VIA MEDICA

EXPERTS' VIEWPOINT

Cardiology Journal
2023, Vol. 30, No. 1, 12–23
DOI: 10.5603/CJ.a2022.0104

ISSN 1897–5593
eISSN 1898–018X

Actual status and future directions of cardiac telerehabilitation

Krzysztof Milewski[1, 2], Paweł Balsam[3], Mateusz Kachel[2], Bronisław Sitek[4], Aleksandra Kolarczyk-Haczyk[2], Szymon Skoczyński[5], Piotr Hirnle[2], Monika Gawałko[3], Łukasz Kołtowski[3], Renata Główczyńska[3], Tomasz Zając[6], Andrzej Małecki[6], Agata Nowak[6], Paweł Kaźmierczak[2], Ewa Piotrowicz[7], Ryszard Piotrowicz[8, 9], Miłosz Jaguszewski[10], Grzegorz Opolski[3], Marcin Grabowski[3]

[1]Academy of Silesia, Faculty of Medicine, Katowice, Poland
[2]American Heart of Poland SA, Katowice, Poland
[3]1st Department of Cardiology, Medical University of Warsaw, Poland
[4]SWPS University of Social Sciences and Humanities, Warsaw, Poland
[5]Department of Pneumonology, Faculty of Medical Sciences in Katowice, Medical University of Silesia, Katowice, Poland
[6]The Jerzy Kukuczka Academy of Physical Education in Katowice, Poland
[7]Telecardiology Center, National Institute of Cardiology, Warsaw, Poland
[8]Department of Cardiac Rehabilitation and Noninvasive Electrocardiology, National Institute of Cardiology, Warsaw, Poland
[9]College of Rehabilitation, National Institute of Cardiology, Warsaw, Poland
[10]Department of Cardiology, Medical University of Gdansk, Poland

Abstract

Telerehabilitation (TR) was developed to achieve the same results as would be achieved by the standard rehabilitation process and to overcome potential geographical barriers and staff deficiencies. This is especially relevant in periodic crisis situations, including the recent COVID-19 pandemic. Proper execution of TR strategy requires both well-educated staff and dedicated equipment. Various studies have shown that TR may have similar effects to traditional rehabilitation in terms of clinical outcomes and may also reduce total healthcare costs per participant, including rehospitalization costs. However, as with any method, TR has its advantages and disadvantages, including a lack of direct contact or prerequisite, rudimentary ability of the patients to handle mobile devices, among other competencies. Herein, is a discussion of the current status of TR, focusing primarily on cardiac TR, describing some technical/organizational and legal aspects, highlighting the indications, examining cost-effectiveness, as well as outlining possible future directions. (Cardiol J 2023; 30, 1: 12–23)

Key words: cardiac telerehabilitation, cardiology, aftercare, COVID-19, quality of life, health care costs

Address for correspondence: Krzysztof Milewski, MD, PhD, University of Technology, Faculty of Medicine, Katowice, Poland; Center For Cardiovascular Research and Development of American Heart of Poland, ul. Armii Krajowej 101, 43–316 Bielsko-Biała, Poland, tel: +48 609 109 131, fax: +48 32 251 02 11, e-mail: kpmilewski@gmail.com

Received: 13.04.2021 Accepted: 22.05.2022 Early publication date: 7.11.2022

Introduction

Cardiovascular diseases remain the most common cause of death in European countries, being responsible for 39 and 47% of all deaths in males and females [1].

Cardiac rehabilitation is regarded as an effective secondary prevention tool to reduce mortality, risk of recurrent cardiovascular events and to improve the quality of life. Unfortunately, staff deficiency and resource limitation across the healthcare industry contribute to the insufficient delivery of rehabilitation services. These limitations may be especially relevant in periodic crises, recently the coronavirus disease 2019 (COVID-19) pandemic. For these reasons, due to the dynamic progress in telecommunication infrastructure and telerehabilitation (TR) being developed to achieve comparable results to those obtained with the traditional rehabilitation processes.

Telerehabilitation, a branch of telehealth, is the clinical application of consultative, preventative, diagnostic, and therapeutic services via a two-way interactive telecommunication technology [2]. It helps all patients to remain in contact with physicians and adhere to their aftercare plans, thus reducing hospital readmissions. Furthermore, TR provides equitable access to geographically remote individuals and those who are physically and economically disadvantaged, thus improving the quality of rehabilitative health care. Similar to traditional rehabilitation, TR consists of patient assessment, clarification of goals, patient-tailored therapies, including exercises and an interdisciplinary collaboration between various health professionals.

Currently, TR is mainly used in cardiology, pulmonology, orthopedics, neurology, audiology, speech-language pathology, occupational and physical therapy. Various studies have shown that TR can have similar effects as traditional rehabilitation [3–6] and may reduce total healthcare costs per participant, including readmission costs [7].

This document describes the current status of cardiac TR (CTR), one of the fastest-growing branches of TR, focusing on some organizational and legal aspects, and outlining future directions.

Traditional cardiac rehabilitation

The history of cardiac rehabilitation dates back to 1772. An English physician, William Heberden, reported the case of a patient suffering from angina pectoris "who set himself the task of sawing wood every day and was nearly cured" [8]. Despite this initial observation, for centuries patients with acute coronary events were advised to limit mobility for 6 weeks to bed rest, until 1940 when more liberal forms of rehabilitation were allowed, e.g., chair therapy [9]. Gradually, it was recognized that mobility restriction increases the risk of mortality and early ambulation should be introduced [10, 11]. In 1993 The World Health Organization defined cardiac rehabilitation as, "The sum of activities required to influence favorably the underlying cause of the disease, as well as to provide the best possible physical, mental and social conditions, so that the patients may, by their own efforts, preserve or resume when lost as normal a place as possible in the community." [12]. Nowadays, prompt introduction of rehabilitation after an intervention is recommended to ensure quick and reliable convalescence. Although becoming increasingly available, the number of patients engaged remains unsatisfactory. In the developed countries merely 20–50% of patients participate in cardiac rehabilitation [13–17]. Moreover, those who complete the center-based rehabilitation (CBR) period are not further supervised, being left on their own. Such a model does not promote long-lasting effects and makes new behavioral habits difficult to maintain. Studies highlight the need for proper secondary prevention of cardiovascular diseases. The mortality rate at 1 year after myocardial infarction (MI) remains high, reaching 10% despite available state-of-the-art methods of immediate vascular interventions and modern drugs that decrease risk [18]. What is more, as reported by Jernberg et al. [19], about half of the patients that suffer from a major acute coronary event have a history of an acute myocardial infarction (AMI). The situation is similar in Poland, as stated in the nation-wide AMI-PL database encompassing patients hospitalized due to acute coronary syndrome. According to the obtained data, in-hospital mortality amounts to 10%, with an additional 10% of patients dying within the following 12 months and more than 1 in 4 patients discharged after hospitalization for AMI, who die within 5 years [20, 21]. Almost 40% of patients were re-hospitalized at least once during the first year due to cardiovascular causes. These unsatisfactory outcomes are attributed to the insufficient access to secondary cardiac prevention and cardiac rehabilitation which means improper lifestyle, low adherence to prescribed pharmacotherapy, limited access to specialized care and a lack of control of cardiovascular disease risk factors [22].

