

# The primary hyperparathyroidism and its complications: Substantiation of funding volume for hospital pharmacotherapy

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## ABSTRACT

This study investigates factors influencing the cost of pharmacotherapy for primary hyperparathyroidism (PHPT) in a hospital setting to optimize therapeutic strategies and rationalize financing. The study was conducted from 2020 to 2023 and included 200 patients with PHPT from two hospitals in Moscow, Russia. The key aspects for analysis were demographic profiles, treatment methods, complications, and associated costs. The majority of patients (52.1%) were aged 60-74 years, while only 2.0% were aged 75 or older. The most frequently prescribed medications were cardiovascular drugs (33.5%) and vitamin supplements (25.1%). Colecalciferol (13.5%), bisoprolol (6.8%), and cinacalcet (4.9%) were the most common individual medications. The study revealed that the cost of conservative treatment without complications was twice that of surgical treatment. These models can aid in justifying and optimizing PHPT treatment financing in hospital settings. The findings highlight the importance of individualized treatment approaches and cost optimization strategies.

**Keywords:** primary hyperparathyroidism, pharmacoeconomics, hospital costs, medication management

## INTRODUCTION

### Overview of Primary Hyperparathyroidism

Primary hyperparathyroidism (PHPT) is a condition where the parathyroid glands produce an excessive amount of parathyroid hormone (PTH), which regulates calcium and phosphate levels in the body [1]. Excess PTH disrupts bone metabolism and blood mineral levels [2].

### Causes

The most common cause of PHPT is benign tumors (adenomas) in the parathyroid glands [3]. These tumors stimulate excessive PTH secretion [4]. Other causes include hyperplasia of the parathyroid glands or, less frequently, malignant tumors [5, 6]. According to the National Institutes of Health, PHPT occurs in approximately 1-2 cases per 1,000 individuals annually [7].

### Symptoms

PHPT can lead to various symptoms and complications affecting multiple organs. Common symptoms include bone pain, fatigue, and depression. Severe complications include osteoporosis, nephrolithiasis (kidney stones), and cardiovascular issues [8, 9]. This condition significantly

deteriorates the quality of life and increases the risk of disability and premature death [10].

### Epidemiology

Studies have shown that PHPT predominantly affects women, with a female-to-male ratio of approximately 3-4:1 [2, 11]. A study in Scotland confirmed this, finding that 72.3% of PHPT patients are women [12]. In our study, women accounted for 82.0% of PHPT cases, with a female-to-male ratio of 4.6:1.

### Age and Gender Distribution

PHPT typically occurs in older individuals, with the average age at diagnosis ranging from 54 to 59 years [11, 13]. The prevalence of PHPT is higher in women, especially those over 50 years old, while gender differences are minimal among younger patients [2, 11, 12]. This age and gender distribution is crucial for clinical assessment and diagnosis of PHPT.

### Diagnosis

The introduction of automated biochemical analyzers and routine calcium level checks has improved the detection of PHPT, especially mild forms with subtle symptoms [14, 15]. The prevalence of PHPT has increased due to better diagnostic practices, with peaks in incidence in 1974 and 1998 [11, 12]. Currently, PHPT affects about 0.3% of the general population,

accounting for 21.6 cases per 100,000 people, and is found in 1-3% of postmenopausal women [12].

### Treatment

Treatment strategies for PHPT depend on the severity of symptoms and the presence of complications [16, 17]. Options include both conservative and surgical approaches. Conservative therapy is used for mild forms of PHPT or when surgery is contraindicated [18, 19]. Key medications for PHPT include antiresorptive agents, calcimimetics, and estrogens [20, 21].

### Economic Impact

The cost of treating PHPT varies significantly. Studies show that the cost of conservative treatment can be higher than surgical treatment, particularly in patients with complications like osteoporosis [22, 23]. For example, the cost of conservative treatment in patients with osteoporosis is nearly nine times higher than the cost of surgical treatment [24, 25]. These costs are influenced by factors such as age, presence of complications, and duration of hospitalization.

