REVIEW ARTICLE

CONTENTS

# Concept of a multifunctional prosthetic and rehabilitation center with an innovative educational component for patients with limb amputation in the context of war in Ukraine

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## ABSTRACT

**Aim:** The development of a multifunctional prosthetic and rehabilitation center with an innovative educational component for patients with limb amputations.

**Materials and Methods:** The authors analyzed contemporary literature sources, including descriptions and discussions of the key aspects of developing a multifunctional prosthetic and rehabilitation center for patients with limb amputations.

**Conclusions:** A modern multifunctional prosthetic and rehabilitation center with an innovative educational component implements a multimodal approach to habilitation and rehabilitation of patients with amputated limbs. This approach encompasses medical-therapeutic interventions, functional physical rehabilitation, psychosocial support, and a mandatory comprehensive educational preparation program for patients. The development of such multidisciplinary centers significantly expands the spectrum of opportunities for effective rehabilitation and subsequent social reintegration of patients into society. The strategic objectives of these centers correlate with global priorities of the healthcare system and align with the integrated medical care model paradigm, which organically combines primary and specialized levels of medical service provision. The strategic objectives of these centers align with the global healthcare priorities and correspond to the paradigm of an integrated healthcare model, which organically combines primary and specialized levels of medical service provision. Implementing a comprehensive approach that integrates accessible therapeutic and preventive services, high-tech rehabilitation methods, and preventive medical supervision enables the Center to not only improve individual health indicators and quality of life for patients with amputations but also achieve broader public health objectives, including reducing the economic burden on healthcare systems associated with suboptimal medical rehabilitation services for individuals with disabilities due to amputations.

**KEY WORDS:** amputation, artificial limbs, rehabilitation, rehabilitation centers

Wiad Lek. 2025;78(6):1160-1167. doi: 10.36740/WLek/207373 DOI

## INTRODUCTION

Limb loss due to combat-related trauma represents a critical public health and medical challenge in multiple global contexts. According to the Limb Loss and Amputation Center in the USA, between 2001 and 2017, at least 1,718 military personnel experienced one or more limb amputations (excluding digit amputations). Notably, approximately 31% of these service members sustained two or more amputations, with explosive injuries accounting for 73% of such cases [1, 2].

In Ukraine, the significance of this medical issue has dramatically escalated with the onset of hostilities in 2014, precipitated by Russian aggression in Eastern Ukraine. Epidemiological investigations reveal that 62,5% of injuries sustained by Anti-Terrorist Operation (ATO) and Joint Forces Operation (JFO) participants involve limb trauma [2]. High-energy weaponry emerges as the primary causative factor, with mine and explosive-related injuries responsible for 74,8% of amputations. Despite improvements in medical intervention strategies, amputation rates remain relatively elevated at approximately 4% (168 cases) [3].

In Ukraine, traumatic injuries sustained during military operations, as well as during aerial attacks and missile strikes on residential and industrial buildings, have become a major concern in terms of both significance and the number of amputations.

Lower limb amputation is a life-altering event that significantly impacts physical function, health, quality of life, and psychosocial well-being. Lower limb ampu-

tations account for 94,8% of all amputations, whereas upper limb amputations constitute only 5,2% [3]. Traumatic lower limb amputations commonly occur among younger individuals, posing unique professional and psychosocial challenges compared to lower limb amputations in older adults caused by peripheral arterial disease or diabetes mellitus.

The necessity of improving healthcare services at all stages of treatment and rehabilitation, as well as developing clear algorithms based on the experience of leading NATO countries, remains a critical and urgent task. In the United States, for example, a veteran amputation prevention program has been established to prevent or delay limb loss [4].

Prosthetic rehabilitation has demonstrated its effectiveness not only in the physical domain—specifically, improving mobility and functional independence—but also in mental health, as it often reduces social isolation and enhances patients' self-confidence. Recent studies emphasize the importance of accessible and high-quality rehabilitation as a global public health priority aimed at supporting societal independence and productivity [5]. By investing in specialized centers, healthcare systems can enhance the quality of life for individuals with amputations and facilitate their full reintegration into society.

