

ANNOTATION

**of the dissertation of Elena Nikolaevna Sergeyeva entitled
«Evaluation of the Effectiveness of Cardiac Rehabilitation within the Mandatory
Social Health Insurance System», submitted for the degree of Doctor of
Philosophy (PhD) in 8D10101 – «Public Health»**

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Relevance of the Study:

Diseases of the circulatory system remain among the leading causes of mortality and disability worldwide and in the Republic of Kazakhstan [1, 2].

Myocardial infarction (MI) is associated with a high risk of recurrent cardiovascular events, hospitalizations, disability, and a substantial medico-social and economic burden [3, 4].

Cardiac rehabilitation (CR) is a key component of secondary prevention and improves functional status and prognosis; however, participation remains insufficient in many countries [5 – 9].

In Kazakhstan, despite the established regulatory framework for medical rehabilitation [10], coverage with Phase II CR remains limited, while national evidence on its medical, medico-social, and economic effectiveness is scarce [11, 12].

This determines the relevance of a comprehensive evaluation of Phase II CR within the Mandatory Social Health Insurance (MSHI) system and the scientific substantiation of improvements in its organization.

Aim of the Study:

To evaluate the effectiveness of the existing cardiac rehabilitation system for patients after myocardial infarction at the Phase II level within the Mandatory Social Health Insurance (MSHI) system.

Objectives of the Study:

1. To analyze trends in the epidemiological indicators of myocardial infarction in the Republic of Kazakhstan in 2012 – 2024 and in the city of Almaty and Almaty Region in 2018–2022, and to forecast national myocardial infarction incidence and mortality through 2035.
2. To determine the impact of Phase II cardiac rehabilitation and the timing of its initiation on the medical and medico-social outcomes of patients after myocardial infarction.
3. To evaluate the economic effectiveness of the management of patients after myocardial infarction according to their participation in Phase II cardiac rehabilitation.
4. To develop and implement an organizational and functional model of Phase II cardiac rehabilitation based on the results of a comprehensive assessment of its medical, medico-social, and economic effectiveness.

The study comprises epidemiological and organizational analyses, a retrospective cohort study, an economic evaluation and the development of an organizational and functional model. Official statistical data for the Republic of Kazakhstan for 2012–2024 and for the city of Almaty and Almaty Region for 2018–2022 were used. National indicators were projected through 2035.

Following screening of 3,450 medical records of patients hospitalized with myocardial infarction at the City Cardiology Center in Almaty in 2018 – 2022, a cohort of 2,672 patients with 24 months of follow-up was established. Of these, 1,092 underwent phase II CR and 1,580 did not. CR initiation within the first three months (n=799) was compared separately with initiation at three to six months (n=293). Data sources included the Avicenna and DamuMed information systems, medical records and government information resources.

Medical outcomes were assessed using left ventricular ejection fraction (LVEF), recurrent myocardial infarction, unstable angina, the duration of repeat hospitalizations and all-cause mortality. Medico-social outcomes included disability status, persistence of disability over two years and its duration. Potential ability to work was assessed indirectly through the absence of persistent disability. The indicators were selected according to their relevance and availability in retrospective data sources.

The economic analysis compared direct medical costs over two years and estimated indirect losses using the human capital approach from a societal perspective. Losses during follow-up and estimated long-term losses were considered separately; the robustness of the estimates was assessed through sensitivity analysis.

Statistical analysis was performed using IBM SPSS Statistics 26.0, with parametric and nonparametric tests, multivariable logistic regression and a general linear model. The association between CR and follow-up LVEF was assessed with baseline LVEF included as a covariate. The significance threshold was $p < 0.05$.

