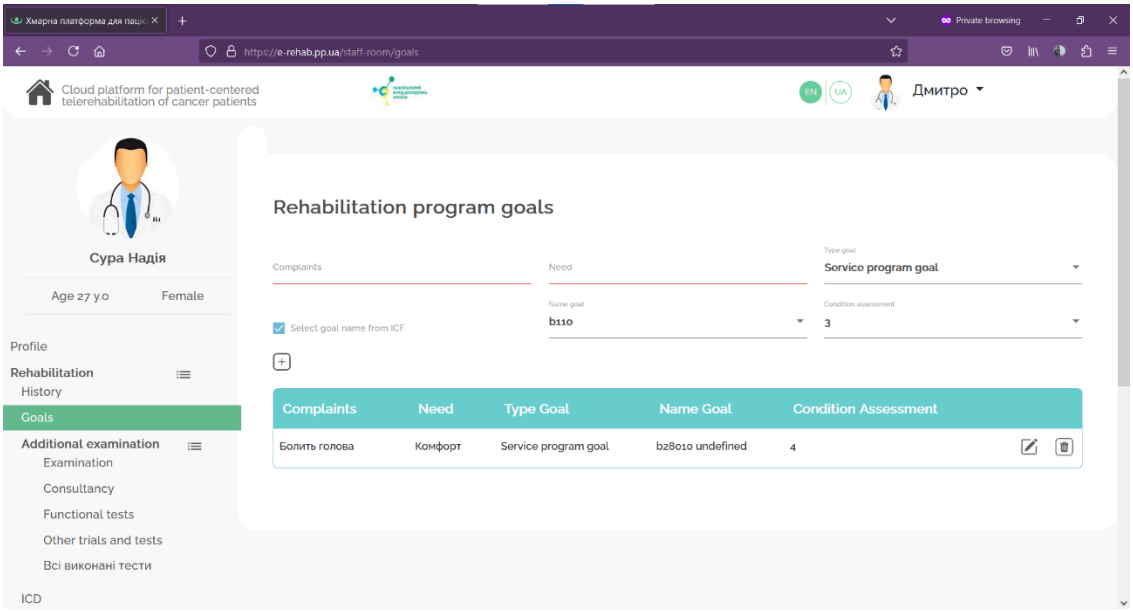
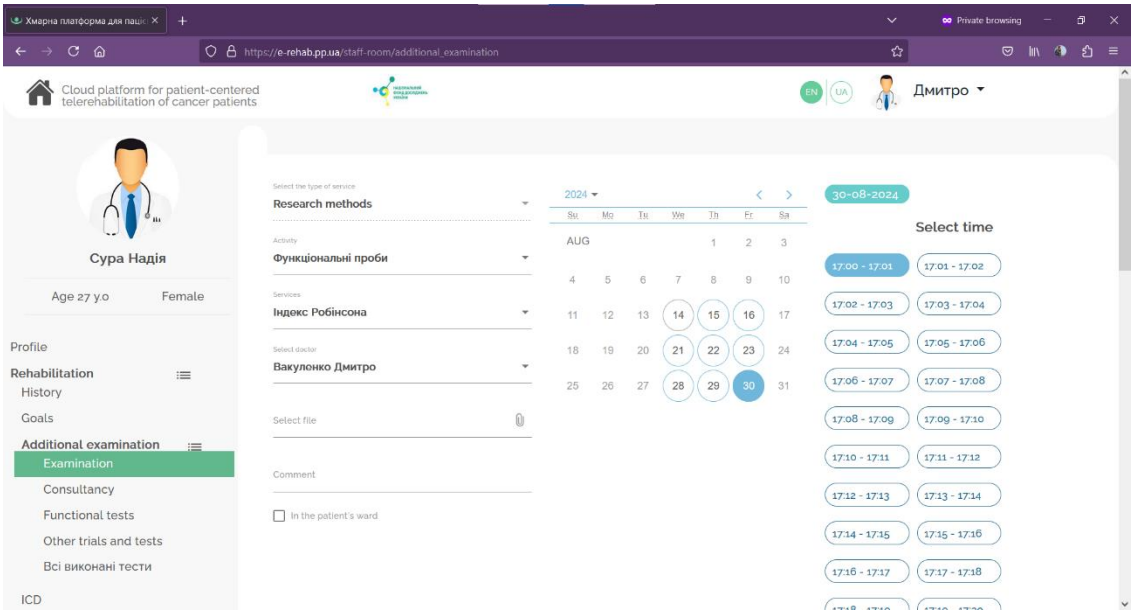


Figure 2.11

The TRP GUI Window for Planning a Procedure (Intervention) with Date and Time Selection

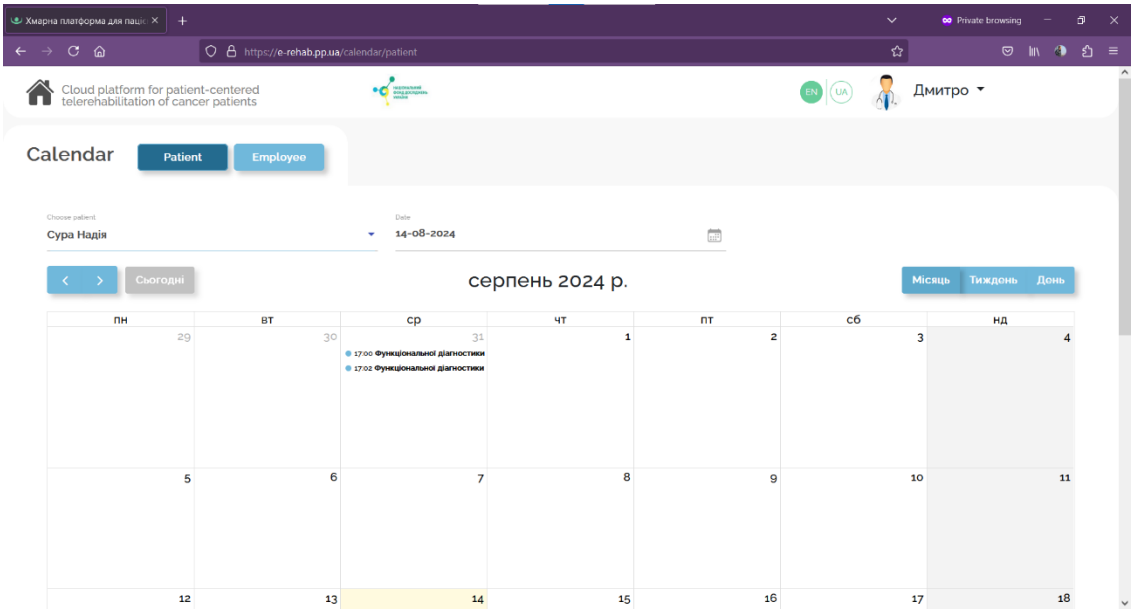


To refine the diagnosis, plan rehabilitation, and evaluate its effectiveness, additional consultations, examinations, and functional tests can be conducted. The TRP provides this functionality, allowing the PM&R physician to schedule the necessary intervention for the patient by selecting the appropriate specialist from the available list, specifying the required number of sessions, frequency, and cost. The physician can choose the necessary dates from the proposed list. Below is the TRP GUI for scheduling a procedure (intervention) with options for selecting possible dates and times for the chosen procedure, as shown in Figure 2.11.

After scheduling a procedure (intervention), the planned event is displayed in the calendar of each involved user. The appearance of the GUI calendar window can display scheduled events for the day, week, or month, along with the planned procedures, as shown in Figure 2.12.

Figure 2.12

The GUI of the Calendar Window (can display scheduled events for the day, week, or month with planned procedures).



When opening additional information about a scheduled procedure (intervention), the modal window in the GUI displays the date, time, information about the physician and patient, the name of the activity, the location, and any additional information in the comment field. The appearance of this window is shown in Figure 2.13.

Figure 2.14 presents information about the examinations and consultations that have been conducted.

After the necessary consultations and functional tests are completed, the PM&R physician can proceed to assess the patient's condition using international classifications such as ICD, ICF, and the International Classification of Health Interventions (ICHI). This component allows users to enter and view data related to referrals and activities under the National Health Service of Ukraine, as well as to use international classifications like the International Classification of Primary Care (ICPC-2, ICPC-3), ICD, ICF, and ICHI.

One of the primary tools for establishing a rehabilitation diagnosis and evaluating the effectiveness of a rehabilitation program is the ICF. The ICF framework allows for assessing impairments in body functions and structures, activities, participation, environmental factors, and the degree of impairment on a scale from 0 to 9. Due to the extensive number of components, with over 1,400 categories in total, its broad application in clinical practice can be challenging. To simplify the use of ICF, more than 100 code sets have been integrated, including general assessment sets, simplified and expanded sets, and sets for specific subgroups of cardiovascular, pulmonary, neurological, and other diseases. An example of the TRP GUI window for selecting models is shown in Figure 2.15.

After selecting the necessary ICF codes, they are added to a special module for the rehabilitation diagnosis, where the selected ICF codes are displayed according to categories of body functions and structures, activities, participation, environmental factors, and personal factors, with a graphical representation of the rehabilitation diagnosis, as shown in Figure 2.17.

An additional tool for selecting individualized ICF sets includes custom-made sets that can be used independently or made available within a single healthcare institution (HCI) or to all TRP users.

The application of the Expert System with linguistic models based on the analysis of patient needs, goals, and examination results allows for the suggestion of optimal ICF code sets.

Planning, assembling, and evaluating the effectiveness of the rehabilitation program. This element allows for creating rehabilitation program plans, including categorical goals, intervention tables, a list of rehabilitation services, and evaluating the program's effectiveness. Specialists from various fields – a multidisciplinary team – can participate in the evaluation.

The "Rehabilitation Services" sub-tab allows for detailing the components of the rehabilitation program. This subcategory includes the following services:

- Morning and therapeutic exercises: physical exercises that help strengthen muscles and improve motor functions.
- Independent activities: exercises or tasks that the patient can perform independently to support rehabilitation.
- Massage: massage techniques used to improve circulation and relieve tension.
- Additional physical activity services: various tools and devices that assist the patient in restoring motor skills.
- Other physical therapy services: other physical methods and therapeutic approaches to improve health.
- Multimedia services: the use of various media formats (images, sound, video) to address psycho-emotional and motivational components through telerehabilitation interventions for breast cancer patients.

For multimedia support in performing exercises from the categories of Morning Exercises, Therapeutic Physical Culture, and Independent Activities, the PM&R physician can upload multimedia files or external links to them, set the order of their display, and provide a title for this set. The appearance of the TRP GUI window is shown in Figure 2.18.

Figure 2.13

The TRP GUI of the Modal Window

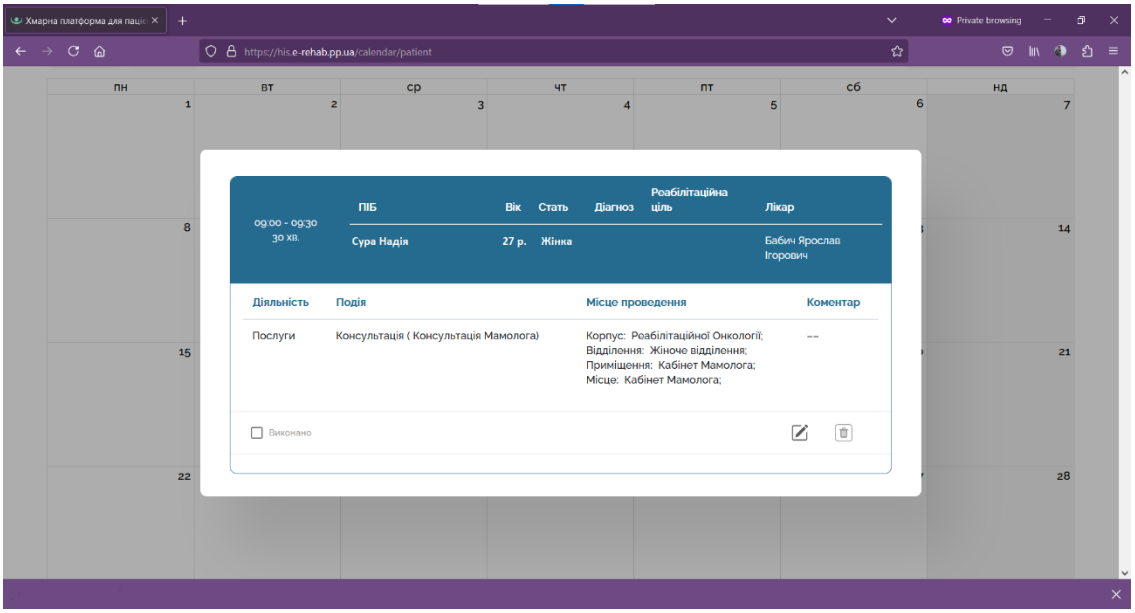


Figure 2.14

The GUI of the PM&R Physician's Digital Workspace in the TRP (information on completed examinations and consultations)

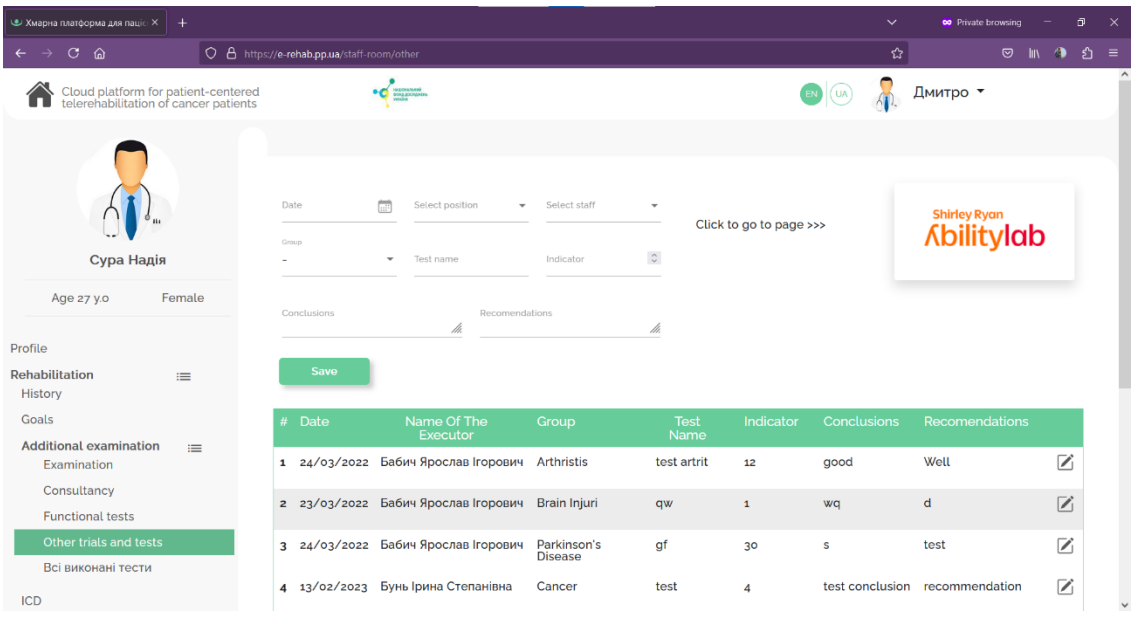


Figure 2.15

The TRP GUI Displaying ICF Code Sets and Sets of Models

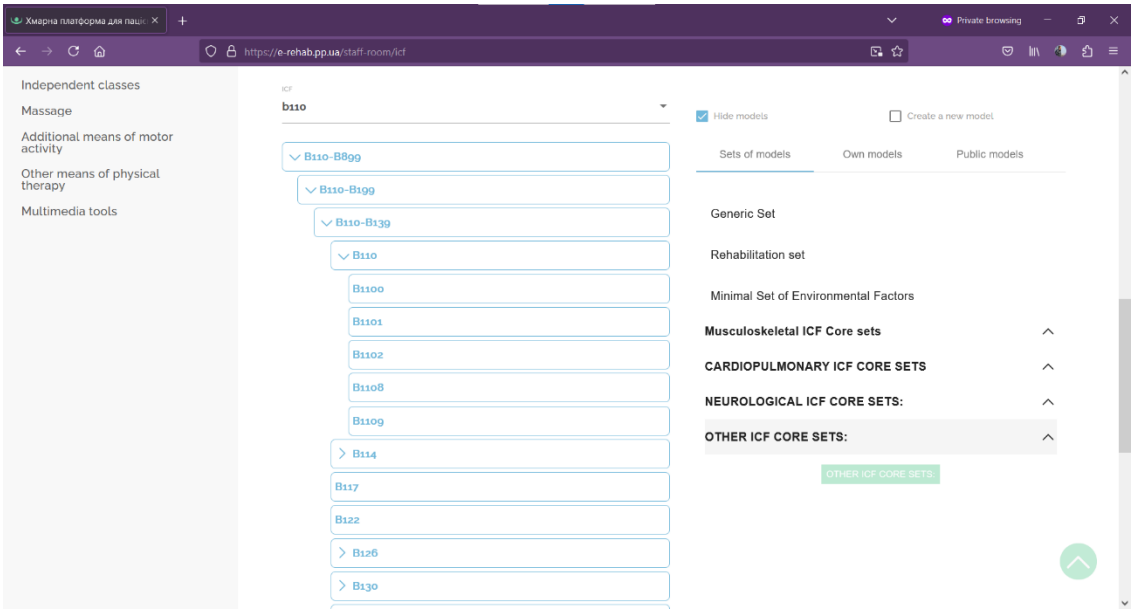


Figure 2.16

The TRP GUI for Displaying the Selection of Deviation from the Norm

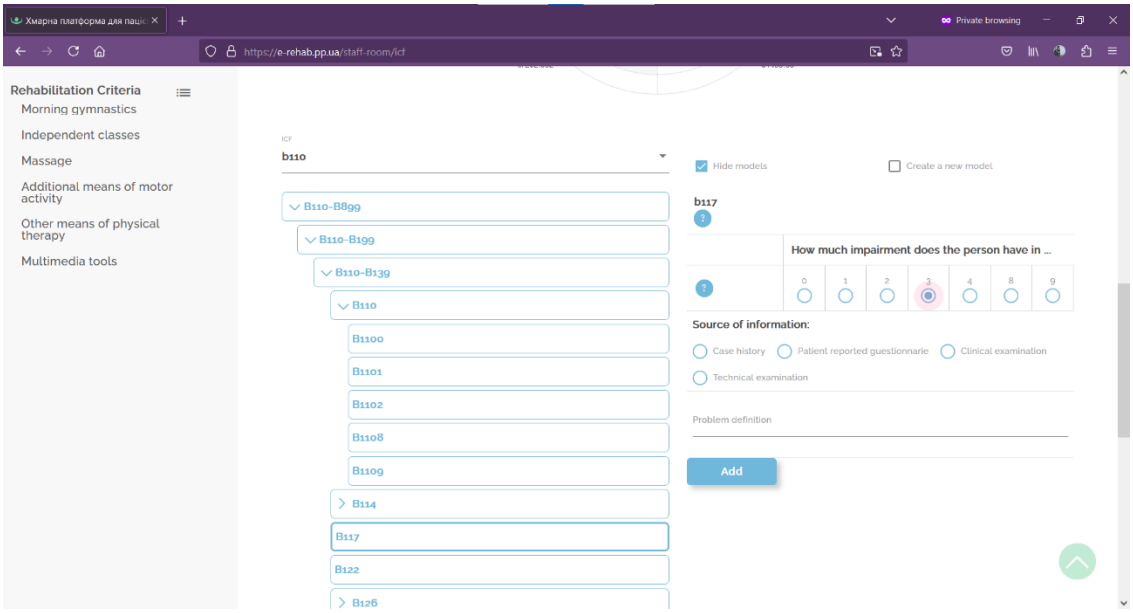


Figure 2.17

The TRP GUI for Working with the ICF Sets (selected ICF codes are displayed according to the relevant categories)