According to an extensive analytical study, a delay in the diagnosis and treatment of PHPT leads to significant medical and economic consequences, increasing the cost of medical care. In order to prevent such cases, systematic interventions are required to ensure timely diagnosis and treatment of PHPT [26]. Another study [27] compares two preoperative imaging modalities for patients with PHPT: the use of 18F-fluorocholine PET/CT as a “one-stop-shop” approach and the current practice, which involves using 18F-fluorocholine PET/CT only after an initial negative or equivocal result of Technetium-99m methoxy isobutyl isonitrile SPECT/CT. The evaluation found that both approaches have similar long-term clinical outcomes and costs. For the “one-stop-shop” strategy to be cost-effective, the cost of 18F-fluorocholine PET/CT must be \$885.

The study [28] concludes that the choice of imaging modality depends on available resources and the patient's preference. The study evaluates the cost-effectiveness of different preoperative imaging techniques in patients with PHPT in the United States. Four imaging modalities were used: positron emission tomography with 18F-fluorocholine (PET-18F), four-dimensional computed tomography (4D CT), medical ultrasound, and the sestamibi SPECT/CT test. PET-18F showed the highest quality-adjusted life years (QALYs)–23.9, but it was also the most expensive modality (\$11,245 per patient). However, its cost per QALY (\$91,066) was below the willingness-to-pay threshold of \$100,000. The analysis suggests that PET-18F may be a cost-effective imaging option for PHPT in the US under certain circumstances.

The study in [29] discusses the cost-effectiveness of various imaging modalities and standard bilateral neck exploration (BNE), in the treatment of non-localized PHPT. The findings indicated that BNE has a cost of \$9,578 and a success rate of 97.3%. Combining SPECT with minimally invasive parathyroidectomy (MIP) results in a cost of \$8,197 and a success rate of 98.6%, while SPECT/CT along with MIP entails a cost of \$8,271 with a success rate of 98.9%. The four-dimensional CT (4D-CT) technique, when coupled with MIP, costs \$8,146 and achieves 99% success rate. This analysis revealed that the use of advanced imaging techniques leads to substantial cost savings compared to conventional BNE. These savings increase with enhanced imaging accuracy and reduced

costs. Additionally, extending the duration of BNE or shortening the time of MIP can further reduce expenses.

### Conclusion

PHPT is a prevalent condition that significantly impacts patients' quality of life and healthcare costs. Improved diagnostic techniques and understanding of the disease's epidemiology are crucial for effective management and treatment. The development of mathematical models to predict treatment costs can help justify funding and optimize patient care.

This study aims to investigate the comprehensive aspects of PHPT to optimize treatment strategies and rational financing of hospital pharmacotherapy.

### Research Objectives

1. Age and gender characteristics in PHPT:
  - a. Evaluate the prevalence of PHPT cases by age group.
  - b. Investigate gender characteristics of PHPT and identify any predominance in specific patient groups.
2. Analysis of hospital stay duration and factors influencing treatment costs:
  - a. Measure the average length of hospital stay for patients with PHPT.
  - b. Identify factors influencing the duration of hospitalization.
  - c. Calculate the total cost of hospital pharmacotherapy for PHPT.
  - d. Compare the costs of conservative versus surgical treatments.
3. Analysis of complications and their co-occurrence:
  - a. Determine the frequency of various complications associated with PHPT.
  - b. Investigate the relationship and co-occurrence of these complications in patients.
4. Medical-social profile of PHPT patients:
  - a. Construct a medical-social profile of patients, including factors such as age, gender, and comorbidities.
  - b. Assess how medical-social factors influence the nature and management of the disease.
5. Medication prescription patterns:
  - a. Study the frequency of prescribing different medications in PHPT treatment.
  - b. Identify the most commonly used medications for PHPT.
6. Development of cost prediction models:
  - a. Investigate how factors like age, presence of complications, and length of hospitalization affect the cost of PHPT treatment.
  - b. Develop mathematical models to predict the cost of PHPT pharmacotherapy based on these factors.

## METHODS AND MATERIALS

### Patients and Selection

The study was conducted from 2020 to 2023 in Moscow, Russia. Two hundred patients with a confirmed diagnosis of PHPT participated in the study. Participants were selected from two medical institutions—the Federal State Budgetary Institution “National Medical Research Center of Endocrinology” of the Ministry of Health of the Russian Federation and Republican Hospital named after Kuvatov, to enhance the representativeness of the sample. The diagnosis was made on the basis of the patients’ medical history. Clinical findings and laboratory tests conducted by the physicians confirmed the diagnosis.

