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ANALYSIS OF MARKET EFFICIENCY OF THE ORGANIZATION OF SERVICES FOR PATIENTS WITH LONGSTANDING AND PERMANENT FORMS OF ATRIAL FIBRILLATION BASED ON THEORETICAL MODEL

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Abstract

Introduction. Rational consumption of medical services requires consideration of several key factors: cost, quality, comfort, and the level of patient awareness. An important aspect is the interrelationship between these parameters, which influences the choice of medical services by patients in various situations. Of particular relevance is the study of the role of these factors in the context of the severity of pathological conditions, as the health of patients and the level of the disease can significantly alter their priorities. This study evaluates patient behavior in situations of varying disease severity and the impact of information noise on their choices.
Aim. To assess demand elasticity in terms of healthcare quality, comfort, and cost, across disease severity to explain evolving behavior of patients and responsiveness of health system to market drivers.
Materials and methods. The study utilized structural equation modeling (SEM) to test six hypotheses related to the influence of healthcare service attributes on patient choices. Data on 600 patients with lasting persistent atrial fibrillation were collected through standardized questionnaires and processed via multifactorial analysis.
Results. Three out of six hypotheses were confirmed, indicating complex interdependencies among cost, quality, and comfort in patient decision-making. In severe pathological conditions, demand elasticity for quality becomes dominant, suggesting a shift in patient priorities from comfort to quality, even at increased costs. Informational noise proved to be a significant factor in differentiating behavioral patterns between patients with different levels of pathological conditions.
Conclusions. Findings indicate that healthcare service delivery systems are adapting to new forms of demand elasticity within market conditions. Patients increasingly prioritize quality, demonstrating a rational trade-off with comfort and cost to improve health outcomes.

Keywords: **medical service effectiveness, atrial fibrillation, theoretical model, medical service quality, patient comfort**

INTRODUCTION

Cardiovascular diseases (CVDs) represent the leading cause of morbidity in most countries worldwide. Among them, ischemic heart disease, arterial hypertension, and cardiac arrhythmias – particularly atrial fibrillation (AF) – constitute the largest share. The prevalence of AF is estimated at 1-2% of the general population and continues to rise steadily [1, 2, 3]. The increasing number of patients with CVDs is largely driven by the widespread occurrence of modifiable risk factors such as smoking, poor dietary habits, physical inactivity, obesity, and chronic psychosocial stress. These factors exert a cumulative effect that contributes to the progression of cardiovascular pathology. Consequently, there is a growing need to improve organizational approaches to the provision of cardiological care, particularly through evaluating its operational efficiency.

AIM

To assess demand elasticity in terms of healthcare quality, comfort, and cost, across disease severity to explain evolving behavior of patients and responsiveness of health system to market drivers.

MATERIALS AND METHODS

A combined (retrospective + prospective) study was conducted to analyze data from 600 patients who were treated in healthcare facilities of varying levels of care and ownership types. The collected information from outpatient and inpatient medical records was entered into specially designed questionnaires. The questionnaire included the following items:

1. Patient number (full name)
2. Age (in years)
3. Gender
4. Place of residence (city/rural)
5. Education
6. Working / not working
7. Presence of concomitant pathology
8. Is the patient's follow-up properly organized? (complies with protocols and recommendations)
9. Number of hospitalizations per year in a cardiac hospital?
10. Number of months from diagnosis to stroke development
11. Number of months from the moment of diagnosis to the development of thromboembolism
12. Number of months from the date of diagnosis to the development of MI
13. Is the patient's follow-up properly organized?
14. Length of service of the family doctor (in years)
15. Category of family doctor
16. Cardiologist's experience (in years)
17. Category of cardiologist
18. Experience of a cardiologist in a hospital (in years)
19. Category of cardiologist
20. Have family doctors changed and how often? (1, 2, 3… times per year)
21. Have cardiologists changed and how often? (1, 2, 3… times per year)
22. Any complaints from patients related to the management by a family doctor
23. Any complaints from patients regarding services provided by a cardiologist
24. Patient's complaints regarding inpatient care by a cardiologist
25. Type of ownership of the facility where the patient is served at the primary care stage
26. Type of ownership of the facility where the patient is served at the stage of inpatient care
27. Name of the facility
28. Is the outpatient clinic separate from the primary care center?
29. Type of ward
30. Are there any notes in the medical history about non-fulfillment of appointments?
31. Number of days spent in the hospital (per year)
32. Number of exacerbations (attacks) per year
33. Amount of money spent by a patient per year (annually from the moment of disease onset) at the primary health care (PHC) stage
34. Amount of money spent by the patient per year (annually since the onset of the disease) at the inpatient stage