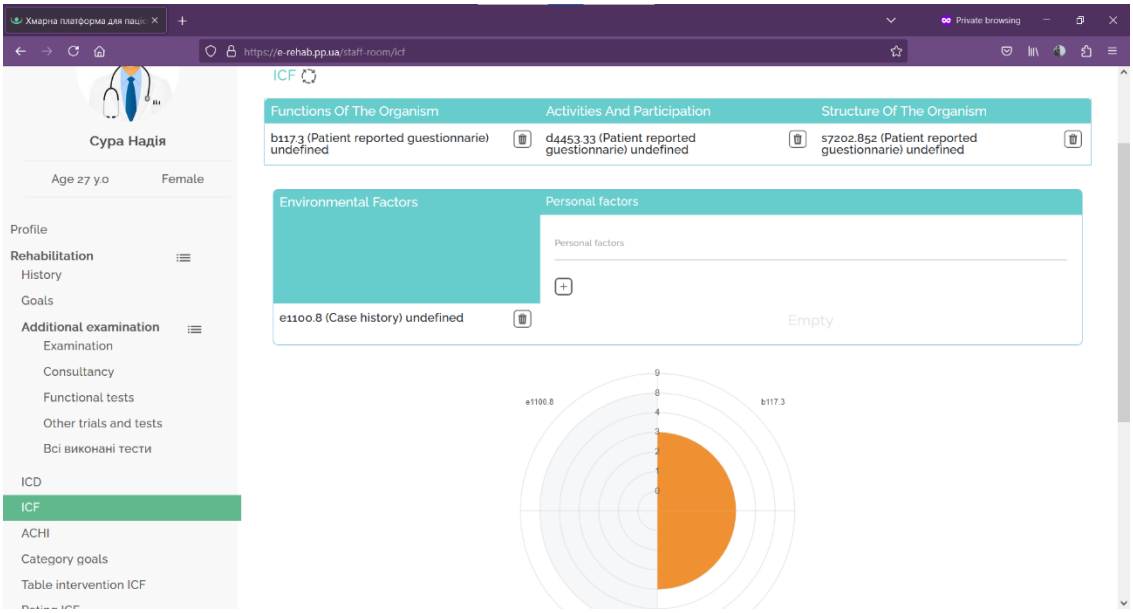


Figure 2.18

The TRP GUI for Planning the Scope of Morning Exercises with Multimedia Support

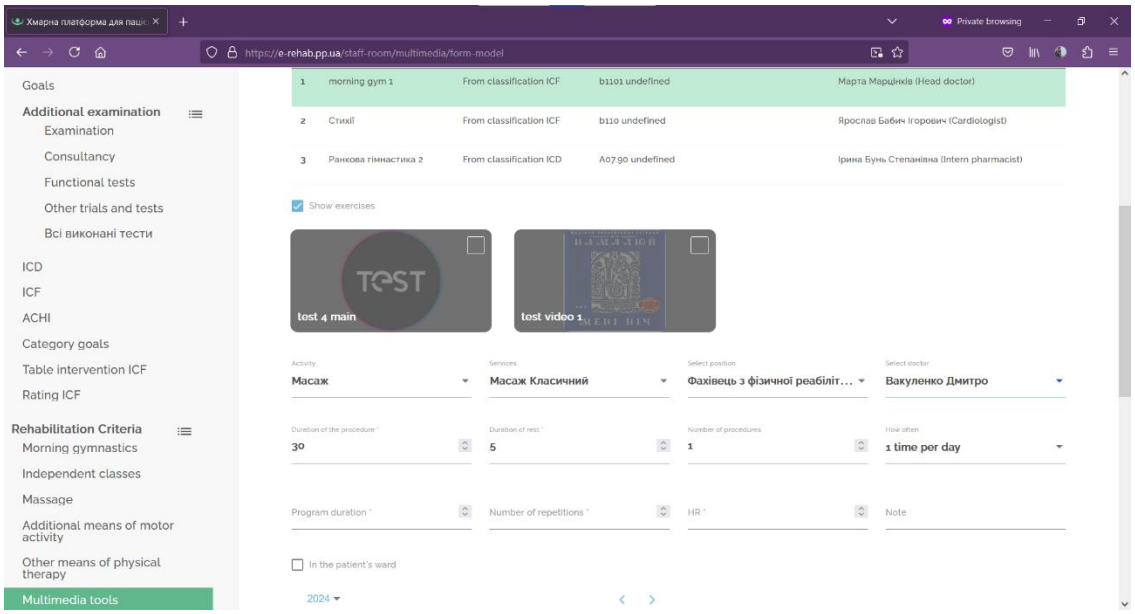
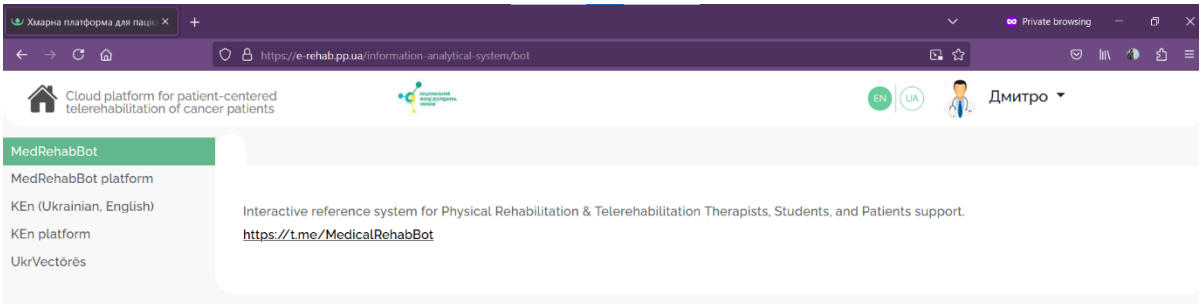


Figure 2.19

The GUI for Interaction with the Modules of the Information-Analytical Support for the Multidisciplinary Team Specialists



2.5. Patient's Digital Workspace

The patient's digital workspace is an integral part of the TRP platform, designed to empower the patient as an active participant in the rehabilitation process. This includes involvement in setting rehabilitation goals, scheduling available consultations and services, and maintaining a diary of psychophysiological indicators during specific prescribed interventions and rehabilitation programs. The patient's profile provides access to submodules such as Profile, Appointments, Staff, Calendar, and Diaries of planned rehabilitation interventions. The GUI of the patient's profile in the TRP is presented in Figure 2.20.

Healthcare facilities have the option to define services that the patient can book independently, specifying their duration and cost. The GUI for planning procedures (interventions) with the selection of available dates and times in the patient's digital workspace is shown in Figure 2.21.

Once a procedure (intervention) is scheduled, the planned event appears on the calendar of each relevant user. The calendar interface can display scheduled events for the day, week, or month, including planned procedures, as shown in Figure 2.22.

When additional information about the scheduled procedure (intervention) is opened, the modal window displays the date, time, information about the doctor and patient, the name of the activity, the location, and additional details in the comments field. This window is depicted in Figure 2.23.

A key tool for documenting the patient's condition during interventions is the diary, which is completed by both the specialist conducting the intervention and the patient. An example of the diary interface is shown in Figure 2.24.

Figure 2.20

The TRP GUI of the Patient's Profile (in Ukrainian Only)

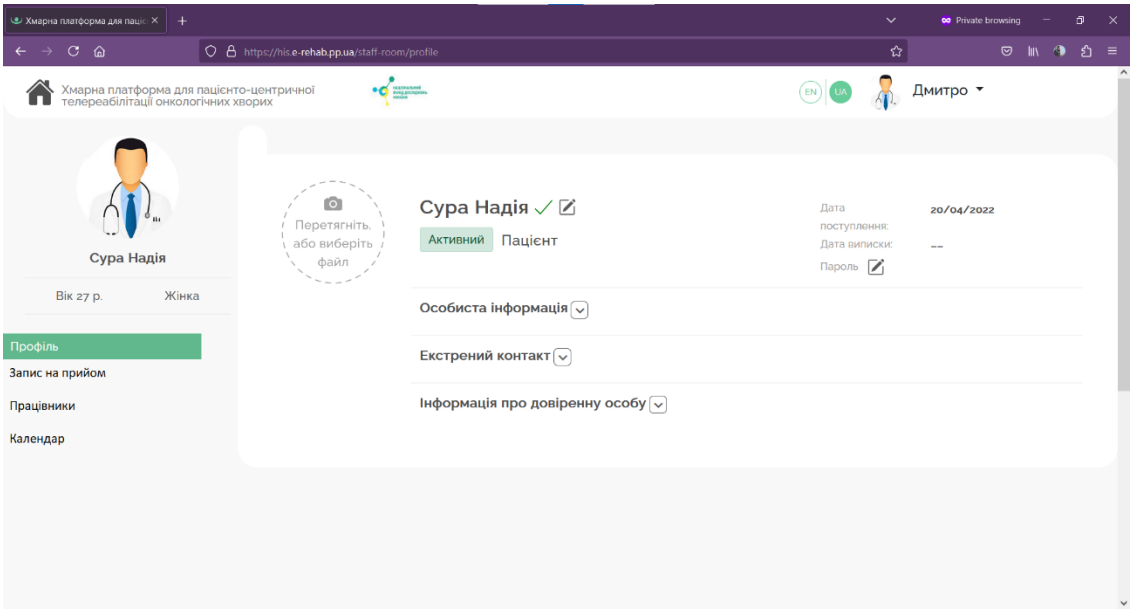


Figure 2.21

The GUI for Service Booking in the Patient's Profile (in Ukrainian Only)

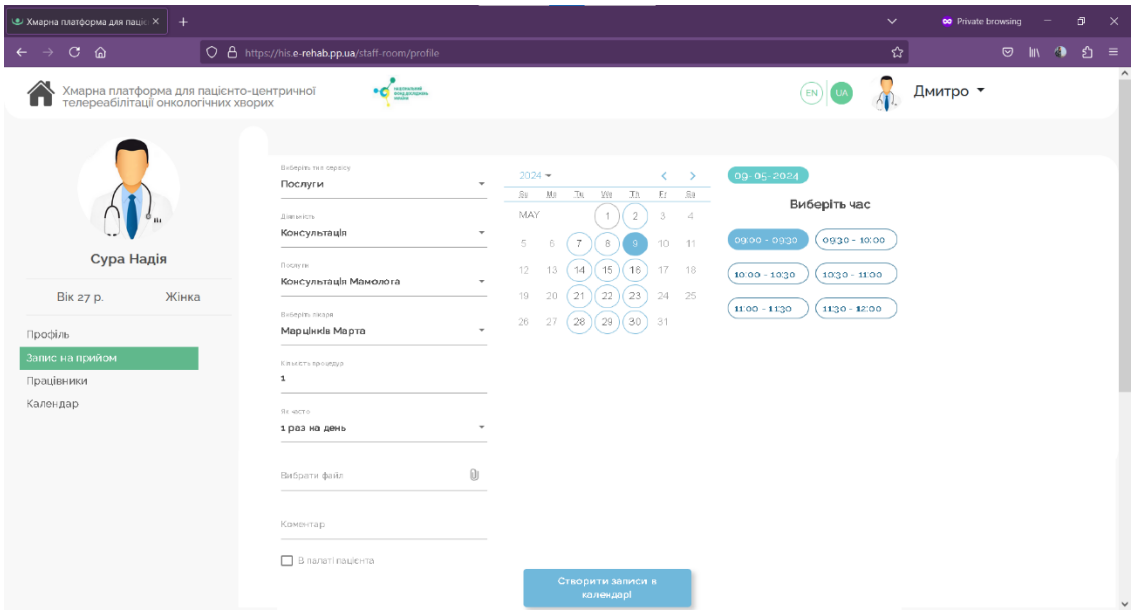


Figure 2.22

The GUI for the Calendar with Scheduled Interventions (in Ukrainian Only)

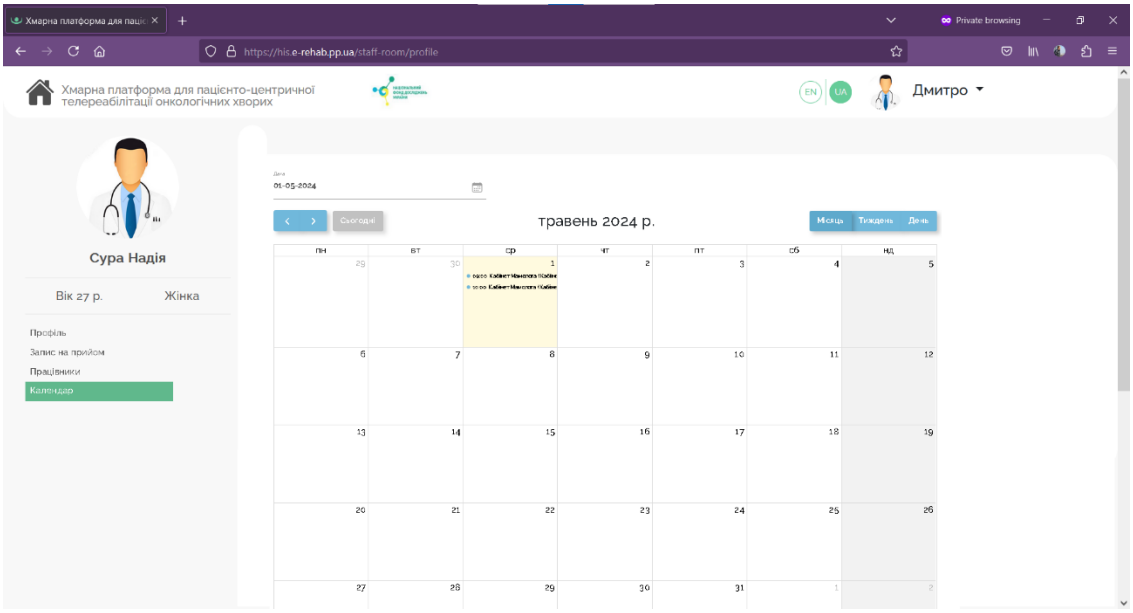


Figure 2.23

The TRP GUI Modal Window Displaying the Date, Time, Information About the Doctor and Patient, Activity Name, Location, and Additional Information in the Comments Field (in Ukrainian Only).

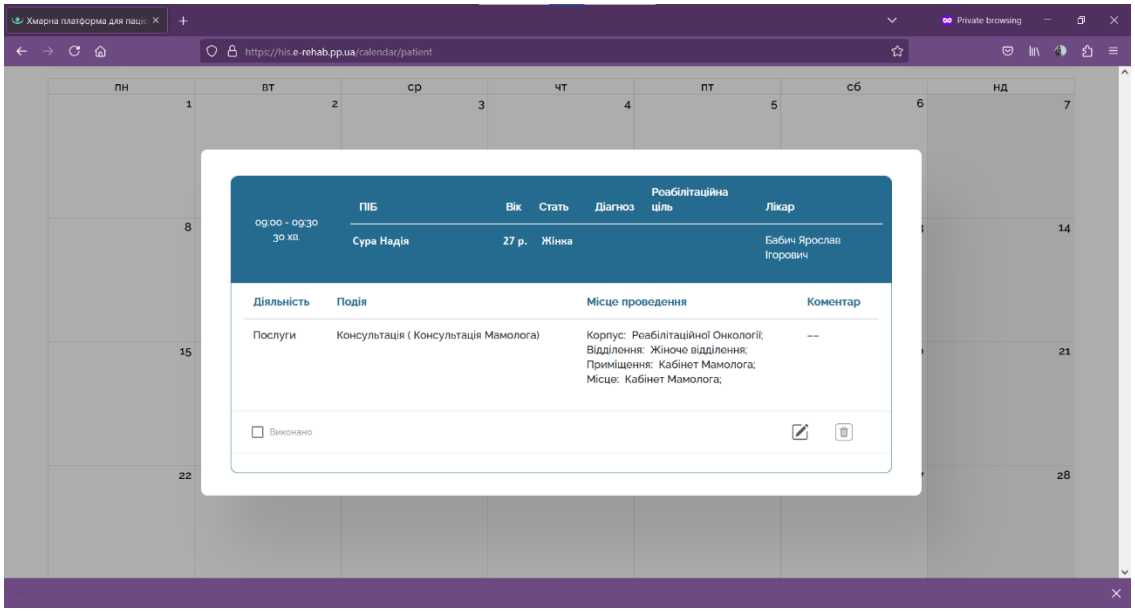
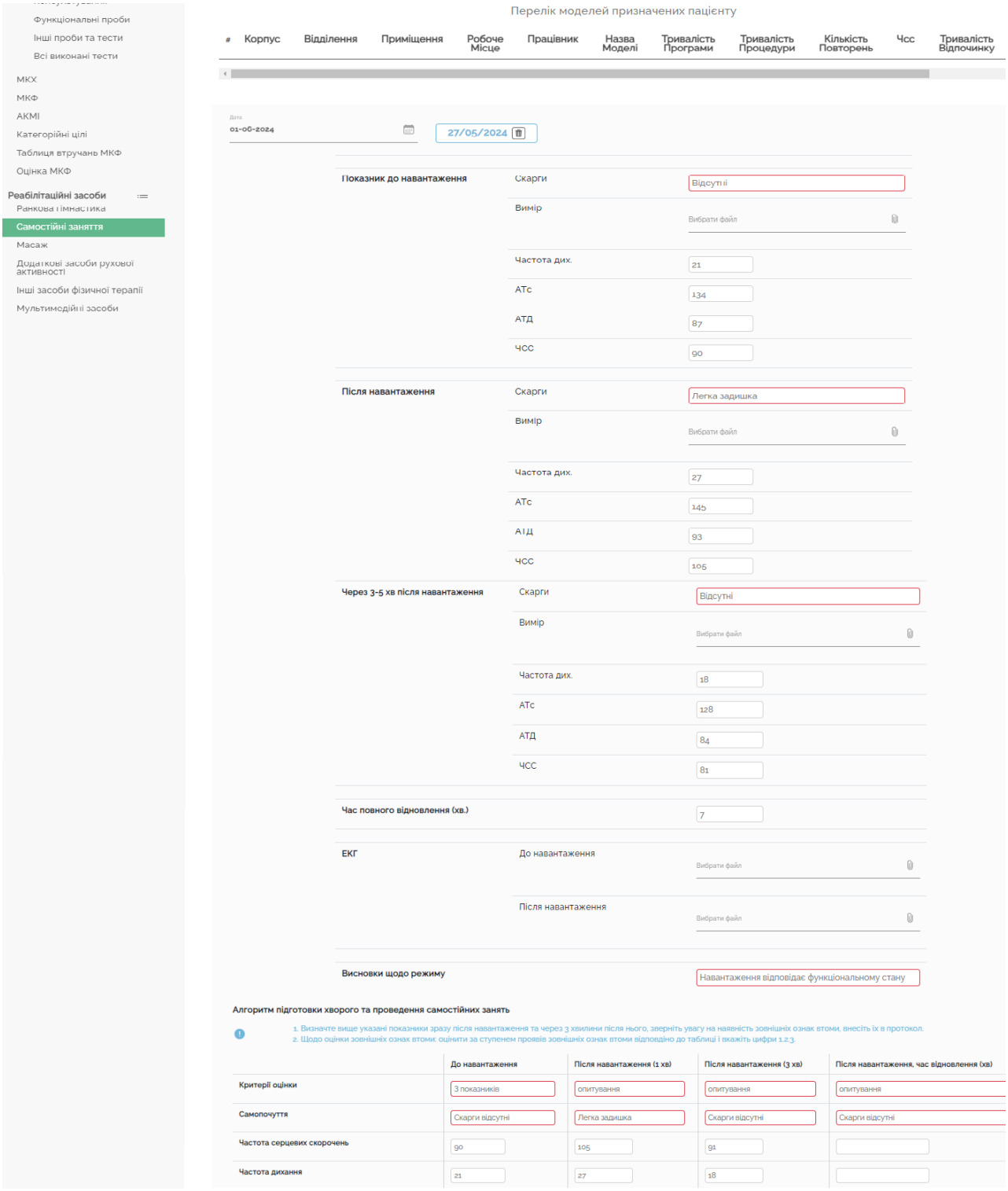