### Study Design

The study was conducted in a multidisciplinary hospital over a specified period of three years. Patients suffering from PHPT and its complications were included in the study.

The study involved an extensive sample of 200 patients, representing various age groups and genders. To evaluate different aspects of PHPT, including the cost of hospital pharmacotherapy, patients were divided into groups with complications such as osteoporosis, and bilateral nephrolithiasis, and those without complications.

Various therapeutic strategies were applied to patients within the study, including pharmacological treatment and preparation for surgical intervention. Pharmacotherapy was conducted using medications from different pharmacological groups.

Key parameters, such as age, gender, presence of complications, duration of hospitalization, and cost of pharmacotherapy, were meticulously recorded and subjected to further statistical analysis.

### Research Methods

To obtain data on the characteristics of PHPT and its treatment, a multidimensional research approach was employed. Clinical data covering a large number of patients diagnosed with PHPT were utilized in the study.

At the outset of the research, data collection regarding patients’ age, gender, and presence of complications upon hospital admission was conducted. This involved the review of medical records and other clinical documents. To analyze the age and gender characteristics in the distribution of PHPT, patients were classified into age groups, and differences in distribution by gender were identified. These data were analyzed using statistical methods.

The analysis of hospital stay duration based on age relied on data on the number of bed days for each age group. This aspect necessitated the comparison of hospital stay duration data with the types of treatment administered. To study complications and their occurrence, an analysis of data on the presence of complications among patients upon admission and their subsequent development was conducted. The study involved the classification of complications and the determination of their frequency.

The data collection on pharmacotherapy involved the analysis of patient medical records documenting treatment courses for PHPT and its complications in hospitals. These data were utilized to determine the frequency of prescriptions for various groups of medications. The methods of data collection

encompassed clinical histories, laboratory results, pharmacy invoices, as well as patient questionnaire data, thereby facilitating a comprehensive analysis of PHPT characteristics and treatment profiles.

The examination of the gender distribution among PHPT patients revealed that the overwhelming majority (82.0%) were female, with a female-to-male ratio of 4.6:1.

The proportion of patients by age initially increases by more than 1.5 times from 17.0% (in the age group of 18 to 44 years) to 28.9% in the group aged 45 to 59 years and reaches its highest value—more than half (52.1%) in the age group of 60 to 74 years, then sharply decreases to 2.0% in the oldest age group (75 years and older). According to the study results, the average age of patients with PHPT was 58 years.

Patients undergoing surgical treatment underwent parathyroidectomy—surgical removal of the parathyroid glands. This procedure included the localization of affected glands, intraoperative monitoring of PTH levels to confirm the completeness of removal of affected tissues, as well as subsequent monitoring of calcium levels in the postoperative period.

The study on the cost of hospital pharmacotherapy for PHPT included three groups of patients: those with complications such as osteoporosis, and bilateral nephrolithiasis, and those without complications. For the analysis of the cost of various therapeutic approaches, two groups of patients were identified: those preparing for surgical treatment pharmacologically and those undergoing pharmacological treatment due to the impossibility of surgical intervention.

### Statistical Analysis

The cost evaluation was conducted considering statistical analysis, allowing for identifying relationships between treatment methods, the presence of complications, and expenses. Microsoft Excel 2016 statistical analysis package (Microsoft, USA) was utilized in the study.

The study employed linear regression analysis to examine the dependencies between the cost of hospital pharmacotherapy for PHPT and various factors such as patient age, presence of complications, and duration of hospitalization.

Initially, factors potentially influencing the cost of pharmacotherapy were selected. In this case, three key factors were chosen: patient age, presence of complications, and duration of treatment (expressed in bed days).