The study included patients with persistent, longstanding, and permanent AF. Patients with paroxysmal AF were not included in the study, as a large proportion of individuals with paroxysmal AF are unaware of their diagnosis, which complicates the analysis of such data. This work reflects only the longstanding and permanent form of AF.

The analysis of the market efficiency of healthcare service delivery for patients with longstanding persistent and permanent forms of AF was conducted using the theoretical econometric model proposed by D. Dranove and M. Satterthwaite (1992) [4, 5, 3]. This model was selected due to its broad applicability: it describes the production of services under competitive conditions, linking key service attributes – price, quality, and comfort – with market characteristics such as demand and price through respective elasticities. The model enables determination of equilibrium values for these variables, forming a dynamic equilibrium that is considered optimal under given market conditions [4, 7, 8].

A review of the available literature revealed a lack of comprehensive studies based on economic theoretical frameworks that analyze the organization of healthcare delivery for AF patients, both in Ukraine and internationally. This gap may be attributed to the limited availability of applicable economic and organizational models, as well as insufficient skills in translating theoretical constructs into empirical tools suitable for practical data analysis. Therefore, this study applies the Dranove–Satterthwaite model to the context of healthcare services for cardiology patients.

The model assumes that service demand (q) is a function of three variables: price (p), quality (ql), and comfort (cm), expressed as $q = q(p, ql, cm)$. The total cost of services (C) is defined as [8, 9]:

$$C(q, ql, cm) = q \bullet (a + b \bullet ql + c \bullet cm) + F,$$

where:
a + b • ql + c • cm are the variable marginal costs,

F represents fixed costs.

The profit function is expressed as:

$$\text{Прибуток} = p \bullet q \bullet (p, ql, cm) - C(q(p, ql, cm), ql, cm) = q(p, ql, cm)(p - b \bullet ql - c \bullet cm) - F$$

To determine the optimal (equilibrium) values of the variables p, ql, and cm, first-order derivatives were obtained and set to zero [8, 9]. Based on this, a system of three simultaneous equations was derived, where the equilibrium values of price, quality, and comfort (p, ql, cm) are expressed in terms of the demand elasticities with respect to each attribute (ε_p, ε_ql, ε_cm) [11, 12, 13].

$$p^* = \frac{a \ \frac{q}{p}}{1 + \frac{q}{p} + \frac{q}{ql} + \frac{q}{cm}} = \frac{(a + b * ql^* + c * cm^*) \ \frac{q}{p}}{1 + \frac{q}{p}}$$

$$ql^* = \frac{a \ \frac{q}{ql}}{b\left(1 + \frac{q}{p} + \frac{q}{ql} + \frac{q}{cm}\right)} = \frac{p^*}{b} \frac{\frac{q}{ql}}{\frac{q}{p}}$$

$$cm^* = \frac{a \ \frac{q}{cm}}{c\left(1 + \frac{q}{p} + \frac{q}{ql} + \frac{q}{cm}\right)} = \frac{p^*}{c} \frac{\frac{q}{cm}}{\frac{q}{p}}$$

Applying this model to the analysis of healthcare service organization allows for assessment of how closely actual parameters (price, quality, and comfort) align with optimal values, thereby indicating the level of market efficiency in service provision [14, 15, 16].

The model structure is based on three latent factors: informational noise (F1), quality (F2), and comfort (F3) of healthcare services (Fig. 1). The primary directly observed variable in the model is the cost of medical services, referred to in the diagram as «Price» in accordance with conventional market terminology [17, 18, 19, 20].