Telerehabilitation was designed to address the needs for improved secondary prevention and to

overcome previously mentioned limitations and act as an auxiliary therapy to the conventional approach. However, with time (and after generating sufficient clinical data) TR was recognized as an alternative standalone technique.

Telerehabilitation

Telerehabilitation provides continuous remote monitoring of a patient's vital signs with unrestricted access to feedback in patient-doctor relations. Due to this, the implementation of different activity modules is relatively easy and both the time and exercise burden can be individualized and perfectly adjusted to provide optimal rehabilitation. Clinical data shows that TR is equivalent to standard rehabilitation with additional beneficiary effects on patient adherence, motivation and promotion of permanent behavioral changes [23–26]. Professional care via telemonitoring can be delivered to almost everyone with no need to worry about geographical barriers — effectively discouraging people from participating in standard rehabilitation. With dedicated software the patients can track their progress and compete with others which can lead to increased motivation to maintain the effort. Furthermore, when required, an on-demand contact can be established from both sides which helps in distinguishing and evaluating even hardly noticeable alerting symptoms, thus preventing potential exacerbation and delivering tailor-made care. Such an approach results in a lower unnecessary hospitalization rate and fewer concerns about patients boosting their quality of life.

Indications

Clinical indications for TR are the same as for standard forms of rehabilitation. However, a prerequisite to qualify for TR is the patient's consent to this form of rehabilitation and the ability to independently implement TR, including remote cooperation with the physicians' team. Other determining factors are a stable clinical status sustained for at least a week in low- and medium-risk patients and at least 3 weeks in high-risk patients [3].

Cardiac telerehabilitation — organizational and technical requirements

Among several CTR models described in literature [27–33], only the hybrid variant was included in the recommendations of the European Society of Cardiology [34]. This model is composed of two stages. The first period is organized in a hospital or outpatient setting and usually lasts between 5 to 14 days. It allows for assessing the patients' clinical condition, pharmacotherapy, physical capacity (medical examination, laboratory tests, electrocardiogram [ECG], transthoracic echocardiography and exercise tests) and developing individual physical training and psychological care programs. During this stage, patients are taught how to exercise properly and operate telemonitoring equipment. They are also educated about sustaining a healthy lifestyle and about the prevention of cardiovascular diseases.

The second period can be performed at any location within mobile network coverage and usually lasts 8–12 weeks. It includes remote-controlled, interactive home CTR training and a final visit comprising an evaluation of clinical condition, the effectiveness of rehabilitation and the provision of further recommendations [33].

The proper execution of a CTR strategy requires well-educated staff as well as dedicated equipment and software. An example of a properly configured CTR system is provided below.

To coordinate all elements, a reliable computer software called a digital integration platform is used. It enables contact with the patient, implementation of procedures, progress monitoring and remote supervision over various electronic devices. The platform also ensures data protection, analysis and archiving from peripheral devices. Members of the team participating in hybrid CTR should have appropriate knowledge in the field of cardiology, cardiac rehabilitation and telemedicine technologies. The team consists of a medical doctor (cardiologist, internist or rehabilitation specialist), a physiotherapist, an ECG technician or a nurse, and a psychologist. Beyond monitoring the training and physical factors, each person in the team is required to educate the patient and provide psychological support.

The monitored patient should be equipped with a set of devices for physical training at home. The system guarantees verbal contact and control of programmed training by sound or light signals understandable to the patient (beginning and ending of the exercise phase and the start and end of the rest phase, lack of adequate pulse acceleration or exceeding training heart rate). Additionally, it ensures ECG registration at the training admission phase, warm-up, start of training, end of training, rest phase, and on-demand (patient or staff demand). On-demand recording should include a period of up to 30 s before and at least 60 s after

device activation. ECG monitoring should include at least two registration channels and be able to recognize ECG changes like tachyarrhythmia, bradyarrhythmia and asystole. Monitoring of saturation, number of breaths, body temperature and motor detection devices improve safety and are also recommended if possible. In patients with heart failure weight measurement is also required. Only the monitoring staff may introduce and execute any training and registration parameter modifications (preferably remotely).

Cardiac telerehabilitation is also crucial for high-risk cardiac patients. The beneficiary character of rehabilitation in the group of heart failure or heart transplant patients has been well documented [35–37]. When introduced to CTR training, such patients' physical capacity should be assessed with an ergospirometric test. Moreover, given their severe condition, they should not be left alone while training in case first aid is required. An important element to ensure the safety of hybrid CTR is to define a special algorithm for dealing with endangering situations and to implement it during the first stage of rehabilitation at the hospital [3].

Potential advantages and disadvantages of cardiac telerehabilitation

The fundamental advantages of CTR are as follows:

— Increased accessibility to supervised rehabilitation;
— Elimination of geographical barriers (travel distance, traffic, weather conditions, etc.);
— Relief for an overloaded medical system, as some rehabilitation programs can be executed automatically or at least semi-automatically;
— Possibility of delivering continuous rehabilitation programs during pandemics (during quarantine, isolation and social distancing);
— Interactive and gamification elements that can create training motivation;
— In-house rehabilitation, which increases the chance for long-term and more frequent exercise sessions;
— Cost reduction compared to traditional rehabilitation, especially over a long-term period.

In terms of potential disadvantages, there are a few potential limitations of CTR, including the skepticism of some of the patients related to the lack of face-to-face interaction with medical personnel [38]. Another group that can obtain only limited benefits from CTR is elderly patients — especially those with dementia or other cognitive impairment. Regardless of age, not every patient may be able to use mobile devices or connect the electrodes properly. An absolute necessity is a stable internet connection and mobile network coverage, while some patient training locations can suffer from weak telecommunication signal and limited access. During CTR the lack of direct contact with the patient makes it impossible to obtain full information e.g., physical examination, resulting in limited possibilities of therapeutic interventions. Moreover, some general concerns in selected countries include insufficient public financing, training systems, or lack of a demand map for TR [38].

Current state of knowledge — clinical trials in cardiac telerehabilitation

The efficacy of TR in cardiac patients has been studied in numerous clinical trials. The available results of randomized clinical trials show that CTR is non-inferior to the standard CBR and can even surpass it in some respects (Table 1) [31, 39–47]. It was confirmed in numerous meta-analyzes. Frederix et al. (37 trials), Huang et al. (9 trials), Hwang et al. (11 trials), Rawstorm et al. (11 trials), Wu et al. (6 trials) and Ramachandran et al. (14 trials) reported that TR is equally effective in comparison to CBR, with some of the studies showing the superiority of TR in terms of the frequency of adverse events, readmission rate, physical activity levels, adherence to physical activity guidelines and both low density lipoprotein-cholesterol and diastolic blood pressure levels (Table 2) [23–26, 48, 49]. CTR can work as a standalone technique when a proper CBR cannot be delivered or as an auxiliary technique to strengthen the results and aim for a long-lasting effect. Nevertheless, the number of large population trials is insufficient and further properly powered studies are required. The 2021 European Society of Cardiology guidelines of cardiovascular disease prevention highlight the need of addressing major gaps in evidence. The experts say that "The effect and the optimal delivery of exercise-based cardiac rehabilitation in women, older/frail patients, patients with cardiac implantable electronic devices, after heart transplantation or valve replacement, and in patients with atrial fibrillation, stroke, heart failure with preserved ejection fraction, lower extremity arterial disease, or multiple comorbidities" requires further studies and prompt for large randomized clinical trials investigating long-term effects of home-based TR and mobile health [50].