Figure 2.24

The GUI for the Patient and Medical specialist's journal



2.6. Working with Identified Patients According to the Requirements of Ukraine's Electronic Healthcare System – eHealth

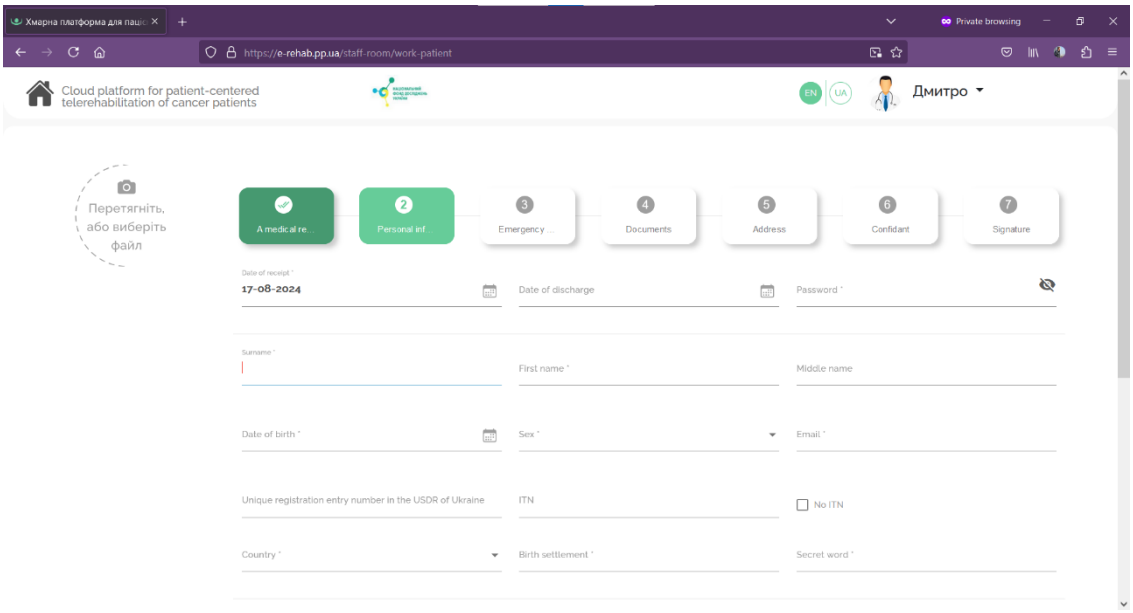
The modern strategy of the state and the Ministry of Health (Malakhov, 2023a) includes the preservation and accounting of medical data in the Central Database (CDB) of Ukraine's Electronic Healthcare System (eHealth). Medical information systems must ensure communication with HCI, and thus, a module has been developed in the TRP to facilitate communication with the Central eHealth Database.

This module includes services for registering HCI, entering the names of departments and service locations, registering employees and patients, signing declarations, conducting appointments, issuing referrals, prescriptions, and more.

An example of the GUI for patient registration is shown in Figure 2.25.

Figure 2.25

The TRP GUI for Patient Registration in eHealth

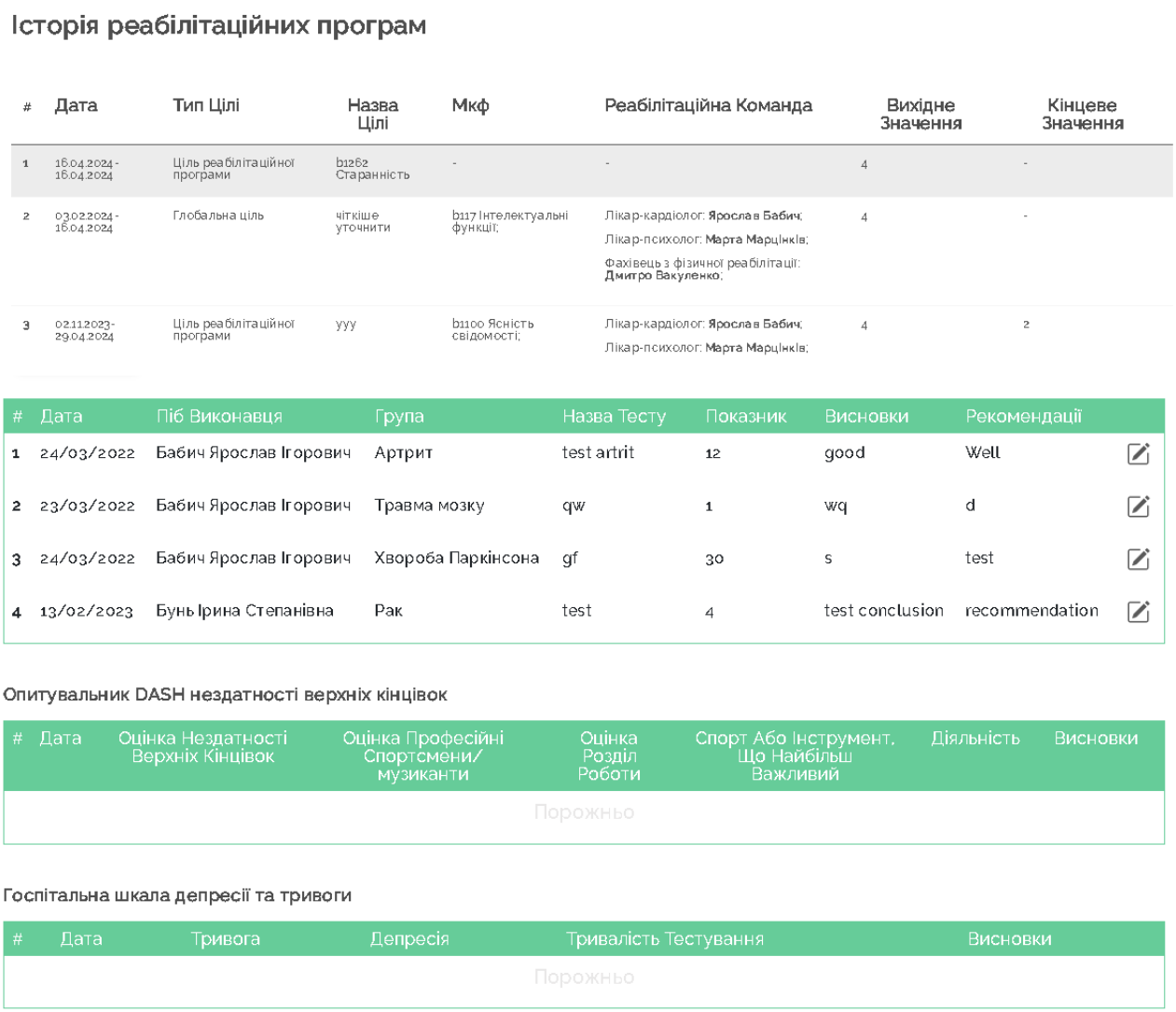


2.7. Medical Reports Module

Throughout the treatment and rehabilitation trajectory, a patient interacts with various experts and undergoes laboratory, diagnostic examinations, and testing. All interventions involving the patient are documented in the Medical Reports Module. An example of the TRP GUI for the Medical Reports Module is presented in Figure 2.26.

Figure 2.26

The TRP GUI of the Medical Reports Module (in Ukrainian only)



Історія реабілітаційних програм

#	Дата	Тип Цілі	Назва Цілі	Мкф	Реабілітаційна Команда	Вихідне Значення	Кінцеве Значення
1	16.04.2024 - 16.04.2024	Ціль реабілітаційної програми	b1262 Старанність	-	-	4	-
2	03.02.2024 - 16.04.2024	Глобальна ціль	чіткіше уточнити	b117 Інтелектуальні функції;	Лікар-кардіолог: Ярослав Бабич; Лікар-психолог: Марта Марцінків; Фахівець з фізичної реабілітації: Дмитро Вакуленко;	4	-
3	02.11.2023 - 29.04.2024	Ціль реабілітаційної програми	yyy	b1100 Ясність свідомості;	Лікар-кардіолог: Ярослав Бабич; Лікар-психолог: Марта Марцінків;	4	2

#	Дата	Піб Виконавця	Група	Назва Тесту	Показник	Висновки	Рекомендації
1	24/03/2022	Бабич Ярослав Ігорович	Артрит	test artrit	12	good	Well
2	23/03/2022	Бабич Ярослав Ігорович	Травма мозку	qw	1	wq	d
3	24/03/2022	Бабич Ярослав Ігорович	Хвороба Паркінсона	gf	30	s	test
4	13/02/2023	Бунь Ірина Степанівна	Рак	test	4	test conclusion	recommendation

Опитувальник DASH нездатності верхніх кінцівок

#	Дата	Оцінка Нездатності Верхніх Кінцівок	Оцінка Професійні Спортсмени/ музиканти	Оцінка Розділ Роботи	Спорт Або Інструмент, Що Найбільш Важливий	Діяльність	Висновки
Порожньо							

Госпітальна шкала депресії та тривоги

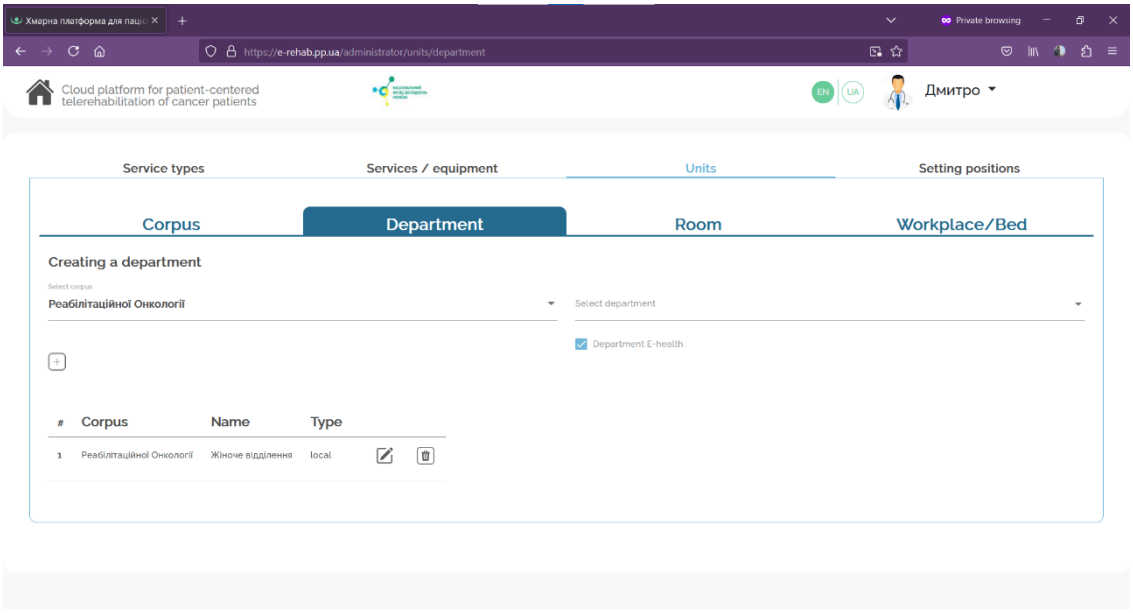
#	Дата	Тривога	Депресія	Тривалість Тестування	Висновки
Порожньо					

2.8. Administrative Subsystem

To ensure the coordination of the TRP's operations, an Administrative Subsystem has been developed. This subsystem, in addition to the Module for working with identified patients according to the requirements of the eHealth, includes modules for service descriptions, equipment management, adding staff to services, and managing their work schedules, among others. An example of the TRP GUI for the Administrative Subsystem is shown in Figure 2.27.

Figure 2.27

The GUI of the Administrative Subsystem for Interaction with eHealth and Administration of Departments and Services



2.9. Telediagnostics and Remote Patient Monitoring

Context and Importance

In wartime conditions, and particularly for patients with BC, numerous challenges arise in the provision of medical care. Telediagnostics and Remote Patient Monitoring (RPM) emerge as vital tools even under such complex circumstances. The application of telediagnostics and Remote Patient Monitoring in Ukraine, especially for patients with BC, offers several advantages:

Access to medical specialists. In conflict zones or areas distant from regional or national centers, access to qualified doctors and medical personnel is often limited. Telediagnostics and RPM bridge this gap by enabling remote consultations and expert reviews, effectively reducing the physical distance between medical professionals and patients.

Emergency medical assessment. Telediagnostics facilitates rapid evaluation of affected individuals, determining the necessity for evacuation to more specialized medical facilities.

Medical equipment utilization. Wartime conditions can lead to the damage of medical equipment and infrastructure. telediagnostics allows for the optimal use of available resources and the exchange of diagnostic data between various medical institutions.

Risk reduction for medical personnel. By enabling diagnostic procedures without direct patient contact, telediagnostics and Remote Patient Monitoring minimize risks for medical staff, which is particularly crucial in war conditions.

Resource optimization. Telediagnostics ensures the efficient use of limited medical resources, providing diagnostic services to a larger patient population.

Enhanced accessibility to medical care. Telediagnostics and RPM guarantee access to medical services for individuals in remote or hard-to-reach areas, especially where medical resources are scarce.

Definition and Mechanism

Telediagnostics is a diagnostic method that employs telecommunication technologies to remotely determine the condition of subjects, particularly within medical systems. Utilizing specialized devices, sensors, and data transmission means, it allows for the acquisition and analysis of information necessary for diagnosis without direct physical contact.

Remote Patient Monitoring is the continuous monitoring of patients' health conditions from a distance, using telecommunication technology. It involves the use of digital devices to collect medical data such as heart rate, blood pressure, and other vital signs, which are then transmitted to healthcare providers for analysis and follow-up.

Application for Patients with Breast Cancer

The implementation of telediagnostics and RPM for patients with BC is particularly significant given the prevalence of the disease and the imperative for early detection and treatment. Key aspects include:

Early diagnosis. Telediagnostics aids in the early detection of breast cancer when treatment efficacy is highest. Imaging methods, such as mammography conducted via telediagnostics, can timely identify pathological signs.

Continuous monitoring. RPM enables healthcare providers to track patients' conditions continuously, allowing for timely interventions if any health issues arise.

Access to specialized care. Patients in remote or inaccessible regions can receive consultations from oncology specialists without the need for extensive travel.

Monitoring and control. Telediagnostics and RPM facilitate the monitoring of patients with BC during treatment and rehabilitation, allowing for the observation of disease dynamics and early detection of complications.

Time-saving and convenience. Reduces the necessity for frequent visits to medical facilities, crucial for patients who may be in physically or emotionally challenging situations.

Expert consultation opportunities. Enables physicians to consult with oncology experts, obtaining second opinions on diagnosis and treatment plans.

Enhanced diagnostic quality. Advanced telediagnostics technologies provide clear and detailed images, while RPM offers continuous data that aids in precise diagnosis and treatment planning.

Cost reduction. The implementation of telediagnostics and RPM can lead to decreased medical expenses by eliminating the need for travel and allowing for early interventions.

Capabilities of Telediagnostics and RPM

Remote monitoring. Real-time observation of patient conditions, technical equipment, or other subjects from distant locations.

Continuous data collection. RPM collects continuous data on vital signs and other health indicators, providing a comprehensive view of a patient's health status.

Distant consultation. Physicians can conduct consultations with patients via video communication, analyzing symptoms and examination results.

Real-time monitoring. Sensors can track indicators such as pulse, blood pressure, temperature, blood sugar levels, among others, which are transmitted in real-time to healthcare providers for analysis.

2.9.1. Conducting Telediagnostic Measurements

Organizational transformations in healthcare require a rethinking of many principles, the activation of reserves, and, most importantly, the integration of the latest technologies. The informatization and computerization of medicine entail fundamental changes in the way doctors interact with patients, as well as the algorithms, methods of collecting and processing information, and decision-making processes (Giaquinto et al., 2022; Siegel et al., 2021).

Modern information technologies are widely implemented in healthcare practice, contributing to the early detection of diseases, timely prevention, and effective treatment. This is particularly relevant for the most common non-infectious pathologies, such as cardiovascular diseases, pulmonary disorders, diabetes, cancer, and others. These conditions account for approximately 68% of all deaths worldwide (Giaquinto et al., 2022; Torres Lacomba et al., 2009). Therefore, it is important to implement advanced technologies for the early detection of pre-disease and pre-morbid states and to assess the body's reserve capacities, enabling healthcare providers to plan preventive, diagnostic, and therapeutic processes more effectively.

Steps for Conducting Telediagnostics:

- Patient preparation. The patient must be instructed on how to properly position the equipment to obtain the highest quality images, perform measurements, and conduct functional tests. For example, in mammography, it is essential to correctly position the breast in front of the camera.
- Equipment preparation. Before starting the telediagnostic session, it is necessary to ensure that the equipment (cameras, microphones, monitors, etc.) is functioning properly and connected to the internet.
- Medical devices for data collection. Depending on the type of diagnostics, various medical devices may be used, such as blood pressure monitors, ultrasound machines, X-ray machines, dermatoscopes, or any other devices used for medical examinations.
- Connection and communication setup. Medical personnel should connect with the patient using video conferencing software or specialized telediagnostic platforms. The transmission of images and audio should be optimized.
- Internet connection. A stable and high-speed internet connection is crucial for successful telediagnostics, ensuring smooth transmission of video and data between the doctor and the patient.
- Software for video communication and data transmission. Specialized software is necessary to ensure secure transmission of medical data and maintain patient confidentiality during telediagnostics.
- Conducting measurements. The doctor or specialist carries out the procedure for registering diagnostic signals, observing the images or data transmitted from the patient. This may include reviewing X-rays, mammography images, ultrasound images, etc.
- Consultation and discussion of results. After completing the diagnostic procedure, the doctor consults with the patient regarding the results, providing conclusions and recommendations for further treatment or diagnostic measures.
- Documenting results. The results and the doctor’s conclusions can be documented for further analysis and stored in the patient's medical records via clinical data repository.
- Data storage system (Clinical Data Repository, CDR). After the telediagnostic session, it is essential to ensure the secure and confidential storage of the collected data.

Cancer can cause systemic changes in various organs and systems of the body. A comprehensive assessment of the state of the body, organs, and systems can ensure a higher quality diagnostic, therapeutic, and rehabilitation trajectory for the patient.

A significant task in expanding the diagnostic capabilities of the TRP is the ability to interact with various telediagnostic platforms.

2.9.2. Registration of Arterial Oscillogram Using a Blood Pressure Monitor

The procedure for measuring blood pressure has become an integral part of the daily routine for medical professionals, the fitness industry, and even among the general public. This procedure allows the determination of blood pressure levels and heart rate, which is crucial for the early detection and management of hypertension. Electronic blood pressure monitors have largely replaced manometric or mercury-based devices. It is predicted that the global market for electronic blood pressure monitors will double from 2020 to 2025, reaching $1.44 billion by 2025 (Giaquinto et al., 2022; Siegel et al., 2021).

