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Market efficiency of the organization of medical services for patients with persistent, long-standing persistent, and permanent forms of atrial fibrillation based on an adapted theoretical model

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Ринкова ефективність організації медичних послуг для пацієнтів із персистуючою, тривало персистуючою та постійною формами фібриляції передсердь на основі адаптованої теоретичної моделі

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Introduction

Cardiovascular diseases (CVDs) are the leading cause of mortality in most countries worldwide [1]. Among the most common forms of cardiac rhythm disorders, atrial fibrillation (AF) occupies a special place [2]. AF includes paroxysmal, persistent, long-standing persistent, and permanent forms [2]. According to numerous epidemiological observations, the prevalence of AF is steadily increasing. This trend is driven by population aging, improved diagnostic capabilities, and changes in lifestyle patterns. In this context, there is an urgent need to develop new approaches to healthcare delivery that emphasize efficiency and a balance between cost, quality, and patient comfort.

Despite extensive research on the clinical management of AF patients, the economic efficiency of service provision remains insufficiently studied. Most publications focus on pharmacoeconomic aspects or cost assessments related to specific treatment methods. However, issues of organizational efficiency, adaptation of medical services to market conditions, and consideration of patients' behavioral characteristics require a more systematic analysis.

This paper proposes a combination of two previously conducted studies on the market efficiency of healthcare services for patients with various forms of AF, using the model developed by D. Dranove and M. Satterthwaite [3]. This integration allows for a broader patient cohort and reveals key patterns in the relationships between price, quality, comfort, and informational noise across different clinical scenarios [4,5].

Goal: To assess the market efficiency of healthcare service organization for patients with persistent, long-standing persistent, and permanent forms of atrial fibrillation based on a modified theoretical model by D. Dranove and M. Satterthwaite. The study also aims to determine the role of informational noise in altering demand elasticities and shaping patients' consumer decisions.

Object, materials and research methods

The object of the study was healthcare services provided to patients with atrial fibrillation (AF) in both outpatient and inpatient settings. A total of 600 patients who received treatment in various medical institutions across five different care pathways were included. The observation period covered the years 2015 to 2023. All patients were stratified according to the form of AF and the characteristics of their healthcare pathway. Data from patients with paroxysmal AF were excluded from the study, as this form often presents asymptomatically and remains undocumented, making data collection and analysis difficult.

Care Pathways

Pathway 1

Family physician (Primary Care Doctor) → Cardiologist (outpatient)

Pathway 2

Cardiologist (outpatient) → Cardiology (or therapeutic) inpatient unit at the cluster level

Pathway 3

Primary Care Doctor → Cardiologist (outpatient) → Cardiology inpatient unit at a supra-cluster hospital

Pathway 4

Primary Care Doctor → Cardiology inpatient unit at a supra-cluster hospital

Pathway 5

Emergency Medical Service (EMS) team → Cardiology inpatient unit at a supra-cluster hospital

As part of the study, a structured questionnaire was developed. This instrument included patient anamnesis data relevant to the course of atrial fibrillation (AF), such as age, sex, place of residence, education level, employment (income) status, and presence of comorbidities.

The study included patients with the following diagnosed and/or past medical conditions: COVID-19, hypertension, use of hormonal medications, varicose veins of the lower extremities without ulcers or inflammation, hemorrhoids and perianal venous thrombosis, use of blood-thickening medications, cardiovascular malformations, myocarditis, heart failure, thyroid disorders, and obesity.

Patients with diabetes mellitus, chronic pulmonary diseases, chronic kidney disease, and obstructive sleep apnea were excluded from the study.

Comorbidity burden was assessed using the Charlson Comorbidity Index.

During the study, attention was paid to whether patient management was conducted in accordance with clinical protocols and guidelines by healthcare providers at all levels of the system. For patients hospitalized at least once due to AF, both elective and urgent hospitalizations were recorded annually.

The questionnaire captured the number of months the patient spent with persistent, long-standing persistent, and permanent forms of AF. The duration of each form may reflect the quality of medical care, influenced by factors such as healthcare provider performance, patient compliance, drug efficacy (which is itself dependent on income, awareness, and access to care), and other variables.

Given the high incidence of stroke, pulmonary embolism (PE), and myocardial infarction (MI) among patients with AF, the study documented:

The number of months from AF diagnosis to the occurrence of stroke

The number of months from diagnosis to MI

The number of months from diagnosis to PE

Patients who had experienced stroke, PE, or MI before the diagnosis of AF were excluded from the study.

Because the quality of medical care also depends on the qualifications of healthcare providers, the questionnaire collected data on the years of experience and professional category of the initial treating physician — the family doctor/general practitioner, outpatient cardiologist, and hospital-based cardiologist. If patients changed doctors over time, only the experience and category of the physician managing the patient at the time of diagnosis or first hospitalization for AF were considered.