Main findings

In the Republic of Kazakhstan, myocardial infarction incidence increased from 57.9 cases per 100,000 population in 2012 to 125.6 in 2024 ($R^2=0.851$; $p < 0.001$). Mortality decreased from 87.22 to 47.70 deaths per 100,000 population, although the trend did not reach statistical significance ($p=0.075$). According to the projections, by 2035 incidence may reach 216.1 cases per 100,000 population, or 49,900 cases annually, and mortality may reach 40.4 deaths per 100,000 population, or 9,300 deaths annually. This indicates an increasing number of patients requiring follow-up and rehabilitation.

In Almaty, incidence reached 198.3 cases per 100,000 population in 2020, while the case fatality rate reached 13.8% in 2021. In Almaty Region, incidence increased from 95.4 to 157.0 cases per 100,000 population between 2018 and 2022. Meanwhile, participation in phase II CR in Almaty was below 2% in 2018–2019 and 21–23% in 2020–2022. In the study cohort, 40.9% of patients underwent CR. Within the first three months, 73.2% of program participants, or 29.9% of the entire cohort, started the program: fewer than one-third of all patients received early rehabilitation.

The mean age was 53.8 ± 6.6 years, and 90.2% of patients were male. The groups were comparable in age, sex and place of residence. However, ST-segment elevation myocardial infarction (58.5% versus 54.5%; $p=0.039$) and coronary artery bypass grafting (18.3% versus 14.8%; $p=0.027$ for differences in treatment distribution) were more common in the CR group. These characteristics were considered when interpreting the findings.

At 6–12 months, LVEF was 53.7% in the CR group and 49.0% in the group without CR. The association with rehabilitation remained after adjustment for baseline LVEF ($F=74.02$; $p < 0.001$); the model explained 46.7% of the variation in the outcome. No differences were found in recurrent myocardial infarction, unstable angina or the duration of repeat hospitalizations. Two-year mortality was 13.4% with CR and 11.2% without CR ($p=0.091$). Thus, improved left ventricular function was not accompanied by an advantage in the other medical outcomes studied.

Among CR participants, starting the program within the first three months was associated with lower two-year mortality than starting at three to six months: 12.1%

versus 16.7% ($p=0.049$). No differences in recurrent myocardial infarction, unstable angina or current disability were identified according to the timing of initiation.

Medico-social indicators did not improve in the CR group. Current disability was recorded in 14.4% of patients versus 10.9% without CR ($p=0.007$), persistent disability over two years in 43.1% versus 37.3% ($p=0.002$), and mean disability duration was 9.68 versus 8.21 months ($p=0.001$). The findings were interpreted in light of baseline differences in infarction type and treatment received.

Excluding the CR program, direct medical costs over two years were KZT 1,155,674.42 per patient in the CR group and KZT 1,102,520.58 without CR ($p=0.061$). Including the program, costs in the CR group reached KZT 1,330,844.42 and were higher by KZT 228,323.84, or 20.7% ($p<0.001$). No reduction in direct costs associated with CR participation was demonstrated.

The total two-year economic burden in the CR group ($n=1092$) was KZT 1.759 billion, or KZT 1,611,046.38 per patient: direct costs accounted for 82.6% and indirect losses for 17.4% (KZT 305.98 million). The index hospitalization accounted for 65.0% of the total burden and CR for 10.9%; their shares of direct costs were 78.7% and 13.2%, respectively. Estimated long-term human capital losses amounted to KZT 5.313 billion, including KZT 2.999 billion due to mortality and KZT 2.142 billion due to disability. Wage levels and the duration of loss of ability to work had the greatest influence on the estimates.

The findings supported the need to expand participation and ensure timely CR initiation. The organizational and functional model developed combines patient stratification, priority referral, care pathways, CR delivery, monitoring and management. Stratification considers LVEF below 50%, infarction type, revascularization, functional limitations, working age and disability. The model provides for referral of at least 85% of patients and an increase in participation to 60–70%.

Elements of the model were implemented in four healthcare organizations. A total of 104 professionals were trained, with paired data available for 101 participants. Knowledge improved in all areas assessed ($p<0.001$), supporting the effectiveness of the educational component. Medical outcomes following model implementation were not evaluated separately.