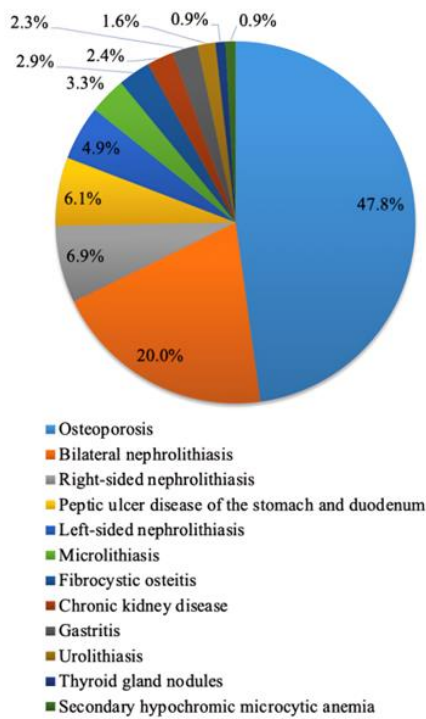
Mathematical models describing the relationship between pharmacotherapy cost and selected factors were constructed using the linear regression method. Regression equations included coefficients estimated based on the provided data.

Additionally, factors influencing the cost of hospital pharmacotherapy for PHPT were identified. These included patient age, presence of complications, and duration of treatment (expressed in bed days).

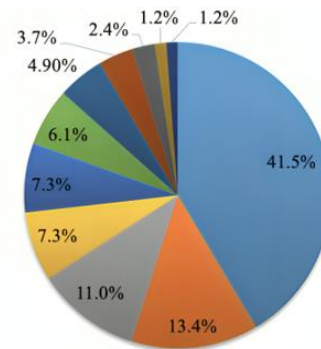
## RESULTS

### Age and Gender Characteristics in the Distribution of PHPT

It has been established that with the increase in patient age, the likelihood of surgical treatment increases, leading to a reduction in the number of patients in the future requiring



**Figure 1.** Structure of complications in patients with PHPT by nosologies (Source: Authors' own elaboration)



- Osteoporosis + Bilateral nephrolithiasis
- Osteoporosis + Left-sided nephrolithiasis
- Osteoporosis + Peptic ulcer disease of the stomach and duodenum
- Osteoporosis + Microlithiasis
- Osteoporosis + Chronic kidney disease
- Osteoporosis + Right-sided nephrolithiasis
- Bilateral nephrolithiasis + Chronic kidney disease
- Gastritis + Peptic ulcer disease of the stomach and duodenum
- Osteoporosis + Bilateral nephrolithiasis + Fibrocystic arthritis + Microlithiasis
- Microlithiasis + Urolithiasis
- Osteoporosis + Microlithiasis + Chronic kidney disease

**Figure 2.** Structure of complication combinations by nosology in patients with PHPT (Source: Authors' own elaboration)

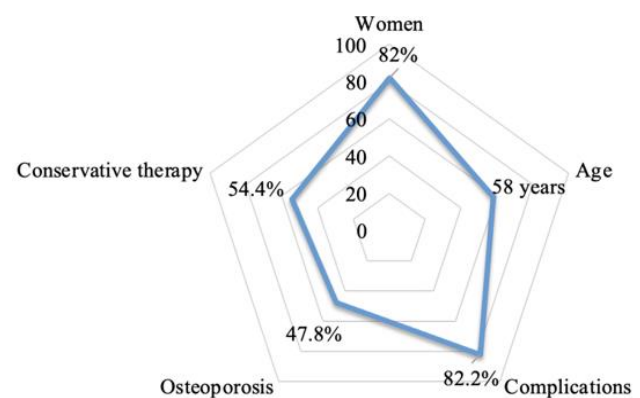
pharmacotherapy for PHPT. Thus, in the age group of 18 to 44 years, 20.6% of PHPT patients received surgical treatment, in the age group of 45 to 59 years—25.0%, in the next group (60 to 74 years) nearly 1.5 times more—36.8%, and in the oldest group (75 years and older), all patients (100%) underwent surgical treatment. On average, 45.6% of PHPT patients received surgical treatment, while 54.4% were solely on conservative therapy.

It has been observed that the number of affected women and men aged 18 to 44 years is close and differs by less than 2 times (62.9% and 37.1%, respectively), in age groups from 45 to 59 years and from 60 to 74 years, the proportion of female patients sharply increases by more than 1.5 times (94.5% and 97.0%, respectively), and in the oldest age group (75 years and older), female patients account for 100%.