Frequent changes in physicians may compromise care continuity; therefore, the questionnaire included questions about whether and how often patients changed their family doctors or cardiologists.

Compliance was a critical variable influencing care effectiveness. The questionnaire captured whether patients had complaints about the services received at the outpatient or inpatient level and whether there were recorded instances of non-adherence to prescribed treatments.

Facility ownership was also considered, as it can influence care delivery. Thus, the study noted the ownership status of the facility providing primary care at the time of diagnosis, as well as the facility providing inpatient care during the patient's first hospitalization. The current type of primary healthcare facility was also recorded, as a change in ownership might reflect patient dissatisfaction with previous care.

Accessibility to healthcare was evaluated through a question about whether the patient's outpatient clinic was located separately from the primary healthcare center (PHC).

Environmental conditions during hospitalization, such as the type of hospital room during the first admission, were also taken into account, as they may affect treatment outcomes.

The speed of disease progression served as an indirect indicator of care quality and patient engagement. For a clearer understanding, the study recorded the number of months each AF form lasted and the transition speed between them. Annual AF exacerbation frequency was also captured.

An essential factor in evaluating healthcare efficiency was the annual out-of-pocket spending on outpatient and inpatient care (from disease onset onward). These expenditures were calculated in U.S. dollars per year, based on prescribed medications, using historical price data from the official drug registry and exchange rates for the corresponding years.

The method of rhythm control was also documented, as it affects disease progression, healthcare costs, and quality of life.

Patient care pathways were analyzed as a critical component of timely and effective healthcare delivery. Each patient was categorized based on a predefined set of modeled pathways.

The data were analyzed using Structural Equation Modeling (SEM) [6,7], which allowed for the assessment of relationships between latent constructs and observed variables. The theoretical model was adapted to the study conditions by constructing three main latent factors – informational noise, quality, and comfort – and specifying regression links between these factors and healthcare cost. SEM analysis was performed using the "lavaan" package in R (version 4.2.2). All data were processed in accordance with ethical standards and anonymity principles, in line with the Declaration of Helsinki.

Data processing. Statistical analysis was conducted using the maximum likelihood (ML) estimation method. To assess model fit, the following indices were employed [8, 9, 10, 11]:

Root Mean Square Error of Approximation (RMSEA)

Standardized Root Mean Square Residual (SRMR)

Comparative Fit Index (CFI)

Tucker-Lewis Index (TLI)

For comparison of nested models, the Satorra-Bentler scaled chi-square difference test was used.

Standardized regression coefficients were evaluated for statistical significance at the level of $p < 0.05$.

To improve the accuracy of estimates, particularly for the variable "cost", instrumental variable modeling was applied.

Research results

The main hypotheses are illustrated using colored arrows and suggest the following associations (Figure 1):

A significant negative regression coefficient between information noise and quality of medical services;

A significant positive regression coefficient between information noise and cost of medical services;

A significant regression coefficient between information noise and comfort of medical services;

A significant positive regression coefficient between quality and cost of medical services;

A significant positive regression coefficient between comfort and cost of medical services;

A significant positive covariance coefficient between quality and comfort of medical services.

The acceptance of most of these hypotheses indicates an approach to equilibrium among the cost, quality, and comfort of medical services.

The first three hypotheses are important because their acceptance indicates that the reduction of individualized price elasticity of demand concerning cost, quality, and comfort, due to insufficient patient awareness, leads to a decrease in the balanced values of cost, quality, and comfort.

We singled out route 1, as it is the only one that does not include inpatient care. Route 1 exclusively serves patients with persistent atrial fibrillation (AF). However, this route is a component of more complex routes. Therefore, the majority of patients with AF are served either directly by this route or as part of other routes, which underlines its significance.

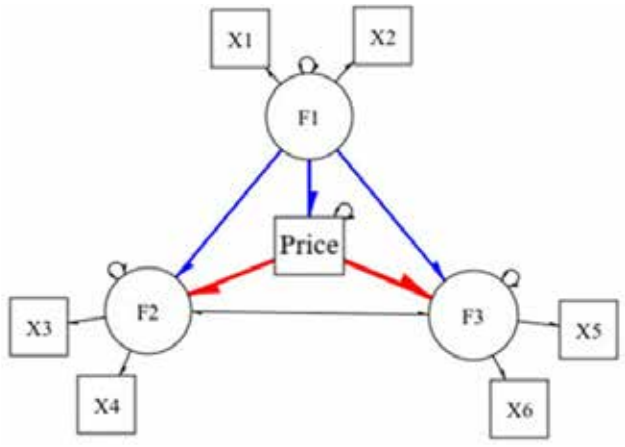

Fig. 1. Diagram of the transformed model by D. Dranov and M. Satterwhite

Model structure (SEM):