Scientific novelty

1. For the first time in the Republic of Kazakhstan, epidemiological forecasting, assessment of actual participation in cardiac rehabilitation, medical and medico-social outcomes, rehabilitation timing and the economic consequences of myocardial infarction have been integrated within a single methodological framework. This approach enabled both an assessment of the existing CR system and identification of the organizational and resource factors limiting its effectiveness.

2. Analysis of long-term statistical data identified patterns in myocardial infarction trends in the Republic of Kazakhstan, the city of Almaty and Almaty Region. A forecast based on these trends was developed through 2035, indicating a further increase in the number of patients requiring long-term follow-up and rehabilitation.

3. A large retrospective cohort revealed an important discrepancy: participation in phase II CR was associated with improved LVEF but not with

differences in recurrent myocardial infarction, unstable angina, hospitalization duration or overall two-year mortality. This established the medical outcomes of CR in real-world practice and showed that improved myocardial function is not always accompanied by changes in other important outcomes.

4. The importance of the timing of phase II CR was established. CR within the first three months was associated with lower two-year mortality than CR at three to six months. At the same time, no differences were found in recurrent cardiovascular events or disability, allowing the medical and medico-social outcomes of early CR to be distinguished.

5. For the first time, a comprehensive assessment was made of direct medical costs, indirect losses and long-term human capital losses after myocardial infarction. A discrepancy was identified between the predominance of expenditure on acute myocardial infarction treatment and the considerably smaller share allocated to rehabilitation, despite substantial losses due to mortality, disability and loss of ability to work.

6. An organizational and functional model of phase II CR was developed on the basis of the medical, medico-social and economic findings. Its novel element is the integration of patient stratification, referral prioritization, care pathways, rehabilitation timing, monitoring and management into a unified system aimed at expanding participation and ensuring timely CR.

Thus, the scientific novelty lies in moving from the isolated assessment of individual CR outcomes to a comprehensive explanation of the reasons for its limited effectiveness in real-world practice. The risk-based approach links the need for cardiac rehabilitation, participation, rehabilitation timing, medical and medico-social outcomes and the structure of economic costs, providing a scientific basis for improving cardiac rehabilitation in the Republic of Kazakhstan.

Key propositions submitted for defense

1. Rising myocardial infarction incidence and the projected increase in patient numbers create a growing need for cardiac rehabilitation that is not met by the current level of participation.

2. The medical effectiveness of phase II CR is heterogeneous: improvement in left ventricular function is not accompanied by changes in all medical and medico-social outcomes studied, while rehabilitation timing has independent importance for two-year mortality.

3. The economic burden after myocardial infarction is driven primarily by the costs of acute care and long-term losses due to mortality, disability and loss of ability to work, while rehabilitation accounts for a considerably smaller share of expenditure.

4. A risk-based organizational and functional model integrating patient stratification, referral prioritization, care pathways, CR timing, monitoring and management represents an evidence-based solution for the systematic organization of phase II cardiac rehabilitation.

Practical significance of the findings

The model and stratification criteria provide a basis for prioritizing referrals to phase II CR, improving the timeliness of initiation and monitoring access to rehabilitation. Practical recommendations include formalizing consideration of CR

referral at discharge, prioritizing initiation within the first three months, increasing participation to 60–70%, increasing the share of funding allocated to cardiac rehabilitation and monitoring program completion.

Elements of the model were implemented at the City Cardiology Center in Almaty, the Central City Clinical Hospital in Almaty, the Almaty Multidisciplinary Clinical Hospital and the East Kazakhstan Regional Hospital. The educational component was incorporated into postgraduate training for healthcare professionals. Five implementation certificates and two copyright registration certificates dated April 16, 2026 were obtained: “Patient Stratification for Referral to Phase II Cardiac Rehabilitation”, No. 70325, and “Organizational and Functional Model of Phase II Cardiac Rehabilitation”, No. 70336.

