

Simulating the Need for Hospital Care for Circulatory Diseases

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ABSTRACT

Inpatient care requires far more resources than outpatient care. In this regard, prognosing its needs is a more important component of the resource management of health organizations and the health system as a whole. It is relevant to create demand models for strategic regional planning. The purpose of this article is to present simulating inpatient care need for diseases of the circulatory system, taking into account gender characteristics. The purpose of the research is simulating inpatient care need for circulatory diseases, taking into account gender characteristics. Data of 420000 patients were used (by 210 000 males and females). The analysis was carried out in relation to the days of inpatient treatment in 6 five-year old age groups: 31–35 years old, 36–40 years old, 41–45 years old, 46–50 years old, 51–55 years old, 56–60 years old. Regression analysis was performed to simulate age dynamics of need. The degree of predictor variables influence was evaluated by calculating the residual variance. A decrease in the level of hospital care need in men in older age groups is specific to diseases characterized by increased blood pressure (I10 – I15), while in relation to the causes associated with cerebrovascular diseases (I60 – I69) and coronary heart diseases (I20 – I25), the age dynamics of need is described by increasing power functions. In women, the dynamics of demanded volumes in medical care provided in inpatient conditions, in cerebrovascular diseases (I60 – I69), diseases characterized by increased blood pressure (I10 – I15) and coronary heart diseases (I20 – I25) is characterized by an upward trend throughout the studied age period, which can be described using power function. The mathematical analysis confirmed the paramount importance of age in hospital care need provided in inpatient conditions for circulatory diseases.

Keywords: hospital care, circulatory diseases, simulating inpatient care

1. INTRODUCTION

Increasing the impact of the health care system is an urgent task that can be solved with a systematic approach and adequate planning of the medical organizations work [1, 2]. One promising way to improve the healthcare planning system is to use data in the planning process to analyze the dependence on the frequency of medical care episodes, that is, its demanded volumes, on age and gender. The knowledge of the required resources avoids "resource crises" and knowledge of the age periods when the need increases, plans preventive measures aimed at reducing the consumption level of inpatient medical care. The demand model developing this approach allows calculations to be made using data on the age-gender

structure of the population. In the second stage, you can also use data on incidence levels [3–6].

Inpatient care requires far more resources than outpatient care. In this regard, forecasting its needs is a more important component of the resource management of health organizations and the health system as a whole. It is relevant to create the demand models for strategic regional planning [7–9].

2. MATERIALS AND METHODS

2.1 Materials

The International Classification of Diseases of the 10th edition (ICD-10) was used as the basic

$$\text{correlation ratio} = \sqrt{\frac{(D_{\text{total dispersion}} - D_{\text{rd}})}{D_{\text{td}}}} \quad (3)$$

The total dispersion value of D_{td} was calculated by the standard method.

If the correlation ratio value was higher than 0.7, then such a dependence was considered significant and the dependence of the demand value on the age of the patient was high. If the correlation ratio value was more than 0.9, the change in the value of the medical care need was almost completely determined by the patient's age. The difference between unit and correlation value was regarded as a proportion of the effect on the magnitude of the care need of other unaccounted factors.

3. RESULTS OF THE RESEARCH

3.1 Results of need simulations in males.

The largest amounts of inpatient care in males (first ranked) were for diseases characterized by high blood pressure (I10 – I15). The need dynamics was characterized by an increase level to the age of 55 years old. Growth rates were maximum in the 31–35 age group (29.5 % of annual demand growth) and minimum in the 51–55 age group (3.7 % of annual demand growth). In the age group of 56–60 years old, there was a decrease in the level by 0.8 % per year. Differences in the level of need in the age groups of 31–35 years old and 56–60 years old were 6.2 times.

Since there is a high probability of a further decrease in the need level with increasing age of a male, it is advisable to use a second-order parabola with a negative first coefficient as a modeling function. According to this model, the bed-day need can be expressed by the following formula:

$$V_{\text{inpatient (bed-day)}} = -19,73x^2 + 277,94x - 158,02 \quad (R^2=0,974) \quad (4)$$

(hereinafter x is the sequence number of the age interval)

The second ranking in terms of the sought-after inpatient medical care is occupied by a block of causes associated with cerebrovascular diseases (I60 – I69). The dynamics of inpatient care demand in males is characterized by an increase need throughout the studied age period. The highest growth rates are recorded in young age groups (37.9 % of annual demand growth), but despite the slowdown in growth, the difference between the age groups of 31–35 and 56–60 years old is 19 times, which is the highest for men. The levels of need achieved 1938 beds per 1000 of males of appropriate age seeking inpatient care are also maximum among the other blocks of causes of hospitalization. The described dynamics are modeled using a power function.

$$V_{\text{inpatient (bed-day)}} = 93,005x^{1,672} \quad (R^2=0,992) \quad (5)$$

The third rank in terms of the sought-after inpatient medical care is occupied by a block of causes associated with coronary heart diseases (I20 – I25). Demand dynamics are characterized by an increase in demand throughout the study age period. Unlike the previous blocks of causes, the highest growth rates are recorded in the age groups of 36–45 years old (27.6 and 19.4 % of the annual increase in demand). In older age groups, the rate of growth in inpatient care needs decreased, but the difference between the age groups of 31–35 and 56–60 is 17 times, and the level of demand achieved is 1,467 beds-days per 1,000 men of appropriate age seeking inpatient care. The described dynamics are modeled using a power function.

$$V_{\text{inpatient (bed-day)}} = 68,204x^{1,68} \quad (R^2=0,972) \quad (6)$$

Characteristics of mathematical models of intensity dynamics of medical care consumption provided in inpatient conditions in males are presented in Table 1.