**Analysis of Hospital Stay Duration**

The analysis of the average number of bed days for patients with this pathology depending on age showed that the highest number of bed days (8.9 days) in the hospital is spent by patients aged 18 to 44 years. This is because patients in this age group undergo combined therapy in the form of pharmacotherapy before preparing for surgical treatment. Patients aged 45 to 59 years and 60 to 74 years spend a similar number of days in the hospital (7.3 and 7.1, respectively), as patients in these age groups predominantly receive conservative treatment. The minimum number of days (6.5 days) in hospital stays is observed in patients aged 75 years and older, as they predominantly undergo surgical treatment. The obtained data are consistent with the results of the analysis regarding the relationship between the increase in the number of operated patients and age.

As the analysis showed, 82.2% of patients had complications upon admission. The remaining 17.8% of patients had a confirmed diagnosis of PHPT without complications.



**Figure 3.** Medical-demographic portrait of patients with PHPT (Source: Authors' own elaboration)

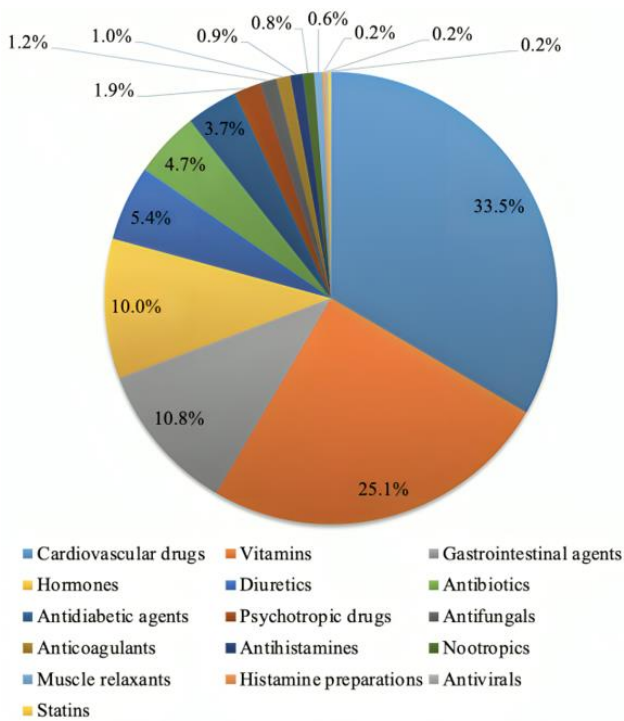
**Analysis of Complication Frequency and Their Co-Occurrence**

Distribution of patients with PHPT by complications (Figure 1) allowed us to determine that the highest proportion is occupied by complications such as osteoporosis and bilateral nephrolithiasis, while peptic ulcer disease of the duodenum and stomach are less common, and the rarest complications of PHPT are parathyroid adenoma and secondary hypochromic microcytic anemia.

The results of the analysis of combinations of complications in patients with PHPT are shown in Figure 2.

In more than one-third of cases, a combination of osteoporosis and bilateral nephrolithiasis is encountered. The next most common combinations of complications are osteoporosis with left-sided nephrolithiasis, as well as osteoporosis with peptic ulcer disease of the stomach and duodenum.

The medical and social profile of patients with PHPT is shown in Figure 3.



**Figure 4.** Structure of prescriptions of medicinal preparations by pharmacotherapeutic groups for the therapy of PHPT in the hospital (Source: Authors' own elaboration)

The typical patient with PHPT is often a 58-year-old woman, with complications of PHPT in the majority of cases, most commonly osteoporosis, and typically undergoing conservative treatment (Figure 3). The frequency of prescription medications (PM) is depicted in Figure 4, illustrating the analysis of PM prescriptions for PHPT hospital therapy.

In total, 16 pharmacotherapeutic groups (PTGs) of medications are used for the treatment of PHPT and its complications in the hospital setting. Among these, cardiovascular medications and vitamin preparations are the most frequently prescribed, while histamine antagonists, antiviral drugs, and statins are used less frequently. This pattern is attributed to the structure of complications of PHPT according to specific nosologies (see Figure 4).

Based on the analysis of the overall prescription structure for individual medications, the most commonly prescribed medications for the treatment of PHPT and its complications have been identified (see Table 1).

In the overall prescription structure, the most frequently prescribed medication is colecalciferol from the group of vitamin preparations, with bisoprolol from the group of cardiovascular drugs and cinacalcet from the group of hormonal medications ranking second and third, respectively (Table 1).