Information noise (F1), as a latent factor, is defined by loadings on the following observed variables (SEM variable names and coding in parentheses; "*" marks recoded variables):

Age

Gender

Place of residence

*Education

Employment

Duration of illness

Quality of medical services (F2), as a latent factor, is defined by loadings on the following observed variables:

Completeness of examination

Ownership form of primary health care facility

Ownership form of the facility where cardiology outpatient service was provided

Medical staff qualification (f0): a latent factor

Medical staff qualification (f0), a latent factor, is defined by loadings on the following observed variables ("*" marks recoded variables):

Work experience of general practitioner

*Category of general practitioner

Work experience of cardiologist

*Category of cardiologist

Comfort of medical services (F3), as a latent factor, is defined by loadings on the following observed variables:

Age

Gender

Number of times the patient changed the general practitioner

Number of times the patient changed the cardiologist

Patient complaints about the general practitioner

Patient complaints about the cardiologist

Ownership form of the facility where cardiology outpatient service was provided

Other definitions of latent factors were also considered. For example, in defining F2, the facility name and whether the outpatient clinic was separate from the central primary care center were included. Also, the ownership form of the primary care facility was used for describing comfort. However, these additional components caused singularity of the covariance matrix due to collinearity (similar information) with included variables and were therefore excluded without loss of information.

The analysis confirmed six hypotheses in different subgroups. In the group of patients with persistent AF, five out of six hypotheses were confirmed. A positive association was found between quality of services and cost, as well as between comfort and cost. Information noise correlated negatively with quality but positively with cost.

For patients with long-term persistent and permanent forms, three out of six hypotheses were confirmed. In these groups, demand elasticity for quality plays a major role, while the influence of comfort and price decreases. This indicates an adaptive shift in patient priorities in more severe clinical conditions.

Additional analysis showed that the factor "physician qualification" significantly affects the quality assessment, while the frequency of physician changes and patient complaints affect comfort. Cost is influenced by multiple factors: insurance coverage, age, number of hospitalizations, treatment intensity, and ownership form of the facility.

Discussion of research results

The obtained results indicate that the Dranov and Satterwhite model is an effective tool for analyzing the market efficiency of medical services [12, 13]. Its application not only allows identifying key factors influencing demand formation but also assesses the effectiveness of adapting medical services to the needs of different patient categories.

The observed shifts in the structure of demand elasticities confirm that patients with more severe forms of atrial fibrillation (AF) focus more on quality, whereas in milder cases, comfort plays a greater role. This has important practical implications for developing individualized healthcare pathways that consider both clinical conditions and patients' behavioral patterns.

Information noise, as a latent factor, helped explain variability in patients' decision-making. Reducing it through educational campaigns or counseling may positively influence the achievement of market equilibrium among cost, quality, and comfort [14, 15].

Prospects for further research

Further studies will focus on expanding the sample size, including other forms of cardiovascular diseases, analyzing the dynamics of demand changes over time, and testing the model on regional subsamples. The development of recommendations aimed at reducing information noise and enhancing the transparency of the healthcare system is also planned.

A promising direction is the expansion of the behavioral component of the potential healthcare consumer, which requires further development of the theoretical framework from the perspective of behavioral economics.

Conclusions

The Dranov and Satterwait model effectively enables the modeling of market behavior within the healthcare services system.

Patients with severe forms of atrial fibrillation prioritize quality, whereas those with milder forms prioritize comfort.

The cost of medical services is derived from a complex set of factors, including clinical, social, and organizational aspects.

Reducing information noise can improve the balance between costs, quality, and comfort.

SEM modeling is a reliable tool for evaluating effectiveness under multifactorial influence.

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Purpose: To evaluate market efficiency in organizing medical services for patients with persistent, long-standing persistent, and permanent atrial fibrillation using an adapted model by Dranov and Satterwait, considering the role of information noise in demand elasticity and consumer decisions.

Materials and methods: The study analyzed services for 250 patients with various atrial fibrillation forms during 2015–2023 across five clinical pathways. Structural Equation Modeling (SEM) with latent variables – quality, comfort, and information noise – was applied using R's «lavaan» package. Model fit was assessed with RMSEA, SRMR, CFI, TLI, and the Satorra-Bentler test.

Results. SEM showed significant links between quality, comfort, cost, and information noise. For persistent atrial fibrillation patients, service cost correlated strongly with quality and comfort; in other forms, quality sensitivity prevailed. Information noise

reduced perceived quality but increased cost. Physician qualification influenced quality, while physician changes affected comfort.

Conclusions. The Dranov and Satterwait model effectively assesses healthcare market behavior. Patients with severe atrial fibrillation prioritize quality; those with milder forms value comfort more. Minimizing information noise can optimize cost, quality, and convenience balance. SEM is a suitable method for analyzing complex consumer behavior factors.