Table 1. Telerehabilitation — randomized clinical trials.

Author/Year/N	Groups	Aim	Conclusion
CAD			
Avila et al., 2019 N = 90	G1 = home TR = 30 G2 = center CR = 30 G3 = control = 30	Comparison of long-term effects of short TR to a prolonged center CR (exercise capacity — VO_2 peak, physical activity behavior, cardiovascular risk and QoL)	Home TR, usual care or prolonged center CR have similar value for maintaining exercise capacity, physical activity strength and QoL
Maddison et al., 2019 N = 162	G1 = center CR = 80 G2 = TR = 82	Comparison of the exercise capacity — VO_2max difference at 12 weeks. Assessment of the laboratory parameters, BP, physical activity, motivation, adherence, QoL	Exercise capacity was comparable in both groups. TR participants were less sedentary. Center CR patients had smaller waist and hip circumference
Vieira et al., 2017 N = 33	G1 = home CR with virtual reality (kinect) = 11 G2 = home CR + booklet = 11 G3 = usual care = 11	Assessment of the effect of a home-based CR specific exercise program for 6 months, changes in executive function, QoL and depression, anxiety, stress	G1 showed better performance in executive function. No significant differences were found in the quality of life, depression, anxiety and stress
Brouwers et al., 2017 N=300	G1 = center CR =150 G2 = home TR = 150	Comparison of cardiac TR with conventional CR in behavior change and physical activity level	TR is better in behavior change strategies results and results in better long-term physical activity levels as compared to conventional
HF			
Piotrowicz et al., 2019 N = 850	G1 = HR = 425 G2 = usual care = 425	Assessment of percent of days alive and out of the hospital calculated as ratio. Comparison of mortality and hospitalizations	Outcomes of both groups were comparable. HR did not lead to the increase in percentage of days alive and out of the hospital, did not reduce mortality and hospitalizations
Spindler et al., 2019 N = 136	G1 = conventional CR = 67 G2 = TR = 69	Assessment of motivation for lifestyle changes and self-care psychological distress, and QoL at 0, 3, 6, and 12 months	There were no differences between groups in all presented terms
Bernocchi et al., 2017 N = 112	G1 = TR = 56 G2 = control = 56	Assessment of the feasibility and efficacy of an integrated home-based TR program in patients with COPD and HF	G1 increased the walked distance, while the G2 showed no significant improvement. Medical Research Council dyspnea scale and Barthel index improved in G1
Piotrowicz et al., 2016 N = 111	G1 = control = 77 G2 = home TR = 34	Assessment of the influence on depression (Beck score) and physical capacity improvement (VO_2 peak)	TR resulted in reversion of depression and improvement in physical capacity
Piotrowicz et al., 2015 N = 111	G1 = home TR = 77 G2 = control = 34	Assessment of the safety, effectiveness, adherence to and acceptance of home-based telemonitored nordic walking training in HF patients, including those with CIEDs (i.e., CRT, ICD)	In HF patients, including those with CIED, home-based telemonitored nordic walking training is safe and effective. TR was well accepted by patients and adherence was high and promising
Piotrowicz et al., 2010 N = 152	G1 = home TR = 77 G2 = standard CR = 75	Assessment of the new model of home-based telemonitored CR using walking training compared with an outpatient-based standard CR using interval training on a cycle ergometer	In patients with HF, TR is equally as effective as standard CR and provides a similar improvement in QoL. Adherence to TR was better than to standard CR

AMI — acute myocardial infarction; BP — blood pressure; CAD — coronary artery disease; CIED — cardiac implantable electronic device; COPD — chronic obstructive pulmonary disease; CR — cardiac rehabilitation; CRT — cardiac resynchronization therapy; G — group; HF — heart failure; HR — hybrid rehabilitation; ICD — implantable cardioverter-defibrillator; QoL — qualify of life; TR — telerehabilitation; VO_2 — oxygen uptake

Table 2. Comparison between telerehabilitation and center-based cardiac rehabilitation programs (based on systematic reviews and meta-analyzes).

Author	Year	Type of study	Number of trials/patients	Primary endpoint	Additional observations
Frederix et al.	2015	Systematic review	37 trials	Impact on adverse events and RR: Favors TR (1.30 [1.13–1.50])	Adherence to physical activity: Favors TR (0.56 [0.45–0.69])
Huang et al.	2015	Systematic review	9 trials/1546 patients	No statistical difference in all-cause mortality	Comparable in exercise capacity, lipid profile, QoL, BP
Hwang et al.	2015	Systematic review	11 trials	No difference in exercise capacity expressed as 6MWD and VO_2 peak	Higher adherence rates of TR compared to CBR, no difference in QoL
Rawstorn et al.	2016	Systematic review	11 trials/1189 patients	Physical activity level and exercise adherence: Both favors TR (0.42 [0.21–0.64])	TR and CBR were comparably effective for improving maximal aerobic exercise capacity and other modifiable cardiovascular risk factors
Wu et al.	2018	Meta-analysis	6 trials/1195 patients	Similar improvement in functional capacity in hybrid and standard CR programs (SMD = –0.04, 95% CI –0.18 to 0.09, p = 0.51)	No significant difference in exercise duration, systolic and diastolic BP, health-related QoL
Ramachandran et al.	2021	Systematic review	14 trials/2869 patients	Functional capacity: no statistically significant difference in 6MWT between the HBCTR vs. CBCR group	Equivalent effects physical activity behavior, smoking, physiological risk factors, QoL, depression, and cardiac-related hospitalization

Statistical results presented as: odd ratio (OR) [95% coincidence interval (CI)]; BP — blood pressure; CBR — center based rehabilitation; RR — rehospitalization rate; QoL — quality of life; TR — telerehabilitation; 6MWD — 6-minute walk distance; VO2 — oxygen uptake; CBCR — center-based cardiac rehabilitation; HBCTR — home-based cardiac telerehabilitation; SMD — standardised mean difference

Cost-effectiveness and funding of cardiac telerehabilitation

According to the study by Moghei et al. [51], 111 (54.7%) out of 203 countries in the world offer cardiac rehabilitation. In some regions public funding for CTR is available (most often in high-income countries), however in 60.2% of countries patients are required to cover some or all of the costs. The results of a systematic review of economic research on cardiac rehabilitation indicate a high cost-effectiveness of implementing these programs [52]. However, the provision of secondary prevention to cardiac patients remains limited due to restrictions in healthcare budgets.