The latent factor informational noise is represented through loadings on a set of measurable variables, conditionally labeled as X_1 and X_2. As this set of indicators is neither exhaustive nor unique, a portion of the variance of the factor remains unexplained. This is illustrated by a residual variance arc with arrows above the factor. The latent variables quality and comfort of healthcare services are defined in a similar manner.

Blue arrows in the diagram indicate the influence of demand elasticities with respect to price, quality, and comfort, while red arrows represent the reverse impact of price on quality and comfort. According to the theoretical model, there is a covariant relationship between the quality and comfort attributes, which is depicted as a bidirectional path between the two latent constructs.

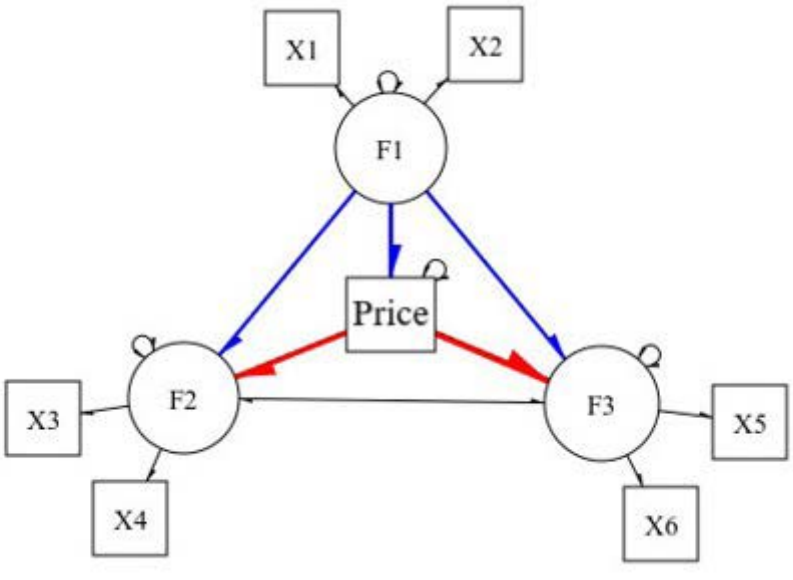

Figure 1. Scheme of transformation of D. Dranov and M. Satterwhite's model.

Although cost is a directly measurable variable, it also contains elements of uncertainty associated with measurement error – an inherent feature of economic variables. To address this, a robust approach is employed, whereby cost is projected onto the space of instrumental variables. This projection is used for testing structural associations within the model.

Based on the transformed Dranove–Satterthwaite model (Fig. 1), six key hypotheses were formulated, illustrated by color-coded arrows, reflecting the following associations:

A negative and statistically significant regression coefficient between informational noise and healthcare service quality.

A positive and statistically significant regression coefficient between informational noise and the cost of medical services.

A statistically significant regression coefficient between informational noise and healthcare service comfort.

A positive and statistically significant regression coefficient between quality and the cost of services.

A positive and statistically significant regression coefficient between comfort and the cost of services.

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

Confirmation of most of these hypotheses would indicate a convergence of cost, quality, and comfort parameters toward market equilibrium. The first three hypotheses are of particular importance, as their acceptance suggests that reduced individual demand elasticity – due to patients' lack of awareness – leads to lower equilibrium levels of expenditure, quality, and comfort in service provision.

RESULTS

The model satisfactorily describes the data compared to the full model and contains significant information compared to the null model. All parameter estimation positions are retained. Specifically, if an effect is close to the threshold of statistical significance and the direction of the relationship is predicted by the theoretical model, we accept the hypothesis based on this relationship.

The first are the loadings for the latent factor (f0) «medical staff qualification.» All loadings – length of experience of general practitioner (Experience1), cardiologist (Experience2), hospital cardiologist (Experience3), general practitioner category (Category1), cardiologist category (Category2), and hospital cardiologist category (Category3) – are positive and significant, clearly identifying f0 as a measure of medical staff qualification. This factor is used to identify the quality of medical care.

The values of the latent factor «Informational noise» (F1) are defined by positive and significant loadings from education (Educ), employment (Occup), and disease duration (T1). Among educated and employed individuals with longer disease duration, the value of the latent factor is higher. This indicates that F1 is inversely related to informational noise – in other words, it reflects the patient's understanding of their condition, needs, the necessity, quality, and comfort of medical services, and choice of service location.