Key words: healthcare service efficiency, atrial fibrillation, theoretical model, quality of health care service, patient comfort, SEM, information noise.

Мета: усебічна оцінка ринкової ефективності організації медичних послуг для пацієнтів із персистуючою, тривало персистуючою та постійною формами фібриляції передсердь (ФП) із використанням адаптованої теоретичної моделі Д. Дранова і М. Саттервейта. Основний акцент зроблено на аналізі впливу інформаційного шуму на зміну еластичності попиту, споживчу поведінку та процес прийняття рішень у сфері охорони здоров'я. Актуальність роботи зумовлена складністю взаємодії між пацієнтами та системою охорони здоров'я в умовах неповної або викривленої інформації про якість, вартість та комфорт медичних послуг.

Матеріали та методи. Об'єктом дослідження виступили медичні послуги, отримані 600 пацієнтами з різними формами ФП у період 2015–2023 рр. у межах п'яти клінічних маршрутів, які включали спеціалізовану та високоспеціалізовану допомогу. Методологічною основою дослідження стало структурне моделювання рівнянь (Structural Equation Modeling, SEM) із застосуванням латентних змінних: якості, комфорту та інформаційного шуму. Аналіз проводився у середовищі програмування R із використанням пакету «lavaan». Оцінка адекватності моделей здійснювалася за допомогою таких індексів: Root Mean Square Error of Approximation (RMSEA), Standardized Root Mean Squared Residual (SRMR), Comparative Fit Index (CFI), Non-Normed Fit Index (Tucker-Lewis Index, TLI) та тесту Satorra-Bentler для корекції на неоднорідність.

Результати. SEM-модель продемонструвала статистично значущі взаємозв'язки між основними латентними змінними: якістю, комфортом, вартістю медичних послуг та рівнем інформаційного шуму. Для пацієнтів із персистуючою формою фібриляції передсердя було виявлено тісну кореляцію між вартістю послуг та їх якісними характеристиками (технічна якість, результативність, професіоналізм персоналу), а також рівнем комфорту (доступність, емоційна підтримка, організація процесу). Натомість у пацієнтів із тривало персистуючою та постійною формами переважала чутливість саме до якісних параметрів послуг. Установлено, що інформаційний шум знижує сприйняття якості послуг, але водночас позитивно корелює з готовністю платити вищу ціну, ймовірно, через недостатню орієнтацію пацієнта у наданій інформації. Також виявлено, що вища кваліфікація лікаря позитивно впливає на сприйняття якості, тоді як часта зміна лікаря має негативний вплив на відчуття комфорту пацієнта. Комфорт пацієнта оцінювався через такі змінні, як організаційна доступність, емоційна підтримка з боку персоналу, стабільність контактної особи (лікаря).

Інформаційний шум, який вимірювався як суб'єктивне сприйняття неповноти, протиріччя чи складності медичної інформації, мав негативний вплив на сприйняття якості послуг, проте, парадоксально, позитивно корелював із вартістю, що, ймовірно, свідчить про нераціональність рішень пацієнтів у середовищі інформаційної асиметрії. Окрім того, виявлено, що рівень кваліфікації лікаря достовірно покращує сприйняття якості, тоді як часта зміна лікаря в межах клінічного маршруту знижує рівень суб'єктивного комфорту.

Висновки. Отримані результати узгоджуються з припущеннями моделі Дранова і Саттервейта про вплив асиметричної інформації на функціонування ринку медичних послуг. У контексті ФП, де важливо забезпечити безперервність та персоналізований підхід, наявність інформаційного шуму може призводити до неефективного розподілу ресурсів, збільшення витрат та зниження задоволеності пацієнтів. SEM дав змогу детально проаналізувати взаємозв'язки між змінними та підтвердити доцільність використання цієї моделі у галузі охорони здоров'я.

Адаптована модель Дранова і Саттервейта показала високу ефективність для аналізу ринкової поведінки споживачів медичних послуг в умовах багатофакторного впливу. Пацієнти з тяжчими формами ФП, які мають більший клінічний ризик, надають перевагу якості медичних послуг, тоді як у пацієнтів із менш тяжкими формами більш важливим виявляється комфорт. Визначено, що зниження інформаційного шуму є ключовим напрямом для підвищення ефективності споживчих рішень та досягнення оптимального балансу між витратами, якістю та зручністю медичних послуг. SEM-моделювання виявилося доцільним інструментом для кількісного аналізу складних взаємозв'язків у сфері охорони здоров'я.

Ключові слова: ефективність медичних послуг, фібриляція передсердь, теоретична модель, якість медичних послуг, комфорт пацієнта, SEM, інформаційний шум.

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