The demand for specialized rehabilitation services for individuals with amputations in Ukraine is a pressing healthcare issue due to the recent surge in war-related amputations. Military injuries generate a high demand for specialized care as they frequently result in complex physical and psychological consequences. Research indicates that timely and specialized rehabilitation significantly improves quality of life and functional independence among war survivors [6].

The socioeconomic impact of limb loss is substantial, as individuals with amputations often face decreased employment opportunities and greater dependence on family or social support services, creating economic strain. Numerous studies have quantified the financial consequences of untreated or inadequately treated amputations, demonstrating that comprehensive rehabilitation can reduce these costs and facilitate the return of individuals to economic productivity [7, 8].

According to recent health statistics [9], individuals with amputations encounter significant barriers to employment [10], social integration [11, 12], and mental health stability [13, 14]. Addressing these challenges through the establishment of a rehabilitation center can mitigate socioeconomic costs and support the reintegration of both veterans and civilians into society.

The United States Department of Veterans Affairs has developed clinical guidelines for post-amputation medical care, which include the involvement of multidisciplinary teams. These teams comprise specialists from various medical and rehabilitation disciplines, such as surgeons, physiotherapists, occupational therapists, prosthetists, social workers, psychologists, and others [15].

The International Society for Prosthetics and Orthotics (ISPO) has attempted to standardize key indicators of successful prosthetic rehabilitation. Studies indicate that while physical functioning is often emphasized, psychological and social aspects of the patient experience tend to be overlooked [4].

The World Health Organization (WHO) initiative "Rehabilitation 2030," announced in 2019, underscores that rehabilitation should be an integral part of universal health coverage, ensuring access to essential services for all individuals, regardless of socioeconomic status [15].

Rehabilitation following war-related traumatic limb loss often requires a multidisciplinary approach, encompassing physical rehabilitation, psychological support, and vocational training [16-19]. These services not only aid individuals in restoring physical independence but also alleviate the overall burden on mental health services.

Developing and implementing the concept of a multifunctional prosthetic and rehabilitation center is a crucial task for Ukraine, particularly in the context of war, which has dramatically increased the number of individuals with amputations. These patients often face multifaceted challenges encompassing physical, psychological, social, and economic dimensions. Limb amputation is not only a medical issue but also a significant social challenge, as it affects patients' ability to secure employment, integrate into society, and meet basic needs. The Center will serve not only as a treatment facility but also as a platform for innovation, education, and social integration, ensuring high-quality service delivery in accordance with international standards.

## AIM

The aim of the review was to substantiate the necessity of establishing a multifunctional prosthetic and rehabilitation center and to develop the conceptual framework for its operation.

## MATERIALS AND METHODS

The authors conducted an extensive analysis of contemporary scientific literature, international rehabilitation standards, and guidelines provided by organizations such as the World Health Organization (WHO), the Inter-

national Society for Prosthetics and Orthotics (ISPO), and the United Nations Convention on the Rights of Persons with Disabilities. The research methodology included a systematic review of global practices in prosthetic rehabilitation, case studies of multidisciplinary rehabilitation centers, and an assessment of socio-economic impacts related to limb loss and rehabilitation interventions.

A combination of qualitative and quantitative research approaches was employed to evaluate the effectiveness of different rehabilitation models, with a specific focus on integrated care, assistive technologies, and the role of psychological and vocational rehabilitation. Additionally, comparative analysis was used to assess the applicability of international rehabilitation models in the Ukrainian healthcare context.

## ETHICS

The preparation of the article adhered to the principles of scientific ethics and academic integrity.

## REVIEW AND DISCUSSION

The development and implementation of the concept of a Multifunctional Prosthetic and Rehabilitation Center is an urgent task for Ukraine, especially in the context of war, which has significantly increased the number of individuals with amputations. These patients face multidimensional challenges encompassing physical, psychological, social, and economic aspects.