Quality of medical services (F2) is significantly defined through positive loadings with the «medical staff qualification» factor and the completeness of examinations. Medical staff qualification did not help identify service quality in atrial fibrillation (AF) cases where, as noted, work experience and qualification category are not associated with quality in less severe forms of AF. However, they are highly relevant when providing services to more severe cases with complicated courses.

The latent indicator for service delivery comfort (F3) is significantly identified by positive loadings from the frequency of changes in the general practitioner (Change1), cardiologist (Change2), hospital cardiologist (Change3), presence of patient complaints about the general practitioner (Complaints1), the cardiologist (Complaints2), inpatient services (Complaints3), non-compliance with the inpatient treatment regimen (Comply), and a less comfortable type of hospital ward (Ward). Therefore, higher values of F3 indicate lower comfort of medical service delivery, as was the case in the model for AF patients.

The projection of costs onto determining variables appears logical. All key cost drivers used in the model had statistically significant positive regression coefficients, including out-of-pocket coverage of outpatient medical expenses (OOP), coverage of inpatient expenses (OOPH), older age (Age), the number of comorbid conditions affecting costs (Concomitant), the number of exacerbations leading to medical consultations (N), the number of exacerbations requiring hospitalization (NH), more intensive inpatient treatment methods (Method), private ownership of inpatient facility (Ownership2), and hospital specialization (Type).

The following regression effects are based on the described latent factors and their meaningful interpretation. These effects test a set of hypotheses (1-6) and are highlighted in the table as key effects.

A significant positive association was confirmed between patient awareness and quality of medical services (F1~~F2). The covariance coefficient is 0.181, $p = 0.041$. Therefore, Hypothesis 1 is confirmed.

As in the case with the milder form of the disease – persistent AF – we were unable to find a significant regression coefficient between patient awareness and the

cost of medical services (β = 0.034, p = 0.6445), effect (Costs~F1). We follow the same logical explanation as for the AF situation. Thus, Hypothesis 2 is rejected.

The existence of a borderline significant positive association between patient awareness and the comfort of medical service delivery (F1~~F3) was not confirmed. The covariance coefficient is 0.181, p = 0.2727. Hypothesis 3 is rejected – contrary to confirmation in the AF model. The explanation is clear: in more serious conditions, patients prioritize quality over comfort.

A significant positive regression coefficient exists between quality and cost of medical services, effect (F2~Costs), β = 0.195, p = 0.0264. Thus, cost significantly determines service quality, confirming Hypothesis 4.

No significant positive relationship was found between comfort and cost of medical services, effect (F3~Costs), β = 0.032, p = 0.6047 (higher F3 values indicate higher discomfort). Therefore, additional cost does not improve the comfort of medical service delivery in more severe clinical forms of arrhythmia, thereby rejecting Hypothesis 5.

A significant negative covariance coefficient between quality and comfort of medical services was found (F2~~F3), with the coefficient being –0.701, p < 0.0001. Thus, Hypothesis 6 is confirmed.

DISCUSSION

Overall, 3 out of 6 hypotheses were supported, indicating a fundamentally different role of demand elasticities with respect to price, quality, and comfort in determining their balanced values. The theoretical model remains valid even for more severe forms of pathology; however, the elasticity of demand with respect to service quality becomes decisive, dominating over other elasticities, as demonstrated by the SEM results. Patients' choices shift from comfort to quality, even at the cost of additional expenses, as confirmed by the results of all six hypothesis tests. The informational noise factor proves to be useful, highlighting the differences between more severe and milder conditions.

Given the qualitative difference in consumer behavior and the hypothesis testing outcomes, we cannot deny the coherence of the identified patterns, which explain a different patient's stimuli dominance. Therefore, we conclude that the organization of services correctly responds to demand elasticities, and, as in the case of the milder form of the disease, cost, quality, and comfort are approaching optimal levels.