Frederix et al. [53] indicated higher cost-effectiveness of cardiac rehabilitation programs with telemedicine follow-up in comparison to programs consisting of cardiac rehabilitation implemented only in a rehabilitation center. The savings mainly concerned the costs associated with rehospitalizations. Another study, which compared TR as an alternative to rehabilitation implemented in a cardiac rehabilitation center, indicated a higher cost-effectiveness of TR programs and lower costs of rehospitalization [54]. Moreover, the Quality-Adjusted Life Years (QALY) values determined in both studies did not differ significantly between the compared groups. Both analyzes were conducted over an annual time horizon [53, 54].

The size of the patient population covered by TR care has a significant impact on the cost-effectiveness of rehabilitation. The larger the population of patients undergoing rehabilitation, the higher the financial benefits are. The choice of the type of rehabilitation will significantly affect the type of costs incurred and savings obtained. For example, TR reduces the fixed costs incurred for stationary care (infrastructure, personnel costs), but may additionally generate costs associated with other medical services, for instance visits to health centers or the necessity of providing emergency medical assistance [55].

Several following studies seem to strengthen the view that home-based cardiac rehabilitation is at least as effective and at the same time more cost-efficient than CBR.

Kraal et al. [56] reported that healthcare costs were non-significantly lower in a home-based rehabilitation (vs. CBR) (€ 437 per patient, 95% confidence interval [CI]: 562–1436; p = 0.39). Maddison et al. [57] randomized patients to receive 12 weeks of TR or CBR. Per capita program delivery and medication costs were lower for the home-

-based rehabilitation (vs. CBR). Another analysis found a trend toward fewer cardiovascular events among the patients in a home-based rehabilitation (vs. CBR) ($p = 0.053$), resulting in gross cost savings of US$ 1,418 per patient [58]. Hwang et al. [7] performed a comparison of home-based TR and traditional CBR in patients with chronic heart failure. According to their findings, the total health care costs per participant were significantly lower in the TR (vs. CBR) (–US$ 1,590; 95% CI: –2.822–359) during 6 months of observation; no significant differences in QALY were observed. Another study by Whittaker et al. [59] indicated lower costs of TR programs as compared to rehabilitation carried out in a cardiac center, at the same time with no difference in the generated health effects. Frederix et al. [60] reported in 2016 that a physical activity telemonitoring program has the potential to be a cost-effective alternative to conventional cardiac rehabilitation, which is consistent with their previous findings. Between-group analysis of aerobic capacity confirmed a significant difference between the intervention group and control group in favor of the intervention group ($p < 0.001$). An incremental cost-effectiveness ratio of -€ 21,707/ /QALY was calculated [60]. The study showed that an additional 6-month patient-specific, comprehensive TR program is both more efficient and cost-effective than classical cardiac rehabilitation alone.

A further study by Frederix et al. [61] — Telerehab III — assessed the long-term persistence of health benefits derived from a supplemental CTR program. Telerehab III long-term follow-up study demonstrated that a 6-month cardiac TR program, carried out in addition to CBR, induces a better exercise capacity and improved adherence to healthy lifestyle behaviors. It also has a positive impact on the quality of life, while remaining cost-effective in the long term, when compared to standalone CBR [61].

A slightly different view regarding the efficiency and cost-effectiveness of TR was presented in a scientific statement from the American Association of Cardiovascular and Pulmonary Rehabilitation, the American Heart Association, and the American College of Cardiology in 2019. The statement shows that the costs to deliver CBR appear to be similar to those related to home-based cardiac rehabilitation. The costs were analyzed based on several studies and the results were as follows [62]:

— Two studies showed no significant difference in costs, if patient travel costs were included;
— One study reported fewer medical visits and hospitalizations with home-based cardiac rehabilitation while 2 studies showed no significant difference in this regard;
— QALYs reported in 2 studies also found no significant difference;
— One study suggested the possibility of lower costs in the case of home-based cardiac rehabilitation.

A review done by Farabi et al. [63] presented less enthusiastic results. The study included 20 articles which used QALY to measure the outcomes of CTR in high-income countries. The study showed that although the increase in QALY due to CTR did not differ from standard care, patient participation and retention was significantly higher. According to the researchers, telemedicine was not cost-effective, predominantly due to the high cost of implementation. Nevertheless, it seems that in the case of a longer follow-up period there could be an increase of cost-effectiveness.

To summarize the above findings, according to recent studies cardiac TR is at least as efficient as standard rehabilitation, while retaining a comparable or higher cost-effectiveness.

The legal basis of cardiac telerehabilitation in selected countries

In Poland, the Ministry of Health, through the regulation of 16th October 2016 amended the regulation of 6th November 2013 on guaranteed services in therapeutic rehabilitation (Journal of Laws of the Republic of Poland, 2016.2162). An important change introduced in this amendment was, from 2017, to cover hybrid cardiac TR with reimbursement from the Polish National Health Fund under the contract for funds from cardiac rehabilitation and reimbursement under the Managed Care after AMI (KOS-MI) program (§ 4 point 3a and b). In the list attached to this regulation and the conditions for the implementation of guaranteed services in the field of therapeutic rehabilitation, the entity providing the medical service 'hybrid cardiac telerehabilitation' may, as part of guaranteed services.

The regulation defines two phases of the implementation of hybrid cardiac rehabilitation, which can be financed from the National Health Fund. The first stage consists of short stationary rehabilitation in the hospital, while the second stage comprises typical hybrid cardiac rehabilitation, which allows remote monitoring of a patient with cardiological diseases The regulation also sets out the rules for the qualification of patients for this type of rehabilitation, the actions which can be reimbursed from

public funds, and the duration of such rehabilitation in its individual stages, depending on the type of disease. Formal requirements that must be met for the patient to benefit from this type of service are also specified. The solutions adopted in the regulation of the Ministry of Health were further specified in 2013 as part of a report of a team of experts, adopted by the Polish Cardiac Society "Optimal Model for Comprehensive Rehabilitation and Secondary Prevention". This Polish normative model belongs to hard law solutions, it means that there are absolutely binding legal norms. It is supported by soft law regulations created, among others by the Polish Cardiac Society or the National Health Fund.

In Germany (the fastest growing market in Europe in the area of TR), CTR as a separate medical service has not been included in any legal act regarding social security or public health services financing. The organization of hybrid CTR is therefore the responsibility of every hospital. The first part of TR is therefore financed as part of the cost of the hospitalization, while the second part is financed just like any other rehabilitation treatment. The patient may therefore benefit from such rehabilitation for up to 3 weeks, once every 4 years. Insured patients over 18 years of age are required to pay up to 15% of the cost of rehabilitation [64]. The hybrid therapy also found its place in the guidelines issued by the Association of the Scientific Medical Societies in Germany, in January 2020. This document describes only the second phase of this rehabilitation model, which takes place outside the hospital. It indicates however the need to develop the third phase of CTR for people with permanent cardiac ailments. This phase is directed not for patients who have undergone an acute cardiovascular event requiring hospitalization (i.e., cardiac surgery, acute coronary event), but for people who need rehabilitation for a longer period of time due to persisting disease [65]. This issue is also raised in other regions of the world, for example in Brazil, while pointing to the effectiveness of CTR [66].