A comparative analysis of the data from Figure 4 and Table 1 indicates that cardiovascular drugs are the most frequently prescribed PTG, while colecalciferol from the group of vitamin preparations tops the list of individual medication prescriptions. Bisoprolol from the group of cardiovascular drugs ranks second in the individual medication prescription ranking. A similar pattern is observed for gastrointestinal drugs: these drugs rank second in the prescription structure by PTGs, while omeprazole from this group occupies only the

**Table 1.** Ranking of medications for the treatment of PHPT and its complications by prescription frequency

Rank	Medication name	PTG	PF (%)
1	Cholecalciferol	Vitamins	13.5
2	Bisoprolol	Cardiovascular drugs	6.8
3	Cinacalcet	Hormones	4.9
4	Omeprazole	Gastrointestinal drugs	4.2
5	Levofloxacin	Antibiotics	2.2
6	Metformin	Antidiabetic drugs	2.1
7	Spironolactone	Diuretics	1.5
8	Cholecalciferol	Nootropics	0.7
9	Tolperisone	Muscle relaxants	0.6
10	Fluconazole	Antifungals	0.4
11	Warfarin	Anticoagulants	0.3
12	Chloropyramide	Antihistamines	0.3
13	Bromdihydrochlorophenyl-	Psychotropic drugs	0.3
14	Benzodiazepam	Histamine preparations	0.14
15	Vestibo	Antivirals	0.14
16	Umifenovir	Statins	0.14

Note. PF: Prescription frequency

fourth position in the individual medication prescription ranking. Consistency between the group and individual prescription rankings is observed for less frequently prescribed medications: umifenovir and rosuvastatin.

More than half (59.0%) of the medications prescribed for inpatient treatment of PHPT, and its complications belong to essential and vital medicinal products (EVMs). It is worth noting that 41.0% of the medications used for inpatient treatment of PHPT and its complications do not fall under the category of EVMs.

The top two positions in the structure of PHPT complications requiring the largest volume of pharmacotherapy are occupied by osteoporosis and bilateral nephrolithiasis (47.8% and 20.0%, respectively), with the third most numerous group being patients with PHPT without complications (17.8%).

#### Cost of Inpatient Pharmacotherapy for PHPT

To further investigate the cost of inpatient pharmacotherapy for PHPT, three groups of patients were selected: those with complications such as osteoporosis, those with bilateral nephrolithiasis, and patients with PHPT without complications. In accordance with the pharmacotherapy administered for PHPT and its complications, all patients were divided into 2 therapeutic groups: patients undergoing preparation for surgical treatment through pharmacotherapy and patients undergoing medical treatment due to the impossibility of radical surgical intervention.

The cost of conservative treatment is higher than the cost of surgical treatment for patients in all three groups. Thus, the cost of surgical treatment for patients without complications is more than twice lower than the cost of conservative treatment (Table 2). It has been established that the cost of conservative treatment for patients with osteoporosis is nearly 9 times higher than the cost of surgical treatment. Meanwhile, for patients with bilateral nephrolithiasis, the cost of conservative and surgical treatment differs slightly. These dependencies are determined by the pathogenesis of PHPT and its complications, as well as the approaches to their therapy.

Thus, it can be concluded that the cost of pharmacotherapy depends on the treatment method (conservative or surgical)

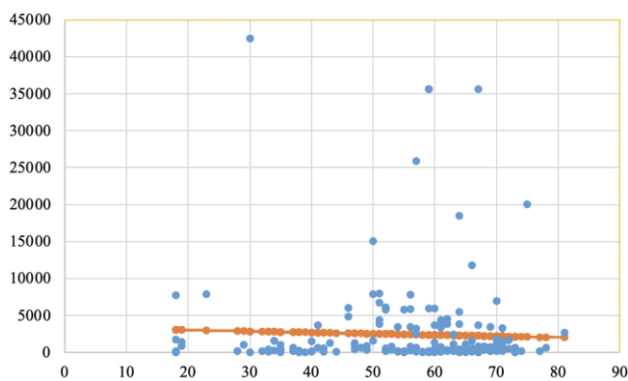
**Table 2.** Average cost of inpatient pharmacotherapy for patients with PHPT and its complications