Table 1. Characteristics of mathematical models of intensity dynamics of medical care consumption (duration of inpatient treatment) provided in inpatient conditions in males (duration of inpatient treatment in bed days)

Modeling state	Formula	$\sum \varepsilon^2$	D_{oct}	σ_{oct}	D_y	The share of influence of the test feature (age)	The share of random fluctuations of the resulting quantity
block I10 – I15	$Y = -19.73x^2 + 277.94x - 158.02$	9501.0	1900.2	43.59	73244.9	0.986	0.014
block I60 – I69	$Y = 93.005x^{1.672}$	24534.8	4906.98	70.04	513569.8	0.995	0.005
block I20 – I25	$Y = 68.204x^{1.68}$	26668.3	5333.7	73.03	306717.9	0.991	0.009

3.2 Results of need simulations in females

The largest amounts of inpatient care in women, as well as in men (first ranked), were in demand for diseases characterized by high blood pressure (I10 – I15). The dynamics are characterized by an increase

level of need throughout the study age period of a woman's life. The largest increases are recorded in younger age groups. The annual growth rate of demand in the age group of 36–40 years old was 48.8 %. Such high rates are due to the "low base" of initial values, which suggests that it is young age that is critical for

starting preventive measures of this type of pathology in women. In older age groups of women, the rate of increase in demand has gradually decreased to a minimum of 3.3 % in the 56–60 age group. Differences in the level of need in the age groups of 31–35 years old and 56–60 years old are 22.2 times.

The described dynamics are modeled using a power function.

$$V_{\text{inpatient (bed-day)}} = 40,248x^{1.868} \quad (R^2=0,996) \quad (7)$$

The dynamics of hospitalization cases of females for cerebral vessel diseases (I60 – I69) was also characterized by an upward trend throughout the age period. The maximum rate is recorded in the young age group (31–35 years old) and accounts 59 % of the annual increase in demand. In older age groups of women, the growth rate decreases to a minimum 8.8 % of the annual increase over the age of 50. During the 30-year age period, the demand for outpatient visits has increased 39 times.

The described dynamics are modeled using a power function.

$$V_{\text{inpatient (bed-day)}} = 45,914x^{2.1} \quad (R^2=0,997) \quad (8)$$

The largest gradient of growth in inpatient care need was recorded for coronary heart diseases (block I20 – I25) as a cause for hospitalization. During the studied age period, the volume of sought-after medical care increased 140 times, which is significantly more than in other analyzed conditions. The greatest growth rate of demand was observed in the age group of 40–45 years old, after which the level of growth stabilized, but remained very significant. It is advisable to consider the age of 35 years old as a critical age. It should be noted that the highest value of the degree indicator among the models of all other causes for hospitalization is 2.84. This determines a significant increase in demand with an increase in the age of the woman.

The described dynamics are also modeled using a power function.

$$V_{\text{inpatient (bed-day)}} = 2,554x^{2.865} \quad (R^2=0,98) \quad (9)$$

Summary characteristics of mathematical models of intensity dynamics of medical care consumption provided in inpatient conditions in females are presented in Table 2.

Table 2. Characteristics of mathematical models of the dynamics of the intensity of consumption of medical care provided in inpatient conditions in females for diseases characterized by high blood pressure (block I10 – I15)

Modeling state	Formula	$\sum \varepsilon^2$	D_{OCT}	σ_{OCT}	D_y	The share of influence of the test feature (age)	The share of random fluctuations of the resulting quantity
block I10 – I15	$Y=40.248x^{1.868}$	2437.8	4947.5	70.3	151409.7	0.984	0.016
block I60 – I69	$Y=45.914x^{2.1}$	2821.6	564.3	23.8	537920.5	0.999	0.001
block I20 – I25	$Y=2.554x^{2.865}$	64.5	12.9	3.59	410.5	0.984	0.016

4. CONCLUSION

The analysis of the age-related dynamics of inpatient care needs to conditions determining the baseline of need showed that, regardless of cause and gender, the volume of inpatient care provided recorded an increasing trend to the volume of need. However, analysis of individual cause groups allows forming a differentiated approach to planning. In males, one of three cause groups defining the baseline demand value can be simulated using second-order parabolas with a negative first coefficient. This choice of function is due to lower requirements for older age groups. This is typical for diseases characterized by high blood pressure (I10 – I15). With regard to the causes of cerebrovascular diseases (I60 – I69) and coronary heart diseases (I20 – I25), the age dynamics of need is described by power functions, which is determined by the constant increase in need throughout the study period.

In females, the baseline need for inpatient care is also determined by three groups of causes. The dynamics of demanded volumes in medical care provided in stationary

conditions, in cerebrovascular diseases [cerebral vessel disease] (I60 – I69), diseases characterized by high blood pressure (I10 – I15) and coronary heart diseases (I20 – I25) is characterized by an upward trend throughout the studied age period, which can be described by power function. For all these conditions, the use of the same functions and similarity of the values of the degree indicator in the simulating process confirms the presence of common mechanisms and factors underlying the need for outpatient and inpatient medical care.

The mathematical analysis confirmed the paramount importance of age for medical care need provided in inpatient conditions for diseases of the circulatory system. The revealed patterns should be taken into account when planning the necessary amounts of inpatient medical care, including the age-gender characteristics of the territory where planning is carried out.

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