CONCLUSIONS

Based on theoretical econometric model proposed by D. Dranove and M. Satterthwaite research findings support market efficiency of the services for patients with longstanding and permanent forms of atrial fibrillation. This means that services are responsive to the health market drivers, in particular to demand side shifters like cost, comfort and quality of services.

The gravity of health impairment, however, unveiled flexibility of the theoretical approach capable of exploring dominancy phenomena when certain elasticity takes a lead. Seriousness of stages in our case induced a dominant imperative for service quality entailing less elastic demand.

We elaborated the transition to an empirical model using structural equation technique that can be useful for substantiation of hypotheses and research design.

Study also demonstrates the appeal of theoretical based approach to framing research.

Patients increasingly prioritize quality, demonstrating a rational trade-off with comfort and cost to improve health outcomes.

Perspectives for further research. Further research should explore the applicability of the proposed model in broader clinical contexts and among diverse patient populations with various chronic conditions. Longitudinal studies could assess the temporal stability of the model and its predictive validity in forecasting patient satisfaction and adherence to treatment. Additionally, the integration of qualitative data may enhance the understanding of latent factors influencing communication and perceived value in healthcare. Cross-national studies could also be valuable for examining the cultural sensitivity and generalizability of the model.

COMPLIANCE WITH ETHICAL REQUIREMENTS

This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. All participants were informed about the purpose of the research and voluntarily provided their informed consent prior to participation. The anonymity and confidentiality of all respondents were ensured. No personal identifying data were collected or stored.

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This research was conducted without financial support from external parties. The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Rudenko A. A.[A, B, C, D, E, F]

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Резюме

АНАЛІЗ РИНКОВОЇ ЕФЕКТИВНОСТІ ОРГАНІЗАЦІЇ НАДАННЯ ПОСЛУГ ПАЦІЄНТАМ З ТРИВАЛО ПЕРСИСТУЮЧОЮ ТА ПОСТІЙНОЮ ФОРМАМИ ФІБРИЛЯЦІЇ ПЕРЕДСЕРДЬ НА ОСНОВІ ТЕОРЕТИЧНОЇ МОДЕЛІ

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Вступ. Раціональне споживання медичних послуг потребує врахування кількох ключових факторів: вартості, якості, комфорту, а також ступеня обізнаності пацієнта. Важливим аспектом є взаємозв'язок між цими параметрами, який впливає на вибір медичних послуг пацієнтами в різних ситуаціях. Особливо актуальним є дослідження ролі цих факторів у контексті тяжкості патологічного стану, оскільки здоров'я пацієнтів і рівень захворювання можуть суттєво змінювати їх пріоритети. У цьому дослідженні оцінюється поведінка пацієнтів у ситуаціях різної складності захворювань та вплив інформаційного шуму на їх вибір.

Мета. Оцінити еластичність попиту за якістю, комфортом та вартістю медичних послуг залежно від тяжкості захворювання, щоб пояснити еволюцію поведінки пацієнтів та реакцію системи охорони здоров'я на ринкові чинники.

Матеріали та методи. У дослідженні використано метод структурного моделювання рівнянь (SEM), що дозволило перевірити шість гіпотез щодо впливу окремих факторів на споживчу поведінку пацієнтів. Збір даних здійснювався за допомогою стандартизованих анкет 600 пацієнтів із тривало персистуючою формою фібриляції передсердь і подальшої багатофакторної обробки.

Результати. Підтверджено три з шести гіпотез, що вказує на складну взаємодію між параметрами якості, вартості та комфорту в прийнятті рішень. Для пацієнтів з тяжчими формами захворювань еластичність попиту за якістю стає визначальною, що свідчить про переорієнтацію пріоритетів із комфорту на якість, навіть за умови зростання витрат. Фактор інформаційного шуму виявився вагомим для розмежування моделей поведінки пацієнтів із різними рівнями патологій.

Висновки. Результати дослідження свідчать про адаптацію системи надання медичних послуг до нових еластичностей попиту в умовах ринку. Поведінка пацієнтів демонструє раціональну чутливість до якості та готовність поступитися комфортом і ціною заради покращення результатів лікування.

Ключові слова: **ефективність медичних послуг, фібриляція передсердь, теоретична модель, якість медичних послуг, комфорт пацієнта**

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