Author’s contribution: development of the study concept and design, creation of the database, analysis of medical, medico-social and economic indicators, development of the organizational and functional model, statistical analysis and interpretation of the findings, and preparation of the dissertation, conclusions and practical recommendations.

Conclusions

1. The epidemiological analysis of myocardial infarction in the Republic of Kazakhstan for 2012–2024 revealed a statistically significant increase in incidence from 57.9 to 125.6 cases per 100,000 population. The decrease in mortality over this period did not reach statistical significance. Data from the city of Almaty and Almaty Region confirmed a continuing epidemiological burden, while the forecast through 2035 indicated a potential increase in annual myocardial infarction cases to 49,900.

2. Participation in phase II cardiac rehabilitation was insufficient, at 40.9%. CR participation was associated with higher follow-up LVEF after adjustment for baseline LVEF; however, no between-group differences were found in recurrent myocardial infarction, unstable angina, hospitalization duration or overall two-year mortality.

3. Within the first three months, 29.9% of all patients underwent phase II CR. CR during this period was associated with lower two-year mortality than CR at three to six months: 12.1% versus 16.7%. However, no improvement in medico-social indicators was established: disability was more frequent and lasted longer in the CR group, and no statistically significant association was found between CR timing and the prevalence of current disability.

4. The economic analysis showed that direct medical costs over two years did not differ significantly between groups when the CR program cost was excluded, but were higher in the rehabilitation group when it was included. Treatment of the index myocardial infarction accounted for 65.0% of the total economic burden and cardiac rehabilitation for 10.9%. Long-term losses due to mortality, disability and loss of ability to work amounted to KZT 5.313 billion, supporting the need to strengthen the rehabilitation phase of care.

5. Based on the findings, an organizational and functional model of phase II CR was developed, incorporating patient stratification, identification of priority groups, care pathways, rehabilitation delivery, monitoring and management. The model provides for referral of at least 85% of patients and an increase in participation

to 60 – 70%. Its elements were implemented in four healthcare organizations, and the educational component was associated with improved knowledge among healthcare professionals.

Implementation of the dissertation findings

Two copyright registration certificates were obtained for work related to the dissertation: 1. “Patient Stratification for Referral to Phase II Cardiac Rehabilitation”, No. 70325, dated April 16, 2026. 2. “Organizational and Functional Model of Phase II Cardiac Rehabilitation”, No. 70336, dated April 16, 2026.

The findings were implemented in the practice of healthcare organizations providing care to patients with acute coronary syndrome, including the City Cardiology Center in Almaty, the Central City Clinical Hospital in Almaty, the Almaty Multidisciplinary Clinical Hospital and the Regional Hospital in Ust-Kamenogorsk.

Implementation included elements of the organizational and functional model, namely patient stratification, prioritization of cardiac rehabilitation referrals and the educational component.

Publications related to the dissertation

The following papers were published on the study:

1. Sergeyeva Y, Yermukhanova LS, Nurbakyt AN, Kurmanalina GL, Walkowiak D, Nogayeva MG, Afshar A. Phase II Cardiac Rehabilitation Under Compulsory Insurance in Kazakhstan: A Five-Year Cohort Analysis of Clinical and Economic Outcomes. *J Clin Med*. 2025;14 (17):6317. doi:10.3390/jcm14176317

2. Sergeyeva Y.N., Nurbakyt A.N., Yermukhanova L.S., Zhakayev M.A. Effective cardiac rehabilitation: a modern perspective. *Phthisiopulmonology*. 2025;15(56):83–88. doi:10.26212/2227-1937.2025.15.56.011. [In Russian].

Length and structure of the dissertation

The dissertation comprises 131 pages and includes an introduction, a literature review, materials and methods, the results of the original research, a concluding discussion, conclusions and practical recommendations. The reference list contains 137 sources. The dissertation includes 41 tables, 19 figures, 4 formulas and 7 appendices.

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