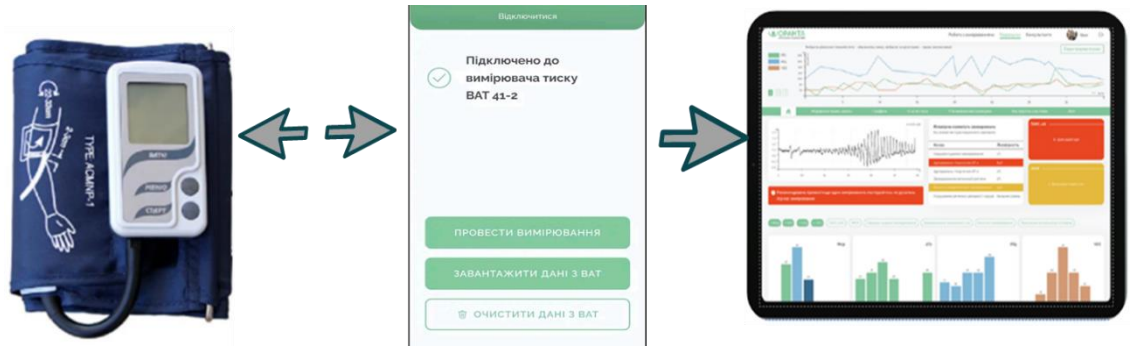
Traditionally, the analysis of arterial pulsations registered through arm (limb) cuff compression has been limited to determining blood pressure and heart rate. However, in other related fields, such as rheography, electrocardiography, encephalography, spirometry, and more, there is a wealth of experience in analyzing biosignals using a wide range of methods. For instance, in electrocardiography, the analysis of intervalograms has led to the widespread use of HRV analysis globally. HRV analysis provides insights into cardiac activity, levels of regulation of the cardiovascular system (CVS), and the state of the autonomic and central nervous systems, as well as their adaptive capacities. Rheographic curve analysis allows for the diagnosis of blood flow and vascular conditions. The components of the telediagnostic complex are shown in Figure 2.28.

The use of software complexes, which may include a web environment, mobile application, and cloud-based computational core to support the "Arterial Oscillography" information technology, offers the ability to:

- conduct a comprehensive assessment of the functional state of the cardiovascular system and its reserve capacities;
- determine the functional state of the autonomic nervous system and its adaptive abilities;
- examine the condition of blood vessels, including their tone, elasticity, and quality of adaptation to various levels of compression during blood pressure measurement, which characterizes both local (at the measurement site) and central hemodynamics;
- evaluate the overall health status, adaptive capacities of the body, premorbid states, and the effectiveness of therapeutic, preventive, and rehabilitation measures.

Figure 2.28

Components of the Telediagnostic Complex (blood pressure monitor, mobile application, personal dashboard GUI)



Using the Expert System, it is possible to conduct differential diagnostics of risks associated with cardiac, pulmonary, and mental diseases, as well as to predict blood parameters, central hemodynamics, and heart function indicators. On the main page of the user's personal dashboard on the web portal, the values of the latest or previous measurements are graphically and numerically displayed according to the user's selection: systolic blood pressure (SBP), diastolic blood pressure (DBP), heart rate (HR), and complex indicators such as the Regulatory Systems Activity Index (RSAI), Integrated Functional Vascular Potential (IFVP), vascular health, predicted disease risks, and certain blood parameters, central hemodynamics, and mental states. The subsequent graphs depict health levels, risks of cardiovascular diseases, pulmonary and mental disorders, and predicted blood parameters, central hemodynamics, and mental states.

To use the portal's resources at https://a.oranta-ao.com/, users need to register (free of charge) to create a personal account and view the results of their measurements. The next step involves installing the mobile application, and once logged into the user's profile, selecting a blood pressure monitor, conducting measurements, and viewing the results in the measurement history and web profile. Additionally, users can send a report to their physician. The interface windows of the mobile application designed for receiving and transmitting signals and blood pressure values are shown in Figure 2.29.

In the main "Results" section of the web-based personal workspace, the primary results of the latest measurements are displayed. If necessary, users can select a specific measurement (by right-clicking, double-clicking with the left mouse button, or using their finger) or a range of measurements (by selecting an interval with the left mouse button). Additionally, there is an option to choose the required measurements and view averaged values in the lower-left "Calculations" window of the interface, as shown in Figure 2.30.

In the "Report" tab, users can generate reports in either a condensed or expanded format, with an additional "Conclusions" field where necessary information can be entered. Selecting the printer icon will print the report (in grayscale for black-and-white printing), as shown in Figure 2.31.

Thus, the physician (or patient) can immediately after measuring blood pressure, in offline or online mode, obtain information not only about blood pressure values but also about health levels, the body's reserve capabilities, the state of the cardiovascular and autonomic nervous systems, and the regulation levels of their activity. This will allow the physician to diagnose pre-morbid conditions early, develop a prevention and correction program based on the obtained results, and evaluate dynamics during treatment and rehabilitation.

Figure 2.29

Mobile Application GUI for Receiving and Transmitting Blood Pressure Signals and Values (in Ukrainian Only)

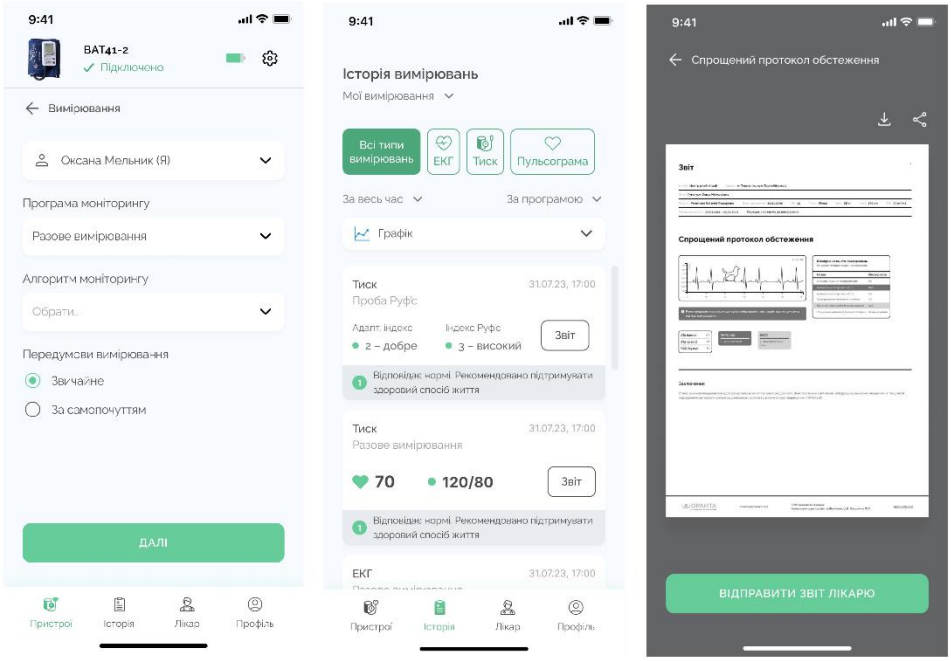


Figure 2.30

Web Workspace GUI of the "Calculations" Page

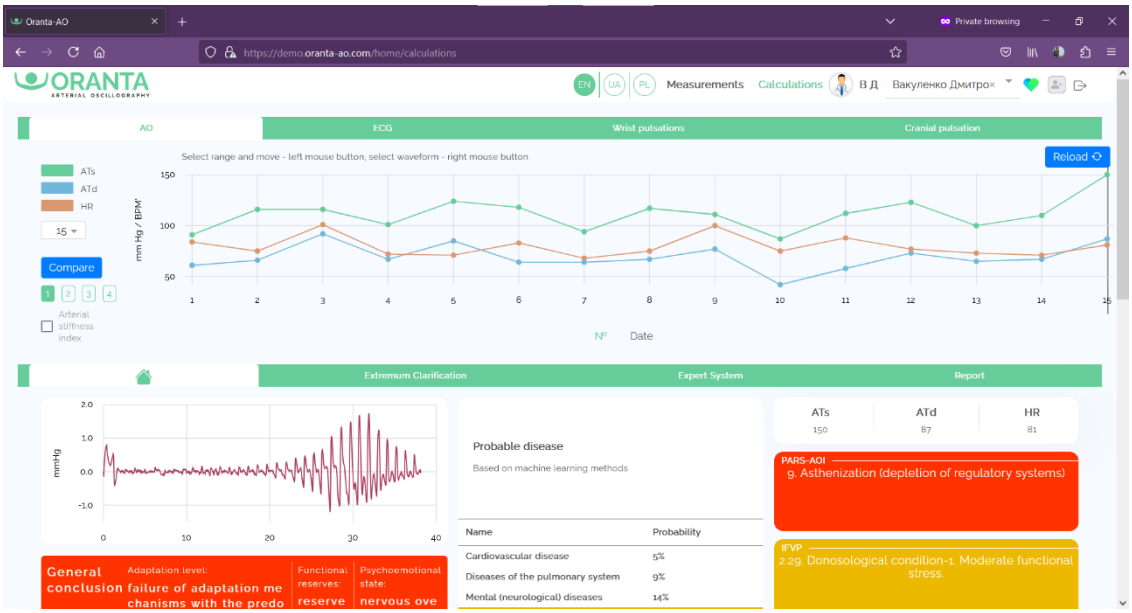
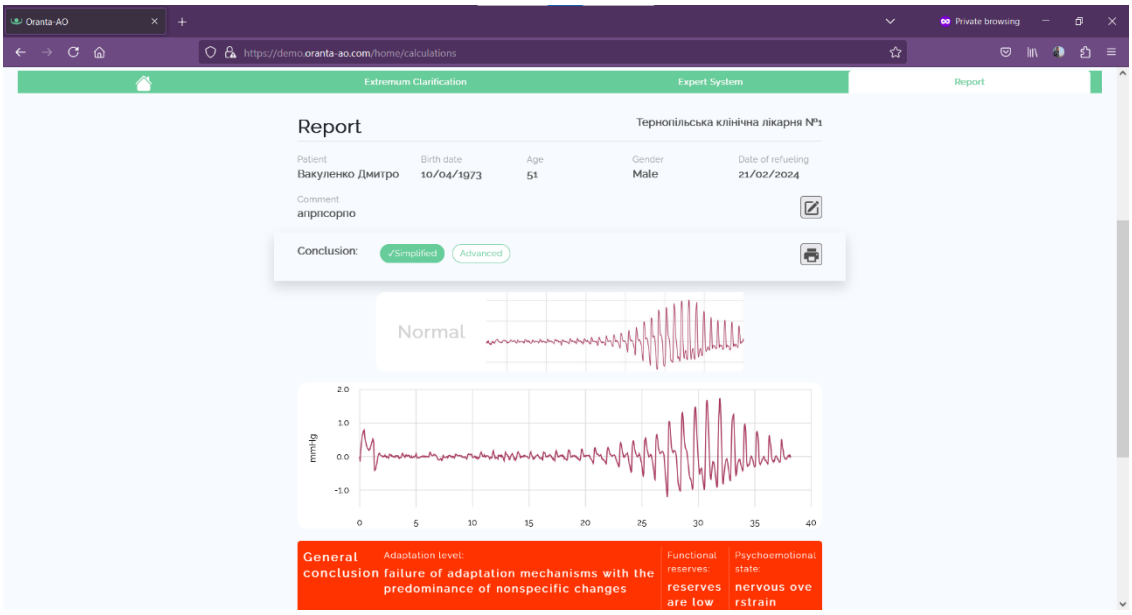


Figure 2.31

Telediagnostics Service Report GUI

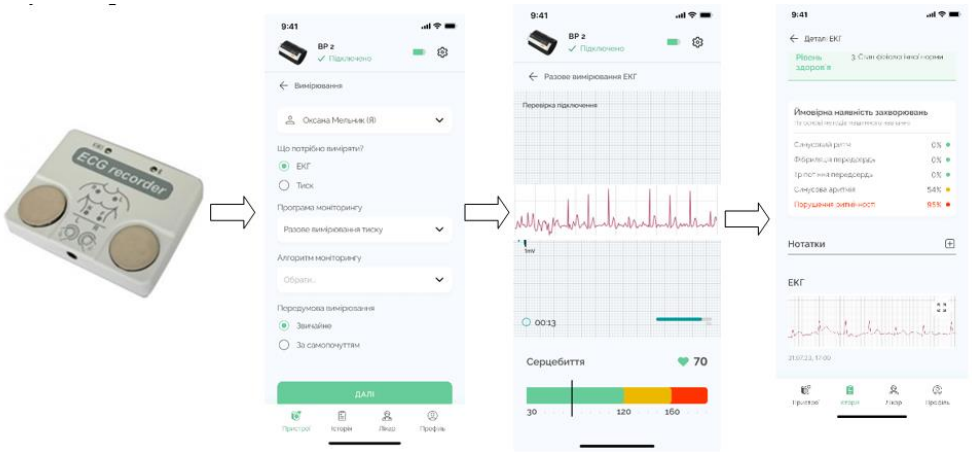


2.9.3. ECG Registration

ECG registration is a common diagnostic method for assessing heart function. Typically, ECG registration occurs within HCIs, but the rapid development of IT allows both medical professionals and patients to conduct ECG registrations. The ability to upload recorded biosignals to cloud-based computational services ensures high-quality calculated indicators, and the support of an Expert System with AI algorithms can enhance the accuracy of diagnostic interpretation. Wearable recorders, smartwatches with ECG functionality (1, 6, or 12 leads), pulsegrams, etc., can be used for this purpose. The interface view of the components for conducting ECG registration and displaying results in the mobile application is shown in Figure 2.32.

Figure 2.32

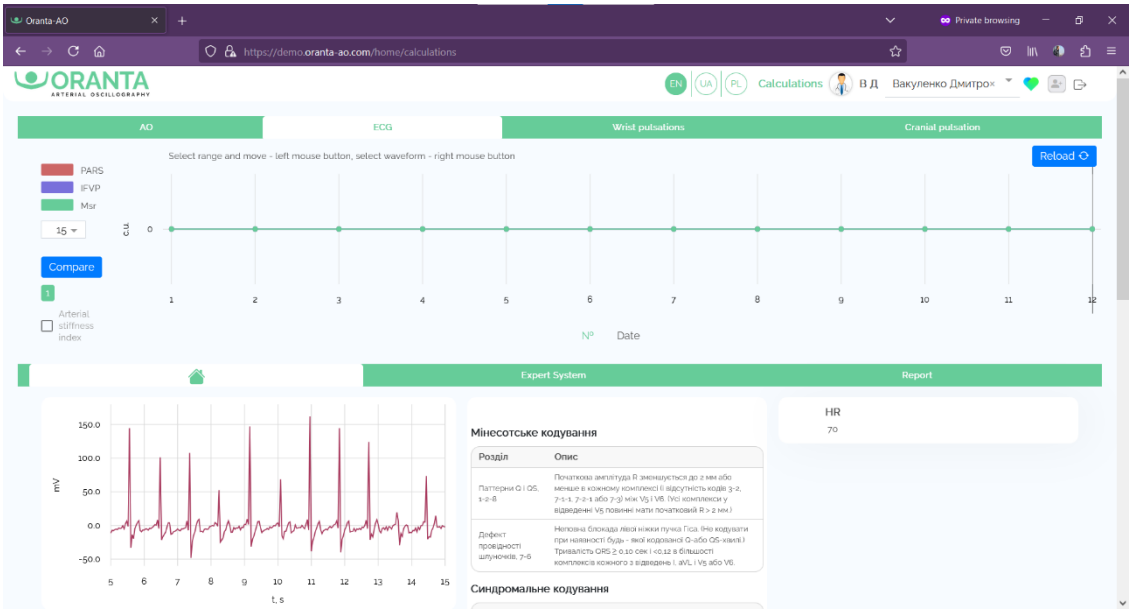
The GUI of the Components for Conducting ECG Registration and Displaying Results in the Mobile Application



In the user's web personal account, within a minute, the calculated indicators based on the ECG registration results will be available, as shown in Figure 2.33.

Figure 2.33

The GUI of the User's Web Personal Account Displaying the Results of ECG Registration



The Expert System will additionally calculate the probability of atrial fibrillation and provide a general and detailed assessment of the heart, autonomic, and central nervous systems. It also offers the capability to send the report from both the mobile and web applications to the physician. The calculated overall score based on the results of Arterial Oscillogram (blood pressure) and ECG measurements, along with the corresponding assessments – excellent, good, satisfactory, unsatisfactory, and extremely unsatisfactory – aligns with the values from 0 to 4 as used in the ICF.

2.10. Expert System

2.10.1. Expert System for Patient Support Before, During, and After the Rehabilitation Phase

The patient support expert system is an innovative and comprehensive tool designed to provide optimal assistance to patients throughout their recovery process following injuries, surgeries, or illnesses. This system integrates advanced artificial intelligence technologies (Kaverinsky & Malakhov, 2023; Malakhov, 2023a, 2024a, 2024b; Palagin, Kaverinsky, et al., 2023; Palagin, Malakhov, Velychko, & Semykopna, 2022; Petrenko et al., 2023), medical knowledge, and an individualized approach to each patient (D. V. Vakulenko, 2023; D. V. Vakulenko & Martseniuk, 2015; L. O. Vakulenko et al., 2005; Verkhovna Rada of Ukraine, 2023).

Pre-Rehabilitation Phase. The expert system analyzes the patient's medical data, considering their medical history, physical condition, medical prescriptions, and other factors. Using machine learning algorithms, it predicts potential challenges during rehabilitation and develops an IRP that best meets the patient's needs and capabilities.

During the Rehabilitation Phase. The expert system interacts with the patient, providing recommendations, reminders, and explanations regarding necessary medical procedures, physical exercises, and other health recovery aspects. By integrating with mobile applications and data collection devices, the system monitors patient progress, evaluates the effectiveness of rehabilitation measures, and promptly addresses potential complications.

Post-Rehabilitation Phase. The expert system continues to serve as a valuable assistant to the patient. It offers advice on maintaining achieved levels of physical and psychological well-being and prevents potential relapses or new health issues. Patient data is stored in a secure electronic system – CDR, ensuring confidentiality and the security of medical information.

The patient support expert system in the rehabilitation process helps ensure a more personalized medical experience, improves recovery outcomes, and facilitates a quicker return to an active and healthy lifestyle. It has become an integral part of modern medicine, assisting patients in maintaining and improving their health and well-being.

Features of the Expert Rehabilitation System:

Patient monitoring: The system collects and analyzes patient data from various sources, including health measurement devices (blood pressure monitors, ECG), laboratory methods, multimedia content analysis (posture assessment, joint mobility), psychological testing, functional tests, etc. This helps determine the patient's current condition and identify which health aspects require special attention.

1. Patient support. The system provides patients with assistance and education in problem identification, offering linguistic support to help patients better understand their issues and facilitate more effective communication with experts.
2. Problem identification. The system assists in identifying health-related problems based on the collected data. This may include anomaly detection, comparison with normal values, and consideration of other factors influencing health.
3. Importance and prioritization assessment. After identifying problems, the system helps the patient assess their importance and prioritize them for resolution. This enables the patient to focus on the most critical aspects of their health and plan effective steps for improvement.
4. Selection of optimal rehabilitation trajectory. The system considers the patient's initial condition, rehabilitation goals, expected outcomes, program duration, budget (both patient and healthcare institution), available time, online or offline modality (inpatient, outpatient), available equipment, and specialist accessibility.
5. Complexity consideration. The system accounts for the complexity of identified problems and proposes appropriate rehabilitation approaches. Depending on the complexity, different treatment and rehabilitation methods may be required, and the system helps make the appropriate choice.