According to the World Health Organization (WHO) [20], rehabilitation is a key element in health restoration, particularly for patients with traumatic injuries. In conflict-affected countries, the absence of effective rehabilitation services often results in long-term public health and economic consequences. In Ukraine, the need for specialized care for individuals with amputations is particularly acute due to the increasing incidence of such cases among both military personnel and civilians.

Under wartime conditions, rehabilitation must extend beyond physical assistance. It should include psychological support, vocational training, and social reintegration opportunities. The experience of other countries that have endured armed conflicts, such as Israel, underscores the importance of a comprehensive approach to the rehabilitation of individuals with amputations. For example, at the Sheba Rehabilitation Center in Israel [21], innovative prosthetic solutions are actively implemented, significantly improving patients' quality of life.

Ukrainian legislation, particularly the Law on Rehabilitation in Healthcare [22], defines the principles of a multidisciplinary approach, integrating medical, social, and psychological support. However, the healthcare system in Ukraine faces significant limitations, including outdated infrastructure, insufficient funding, and a shortage of qualified personnel.

A Multifunctional Rehabilitation Center could serve as the foundation for the development of modern rehabilitation medicine in Ukraine. It would not only provide treatment for individuals with limb loss but also serve as a scientific hub for introducing innovations in prosthetics. Integrating advanced technologies, such as bionic prosthetics and digital telemedicine platforms, offers new possibilities for enhancing rehabilitation quality. Studies [23] demonstrate that bionic prosthetics with artificial intelligence integration provide greater functionality and adaptation for patients.

Additionally, the center would play an educational role, offering training programs for healthcare professionals and patients, thereby contributing to the long-term sustainability of the rehabilitation system.

Special attention should be given to family members of amputees, who often encounter difficulties in providing care. Educational programs for relatives can help create a supportive environment for patients, a factor confirmed by studies published by the American Psychological Association [24].

A WHO report from 2019 [25] highlights the significant gaps in the accessibility of prosthetic rehabilitation services, particularly in low- and middle-income regions, where limited infrastructure and funding constrain specialized care.

Current health indicators reveal a high incidence of comorbidities among individuals with untreated amputations. Lack of prosthetic rehabilitation exacerbates these issues, leading to secondary health complications, such as cardiovascular diseases, due to reduced physical activity. Recent research [26] highlights that comprehensive rehabilitation significantly reduces these risks. However, without adequate funding and infrastructure, these services remain inaccessible to many.

The Ukrainian healthcare system and rehabilitation infrastructure may not be sufficient to meet the needs of the growing number of amputees [27]. Financial constraints represent a major barrier to prosthetic rehabilitation, as current healthcare budgets often prioritize emergency care over long-term rehabilitation. WHO emphasizes the funding gap between acute care and rehabilitation services [28], underlining the necessity for dedicated financial resources to support comprehensive prosthetic rehabilitation.

Analyses [29] indicate that rehabilitation systems benefit significantly from international partnerships [30], which facilitate the implementation of cutting-edge technologies and training programs.

The regulatory framework for prosthetics varies significantly across regions, impacting the standardization of care. In many countries, the lack of clear clinical guidelines for prosthetic services leads to inequities in quality and accessibility. The development of standardized protocols is essential for ensuring consistent, high-quality care for patients. Ukraine's healthcare system may require updated regulations and additional funding to meet the increasing demand for prosthetic rehabilitation.

The analysis of the current situation reveals both high demand and a shortage of prosthetic rehabilitation services. Addressing these issues requires targeted investment in infrastructure, funding, and regulatory standards to ensure access to rehabilitation for all individuals with limb loss.