Ongoing cardiac telerehabilitation programs in Poland

In 2017, the KOS-MI program was introduced to achieve complete revascularization, proper electrotherapy, adequate cardiac rehabilitation, and easier access to cardiologists for patients after MI. The KOS-MI program includes four modules: hospitalization with complete revascularization and coordinating visit (module I), post discharge cardiac rehabilitation starting approximately 2 weeks after the discharge (module II), electrotherapy in eligible patients — control of ejection fraction 6–9 weeks after MI (module III) and systematic outpatient meetings with a cardiologist throughout the first year (module IV) [67].

A prospective, multicenter study performed in 5 cardiology centers in Poland dedicated for up to 1000 patients with coronary artery disease undergoing coronary revascularization (the RESTORE research project) was introduced in March 2016 [68]. The aim of the project is to determine an optimal cardiac rehabilitation strategy using novel medical technologies and, through effective patient monitoring, to decrease annual mortality and risk of cardiovascular events in coronary artery disease patients at 9 and 12-month follow-up. An intensive dietary and educational program focused on lifestyle and risk factor modification is also implemented. Additionally, intravascular imaging with atherosclerotic plaque and intraarterial lipid characterization and the molecular aspect of optimal cardiac rehabilitation are analyzed to assess the impact of rehabilitation on atherosclerosis progression.

Telerehabilitation in elderly population

One of the key factors driving the TR market globally is a growing elderly population. According to the World Bank Group, the global population aged 65 or older grew in the last decade from 502.23 million in 2008 to 673.62 million in 2018. The geriatric population and the population aged above 65 years of age in the United States, Canada, Europe and Central Asia underwent significant growth over the last 10 years, increasing by 36.2% and 17.1%, respectively, between 2008 and 2018 [69]. The elderly population is susceptible to several chronic diseases such as heart failure, cancer, chronic obstructive pulmonary disease and Parkinson's disease, which require rehabilitation solutions to improve the quality of treatment. Thus, an increasing incidence of chronic diseases among the elderly population generates the need for improved levels of medical assistance. This has led to the advent of new mobile applications and systems implementing TR, thereby creating growth opportunities for the global TR systems market. Nowadays, TR can work as an adjunct therapy and has been regarded as beneficial in a handful of common medical conditions found in the elderly namely diabetes, frailty, chronic pain, wounds, cancer, incontinence, and dementia [70]. Studies have shown that TR can help enhance glycemic control, improve balance, gait speed, and quality of life in a frail elderly popula-

tion, shorten the wound healing time and even help with combating various cancers [71–75]. Current TR technologies constitute a significant treatment approach that can provide multidisciplinary care even in such complex populations.

Telerehabilitation market growth

Global TR systems market was estimated at US$ 179.1 million in 2019 and is expected to increase to US$ 485.6 million by 2027 [76].

The cardio-pulmonary segment share of the global TR market currently amounts to 2.6% (US$ 5.3 million) and is expected to be around 1.7% in 2027, while the value of the market in 2027 will be US$ 8.1 million.

Currently, North America has been ranked as the largest market for TR (42.9% of market share) and is estimated to be valued at US$ 70.2 million in 2019. This value is projected to increase to US$ 208.1 million by 2027, mainly due to the presence of major players, well developed healthcare infrastructure and various policies supporting TR. The cardio-pulmonary market is expected to grow in the United States within the next 7 years by almost twice.

In Europe, the TR systems market was estimated at US$ 56.0 million in 2019 and is projected to increase to US$ 149.3 million by 2027. Germany is expected to be the fastest growing market in Europe during the forecast period and is expected to witness significant growth in the near future. Europe is expected to exhibit growth, owing to an increasing number of approvals from the European Union for virtual reality rehabilitation devices. The value of the cardio-pulmonary market in Europe will increase from US$ 1.6 to 2.5 million.

The TR market is expected to grow exponentially, but it is highly dependent on the rapid development and wide adoption of novel and innovative hardware and software systems for TR. This includes advanced technologies such as wearable sensors, fast network and Bluetooth devices, industrial Internet of Things, augmented reality, virtual reality, artificial intelligence, and big data analytics. In addition, the adoption of these technologies may further boost the market if they prove to be cost-effective.

Another important factor that may potentially stimulate the development of the TR market is the expected increased risk for infectious diseases that will affect society globally and will necessitate social distancing.

The risks to TR market development include a lack of awareness regarding novel technologies and advanced therapies among patients and healthcare providers, as well as a lack of skilled professionals.

Summary

Cardiac telerehabilitation was designed to overcome the limitations of standard rehabilitation services but has been quickly recognized as an alternative standalone technique. Clinical data shows that CTR is equivalent to the standard rehabilitation, with additional beneficiary effects, while retaining comparable or higher cost-effectiveness. This technology has a great potential to relieve the burden on public healthcare, however as underlined in the 2021 European Society of Cardiology guidelines, there are still major gaps in evidence and all risks and opportunities must be identified and adequately addressed.

Conflict of interest: None declared

References

1. Timmis A, Townsend N, Gale CP, et al. European Society of Cardiology. European Society of Cardiology: Cardiovascular Disease Statistics 2019. Eur Heart J. 2020; 41: 12–85, doi: 10.1093/eurheartj/ehz859, indexed in Pubmed: 31820000.
2. Rosen M. Telerehabilitation. NeuroRehabilitation. 1999; 12(1): 11–26, doi: 10.3233/nre-1999-12103.
3. Piotrowicz R, Krzesiński P, Balsam P, et al. [Cardiology telemedicine solutions — opinion of the experts of the Committee of Informatics and Telemedicine of Polish Society of Cardiology, Section of Non-invasive Electrocardiology and Telemedicine of Polish Society of Cardiology and Clinical Sciences C]. Kardiol Pol. 2018; 76(3): 698–707, doi: 10.5603/KP.a2018.0058, indexed in Pubmed: 29441511.
4. Galea MD. Telemedicine in Rehabilitation. Phys Med Rehabil Clin N Am. 2019; 30(2): 473–483, doi: 10.1016/j.pmr.2018.12.002, indexed in Pubmed: 30954160.
5. Hung Kn G, Fong KN. Effects of telerehabilitation in occupational therapy practice: A systematic review. Hong Kong J Occup Ther. 2019; 32(1): 3–21, doi: 10.1177/1569186119849119, indexed in Pubmed: 31217758.
6. Zhou L, Parmanto B. Reaching people with disabilities in underserved areas through digital interventions: systematic review. J Med Internet Res. 2019; 21(10): e12981, doi: 10.2196/12981, indexed in Pubmed: 31654569.
7. Hwang R, Morris NR, Mandrusiak A, et al. Cost-Utility analysis of home-based telerehabilitation compared with centre-based rehabilitation in patients with heart failure. Heart Lung Circ. 2019; 28(12): 1795–1803, doi: 10.1016/j.hlc.2018.11.010, indexed in Pubmed: 30528811.
8. Heberden W. Commentaries on the history and cure of diseases. T Payne, London 1802.