In summary, the expert system provides essential support to the patient, helping effectively identify, assess, and address health issues, ensuring an efficient rehabilitation process and an improved quality of life for the patient.

2.10.2. Expert System for PM&R Physicians

The Expert System for PM&R Physicians is a powerful tool designed to enhance medical practice and support informed decision-making in the healthcare sector. It assists medical professionals in making well-founded and balanced decisions regarding additional diagnostics, monitoring, and rehabilitation, ultimately improving the quality of healthcare services and facilitating faster and more successful patient recovery.

The Expert System for PM&R Physicians includes services that support the classification of clinical cases using the ICF based on the patient's reported issues. The primary goal of the system is to generate a set of ICF codes that help physicians accurately identify pathology and prescribe appropriate treatment (Malakhov et al., 2022; D. V. Vakulenko, 2023; D. V. Vakulenko et al., 2023; D. V. Vakulenko & Martseniuk, 2015; L. O. Vakulenko et al., 2005; Velychko et al., 2021; Verkhovna Rada of Ukraine, 2023). The main functions include:

1. Selection of additional diagnostic tools. The system analyzes patient data and their current condition to recommend additional diagnostic methods that help refine the diagnosis and plan effective treatment.
2. Consideration of information sources. The system is based on reliable sources of information, such as recognized functional tests and assessments, resources like sralab.org, and other laboratory methods, ensuring the accuracy and reliability of its recommendations.
3. Monitoring and reporting. The system maintains detailed records of each patient's progress and generates reports for self-monitoring.

Implemented components of the expert system for PM&R physicians include:

- Convenient access to medical data. Physicians can quickly access necessary information about their patients and their rehabilitation programs.
- Progress monitoring. An effective monitoring system tracks the condition and rehabilitation progress of patients, enabling physicians to respond appropriately to changes and make necessary adjustments to the therapeutic plan.

The assessment of the effectiveness of rehabilitation interventions on patients with breast cancer, healthcare professionals, and rehabilitation centers is a key feature of the system (Malakhov et al., 2022; D. V. Vakulenko, 2023; D. V. Vakulenko et al., 2023; D. V. Vakulenko & Martseniuk, 2015; L. O. Vakulenko et al., 2005; Velychko et al., 2021; Verkhovna Rada of Ukraine, 2023).

Completed rehabilitation journals contain detailed records of the patient's progress during the rehabilitation program, including information about procedures, exercises, treatments, and other aspects of rehabilitation. This information helps understand the changes occurring in the patient throughout the rehabilitation process.

The dynamics of changes in ICF weighting indicators are used for an objective assessment of the patient's functional state. This classification allows for the measurement and comparison of patient indicators before, during, and after the rehabilitation intervention, providing an objective evaluation of rehabilitation outcomes.

Overall, these components together form an expert system that helps assess the effectiveness of rehabilitation interventions at various levels: the patient, the specialist, and the rehabilitation center. It provides objective information that can be used to improve rehabilitation programs and methods, ultimately enhancing outcomes and satisfaction for all participants in the process.

The developed service for optimizing the rehabilitation trajectory for breast cancer patients offers the following capabilities:

- assessment of the effectiveness of the previous rehabilitation program;
- availability of resources and specialists to continue the program;
- models (matrices) of the patient's condition before, during, and after the rehabilitation program;
- completion of rehabilitation journals;
- selection of the patient's rehabilitation trajectory (balance of offline and online participation).

Individualized formation of multidisciplinary team members based on:

- the specialization of the medical professional;
- tasks completed in previous multidisciplinary teams;
- availability of equipment and facilities;
- availability of the specialist;
- patient and other participant preferences;
- patient requests, questionnaires;
- consulted specialists;
- diagnostic and previous interventions;
- monitoring results;
- educational (text and video) materials.

Selection of additional diagnostic, monitoring, and rehabilitation tools (for the patient, rehabilitation tools, equipment, sralab.org, laboratory methods, price, availability) based on:

- patient requests for rehabilitation program goals;
- patient history;
- established ICD and ICPC2 codes;
- types of examinations and their conclusions;
- available equipment and specialists.

Section 3. Organizational and Methodological Aspects of Telerehabilitation

3.1. Initial and Periodic Rehabilitation Assessments

Evidence indicates that early postoperative rehabilitation assessment should occur within the first month after surgery. During this assessment, basic tests and measurements can be conducted, along with continued education on physical exercises and the return to activity. If functional limitations are present at this time, rehabilitation interventions can be initiated.

Anthropometric measurements are evaluated, including diastolic and systolic blood pressure, pulse rate, waist, arm, and hip circumference, weight, and BMI.

Pain assessment is mandatory for patients who have undergone breast cancer treatment. Pain scales such as the visual analog scale and the numerical pain rating scale evaluate only the intensity of pain, while other scales, like the Brief Pain Inventory (Cleeland, 2009), assess the severity of pain and its impact on key aspects of the patient's quality of life, including daily activities, mobility, ability to perform household chores, relationships with others, mood, sleep, and overall enjoyment of life.

Functional capacity assessment. The cardiorespiratory system is evaluated using the 6-minute walk test, which serves as an indirect indicator of aerobic fitness in individuals who have survived breast cancer. The test measures the distance a person can quickly walk on a flat, hard surface in 6 minutes and is used to assess submaximal functional capacity.

The perceived exertion level is a widely used and reliable indicator for monitoring and managing exercise intensity. This scale allows individuals to subjectively assess their level of exertion during exercise or testing (Zhou et al., 2022). Developed by Gunnar Borg, it is known as the Borg Scale.

Muscle strength assessment. General muscle strength of the upper or lower body is assessed. The one-repetition maximum (1-RM) test for squats or leg presses is the gold standard for measuring overall lower body strength, while the corresponding test for the upper body is typically the bench press or shoulder press. Although 1-RM testing is more common in scientific research than in clinical practice, it has recently been proven safe for women who have survived breast cancer. The 1-RM test with maximum resistance for 6-8 repetitions has been used in intervention studies on breast cancer survivors. Grip strength, an indirect measure of upper limb strength, is also used to measure strength in women who have survived breast cancer.

Functional mobility tests. Tests like the "Timed Up and Go" and gait speed studies have also been used in women who have survived breast cancer to explore both the impact of function on fall risk and the effects of neurotoxic chemotherapy drugs used in breast cancer treatment. Range of motion in the shoulder, assessed by goniometry, is an objective indicator of upper limb function widely used in breast cancer rehabilitation. Limitations in shoulder flexion and abduction are the most commonly reported issues after breast cancer surgery.

The DASH scale is designed to measure upper limb function and assess symptoms such as pain, weakness, and numbness, as well as the degree of disability related to work and recreational activities. Treatment-related side effects, including fatigue and pain, are measured using standardized questionnaires (pain and fatigue scales).

Limb volume measurement. Limb volume should be measured because breast cancer-related lymphedema is a concern for many women diagnosed with breast cancer. Circumference measurement using a measuring tape at specified points on the limb, followed by conversion to volume, is the most common method of calculating lymphedema in routine clinical practice.

Fatigue assessment. The primary tool for assessing fatigue is the BFI, a multidimensional self-assessment scale that determines the impact of fatigue on quality of life. This questionnaire consists of two parts and nine questions, rated on a scale from 0 to 10. The first three questions assess the current, usual, and worst levels of fatigue over the past 24 hours, while the remaining six questions address the impact of fatigue on activity, mood, mobility, work, relationships, and enjoyment of life. The overall BFI score is calculated as the arithmetic mean of the nine scores, where scores of 1-3 indicate mild fatigue, 4-6 moderate fatigue, and 7-10 severe fatigue. BFI is a reliable tool that allows for the quick assessment of fatigue levels in cancer patients and identifies those with severe fatigue.

Tools designed to measure quality of life after breast cancer treatment, such as the EORTC QLQ-C30, are based on the subjective assessment of the patient's experiences, symptoms, and functional limitations. Despite the complexity of

construction, well-developed tools with high psychometric properties are essential for gaining a comprehensive understanding of the functioning of women who have survived breast cancer (Wang & Zhou, 2021).

3.2. Basic ICF Core Sets – Breast Cancer Brief

Given the numerous needs of cancer patients during and after treatment, the growing number of cancer survivors, and the evidence supporting rehabilitation as a means to improve overall functional mobility and quality of life, rehabilitation specialists must utilize tools that accurately assess and measure treatment-related impairments. Additionally, they should quantify the impact of rehabilitation interventions on function to demonstrate their value throughout a patient's life.

The ICF model integrates diagnosis and subsequent functional impairments within the context of environmental and personal factors. Environmental factors interact with all aspects of people's lives (physical, social, and psychological), while personal factors (e.g., influences or attributes like self-efficacy) contribute to adaptation. It is essential to understand the terms used in this model. Body functions refer to the physiological functions of the body, and structures pertain to anatomical parts involved in the process. Activity limitations are defined as difficulties in executing tasks, while participation restrictions involve problems related to engaging in life situations.

Functioning is a general term encompassing body functions, body structures, activities, and participation, denoting the positive aspects of the interaction between an individual (with a health condition) and their contextual factors (environmental and personal factors). Disability, on the other hand, highlights the negative aspects of these same components.

In the context of BC, a short ICF set – *Breast Cancer Brief* with relevant codes and categories is most commonly used. The components of the ICF *Breast Cancer Brief Core Set* include:

BODY FUNCTIONS

Physiological functions of body systems (including psychological functions):

- b130 Energy and drive functions (G);
- b134 Sleep functions;
- b152 Emotional functions (G);
- b180 Experience of self and time functions;
- b280 Sensation of pain (G);
- b435 Immunological system functions;
- b640 Sexual functions;
- b710 Mobility of joint functions.

BODY STRUCTURES

- s420 Structure of immune system Extent;
- s630 Structure of reproductive system Extent;
- s720 Structure of shoulder region.

ACTIVITIES AND PARTICIPATION

- d230 Carrying out daily routine (G);
- d240 Handling stress and other psychological demands;
- d430 Lifting and carrying objects;
- d445 Hand and arm use;
- d640 Doing housework;
- d760 Family relationships;
- d770 Intimate relationships;

- d850 Remunerative employment (G).

ENVIRONMENTAL FACTORS

- e115 Products and technology for personal use in daily living;
- e310 Immediate family;
- e320 Friends;
- e355 Health professionals;
- e410 Individual attitudes of immediate family members;
- e420 Individual attitudes of friends;
- e450 Individual attitudes of health professionals;
- e570 Social security services, systems and policies;
- e580 Health services, systems and policies;
- e590 Labour and employment services, systems and policies.

By utilizing these ICF components, PM&R professionals can comprehensively assess the impact of breast cancer and its treatment on a patient's overall functioning and quality of life, facilitating the development of targeted rehabilitation programs.

3.3. Individual Rehabilitation Plan for Providing Telerehabilitation

The experiences of women who have survived BC impact many aspects of their lives, starting from the moment of diagnosis and continuing for many years thereafter. Immediately after surgery, during the "early phase," it is crucial to inform and guide patients in resuming their daily activities, as well as to monitor and manage post-operative complications. Rehabilitation interventions should begin shortly after surgery, regardless of the type of surgery (whether it is a quadrantectomy or mastectomy) and should focus on restoring the range of motion in the upper limb on the operated side, rebuilding strength, and controlling pain. At a later stage, it is also important to consider the restoration of proper posture evaluation. Evidence suggests that rehabilitation is an effective means of preventing and treating many physical side effects of BC treatment.

An Individual Rehabilitation Plan (IRP) is developed and agreed upon by a multidisciplinary rehabilitation team following a thorough rehabilitation assessment of the individual by each team member, taking into account the existing impairments, limitations in daily functioning, and the individual's needs. The IRP is then approved during a general team meeting by the physician specializing in (PM&R). The IRP is created based on the results of the rehabilitation assessment, the rehabilitation period, the determination of the rehabilitation prognosis, and the location(s) where the rehabilitation activities will be conducted.

The IRP consists of three sections:

1. The first section is completed when the patient is in the acute rehabilitation period (prior to the commencement of telerehabilitation activities).
2. The second section covers the post-acute period (during the telerehabilitation phase).
3. The third section addresses long-term rehabilitation (also during the telerehabilitation phase).

Each section of the IRP may include several rehabilitation cycles. Each cycle lasts up to two weeks, after which the results are evaluated, and the rehabilitation plan is adjusted accordingly. The overall goal of rehabilitation is sometimes distant and can be difficult to measure, perceive, and fully comprehend. Setting small, achievable goals along the way can be particularly beneficial, especially during telerehabilitation, where it can be challenging to measure progress.

The IRP should include the overall goals and objectives of rehabilitation, with an estimate of the time needed to achieve them, a list of necessary rehabilitation activities, quantitative requirements for rehabilitation specialists, needs for rehabilitation and other equipment, and potential needs for continuing rehabilitation care in another rehabilitation facility, department, or unit. These elements should align with the individual's functional limitations, capabilities, preferences, expectations, and aspirations.

Additionally, using the SMART (Specific, Measurable, Achievable, Realistic, Time-related) goal-setting method can be highly beneficial. This approach is widely used for setting goals in business development. Examples of SMART goals could be: "Eat independently within 2 weeks," "Play Beethoven's Moonlight Sonata on the piano by April," or "Plant flowers without back pain by next weekend."

After the IRP is approved, each rehabilitation specialist, within their professional competencies and based on the results of the rehabilitation assessment, independently develops their therapy program, implements it, and evaluates its effectiveness.

Section 4. Telerehabilitation Programs

4.1. Personalized Telerehabilitation Program in the Preoperative Stage (Prehabilitation)

The term "prehabilitation" was introduced to describe interventions aimed at supporting cancer patients during the period before the start of specific treatment, such as surgical intervention. Cancer prehabilitation is a type of preliminary treatment designed to improve the functional status of patients diagnosed with cancer before the onset of cancer treatment. It is a modern strategy within the continuum of cancer care, intended to enhance patients' ability to undergo specific treatments and to increase their compliance and commitment to all rehabilitation interventions during and after specific treatments.

One definition of cancer prehabilitation is "the identification of impairments and the implementation of measures aimed at strengthening and stabilizing the potential of those body systems most at risk before the start of specific treatment." Another definition describes prehabilitation as "a systematic process of improving the physical, psychosocial, and nutritional status of cancer patients in the period between diagnosis and recovery after treatment."

Cancer prehabilitation occurs during the period of examination and/or treatment before the start of necessary specific cancer treatment. During this interval, following diagnosis, an IRP can be proposed. This plan may include elements such as physical exercises, proper nutrition and dietary modification, psychological stabilization, and lifestyle modification, such as quitting smoking and reducing alcohol consumption. After these interventions, cancer patients may achieve better functional status (improving endurance, muscle strength, and mental health) and may better withstand the effects of surgery, radiation, and chemotherapy than cancer patients who have not undergone prehabilitation, resulting in a worse functional state.

There are two typical approaches to prehabilitation: unimodal and multimodal prehabilitation. Regular physical activity, such as exercise, is part of both approaches in rehabilitation and has proven to be very important for the treatment and rehabilitation of cancer patients over the past 27 years. Exercise can improve functional health, positively affecting physical performance, mental health, and quality of life, and in some cases, survival rates.

Unimodal prehabilitation schemes, which consist solely of physical exercises, are most commonly used. These schemes have demonstrated effectiveness in reducing postoperative stress and complications, shortening hospital stays, and improving clinical outcomes by optimizing cardiopulmonary reserve before surgery. There is growing scientific evidence regarding the effects of exercise during cancer prehabilitation. It is important to note that almost every patient has comorbidities and individual physical characteristics, so exercise should be recommended on an individual basis to meet these specific needs. A thorough medical history, clinical examination, certain laboratory parameters, ECG and echocardiography data, physical endurance testing, spirometry, and in some cases, radiological data and bone scans form the basis for planning individual exercise programs for prehabilitation.

Increasingly, studies are focusing on the utility of preoperative interventions, known as prehabilitation, for optimizing postoperative outcomes. Numerous literature reviews on prehabilitation in oncology populations demonstrate several significant benefits, including improvements in preoperative and postoperative physical function, reduced hospital stays, and fewer postoperative complications.

Telerehabilitation interventions include individually tailored home exercises that begin immediately after the initial assessment and continue until the time of surgery. For example, a program might include aerobic exercises 3-5 days a week for 30-40 minutes per session and strength exercises for the upper body 2-3 days a week. Aerobic exercises typically include brisk walking at an intensity of 4-6 points on the 10-point Borg scale. Strength training for the body consists of 2-3 sets of 10-12 repetitions per exercise, with each session including up to 8 exercises. Training progress in each method is determined by

the 10-point Borg scale and occurs when the patient can perform aerobic exercise with light exertion (Borg scale 0-3) or when the patient can perform 15 repetitions of any strength exercise (Borg scale 3-6).

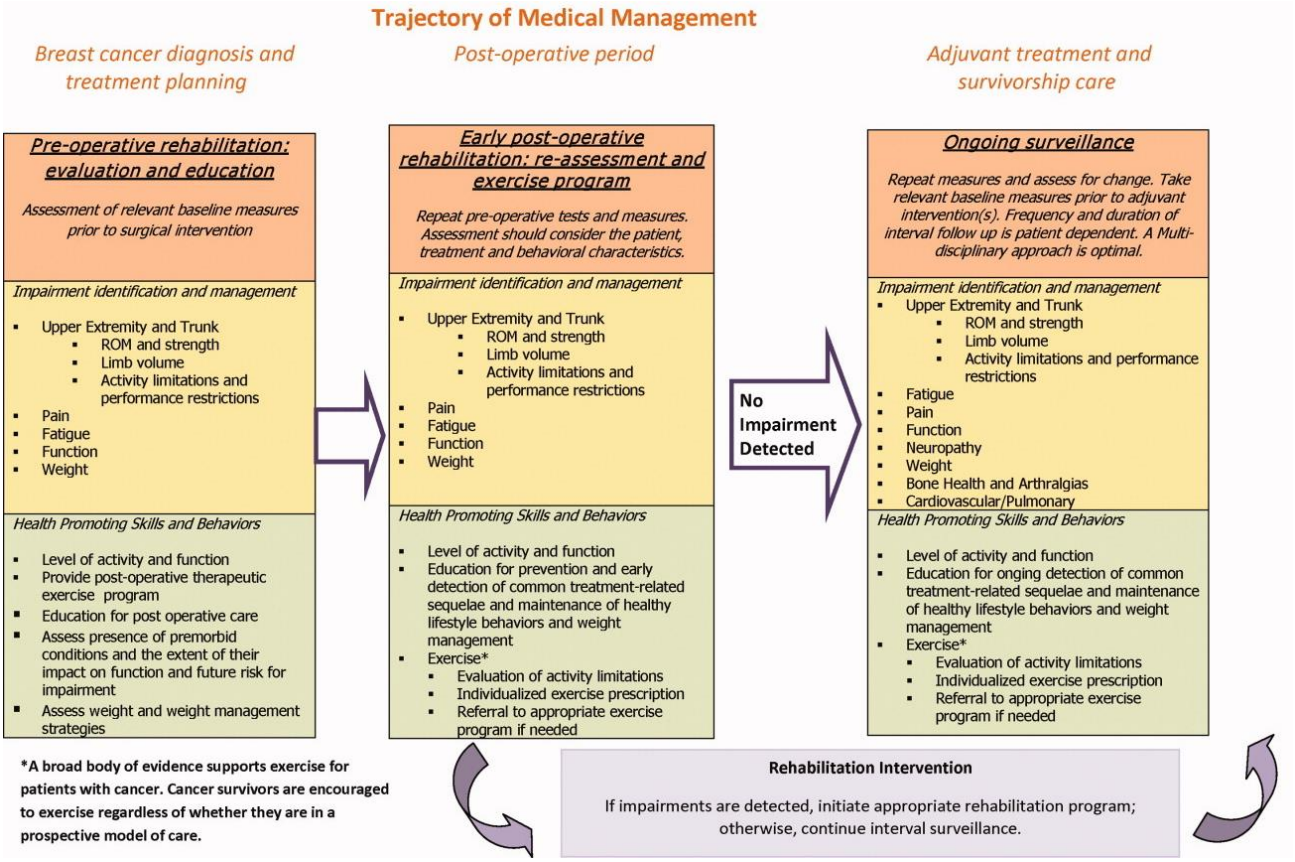
The patient also has the opportunity to receive valuable information about postoperative rehabilitation exercises (stretching and mobility exercises according to postoperative protocols without functional impairments), advice on returning to daily life activities during and after treatment, and discussions on risk factors for adverse outcomes of the treatment plan.