The primary goal of establishing the Center in Ukraine is to improve the health and well-being of individuals who have undergone limb amputations, as well as to provide education and training for them and their families. Achieving this goal entails addressing a range of pressing healthcare needs, including improving access to rehabilitation services, reducing the frequency of post-amputation complications, and enhancing overall quality of life. The main task of the center is to improve the health and functional capacity of individuals with amputations, particularly military personnel. Studies show that comprehensive, trauma-focused rehabilitation improves long-term functional outcomes and mental health in patients with combat-related injuries [31, 32]. The Center's activities can be directed toward providing high-quality, personalized care, focused on restoring independence, mobility, and psychological resilience among patients.

A key objective of this concept is to increase the availability of services for individuals with amputated limbs. Research on the WHO Rehabilitation Initiative launched in 2019 [15] highlighted the need for universal access to rehabilitation services to improve healthcare, emphasizing that all people, regardless of origin, should have access to necessary resources for optimal functioning and quality of life.

The Center's tasks include facilitating access to specialized care, ensuring timely treatment to reduce secondary complications, and enhancing the psychological resilience of patients. Research emphasizes that achieving these outcomes requires immediate rehabilitation and psychological support [33].

Multifunctional prosthetic rehabilitation centers with an innovative educational component are becoming an integral part of modern medicine. They offer a comprehensive approach to rehabilitation, which includes medical, physical, and psychological support, and educational training for patients with amputations. The development of such centers creates new opportunities for patient rehabilitation and social integration.

The Center's goals align with global health priorities, providing an integrated, holistic model of care that combines primary and specialized medical services. The combination of accessible services, advanced technologies, and preventive care will enable the Center to contribute not only to individual health improvements but also to broader public health objectives, reducing healthcare costs associated with amputations due to inadequate or insufficient treatment of individuals with disabilities.

The Center will provide comprehensive prosthetics and rehabilitation services, combining advanced technologies, a personalized approach, and multidisciplinary collaboration. The Center will also function as a platform for education, research, and social integration, facilitating the return of patients to an active and independent life.

The main components of the Center include:

1. Medical and Rehabilitation Services. The Center will offer specialized medical services related to the recovery of patients following prosthetic fitting, rehabilitation services, and psychological support, focusing on the individual needs of each patient. Key services will include:
   - Assessment and Diagnosis: A comprehensive evaluation of both the physical and psychological condition of patients is crucial for successful prosthetic rehabilitation.
   - Prosthetics and Customization: Improving flexibility, mobility, and user satisfaction, especially with bionic limbs.
   - Physical Rehabilitation: Task-oriented training that enhances motor learning and the integration of prosthetics into daily life.
   - Occupational Therapy: Early integration of occupational therapy significantly enhances long-term functionality and user satisfaction with prosthetics.
   - Psychological Support: Early psychological intervention improves mental health and accelerates the rehabilitation process for individuals with amputations.
2. Innovation and Scientific Research. The Center will serve as a hub for innovation in prosthetics and rehabilitation, continuously exploring new technologies and methodologies:
   - Scientific Research and Development in Prosthetics: Utilizing modern manufacturing technologies to create lightweight, durable, and affordable prostheses.

- 3D Printing: This will significantly change the methods of prosthesis production, enabling the creation of custom solutions for patients with high precision, speed, and cost-efficiency.
- Robotics: Automation of production processes and the integration of bionic components will expand the functional capabilities of prosthetics.
- Intelligent Prostheses: Bionic prosthetics that use neural sensors and artificial intelligence will provide patients with enhanced control and more natural limb movements.
- Virtual Reality Therapy: Creating safe and controlled environments for training and recovery, aiding in rehabilitation.