9. Levine SA, Lown B. The "chair" treatment of acute thrombosis. Trans Assoc Am Physicians. 1951; 64: 316–327, indexed in Pubmed: 14884265.
10. Kavanagh T. Exercise in cardiac rehabilitation. Br J Sports Med. 2000; 34(1): 3, doi: 10.1136/bjsm.34.1.3, indexed in Pubmed: 10690440.
11. Mampuya WM. Cardiac rehabilitation past, present and future: an overview. Cardiovasc Diagn Ther. 2012; 2(1): 38–49, doi: 10.3978/j.issn.2223-3652.2012.01.02, indexed in Pubmed: 24282695.
12. World Health Organization. Needs and Action Priorities in Cardiac Rehabilitation and Secondary Prevention in Patients with Coronary Heart Disease. WHO Regional Office for Europe; Geneva 1993.
13. NACR. The national audit of cardiac rehabilitation annual statistical report 2015. British Heart Foundation; London 2015.
14. Menezes AR, Lavie CJ, DeSchutter A, et al. Cardiac rehabilitation in the United States. Prog Cardiovasc Dis. 2014; 56(5): 522–529, doi: 10.1016/j.pcad.2013.09.018, indexed in Pubmed: 24607017.
15. Jelinek MV, Thompson DR, Ski C, et al. 40 years of cardiac rehabilitation and secondary prevention in post-cardiac ischaemic patients. Are we still in the wilderness? Int J Cardiol. 2015; 179: 153–159, doi: 10.1016/j.ijcard.2014.10.154, indexed in Pubmed: 25464436.
16. Forman DE, Sanderson BK, Josephson RA, et al. American College of Cardiology's Prevention of Cardiovascular Disease Section. Heart Failure as a Newly Approved Diagnosis for Cardiac Rehabilitation: Challenges and Opportunities. J Am Coll Cardiol. 2015; 65(24): 2652–2659, doi: 10.1016/j.jacc.2015.04.052, indexed in Pubmed: 26088305.
17. Altenhoener T, Leppin A, Grande G, et al. Social inequality in patients' physical and psychological state and participation in rehabilitation after myocardial infarction in Germany. Int J Rehabil Res. 2005; 28(3): 251–257, doi: 10.1097/00004356-200509000-00008, indexed in Pubmed: 16046919.
18. Pedersen F, Butrymovich V, Kelbæk H, et al. Short- and long--term cause of death in patients treated with primary PCI for STEMI. J Am Coll Cardiol. 2014; 64(20): 2101–2108, doi: 10.1016/j.jacc.2014.08.037, indexed in Pubmed: 25457398.
19. Jernberg T, Hasvold P, Henriksson M, et al. Cardiovascular risk in post-myocardial infarction patients: nationwide real world data demonstrate the importance of a long-term perspective. Eur Heart J. 2015; 36(19): 1163–1170, doi: 10.1093/eurheartj/ehu505, indexed in Pubmed: 25586123.
20. Gierlotka M, Zdrojewski T, Wojtyniak B, et al. Incidence, treatment, in-hospital mortality and one-year outcomes of acute myocardial infarction in Poland in 2009-2012--nationwide AMI-PL database. Kardiol Pol. 2015; 73(3): 142–158, doi: 10.5603/KP.a2014.0213, indexed in Pubmed: 25371307.
21. Wojtyniak B, Gierlotka M, Opolski G, et al. Observed and relative survival and 5-year outcomes of patients discharged after acute myocardial infarction: the nationwide AMI-PL database. Kardiol Pol. 2020; 78(10): 990–998, doi: 10.33963/kp.15465, indexed in Pubmed: 32631026.
22. Jankowski P, Gąsior M, Gierlotka M, et al. [Coordinated care after myocardial infarction. The statement of the Polish Cardiac Society and the Agency for Health Technology Assessment and Tariff System]. Kardiol Pol. 2016; 74(8): 800–811, doi: 10.5603/KP.2016.0118, indexed in Pubmed: 27553352.
23. Frederix I, Vanhees L, Dendale P, et al. A review of telerehabilitation for cardiac patients. J Telemed Telecare. 2015; 21(1): 45–53, doi: 10.1177/1357633X14562732, indexed in Pubmed: 25475219.
24. Rawstorn JC, Gant N, Direito A, et al. Telehealth exercise-based cardiac rehabilitation: a systematic review and meta-analysis. Heart. 2016; 102(15): 1183–1192, doi: 10.1136/heartjnl-2015-308966, indexed in Pubmed: 26936337.
25. Huang K, Liu W, He D, et al. Telehealth interventions versus center-based cardiac rehabilitation of coronary artery disease: A systematic review and meta-analysis. Eur J Prev Cardiol. 2015; 22(8): 959–971, doi: 10.1177/2047487314561168, indexed in Pubmed: 25488550.
26. Hwang R, Bruning J, Morris N, et al. A systematic review of the effects of telerehabilitation in patients with cardiopulmonary diseases. J Cardiopulm Rehabil Prev. 2015; 35(6): 380––389, doi: 10.1097/HCR.0000000000000121, indexed in Pubmed: 26034937.
27. Smart N, Haluska B, Jeffriess L, et al. Predictors of a sustained response to exercise training in patients with chronic heart failure: a telemonitoring study. Am Heart J. 2005; 150(6): 1240–1247, doi: 10.1016/j.ahj.2005.01.035, indexed in Pubmed: 16338266.
28. Kouidi E, Farmakiotis A, Kouidis N, et al. Transtelephonic electrocardiographic monitoring of an outpatient cardiac rehabilitation programme. Clin Rehabil. 2006; 20(12): 1100–1104, doi: 10.1177/0269215506071256, indexed in Pubmed: 17148522.
29. Ades PA, Pashkow FJ, Fletcher G, et al. A controlled trial of cardiac rehabilitation in the home setting using electrocardiographic and voice transtelephonic monitoring. Am Heart J. 2000; 139(3): 543–548, doi: 10.1016/s0002-8703(00)90100-5, indexed in Pubmed: 10689271.
30. Squires RW, Miller TD, Harn T, et al. Transtelephonic electrocardiographic monitoring of cardiac rehabilitation exercise sessions in coronary artery disease. Am J Cardiol. 1991; 67(11): 962–964, doi: 10.1016/0002-9149(91)90168-k, indexed in Pubmed: 2018015.
31. Piotrowicz E, Baranowski R, Bilinska M, et al. A new model of home-based telemonitored cardiac rehabilitation in patients with heart failure: effectiveness, quality of life, and adherence. Eur J Heart Fail. 2010; 12(2): 164–171, doi: 10.1093/eurjhf/hfp181, indexed in Pubmed: 20042423.
32. Piotrowicz E, Korzeniowska-Kubacka I, Chrapowicka A, et al. Feasibility of home-based cardiac telerehabilitation: Results of TeleInterMed study. Cardiol J. 2014; 21(5): 539–546, doi: 10.5603/CJ.a2014.0005, indexed in Pubmed: 24526507.
33. Piotrowicz E. How to do: telerehabilitation in heart failure patients. Cardiol J. 2012; 19(3): 243–248, doi: 10.5603/cj.2012.0045, indexed in Pubmed: 22641542.
34. Piepoli M, Hoes A, Agewall S, et al. 2016 European Guidelines on cardiovascular disease prevention in clinical practice. Eur Heart J. 2016; 37(29): 2315–2381, doi: 10.1093/eurheartj/ehw106, indexed in Pubmed: 27222591.
35. Bachmann JM, Shah AS, Duncan MS, et al. Cardiac rehabilitation and readmissions after heart transplantation. J Heart Lung Transplant. 2018; 37(4): 467–476, doi: 10.1016/j.healun.2017.05.017, indexed in Pubmed: 28619383.
36. Anderson L, Nguyen TT, Dall CH, et al. Exercise-based cardiac rehabilitation in heart transplant recipients. Cochrane Database Syst Rev. 2017; 4: CD012264, doi: 10.1002/14651858.CD012264.pub2, indexed in Pubmed: 28375548.
37. Alvarez P, Hannawi B, Guha A. Exercise and heart failure: advancing knowledge and improving care. Methodist Debakey Cardiovasc J. 2016; 12(2): 110–115, doi: 10.14797/mdcj-12-2-110, indexed in Pubmed: 27486494.