For example, the model of prospective surveillance described by Nicole Stout and colleagues (Stout et al., 2012) recommends preoperative assessment of all BC patients to evaluate premorbid functional levels, prior physical limitations, existing exercise habits, and other comorbid conditions, as well as to include a battery of tests and measures to establish baseline functional levels (see Figure 4.1).

For women who have undergone surgery for BC, prehabilitation can ease postoperative recovery, influence behavior changes regarding health in both the preoperative and postoperative periods, and increase physical activity levels and functional ability both before and after surgery.

Figure 4.1

A Prospective Surveillance Model for Physical Rehabilitation for Women with BC



4.2. Individual Programs in the Post-Acute and Long-Term Phases of Telerehabilitation

Currently, the primary treatment for BC is surgical resection, with the modified radical mastectomy being the most common surgical option. However, after surgery, each patient may experience different levels of axillary lymphatic reflux, blood supply disruption, and upper limb functional impairment. The goal of telerehabilitation interventions at this stage is to improve upper limb function and enhance the quality of life for patients' post-surgery.

At this stage, it is essential to develop a scientifically based telerehabilitation program to enhance the recovery of upper limb function. Individual rehabilitation exercises can be divided into three stages: (I) early stage; (II) middle stage; and (III) late stage. The primary goals of interventions differ at each stage. Telerehabilitation programs are designed for patients in the second and third stages of post-acute rehabilitation and during the long-term period.

Early rehabilitation aims to improve blood and lymph circulation, reduce local exudation, and promote wound healing. While early exercises might increase postoperative pain in the upper limb, regular upper limb exercises can alleviate long-term pain and reduce swelling over time.

Practical Recommendations for Upper Limb Dysfunction Related to BC:

Standard postoperative functional exercises are generally performed by patients themselves. There is no universal standard for exercise methods. Rehabilitation exercises, also known as postoperative functional exercises, are specific exercises designed to improve blood circulation, regulate limb function, and thus facilitate early recovery after surgery (Campbell et al., 2019).

Active stretching exercises can begin from the first week after surgery or after drain removal and continue for 6-8 weeks or until the full range of motion is achieved in the affected upper limb. Progressive resistance exercises, such as strength training, can start with light weights (1-2 kg) 4-6 weeks after surgery.

During the post-acute phase, the focus should be on training the shoulder muscles and stretching the tissues around the wound, which helps prevent scar adhesions and corrects shoulder joint movements. The online telerehabilitation program is aimed at increasing muscle strength, joint mobility, and cardiovascular capacity to improve quality of life under the supervision and guidance of a specialized professional.

The sessions are divided into three parts. The first 10 minutes of warm-up are dedicated to joint mobility exercises. The main part consists of 40 minutes of resistance exercises (e.g., squats, lunges, biceps curls, triceps extensions, etc.). The final 10-minute segment includes flexibility exercises for large muscle groups. At the end of the session, the Borg scale is used, and the intensity of subsequent sessions is planned based on the evaluation results. Women should also be instructed on scar tissue massage.

Patients should be educated on meticulous hand care – for example, maintaining proper hygiene and avoiding hand injuries – to minimize the risks of infection and the development of lymphedema. Evidence suggests that a BMI>30 is a risk factor for developing lymphedema. Although there is no clear link between high BMI and the development of secondary lymphedema after cancer treatment, patients who have survived cancer should be encouraged to maintain a healthy body weight due to the associated health benefits. If upper limb and/or breast lymphedema develops, the telerehabilitation program should include comprehensive decongestive physical therapy, which is the recommended treatment method for lymphedema (Zou et al., 2018).

Developing a comprehensive and effective pain management plan involves educating and engaging the patient and their family, as well as employing an interdisciplinary team approach. Conducting brief educational sessions and keeping pain management diaries are useful strategies that improve treatment adherence and reduce pain intensity (Invernizzi et al., 2020).

All cancer patients should be provided with educational materials about fatigue and its natural course. Educational interventions (including training, counseling, support, early information about fatigue patterns, coping skills training, and coaching) are "likely to be effective" in supporting positive coping with fatigue in patients experiencing fatigue and reducing fatigue levels (Dinapoli et al., 2021). Engaging in physical exercise several times a week (including walking, cycling, resistance exercises, or a combination of aerobic and resistance exercises) can be effective in reducing fatigue during and after cancer treatment (Carletto et al., 2019).

Patients should be taught energy conservation techniques. Energy conservation is the conscious, planned management of a person's personal energy resources to prevent their depletion. The goal of energy conservation is to balance rest and activity during periods of high fatigue so that important tasks can still be accomplished, and goals can be achieved. Taking an

additional rest break is one energy conservation strategy (Jarero et al., 2018). Other strategies include prioritization, delegation, pacing, and planning high-energy activities during peak energy times (Esplen et al., 2018).

Furthermore, it is recommended to encourage patients to engage in moderate-intensity physical activity during and after treatment, including walking, cycling, strength exercises, or a combination of aerobic and strength exercises for 30 minutes most days of the week (Gilchrist et al., 2009; Maldonado et al., 2021).

Conclusions

At present, rehabilitation services for patients with malignant diseases via telerehabilitation are not provided in Ukraine. Theoretical analysis of international and domestic experiences in healthcare rehabilitation indicates the possibility of developing an effective complex of methodological and technological means for telerehabilitation of patients with malignant neoplasms, particularly BC, at the outpatient stage of rehabilitation care.

This encompasses addressing the following tasks: studying the existing legal regulations of Ukraine that govern the provision of telerehabilitation services; familiarizing with WHO recommendation documents, standards, clinical guidelines, and protocols used in oncological rehabilitation; selecting, implementing, and integrating subsets of tests and scales for assessing various components of the ICF to achieve maximum effectiveness with minimal effort; developing and selecting new online information technologies to support all telerehabilitation processes, based on extensive and targeted application of information technologies, particularly artificial intelligence; applying mathematical modeling, optimization, and forecasting methods at all stages of the life cycle (routing, forming the logical structure of evidence-based methods and technologies for providing rehabilitation services in oncological rehabilitation, building a scientifically grounded overall model of patient-centered comprehensive telerehabilitation in oncology, which includes all necessary stages, from patient rehabilitation assessment, formulating rehabilitation goals, making rehabilitation diagnoses based on the ICF, to forming a personalized rehabilitation plan with continuous monitoring and evaluation of the effectiveness of rehabilitation interventions in a remote interaction mode between the patient and rehabilitation specialists). A significant role is also played by the modernization of pre- and post-graduate education for rehabilitation specialists.

Expert evaluations in numerous studies confirm the feasibility of implementing telerehabilitation in the rehabilitation care system for cancer patients, particularly BC patients. Thanks to innovative technologies, it becomes possible not only to improve and diversify the rehabilitation process but also to create new opportunities and comfort for patients. Developing a comprehensive approach to evaluating the impact of telerehabilitation interventions on the condition and quality of life of cancer patients, as well as assessing the best practices for utilizing telemedicine technologies, is advisable.

Components of the developed telerehabilitation platform are presented. Algorithms for the telerehabilitation program for BC patients are proposed. A description of the developed PM&R Physician's digital workspace is provided, allowing the selection of patients, setting rehabilitation goals, conducting additional consultations and examinations, and forming a rehabilitation program considering recommendations on duration, multidisciplinary team specialists, and phase-based limitations regarding time, finances, and other factors.

The information-analytical service provides PM&R Physicians and rehabilitation program specialists with informational support at various stages of the rehabilitation program. The patient's digital workspace has been enhanced with features for viewing personal data, supporting the information-analytical module, managing the calendar, and filling out diaries based on the results of interventions. The Medical Reports module includes information on completed rehabilitation programs, consultations, telediagnostic examinations, and tests. The Administrative module gathers the necessary tools for creating service provision locations, positions, services, and their configurations.

The organization of telediagnostics has been described. Integrated modules for conducting telediagnostics of patients using ECG, blood pressure monitors, posture assessment, and joint mobility evaluation are presented. An important component of the entire rehabilitation process is conducting functional tests. The Expert System module presents developed mathematical and linguistic models for PM&R Physicians and patients to optimize various stages of rehabilitation.

Our team remains committed to continuing research in the field of telerehabilitation for cancer patients. We are also preparing to update the legislative framework to support such initiatives. As we implement telerehabilitation for cancer patients, we will rigorously analyze the effectiveness of this approach, continually improving and updating the *Telerehabilitation of Breast Cancer Patients Playbook* based on the insights and experience gained.

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Data Availability

- The hybrid cloud platform for patient-centered telerehabilitation of cancer patients: https://e-rehab.pp.ua; https://his.e-rehab.pp.ua/;
- Telediagnostic complex Oranta AO: https://a.oranta-ao.com/;
- Interactive reference system MedRehabBot for informational support of PM&R physicians, students in the relevant specialty, and patients: https://t.me/MedicalRehabBot; https://github.com/knowledge-ukraine/MedRehabBot;
- Personal AI assistant based on Large Language Models – MedLocalGPT: https://demo.medlocalgpt.pp.ua; https://github.com/knowledge-ukraine/medlocalgpt;
- Reference System for the White Book on Physical and Rehabilitation Medicine in Europe – WhiteBookBot: https://wb-prm.e-rehab.pp.ua; https://t.me/ExperimentalUkrAIBot;
- Network Toolset with NLP Support (Web Service with API) for contextual and semantic analysis with document taxonomy-building functions KEn Web Service: https://ken.e-rehab.pp.ua; https://github.com/malakhovks/ken;
- Network Toolset with NLU Support for knowledge discovery, classification, diagnosis, and prediction UkrVectōrēs: https://ukrvectores.e-rehab.pp.ua; https://github.com/malakhovks/docsim;
- Complex Information System for Knowledge Production in the Research and Development Workstation Environment class – OntoChatGPT: https://github.com/knowledge-ukraine/OntoChatGPT;

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Appendix A. DASH Questionnaire for Upper Limb Disability

The DASH (Disabilities of the Arm, Shoulder, and Hand) Questionnaire is a standardized tool designed to assess upper limb disability and monitor changes in function over time. It evaluates a range of symptoms and the ability to perform specific activities, providing a comprehensive measure of the impact of upper limb conditions on daily life.

DASH Questionnaire Sections:

1. Symptoms:
   Pain: intensity, duration, and effect on daily activities.
   Weakness: impact on the ability to perform tasks.
   Stiffness: level and how it restricts movement.
   Numbness: frequency and areas affected.
2. Daily activities:
   Physical activities: ability to carry out physical tasks such as lifting, pushing, or pulling.
   Self-care: difficulty in performing self-care tasks like dressing, washing, or grooming.
   Household tasks: challenges faced while performing household chores such as cleaning, cooking, or carrying groceries.
   Work-related tasks: impact on professional activities, especially those requiring manual dexterity.
3. Social and recreational activities:
   Sports and hobbies: ability to participate in recreational activities and sports.
   Social engagement: the effect of upper limb conditions on social interactions and participation in community activities.
4. Emotional impact:
   Frustration: the emotional toll of upper limb disability.
   Depression: feelings of sadness or hopelessness associated with the inability to perform usual tasks.
5. Overall function:
   General health: perception of overall health and well-being in relation to upper limb functionality.
   Work capability: ability to work efficiently despite upper limb problems.

Scoring:

- Each item in the DASH Questionnaire is scored on a scale from 1 (no difficulty) to 5 (unable to perform).
- The total score is calculated by summing the responses and converting it to a score out of 100, where higher scores indicate greater disability.

Usage:

- Clinical assessment: used by healthcare providers to diagnose and evaluate the severity of upper limb conditions.
- Monitoring progress: helpful in tracking recovery and effectiveness of rehabilitation programs.
- Research: utilized in studies focusing on upper limb disabilities to assess the impact of various treatments.

This questionnaire is a vital tool in the comprehensive management and rehabilitation of patients with upper limb disabilities, aiding in personalized treatment planning and outcome assessment.

The DASH Questionnaire available via link: https://healthcare.msu.edu/_assets/documents/lymphedema/DASH-questionnaire.pdf.

Appendix B. EORTC QLQ-C30 Quality of Life Questionnaire for Breast Cancer Patients

The EORTC QLQ-C30 (European Organization for Research and Treatment of Cancer Quality of Life Questionnaire Core 30) is a widely used instrument designed to assess the quality of life of cancer patients, including those with breast cancer. It provides a comprehensive evaluation of a patient's physical, emotional, and social well-being, as well as the impact of cancer and its treatment on their daily lives.

EORTC QLQ-C30 Questionnaire Sections:

1. Global health status/quality of life:
    - Overall health: general perception of health and well-being.
    - Quality of life: assessment of the overall quality of life, considering the impact of cancer and its treatment.
2. Functional scales:
    - Physical functioning: ability to carry out daily physical activities, such as walking, self-care, and mobility.
    - Role functioning: impact of health on work, household tasks, and leisure activities.
    - Emotional functioning: feelings of anxiety, depression, and general emotional well-being.
    - Cognitive functioning: ability to concentrate, remember things, and think clearly.
    - Social functioning: effect of health on social interactions and relationships with family and friends.
3. Symptom scales:
    - Fatigue: frequency and intensity of tiredness and its impact on daily life.
    - Nausea and vomiting: occurrence and severity of nausea and vomiting symptoms.
    - Pain: level of pain experienced and its effect on activities.
    - Dyspnea: difficulty in breathing and its impact on daily activities.
    - Insomnia: problems with sleep, including difficulty falling asleep or staying asleep.
    - Appetite loss: changes in appetite and its effect on nutrition.
    - Constipation: frequency and severity of constipation.
    - Diarrhea: occurrence and impact of diarrhea.
    - Financial difficulties: economic impact of cancer and its treatment on the patient and their family.
4. Single items:
    - Additional concerns: specific issues such as tingling or numbness in the hands or feet, and the effect of treatment on body image and sexual enjoyment.

Scoring:

- Each item is scored on a 4-point scale ranging from 1 ("Not at all") to 4 ("Very much").
- Scores are linearly transformed to a 0-100 scale. For functional scales and the global health status, higher scores indicate better functioning or quality of life. For symptom scales, higher scores represent greater symptom severity.

Usage:

- Clinical practice: used by oncologists and healthcare providers to monitor the quality of life of breast cancer patients throughout treatment.
- Research: employed in clinical trials and studies to evaluate the impact of cancer treatments on patients' quality of life.
- Patient care: helps in identifying areas where patients may need additional support or intervention, such as managing symptoms or addressing emotional distress.

The EORTC QLQ-C30 is a critical tool for understanding the broad impact of breast cancer and its treatment on patients' lives, guiding both clinical decision-making and research in oncology.

The EORTC QLQ-C30 Quality of Life Questionnaire available via link: https://qol.eortc.org/questionnaires/.

Appendix C. Physical Therapy Program (Weeks 3-6 Post-Surgery)

Exercise 1: Walking.

Objective: walking can improve heart and lung function, increase energy levels, and elevate mood.

Instructions for the patient:

- Walk at least 4 times a day.
- Start with walks lasting 10 to 15 minutes.

Exercise 2: Posture Practice.

Objective: this exercise helps improve breathing and prevents muscle tension around the chest, neck, back, and shoulders.

Instructions for the patient:

- Let your arms naturally hang by your sides.
- Stand straight and tall with your shoulders down and relaxed.
- Avoid rounding your shoulders or slouching. Keep your shoulders down and relaxed.
- Do not tilt your head forward or backward. Keep your head level with your earlobes in line with your shoulders.
- Frequently adjust your posture throughout the day.
- Goal: to help restore full movement in the shoulder.

Instructions for the patient:

- Hold each stretch for 15-30 seconds.
- You should feel a stretch but not sharp pain.
- Repeat each exercise 10 times.
- Perform these exercises 3 times a day.

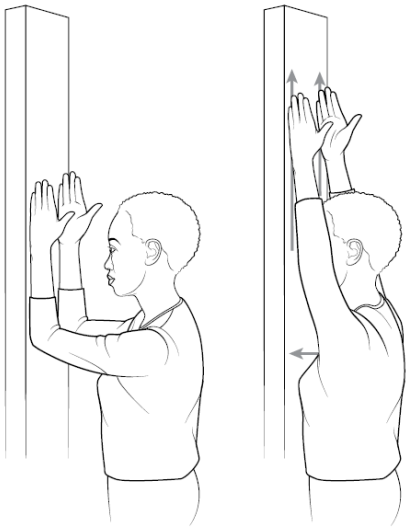
Exercise 3: Elbow Push-Back.

Objective: this exercise helps increase movement in the front of the chest and shoulder. It can be done standing against a wall or lying on your back.

Instructions for the patient:

- Clasp your hands together behind your head at neck level.
- Spread your elbows out as far as possible.
- When you reach a point where you feel a good stretch (but no pain), take 3-5 deep breaths and hold the position. Keep your neck straight and relaxed. Repeat 5-10 times.

Exercise 4: Shoulder Flexion Against the Wall.

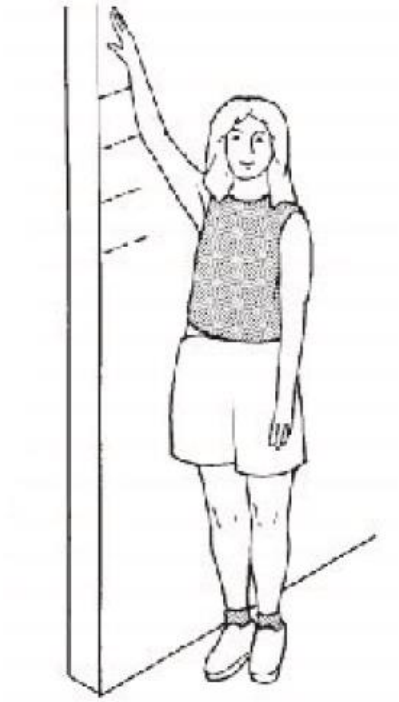


Objective: this exercise helps increase forward movement in the shoulder.

Instructions for the patient:

- Aim to reach a little higher each time.
- Starting position: stand facing the wall.
- Raise your arm up the wall as far as possible.
- When you reach a point where you feel a good stretch (but not pain), take a deep breath and hold your arm in this position for 15 seconds.
- Return to the starting position by slowly lowering your arm.
- Take 3-5 deep breaths and hold in this position. Repeat 5-10 times.