3. Education and Workforce Training. The Center will be an educational institution offering training programs for professionals, students, and the public:
   - For Specialists: Certified courses, advanced training, thematic improvement cycles, workshops, and masterclasses for healthcare professionals, prosthetists, and rehabilitation specialists, focusing on the latest advancements in prosthetics and patient care.
   - For Patients: Training programs for patients and their families on the use and maintenance of prostheses are essential for maximizing the functionality of devices and supporting overall health.
   - For Higher Education Students and Researchers: Opportunities for internships, scientific research, employment, and participation in multidisciplinary teams.
   - Inclusion and Social Integration. The Center will promote inclusion and remove barriers for individuals with amputations:
   - Accessibility: Ensuring full participation in rehabilitation services for individuals with amputations is critical for their successful rehabilitation.
   - Support Groups: Social connections positively influence rehabilitation outcomes and overall well-being.
   - Inclusive Sports Events: Organizing adaptive sports programs will contribute to physical health and social interaction, which are vital for the comprehensive rehabilitation of individuals with limb loss.
   - Public Awareness Campaigns: Raising awareness and creating a more accepting environment for individuals with amputations, as well as providing education and advocacy.

Quality standards and digital solutions will also play a crucial role in the implementation strategy of the center. The quality standard ISO 9001:2015 [34], which focuses on improving organizational efficiency and patient safety, can be adopted in the management practices of the center to ensure a high level of service.

Given the psychological impact of traumatic amputations, providing comprehensive psychological support services is essential. Recent studies [35, 36] indicate that integrated psychological support in rehabilitation centers improves treatment outcomes and quality of life for patients affected by war-related injuries.

Healthcare professionals require specialized training in traumatology for treating combat-related injuries. Training programs focused on trauma-informed approaches help reduce professional burnout among specialists and improve patient treatment outcomes [37, 38]. Furthermore, creating a supportive working environment for medical staff is crucial for retaining skilled personnel. Enhancing job satisfaction and opportunities for professional development for healthcare workers helps reduce turnover. Research in healthcare [39, 40] shows that well-equipped and supportive workplaces lead to better patient treatment outcomes and contribute to the sustainable functioning of healthcare systems.

By focusing on key aspects such as preventive measures, advanced technologies, quality standards, and support for professionals, aimed at ensuring the ability to meet current and future healthcare needs, the Center will be able to provide comprehensive, effective, and high-quality care for individuals with amputations.

## CONCLUSIONS

The establishment of an advanced prosthetics and rehabilitation center focused on restoring mobility, functionality, and quality of life for individuals with amputations will enable their reintegration into society. Individuals who regain mobility and independence through proper rehabilitation and prosthetics experience significant improvements in mental health, social integration, and overall quality of life. Restoring physical and psychological independence through effective rehabilitation significantly reduces the risk of secondary conditions, such as cardiovascular problems caused by a sedentary lifestyle.

By implementing these innovations, the Center can lower the cost of high-quality prosthetics, making them more accessible to a broader population, especially in resource-limited settings. The integration of advanced technologies will lead to substantial improvements in the design and functionality of prosthetics, enabling patients to participate in a wider range of activities, from basic tasks to complex movements. This will set a global precedent for the accessibility and economic efficiency of prosthetics.

The Center aims to achieve measurable improvements in patient health outcomes, service quality, and healthcare efficiency, contributing to broader health goals, such as ensuring equal access to essential rehabilitation services.

The research and practical applications of the Center can not only enhance rehabilitation outcomes at the local level but also influence the development of international policy, setting a global standard for prosthetic and social rehabilitation with an educational component. By collaborating with international organizations, government agencies, and private partners, the Center can impact healthcare delivery models worldwide, ensuring the best possible treatment for individuals with amputations.

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*This work was supported by a grant from the National Research Foundation of Ukraine No. 149/0073, "Development of the Concept of a Polyfunctional Prosthetic and Rehabilitation Center with an Innovative Educational Component for Patients with Limb Amputations," as part of the scientific research and development program for 2025, and KOLO Charitable Foundation.*

**CONFLICT OF INTEREST**
The Authors declare no conflict of interest

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A – Work concept and design, B – Data collection and analysis, C – Responsibility for statistical analysis, D – Writing the article, E – Critical review, F – Final approval of the article

**RECEIVED:** 15.01.2025
**ACCEPTED:** 29.05.2025