38. Peretti A, Amenta F, Tayebati SK, et al. Telerehabilitation: review of the state-of-the-art and areas of application. JMIR Rehabil Assist Technol. 2017; 4(2): e7, doi: 10.2196/rehab.7511, indexed in Pubmed: 28733271.
39. Vieira Á, Melo C, Machado J, et al. Virtual reality exercise on a home-based phase III cardiac rehabilitation program, effect on executive function, quality of life and depression, anxiety and stress: a randomized controlled trial. Disabil Rehabil Assist Technol. 2018; 13(2): 112–123, doi: 10.1080/17483107.2017.1297858, indexed in Pubmed: 28285574.
40. Avila A, Claes J, Buys R, et al. Home-based exercise with telemonitoring guidance in patients with coronary artery disease: Does it improve long-term physical fitness? Eur J Prev Cardiol. 2020; 27(4): 367–377, doi: 10.1177/2047487319892201, indexed in Pubmed: 31787026.
41. Maddison R, Rawstorn JC, Stewart RAH, et al. Effects and costs of real-time cardiac telerehabilitation: randomised controlled non-inferiority trial. Heart. 2019; 105(2): 122–129, doi: 10.1136/heartjnl-2018-313189, indexed in Pubmed: 30150328.
42. Brouwers RWM, Kraal JJ, Traa SCJ, et al. Effects of cardiac telerehabilitation in patients with coronary artery disease using a personalised patient-centred web application: protocol for the SmartCare-CAD randomised controlled trial. BMC Cardiovasc Disord. 2017; 17(1): 46, doi: 10.1186/s12872-017-0477-6, indexed in Pubmed: 28143388.
43. Piotrowicz E, Pencina MJ, Opolski G, et al. Effects of a 9-Week Hybrid Comprehensive Telerehabilitation Program on Long-term Outcomes in Patients With Heart Failure: The Telerehabilitation in Heart Failure Patients (TELEREH-HF) Randomized Clinical Trial. JAMA Cardiol. 2020; 5(3): 300–308, doi: 10.1001/jamacardio.2019.5006, indexed in Pubmed: 31734701.
44. Spindler H, Leerskov K, Joensson K, et al. Conventional rehabilitation therapy versus telerehabilitation in cardiac patients: a comparison of motivation, psychological distress, and quality of life. Int J Environ Res Public Health. 2019; 16(3), doi: 10.3390/ijerph16030512, indexed in Pubmed: 30759761.
45. Bernocchi P, Vitacca M, La Rovere MT, et al. Home-based telerehabilitation in older patients with chronic obstructive pulmonary disease and heart failure: a randomised controlled trial. Age Ageing. 2018; 47(1): 82–88, doi: 10.1093/ageing/afx146, indexed in Pubmed: 28985325.
46. Piotrowicz E, Piotrowski W, Piotrowicz R. Positive effects of the reversion of depression on the sympathovagal balance after telerehabilitation in heart failure patients. Ann Noninvasive Electrocardiol. 2016; 21(4): 358–368, doi: 10.1111/anec.12320, indexed in Pubmed: 26524699.
47. Piotrowicz E, Zieliński T, Bodalski R, et al. Home-based telemonitored Nordic walking training is well accepted, safe, effective and has high adherence among heart failure patients, including those with cardiovascular implantable electronic devices: a randomised controlled study. Eur J Prev Cardiol. 2015; 22(11): 1368–1377, doi: 10.1177/2047487314551537, indexed in Pubmed: 25261268.
48. Wu C, Li Y, Chen J. Hybrid versus traditional cardiac rehabilitation models: a systematic review and meta-analysis. Kardiol Pol. 2018; 76(12): 1717–1724, doi: 10.5603/KP.a2018.0175, indexed in Pubmed: 30251248.
49. Ramachandran HJ, Jiang Y, Tam WW, et al. Effectiveness of home-based cardiac telerehabilitation as an alternative to phase 2 cardiac rehabilitation of coronary heart disease: a systematic review and meta-analysis. Eur J Prev Cardiol. 2022; 29(7): 1017–1043, doi: 10.1093/eurjpc/zwab106, indexed in Pubmed: 34254118.
50. Visseren FLJ, Mach F, Smulders YM, et al. 2021 ESC Guidelines on cardiovascular disease prevention in clinical practice. Eur Heart J. 2021; 42(34): 3227–3337, doi: 10.1093/eurheartj/ehab484, indexed in Pubmed: 34458905.
51. Moghei M, Pesah E, Turk-Adawi K, et al. Funding sources and costs to deliver cardiac rehabilitation around the globe: Drivers and barriers. Int J Cardiol. 2019; 276: 278–286, doi: 10.1016/j.ijcard.2018.10.089, indexed in Pubmed: 30414751.
52. Wong WP, Feng J, Pwee KHo, et al. A systematic review of economic evaluations of cardiac rehabilitation. BMC Health Serv Res. 2012; 12: 243, doi: 10.1186/1472-6963-12-243, indexed in Pubmed: 22873828.
53. Frederix I, Hansen D, Coninx K, et al. Medium-Term effectiveness of a comprehensive internet-based and patient-specific telerehabilitation program with text messaging support for cardiac patients: randomized controlled trial. J Med Internet Res. 2015; 17(7): e185, doi: 10.2196/jmir.4799, indexed in Pubmed: 26206311.
54. Kidholm K, Rasmussen MK, Andreasen JJ, et al. Cost-Utility analysis of a cardiac telerehabilitation program: the teledialog project. Telemed J E Health. 2016; 22(7): 553–563, doi: 10.1089/tmj.2015.0194, indexed in Pubmed: 26713491.
55. Raport "Opieka kompleksowa po zawale mięśnia sercowego" Agencja Oceny Technologii Medycznych i Taryfikacji Wydział Taryfikacji, AOTMiT-WT-553-13/2015, 29.04.2016.
56. Kraal JJ, Van den Akker-Van Marle ME, Abu-Hanna A, et al. Clinical and cost-effectiveness of home-based cardiac rehabilitation compared to conventional, centre-based cardiac rehabilitation: Results of the FIT@Home study. Eur J Prev Cardiol. 2017; 24(12): 1260–1273, doi: 10.1177/2047487317710803, indexed in Pubmed: 28534417.
57. Maddison R, Rawstorn JC, Stewart RAH, et al. Effects and costs of real-time cardiac telerehabilitation: randomised controlled non-inferiority trial. Heart. 2019; 105(2): 122–129, doi: 10.1136/heartjnl-2018-313189, indexed in Pubmed: 30150328.
58. Southard BH, Southard DR, Nuckolls J. Clinical trial of an Internet-based case management system for secondary prevention of heart disease. J Cardiopulm Rehabil. 2003; 23(5): 341–348, doi: 10.1097/00008483-200309000-00003, indexed in Pubmed: 14512778.
59. Whittaker F, Wade V. The costs and benefits of technology-enabled, home-based cardiac rehabilitation measured in a randomised controlled trial. J Telemed Telecare. 2014; 20(7): 419–422, doi: 10.1177/1357633X14552376, indexed in Pubmed: 25400004.
60. Frederix I, Hansen D, Coninx K, et al. Effect of comprehensive cardiac telerehabilitation on one-year cardiovascular rehospitalization rate, medical costs and quality of life: A cost-effectiveness analysis. Eur J Prev Cardiol. 2016; 23(7): 674–682, doi: 10.1177/2047487315602257, indexed in Pubmed: 26289723.
61. Frederix I, Solmi F, Piepoli MF, et al. Cardiac telerehabilitation: A novel cost-efficient care delivery strategy that can induce long-term health benefits. Eur J Prev Cardiol. 2017; 24(16): 1708–1717, doi: 10.1177/2047487317732274, indexed in Pubmed: 28925749.
62. Thomas RJ, Beatty AL, Beckie TM, et al. Home-Based cardiac rehabilitation: a scientific statement from the American Association of Cardiovascular and Pulmonary Rehabilitation, the American Heart Association, and the American College of Cardiology. Circulation. 2019; 140(1): e69–e89, doi: 10.1161/CIR.0000000000000663, indexed in Pubmed: 31082266.