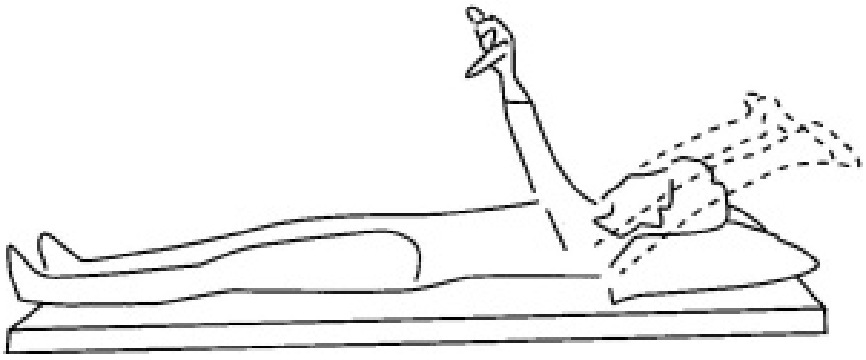
Exercise 5: Shoulder Abduction Against the Wall.



Instructions for the patient:

- Starting position: stand beside the wall on the side where the surgery was performed.
- Lift your arm sideways up towards the wall as high as possible. When you feel a slight stretch (but not pain), hold for 10 seconds.
- Return to the starting position by lowering your arm down the wall.
- Take 3-5 deep breaths and hold in this position. Repeat 5-10 times.

Exercise 6: Increasing Range of Motion in the Shoulder Joint (Lying Down).

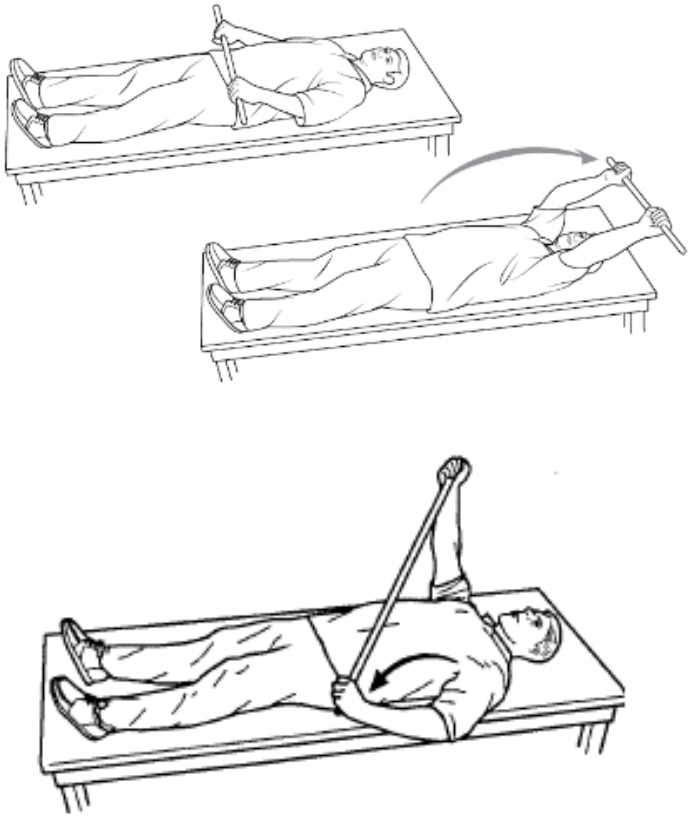


Instructions for the patient:

- Lie on your back and hold a stick with both hands, palms facing down.

- Keeping your elbows straight, lift the stick overhead, using your healthy arm to assist.
- Take 3-5 deep breaths and hold in this position. Repeat 5-10 times, feeling a slight stretch at the scar site.

Exercise 7: Side Arm Raises Using a Cane.



Instructions for the patient:

- Starting position: lie on your back and hold a stick with both hands, palms facing down.
- Lift the stick up in front of you.
- Move the stick towards the side where you had surgery.
- Take 3-5 deep breaths and hold in this position. Repeat 5-10 times, feeling a slight stretch at the scar site.

Exercise 8: Chest Stretch Against the Wall.

Instructions for the patient:

- Starting position: stand facing a corner of a wall or in a doorway to stretch both sides of the chest.
- Bend your arms at the shoulder joints to 90 degrees, elbows at shoulder level.
- Take 3-5 deep breaths and hold in this position. Repeat 5-10 times, feeling a slight stretch at the scar site.

Appendix D. ICF Core Set – Breast Cancer Brief

BODY FUNCTIONS Physiological functions of body systems (including psychological functions) ***How much impairment does the person have in ...***		No impairment	Mild impairment	Moderate impairment	Severe impairment	Complete impairment	Not specified	Not applicable
		0	1	2	3	4	8	9
b130	**Energy and drive functions (G)**	☐	☐	☐	☐	☐	☐	☐
	General mental functions of physiological and psychological mechanisms that cause the individual to move towards satisfying specific needs and general goals in a persistent manner. Inclusions: functions of energy level, motivation, appetite, craving (including craving for substances that can be abused) and impulse control Exclusions: consciousness functions (b110); temperament and personality functions (b126); sleep functions (b134); psychomotor functions (b147); emotional functions (b152)							
	Sources of information: ☐ Case history ☐ Patient reported questionnaire ☐ Clinical examination ☐ Technical investigation							
	Description of the problem:							
		0	1	2	3	4	8	9
b134	**Sleep functions**	☐	☐	☐	☐	☐	☐	☐
	General mental functions of periodic, reversible and selective physical and mental disengagement from one's immediate environment accompanied by characteristic physiological changes. Inclusions: functions of amount of sleeping, and onset, maintenance and quality of sleep; functions involving the sleep cycle, such as in insomnia, hypersomnia and narcolepsy Exclusions: consciousness functions (b110); energy and drive functions (b130); attention functions (b140); psychomotor functions (b147)							
	Sources of information: ☐ Case history ☐ Patient reported questionnaire ☐ Clinical examination ☐ Technical investigation							
	Description of the problem:							
		0	1	2	3	4	8	9
b152	**Emotional functions (G)**	☐	☐	☐	☐	☐	☐	☐
	Specific mental functions related to the feeling and affective components of the processes of the mind. Inclusions: functions of appropriateness of emotion, regulation and range of emotion; affect; sadness, happiness, love, fear, anger, hate, tension, anxiety, joy, sorrow; lability of emotion; flattening of affect Exclusions: temperament and personality functions (b126); energy and drive functions (b130)							
	Sources of information: ☐ Case history ☐ Patient reported questionnaire ☐ Clinical examination ☐ Technical investigation							
	Description of the problem:							
		0	1	2	3	4	8	9
b180	**Experience of self and time functions**	☐	☐	☐	☐	☐	☐	☐
	Specific mental functions related to the awareness of one's identity, one's body, one's position in the reality of one's environment and of time. Inclusions: functions of experience of self, body image and time							
	Sources of information: ☐ Case history ☐ Patient reported questionnaire ☐ Clinical examination ☐ Technical investigation							
	Description of the problem:							
		0	1	2	3	4	8	9
b280	**Sensation of pain (G)**	☐	☐	☐	☐	☐	☐	☐
	Sensation of unpleasant feeling indicating potential or actual damage to some body structure. Inclusions: sensations of generalized or localized pain in one or more body part, pain in a dermatome, stabbing pain, burning pain, dull pain, aching pain; impairments such as myalgia, analgesia and hyperalgesia							
	Sources of information: ☐ Case history ☐ Patient reported questionnaire ☐ Clinical examination ☐ Technical investigation							
	Description of the problem:							

		0	1	2	3	4	8	9
b435	**Immunological system functions**	☐	☐	☐	☐	☐	☐	☐
	Functions of the body related to protection against foreign substances, including infections, by specific and non-specific immune responses. Inclusions: immune response (specific and non-specific); hypersensitivity reactions; functions of lymphatic vessels and nodes; functions of cell-mediated immunity, antibody-mediated immunity; response to immunization; impairments such as in autoimmunity, allergic reactions, lymphadenitis and lymphoedema Exclusion: haematological system functions (b430)							
	Sources of information: ☐ Case history ☐ Patient reported questionnaire ☐ Clinical examination ☐ Technical investigation							
	Description of the problem:							

		0	1	2	3	4	8	9
b640	**Sexual functions**	☐	☐	☐	☐	☐	☐	☐
	Mental and physical functions related to the sexual act, including the arousal, preparatory, orgasmic and resolution stages. Inclusions: functions of the sexual arousal, preparatory, orgasmic and resolution phase: functions related to sexual interest, performance, penile erection, clitoral erection, vaginal lubrication, ejaculation, orgasm; impairments such as in impotence, frigidity, vaginismus, premature ejaculation, priapism and delayed ejaculation Exclusions: procreation functions (b660); sensations associated with genital and reproductive functions (b670)							
	Sources of information: ☐ Case history ☐ Patient reported questionnaire ☐ Clinical examination ☐ Technical investigation							
	Description of the problem:							

		0	1	2	3	4	8	9
b710	**Mobility of joint functions**	☐	☐	☐	☐	☐	☐	☐
	Functions of the range and ease of movement of a joint. Inclusions: functions of mobility of single or several joints, vertebral, shoulder, elbow, wrist, hip, knee, ankle, small joints of hands and feet; mobility of joints generalized; impairments such as in hypermobility of joints, frozen joints, frozen shoulder, arthritis Exclusions: stability of joint functions (b715); control of voluntary movement functions (b760)							
	Sources of information: ☐ Case history ☐ Patient reported questionnaire ☐ Clinical examination ☐ Technical investigation							
	Description of the problem:							

BODY STRUCTURES Anatomical parts of the body such as organs, limbs and their components ***How much impairment does the person have in the ...***			No impairment	Mild impairment	Moderate impairment	Severe impairment	Complete impairment	Not specified	Not applicable
			0	1	2	3	4	8	9
s420	**Structure of immune system**	**Extent**	☐	☐	☐	☐	☐	☐	☐
			0 1 2 3 4 5 6 7 8 9						
		Nature*	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐						
		Location**	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐						
	Sources of information: ☐ Case history ☐ Patient reported questionnaire ☐ Clinical examination ☐ Technical investigation								
	Description of the problem:								
			0	1	2	3	4	8	9
s630	**Structure of reproductive system**	**Extent**	☐	☐	☐	☐	☐	☐	☐
			0 1 2 3 4 5 6 7 8 9						
		Nature*	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐						
		Location**	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐						
	Sources of information: ☐ Case history ☐ Patient reported questionnaire ☐ Clinical examination ☐ Technical investigation								
	Description of the problem:								
			0	1	2	3	4	8	9
s720	**Structure of shoulder region**	**Extent**	☐	☐	☐	☐	☐	☐	☐
			0 1 2 3 4 5 6 7 8 9						
		Nature*	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐						
		Location**	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐						
	Sources of information: ☐ Case history ☐ Patient reported questionnaire ☐ Clinical examination ☐ Technical investigation								
	Description of the problem:								

* 0=no change in structure, 1=total absence, 2=partial absence, 3=additional part, 4=aberrant dimension, 5=discontinuity, 6= deviating position, 7=qualitative changes in structure, 8=not specified, 9=not applicable

** 0=more than one region, 1=right, 2=left, 3=both sides, 4=front, 5=back, 6=proximal, 7=distal, 8=not specified, 9=not applicable

ACTIVITIES AND PARTICIPATION Execution of a task or action by an individual and involvement in a life situation ***How much difficulty does the person have in the ...*** ***P*** **= *performance of ...*** ***C*** **= *capacity in ...***			**No difficulty**	**Mild difficulty**	**Moderate difficulty**	**Severe difficulty**	**Complete difficulty**	**Not specified**	**Not applicable**
			0	1	2	3	4	8	9
d230	**Carrying out daily routine (G)**	**P**	☐	☐	☐	☐	☐	☐	☐
		C	☐	☐	☐	☐	☐	☐	☐
	Carrying out simple or complex and coordinated actions in order to plan, manage and complete the requirements of day-to-day procedures or duties, such as budgeting time and making plans for separate activities throughout the day. Inclusions: managing and completing the daily routine; managing one's own activity level Exclusion: undertaking multiple tasks (d220)								
	Sources of information: ☐ Case history ☐ Patient reported questionnaire ☐ Clinical examination ☐ Technical investigation								
	Description of the problem:								
			0	1	2	3	4	8	9
d240	**Handling stress and other psychological demands**	**P**	☐	☐	☐	☐	☐	☐	☐
		C	☐	☐	☐	☐	☐	☐	☐
	Carrying out simple or complex and coordinated actions to manage and control the psychological demands required to carry out tasks demanding significant responsibilities and involving stress, distraction or crises, such as driving a vehicle during heavy traffic or taking care of many children. Inclusions: handling responsibilities; handling stress and crisis								
	Sources of information: ☐ Case history ☐ Patient reported questionnaire ☐ Clinical examination ☐ Technical investigation								
	Description of the problem:								
			0	1	2	3	4	8	9
d430	**Lifting and carrying objects**	**P**	☐	☐	☐	☐	☐	☐	☐
		C	☐	☐	☐	☐	☐	☐	☐
	Raising up an object or taking something from one place to another, such as when lifting a cup or carrying a child from one room to another. Inclusions: lifting, carrying in the hands or arms, or on shoulders, hip, back or head; putting down								
	Sources of information: ☐ Case history ☐ Patient reported questionnaire ☐ Clinical examination ☐ Technical investigation								
	Description of the problem:								
			0	1	2	3	4	8	9
d445	**Hand and arm use**	**P**	☐	☐	☐	☐	☐	☐	☐
		C	☐	☐	☐	☐	☐	☐	☐
	Performing the coordinated actions required to move objects or to manipulate them by using hands and arms, such as when turning door handles or throwing or catching an object Inclusions: pulling or pushing objects; reaching; turning or twisting the hands or arms; throwing; catching Exclusion: fine hand use (d440)								
	Sources of information: ☐ Case history ☐ Patient reported questionnaire ☐ Clinical examination ☐ Technical investigation								
	Description of the problem:								

			0	1	2	3	4	8	9
d640	**Doing housework**	P	☐	☐	☐	☐	☐	☐	☐
		C	☐	☐	☐	☐	☐	☐	☐
	Managing a household by cleaning the house, washing clothes, using household appliances, storing food and disposing of garbage, such as by sweeping, mopping, washing counters, walls and other surfaces; collecting and disposing of household garbage; tidying rooms, closets and drawers; collecting, washing, drying, folding and ironing clothes; cleaning footwear; using brooms, brushes and vacuum cleaners; using washing machines, driers and irons. Inclusions: washing and drying clothes and garments; cleaning cooking area and utensils; cleaning living area; using household appliances, storing daily necessities and disposing of garbage Exclusions: acquiring a place to live (d610); acquisition of goods and services (d620); preparing meals (d630); caring for household objects (d650); caring for others (d660)								
	Sources of information: ☐ Case history ☐ Patient reported questionnaire ☐ Clinical examination ☐ Technical investigation								
	Description of the problem:								

			0	1	2	3	4	8	9
d760	**Family relationships**	P	☐	☐	☐	☐	☐	☐	☐
		C	☐	☐	☐	☐	☐	☐	☐
	Creating and maintaining kinship relationships, such as with members of the nuclear family, extended family, foster and adopted family and step-relationships, more distant relationships such as second cousins or legal guardians. Inclusions: parent-child and child-parent relationships, sibling and extended family relationships								
	Sources of information: ☐ Case history ☐ Patient reported questionnaire ☐ Clinical examination ☐ Technical investigation								
	Description of the problem:								

			0	1	2	3	4	8	9
d770	**Intimate relationships**	P	☐	☐	☐	☐	☐	☐	☐
		C	☐	☐	☐	☐	☐	☐	☐
	Creating and maintaining close or romantic relationships between individuals, such as husband and wife, lovers or sexual partners. Inclusions: romantic, spousal and sexual relationships								
	Sources of information: ☐ Case history ☐ Patient reported questionnaire ☐ Clinical examination ☐ Technical investigation								
	Description of the problem:								

			0	1	2	3	4	8	9
d850	**Remunerative employment (G)**	P	☐	☐	☐	☐	☐	☐	☐
		C	☐	☐	☐	☐	☐	☐	☐
	Engaging in all aspects of work, as an occupation, trade, profession or other form of employment, for payment, as an employee, full or part time, or self-employed, such as seeking employment and getting a job, doing the required tasks of the job, attending work on time as required, supervising other workers or being supervised, and performing required tasks alone or in groups. Inclusions: self-employment, part-time and full-time employment								
	Sources of information: ☐ Case history ☐ Patient reported questionnaire ☐ Clinical examination ☐ Technical investigation								
	Description of the problem:								

ENVIRONMENTAL FACTORS Make up the physical, social and attitudinal environment in which people live and conduct their lives. ***How much of a facilitator or barrier does the person experience with respect to ...*** You can also rate environmental factors as both a facilitator and barrier if applicable.		Complete facilitator	Substantial facilitator	Moderate facilitator	Mild facilitator	No barrier / facilitator	Mild barrier	Moderate barrier	Severe barrier	Complete barrier	Not specified	Not applicable
		+4	+3	+2	+1	0	1	2	3	4	8	9
e115	**Products and technology for personal use in daily living**	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Equipment, products and technologies used by people in daily activities, including those adapted or specially designed, located in, on or near the person using them. Inclusions: general and assistive products and technology for personal use											
	Sources of information: ☐ Case history ☐ Patient reported questionnaire ☐ Clinical examination ☐ Technical investigation											
	Description of the facilitator/barrier:											
		+4	+3	+2	+1	0	1	2	3	4	8	9
e310	**Immediate family**	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Individuals related by birth, marriage or other relationship recognized by the culture as immediate family, such as spouses, partners, parents, siblings, children, foster parents, adoptive parents and grandparents. Exclusions: extended family (e315); personal care providers and personal assistants (e340)											
	Sources of information: ☐ Case history ☐ Patient reported questionnaire ☐ Clinical examination ☐ Technical investigation											
	Description of the facilitator/barrier:											
		+4	+3	+2	+1	0	1	2	3	4	8	9
e320	**Friends**	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Individuals who are close and ongoing participants in relationships characterized by trust and mutual support.											
	Sources of information: ☐ Case history ☐ Patient reported questionnaire ☐ Clinical examination ☐ Technical investigation											
	Description of the facilitator/barrier:											
		+4	+3	+2	+1	0	1	2	3	4	8	9
e355	**Health professionals**	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	All service providers working within the context of the health system, such as doctors, nurses, physiotherapists, occupational therapists, speech therapists, audiologists, orthotist-prosthetists, medical social workers. Exclusion: other professionals (e360)											
	Sources of information: ☐ Case history ☐ Patient reported questionnaire ☐ Clinical examination ☐ Technical investigation											
	Description of the facilitator/barrier:											
		+4	+3	+2	+1	0	1	2	3	4	8	9
e410	**Individual attitudes of immediate family members**	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	General or specific opinions and beliefs of immediate family members about the person or about other matters (e.g. social, political and economic issues) that influence individual behaviour and actions.											
	Sources of information: ☐ Case history ☐ Patient reported questionnaire ☐ Clinical examination ☐ Technical investigation											
	Description of the facilitator/barrier:											
		+4	+3	+2	+1	0	1	2	3	4	8	9
e420	**Individual attitudes of friends**	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	General or specific opinions and beliefs of friends about the person or about other matters (e.g. social, political and economic issues) that influence individual behaviour and actions.											
	Sources of information: ☐ Case history ☐ Patient reported questionnaire ☐ Clinical examination ☐ Technical investigation											
	Description of the facilitator/barrier:											

		+4	+3	+2	+1	0	1	2	3	4	8	9
e450	**Individual attitudes of health professionals**	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	General or specific opinions and beliefs of health professionals about the person or about other matters (e.g. social, political and economic issues) that influence individual behaviour and actions.											
	Sources of information: ☐ Case history ☐ Patient reported questionnaire ☐ Clinical examination ☐ Technical investigation											
	Description of the facilitator/barrier:											
		+4	+3	+2	+1	0	1	2	3	4	8	9
e570	**Social security services, systems and policies**	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Services, systems and policies aimed at providing income support to people who, because of age, poverty, unemployment, health condition or disability require public assistance that is funded either by general tax revenues or contributory schemes. Exclusion: economic services, systems and policies (e565)											
	Sources of information: ☐ Case history ☐ Patient reported questionnaire ☐ Clinical examination ☐ Technical investigation											
	Description of the facilitator/barrier:											
		+4	+3	+2	+1	0	1	2	3	4	8	9
e580	**Health services, systems and policies**	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Services, systems and policies for preventing and treating health problems, providing medical rehabilitation and promoting a healthy lifestyle. Exclusion: general social support services, systems and policies (e575)											
	Sources of information: ☐ Case history ☐ Patient reported questionnaire ☐ Clinical examination ☐ Technical investigation											
	Description of the facilitator/barrier:											
		+4	+3	+2	+1	0	1	2	3	4	8	9
e590	**Labour and employment services, systems and policies**	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Services, systems and policies related to finding suitable work for persons who are unemployed or looking for different work, or to support individuals already employed who are seeking promotion. Exclusion: economic services, systems and policies (e565)											
	Sources of information: ☐ Case history ☐ Patient reported questionnaire ☐ Clinical examination ☐ Technical investigation											
	Description of the facilitator/barrier:											

The ICF-based Documentation Tool is a versatile and essential resource for healthcare professionals engaged in rehabilitation. Available via link: https://www.icf-core-sets.org/. This tool is designed to facilitate the systematic documentation of patient data using the International Classification of Functioning, Disability, and Health framework. It enables the use of basic ICF Core Sets, which are standardized groups of ICF categories that are most relevant to specific health conditions, ensuring a consistent approach to assessing and documenting patient functioning across different domains. Additionally, the tool allows PM&R specialist to create their own custom ICF Core Sets tailored to the unique needs of individual patients or specific clinical settings. This flexibility supports the development of personalized rehabilitation plans, enhances the accuracy of patient assessments, and improves communication among multidisciplinary teams by providing a common language for describing patient health and functioning.