63. Farabi H, Rezapour A, Jahangiri R, et al. Economic evaluation of the utilization of telemedicine for patients with cardiovascular disease: a systematic review. Heart Fail Rev. 2020; 25(6): 1063–1075, doi: 10.1007/s10741-019-09864-4, indexed in Pubmed: 31760593.
64. Sommer JH. Vergleichsstudie Deutschland / Schweiz im Rehabilitationsbereich, Basel 2012: 11.
65. Schwab B. Tele-Rehabilitation, "home-based" Rehabilitation, S3-Leitlinie zur kardiologischen Rehabilitation (LL-KardReha) in deutschsprachigen Raum Europas Deutschland, Osterreich, Schweiz. Langeversion – Teil 1, Online:. https://www.awmf.org/uploads/tx_szleitlinien/133-001l_S3-Kardiologische-Rehabilitation-in-D-A-CH_2020-01_2.pdf: 268 (Accessed on 10.02.2020).
66. Vieira Á, Melo C, Machado J, et al. Virtual reality exercise on a home-based phase III cardiac rehabilitation program, effect on executive function, quality of life and depression, anxiety and stress: a randomized controlled trial. Disabil Rehabil Assist Technol. 2018; 13(2): 112–123, doi: 10.1080/17483107.2017.1297858, indexed in Pubmed: 28285574.
67. Jankowski P, Gąsior M, Gierlotka M, et al. [Coordinated care after myocardial infarction. The statement of the Polish Cardiac Society and the Agency for Health Technology Assessment and Tariff System]. Kardiol Pol. 2016; 74(8): 800–811, doi: 10.5603/KP.2016.0118, indexed in Pubmed: 27553352.
68. Milewski K, Małecki A, Orszulik-Baron D, et al. The use of modern telemedicine technologies in an innovative optimal cardiac rehabilitation program for patients after myocardial revascularization: Concept and design of RESTORE, a randomized clinical trial. Cardiol J. 2019; 26(5): 594–603, doi: 10.5603/CJ.a2018.0157, indexed in Pubmed: 30566211.
69. https://databank.worldbank.org/reports (Accessed on 10.02.2020).
70. Hayes D. Telerehabilitation for Older Adults. Topics in Geriatric Rehabilitation. 2020; 36(4): 205–211, doi: 10.1097/tgr.0000000000000282.
71. Valencia WM, Botros D, Vera-Nunez M, et al. Diabetes treatment in the elderly: incorporating geriatrics, technology, and functional medicine. Curr Diab Rep. 2018; 18(10): 95, doi: 10.1007/s11892-018-1052-y, indexed in Pubmed: 30187176.
72. Bruns ERJ, Argillander TE, Schuijt HJ, et al. Fit4SurgeryTV at-home prehabilitation for frail older patients planned for colorectal cancer surgery: a pilot study. Am J Phys Med Rehabil. 2019; 98(5): 399–406, doi: 10.1097/PHM.0000000000001108, indexed in Pubmed: 30550454.
73. Le Goff-Pronost M, Mourgeon B, Blanchère JP, et al. Real-world clinical evaluation and costs of telemedicine for chronic wound management. Int J Technol Assess Health Care. 2018; 34(6): 567–575, doi: 10.1017/S0266462318000685, indexed in Pubmed: 30369340.
74. Cheville AL, Moynihan T, Herrin J, et al. Effect of collaborative telerehabilitation on functional impairment and pain among patients with advanced-stage cancer: a randomized clinical trial. JAMA Oncol. 2019; 5(5): 644–652, doi: 10.1001/jamaoncol.2019.0011, indexed in Pubmed: 30946436.
75. Galiano-Castillo N, Cantarero-Villanueva I, Fernández-Lao C, et al. Telehealth system: A randomized controlled trial evaluating the impact of an internet-based exercise intervention on quality of life, pain, muscle strength, and fatigue in breast cancer survivors. Cancer. 2016; 122(20): 3166–3174, doi: 10.1002/cncr.30172, indexed in Pubmed: 27332968.
76. Telerehabilitation systems Market. Global Industry Insights, Trends, Outlook, and Opportunity Analysis, 2020–2027. Coherent Market Insights.