Appendix E. Energy Conservation and Its 7 Principles

What is energy conservation?

Energy conservation for individuals refers to strategies and approaches aimed at optimizing the use of energy for completing daily tasks and activities. This is particularly important for people with limited energy, such as those with chronic illnesses, recovering from surgery, or undergoing intensive treatment. It is a thoughtful approach to:

- achieving more with less effort;
- balancing rest and energy use;
- helping to continue participating in activities that matter to you.

When should you use energy conservation strategies?

During periods of low energy, such as during cancer treatment, when activities are challenging or draining your energy. When you want to ensure you are using your energy for more meaningful or important tasks. Remember—stay active in your usual activities as much as possible to maintain physical fitness.

7 Principles of energy conservation:

1. Scheduling.

   Plan ahead. Balance your day with activities that require less energy, such as reading a newspaper, and those that require more energy, such as gardening. Create a list of daily or weekly tasks that need to be done. Complete important tasks when you have the most energy.
2. Pacing.

   Move at a comfortable pace or speed. Perform some activities less frequently (cleaning), with less detail, or not at all.
3. Delegating.

   Seek help with tasks that are difficult and require a lot of energy or are not important to you. Consider involving family, friends, volunteers, community resources, or hiring services.
4. Storing.

   Organize items close to where they are used and at waist level whenever possible to avoid bending down to pick them up. Consider keeping two sets of frequently used items in convenient locations. For example, keep a set of salt and pepper shakers by the stove and another set on the dining table.
5. Sitting.

   Sit to perform tasks whenever possible to conserve energy. Sit on higher surfaces to save energy when getting up. Also, check your posture—keep your body in a straight line. Avoid leaning or stretching, especially for heavy items.
6. Simplifying.

   Adapt activities or the environment to use less energy or simplify tasks. Alternate between heavy and light work throughout your daily and weekly schedule. Plan breaks and take a break before you feel tired.
7. Resting.

   Plan rest periods throughout the day. Several short rest periods are better than 2-3 long rest periods. Avoid long or late afternoon naps.

Appendix F. Telerehabilitation Protocol for Breast Cancer Patients

Telerehabilitation is a comprehensive set of rehabilitation activities and educational programs provided to patients remotely through telecommunications and computer technologies (primarily at the outpatient stage of treatment). Telerehabilitation can also be conducted during the post-acute rehabilitation phase when a relevant specialist is unavailable at the medical facility, or when distance is a critical factor.

Telerehabilitation includes online physical therapy, continuous electronic monitoring of functional status, control of the adequacy of the rehabilitation program, program adjustments as necessary, and assessment of the patient's overall condition. Telerehabilitation involves the independent implementation of the rehabilitation program by the patient during the post-acute or long-term rehabilitation stages, under the remote supervision and guidance of a rehabilitation specialist, as well as conducting telemonitoring questionnaires on the patient's condition and well-being.

Physical therapy is one of the main tools of telerehabilitation. Depending on the impact and volume of physical activity, the rehabilitation process for oncogynecological patients is divided into periods:

1. *Prehabilitation* – from the moment of hospitalization to the day of surgery. At this stage, telerehabilitation can be applied in a hospital setting if a telerehabilitation specialist is not available. The primary objectives at this stage include improving tolerance to physical activity, enhancing muscle tone, and teaching the patient how to change positions in bed. Prehabilitation significantly accelerates functional recovery, reduces hospitalization time post-surgery, and decreases the incidence of complications and mortality associated with cancer treatment. Physical prehabilitation consists of a combination of aerobic and anaerobic stress. This combination improves tolerance to physical activity, enhances the quality of life, and increases muscle tone.
2. *Postoperative period* – the main goals of the postoperative period include preventing respiratory complications (such as pneumonia and atelectasis), preventing adhesions, promoting the formation of an elastic and mobile scar (after mastectomy), preventing bladder dysfunction, improving gastrointestinal activity, and enhancing general and local blood and lymph circulation.
    - Early stage (1-3 days post-surgery);
    - Delayed stage (4-7 days post-surgery) (telerehabilitation is possible under the supervision of a physician if a specialist is not available).
    - Recovery stage (8 to 21 days post-surgery) (group telerehabilitation is possible).
    - Learning stage (3 weeks post-surgery) (online group supervision or self-rehabilitation is possible).

Objectives and tasks of telerehabilitation:

Telerehabilitation during the hospital period (prehabilitation, second stage of rehabilitation): improve access to specialized care, support the direct education of healthcare workers providing immediate care, ensure stability and quality of medical care in the context of staffing challenges, and enhance the manageability of the rehabilitation process.

Objectives of telerehabilitation in the ambulatory (post-acute) period:

Social and professional adaptation in the post-hospital period, maximum recovery of functions, self-care skills, and work; increasing the patient's ability to work at home; directing therapeutic assistance if necessary; improving the outpatient follow-up of the population in rural areas; enhancing the manageability of the rehabilitation treatment process.

Method design:

- Necessary equipment for the patient: smartphone, tablet, laptop with a built-in camera, or computer with a webcam, along with the skills to use a smartphone/tablet or basic computer literacy.
- Discuss the importance of physical rehabilitation with the patient.
- Obtain consent for remote rehabilitation – have the patient sign a paper consent form for personal data and remote rehabilitation.
- Ask the patient to provide an email address (possibly of a relative); conduct an instruction session – send the patient a video tutorial on how to use the system.

There are two possible session formats:

1. Online guided group rehabilitation.
    - After analyzing the results and based on a monitoring scale, the patient is enrolled in a group where daily sessions are conducted online with the participation of a physical therapist and under the supervision of a

rehabilitation physician. The duration of one rehabilitation session is 10-14 days, with each session lasting 20-30 minutes.

- Before joining the group, the patient fills out an electronic questionnaire (Appendix A). Based on the data analysis, the physician recommends a stage corresponding to the patient's condition and diagnosis and enrolls the patient in the appropriate group.
- The patient receives a daily schedule of sessions and reminders about the next exercise session (15 minutes prior).
- The patient participates in online group sessions under the guidance of a physical therapist.
- At the end of each session, the patient fills out a brief questionnaire about the tolerability of telerehabilitation (Appendix B).
- After completing the rehabilitation course, the patient fills out a final electronic questionnaire, which is analyzed by the rehabilitation physician (Appendix A).

2. Combination of online and offline sessions

- The patient is enrolled in a group where sessions are held online once a week with the participation of a physical therapist and four times a week offline via video links under the supervision of a physician. The duration of one rehabilitation session is 10-14 days, with each session lasting 20-30 minutes.
- The physician's observation of the patient is entirely based on the results of electronic questionnaires. Online communication with the physician occurs once a week.
- Before joining the group, the patient fills out an electronic questionnaire. Based on the data analysis, the physician recommends a stage corresponding to the patient's condition and diagnosis and enrolls the patient in the appropriate group.
- The patient receives a daily schedule of sessions and reminders about the upcoming exercise session (15 minutes prior).
- The patient participates in online group sessions under the guidance of a physical therapist once a week (or every four days); for the rest of the days until the next online session, the patient exercises independently according to the schedule (or at a convenient time) using physical culture video courses prescribed by the physician and tailored specifically to this group.
- At the end of each session, the patient fills out a brief questionnaire about the tolerability of telerehabilitation.
- The next day, the patient receives a reminder about the upcoming session and repeats the process.
- After completing the rehabilitation course, the patient fills out a final electronic questionnaire, which is analyzed by the physician.

Physician's responsibilities:

– Discuss the importance of physical rehabilitation with the patient.

– Obtain consent for remote rehabilitation – have the patient sign a paper consent form for personal data and remote rehabilitation.

– Ask the patient to provide an email address (possibly of a relative); conduct an instruction session – send the patient a video tutorial on how to use the system.

Appendix G. Equipment Requirements for a Telerehabilitation Room/Office

Setting up a telerehabilitation room or office involves careful consideration of modern standards to ensure an environment that is both effective for patient care and compliant with technical, medical, and safety regulations. Below are the detailed requirements for organizing a telerehabilitation room/office:

1. Location and space requirements.
   - Privacy. The room should be located in a quiet area to ensure patient privacy and minimize interruptions during teleconsultations and therapy sessions.
   - Space. The room should have enough space to accommodate necessary equipment, seating for patients, and any accompanying caregivers or healthcare providers. A minimum of 15 square meters is recommended to allow for movement during physical therapy sessions.
   - Accessibility. The room should be accessible to patients with mobility issues. This includes wide doorways, ramps (if needed), and sufficient space for wheelchair maneuverability.
2. Environmental controls.
   - Lighting. Proper lighting is crucial for video consultations. The room should be equipped with adjustable lighting that minimizes shadows and glare on video feeds. Natural light should be supplemented with soft, diffused artificial lighting.
   - Temperature control. The room should have a reliable heating, ventilation, and air conditioning (HVAC) system to maintain a comfortable environment. This is particularly important for patients who may spend extended periods in the room.
   - Noise control. Soundproofing or noise-canceling materials should be used to minimize external noise. This is essential to ensure clear communication during teleconsultations.
3. Technical equipment.
   - Computers and monitors. The room should be equipped with high-performance computers capable of handling video conferencing software, patient data management, and any specialized rehabilitation software. Dual monitors are recommended for multitasking between patient records and video calls.
   - High-resolution camera. A high-quality camera is essential for clear video communication. The camera should have a minimum resolution of 1080p and should be adjustable to capture different angles during physical therapy sessions.
   - Microphone and speakers. A high-quality microphone and speakers or a headset are necessary to ensure clear communication between the patient and the healthcare provider. Noise-canceling features are recommended.
   - Stable Internet connection. A high-speed internet connection is critical for uninterrupted telehealth services. A minimum speed of 100 Mbps is recommended for smooth video streaming.
   - Telemedicine software: The room should be equipped with secure, HIPAA-compliant telemedicine software that allows for video consultations, patient monitoring, and secure communication of health information.
4. Medical equipment.
   - Vital signs monitoring devices. The room should have devices for monitoring vital signs such as blood pressure monitors, pulse oximeters, and digital thermometers that can connect to the computer system for remote monitoring.
   - Rehabilitation equipment. Depending on the type of rehabilitation provided, the room should be equipped with items such as exercise mats, resistance bands, therapy balls, and other physical therapy tools.
   - Adjustable examination table. An examination table that can be adjusted for height and angle is essential for physical assessments and treatments.
   - Ergonomic furniture. The room should have ergonomic chairs and desks to ensure comfort for both patients and healthcare providers during extended sessions.
5. Safety and compliance.
   - Infection control. The room should have hand sanitizers, disposable gloves, and other hygiene products to maintain cleanliness, especially in a post-pandemic context.
   - Emergency protocols. The room should be equipped with an emergency call system or panic button to quickly summon help if needed.
   - Data security. All computer systems should have robust security measures in place, including firewalls, antivirus software, and secure access controls to protect patient information.

- Compliance with health standards. The room must comply with local and national health regulations regarding medical facilities, including those for electrical safety, waste disposal, and patient care.

6. Patient comfort and engagement.
   - Comfortable seating. Provide comfortable seating options for patients, including chairs with proper back support.
   - Visual and audio aids. The room should have visual and audio aids to assist patients with hearing or vision impairments.
   - Patient education materials. The room should have access to digital or printed educational materials to help patients understand their rehabilitation process.

By adhering to these requirements, the telerehabilitation room or office will be well-equipped to provide high-quality, patient-centered care in a safe and efficient environment.

The telerehabilitation room or office within a hospital is designed to be a flexible and patient-centered space, offering patients the opportunity to engage in their rehabilitation process even while they are in the hospital.

Example case: post-surgical telerehabilitation for a BC Patient.

Patient background. Mrs. A, a 45-year-old woman, recently underwent a modified radical mastectomy due to breast cancer. Following the surgery, her healthcare team recommended an immediate start to a post-surgical rehabilitation program to restore mobility in her upper limb and manage potential post-operative complications, such as lymphedema and scar tissue formation.

Telerehabilitation room usage. Mrs. A was admitted to the hospital for a week after her surgery to monitor her recovery. During this time, she was introduced to the hospital's telerehabilitation room, where she could begin her rehabilitation program under the guidance of her physical therapist, even though her therapist was not physically present in the hospital.

Daily telerehabilitation routine.

Morning session:

- Guided exercises. Every morning, Mrs. A visited the telerehabilitation room, where she logged into the hospital's telemedicine platform. Her physical therapist, who was located in a different part of the city, connected with her through a high-definition video conferencing system.
- Upper limb mobility exercises. Using the room's equipment, including resistance bands and a wall pulley system, Mrs. A performed specific exercise aimed at improving the range of motion in her shoulder and arm on the operated side. The therapist monitored her movements in real-time, offering corrections and encouragement as needed.

Midday check-in:

- Virtual consultation. Around midday, Mrs. A returned to the room for a virtual consultation with her rehabilitation specialist. They discussed her progress, pain levels, and any difficulties she encountered during the morning exercises. The specialist adjusted her exercise regimen based on this feedback.
- Educational session. During this time, Mrs. A also accessed educational videos on post-mastectomy care, lymphedema prevention, and self-massage techniques for scar management. This information empowered her to take an active role in her recovery.

Afternoon relaxation and mindfulness.

- Guided relaxation. In the afternoon, Mrs. A used the room's facilities to engage in a guided mindfulness and relaxation session. This was particularly important for managing her anxiety and promoting overall well-being. The session was led by a psychologist who specialized in cancer recovery and was conducted virtually from another location.

Evening follow-up:

- Assessment and planning. Before ending her day, Mrs. A had a final check-in with her therapist through the telerehabilitation room's system. They reviewed her progress, and the therapist provided her with exercises to perform independently in her hospital room or at home after discharge. The therapist also discussed the plan for the next day's session.

By using the telerehabilitation room during her hospital stay, Mrs. A was able to start her rehabilitation process immediately after surgery, ensuring a quicker and more effective recovery. The ability to receive expert guidance and support

in real-time, despite the therapist's physical absence, made the telerehabilitation room an invaluable resource in her post-surgical care.

This approach not only facilitated her physical recovery but also provided psychological support and education, which were crucial for her overall well-being. Mrs. A left the hospital with a clear rehabilitation plan and the confidence to continue her exercises at home, knowing that she could still connect with her healthcare team remotely whenever needed.

Appendix H. Telemedicine Room Personnel and Patient Selection Criteria

Personnel composition.

The telemedicine room is staffed by a multidisciplinary team, including:

- Physicians specializing in PM&R. These physicians have completed specific training in telemedicine during their postgraduate education, particularly in providing medical care via telemedicine, as part of their professional qualification certification.
- Nurses. Responsible for managing both electronic and paper-based medical and statistical documentation.
- Support personnel. Ensures the smooth operation of technical and software systems necessary for telemedicine services.

Data required from patients prior to starting telerehabilitation.

According to the Ministry of Health of Ukraine regulatory documents, the following patient data must be provided:

- Full Name, Age, Weight, Height.
- Primary diagnosis and type of treatment received.
- Significant comorbidities (e.g., hypertension, myocardial infarctions/strokes with dates, heart failure classification, rhythm disorders, respiratory failure classification, bronchial asthma frequency and treatment, diabetes mellitus control).
- Date and extent of surgery.
- Details on any reconstructive surgery performed (type, date, and method of reconstruction, such as implants or transplanted tissue).
- Postoperative complications (e.g., fever, wound dehiscence).
- Previous rehabilitation received after surgery.
- Recommendations from the oncologist.
- Rehabilitation diagnosis.

Criteria for including and excluding patients from telerehabilitation.

Inclusion criteria:

- All patients with malignant breast neoplasms, with or without reconstruction.
- Expected life expectancy of at least 3 months, creatinine levels not exceeding 1.5 times the normal range, ALT and AST levels not more than 2 times the upper limit of normal.
- Hematological parameters: leukocytes not less than 3000/mm^3, platelets not less than 100,000/mm^3, hemoglobin not less than 8 g/dL.
- Absence of uncontrolled comorbid conditions.

Exclusion criteria:

Less than one month since the reconstructive surgery component.

- Non-compliance with the above inclusion criteria: severe cardiovascular conditions (e.g., myocardial infarction within the last year, uncontrolled arterial hypertension, stroke within the last year, current deep vein thrombosis, embolism, paroxysmal atrial arrhythmias, or other life-threatening arrhythmias, external or internal bleeding, or threat of bleeding, ECG changes indicating worsening coronary circulation, sinus tachycardia over 100 beats/min, bradycardia below 50 beats/min, hypertension above 220/120 mmHg, hypotension below 90/50 mmHg, frequent hyper- or hypotensive crises).
- Clinically significant renal pathology (e.g., bilateral renal artery stenosis, single kidney artery stenosis, kidney transplant patients, significant electrolyte imbalances, creatinine levels exceeding 1.5 times the normal range).
- Psychiatric disorders, acute infectious-inflammatory diseases, intoxication, severe pain syndrome, fever above 37.6°C, presence of foreign bodies near major vessels or nerve trunks.
- Any clinical condition deemed by the physician to make remote telerehabilitation unsafe.

Exclusion criteria during rehabilitation:

- Violation of training conditions.
- Progression of lymphedema during training, exacerbation of chronic diseases, complications in disease progression, intercurrent infectious or inflammatory diseases, signs of disease progression, or deterioration of the patient's condition.
- Vascular crises (hypertensive or hypotensive), arrhythmias: sinus tachycardia over 100 beats/min, bradycardia below 50 beats/min, paroxysmal or flutter arrhythmia attacks, frequent extrasystoles.
- Any clinical condition deemed by the physician to make telerehabilitation unsafe for the patient.