Treatment type and presence of complications					
Conservative treatment			Surgical treatment		
Osteoporosis	Bilateral nephrolithiasis	Without complications	Osteoporosis	Bilateral nephrolithiasis	Without complications
8,701.1 rubles (97.61 dollars)	1,907.5 rubles (21.40 dollars)	772.7 rubles (8.66 dollars)	971.8 rubles (10.89 dollars)	1,526.5 rubles (17.12 dollars)	353.2 rubles (3.96 dollars)

Note. \*1 USD = 88.5 RUB

**Table 3.** Mathematical models predicting the cost of hospital pharmacotherapy for PHPT

Factors (X)	Regression equations
Font size	Max. 8
Patient age (years)	$Y = 3,359.343 + -16.71X$
Duration of hospitalization (days)	$Y = 8,076.520 + -96.36X$

**Figure 5.** Graph depicting the dependence of pharmacotherapy cost for patients with primary hyperparathyroidism on age (Source: Authors' own elaboration)

and the severity of the disease at the time of hospitalization (presence of accompanying complications).

#### Factors Influencing the Cost of Pharmacotherapy for PHPT

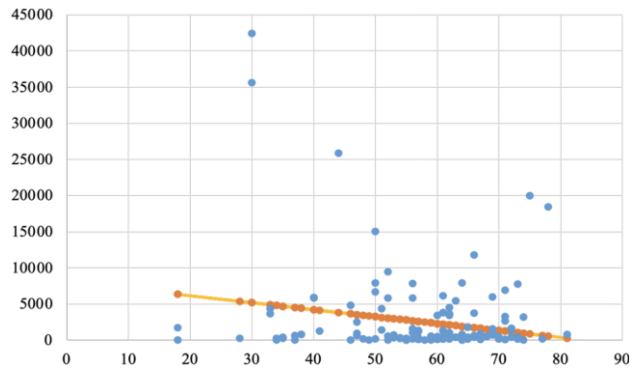
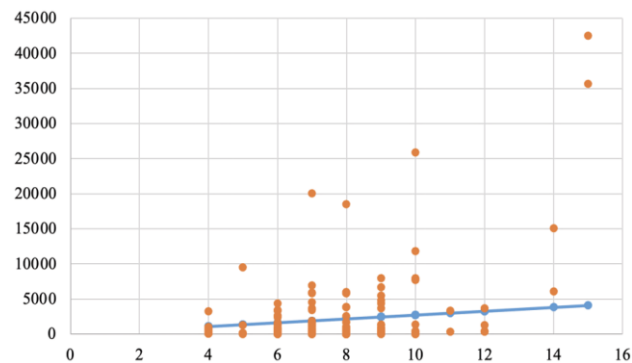
Based on a critical analysis of the results of this study, factors influencing the cost of pharmacotherapy for PHPT and its complications in a hospital setting were selected: the age of PHPT patients; the presence of PHPT complications (cost of complication treatment); duration of treatment (number of hospitalization days).

Considering the selected factors, mathematical prediction models for the cost of hospital pharmacotherapy for PHPT were constructed using the linear regression method based on correlation regression analysis (Table 3).

With the increasing age of patients, its influence on the cost of pharmacotherapy for PHPT main disease weakens, while the highest expenses for pharmacotherapy are noted for patients in the age group from 60 to 74 years (Figure 5).

As patients' age increases, its influence on the cost of pharmacotherapy for PHPT and its complications diminishes (Figure 6).

With an increase in the duration of hospitalization, the cost of pharmacotherapy for PHPT increases (Figure 7). Thus, based on the conducted correlation-regression analysis of the relationship between the cost of PHPT pharmacotherapy and the main factors (patient age, duration of hospitalization, and cost of treating PHPT complications), mathematical models for predicting the cost of hospital pharmacotherapy for PHPT have

**Figure 6.** Graph depicting the relationship between the cost of pharmacotherapy for patients with primary hyperparathyroidism and its complications, and age (Source: Authors' own elaboration)**Figure 7.** Graph depicting the relationship between the cost of pharmacotherapy for patients with primary hyperparathyroidism and the duration of hospitalization (number of bed-days) (Source: Authors' own elaboration)

been obtained. These mathematical models can be used to justify the funding volume for the pharmacotherapy of this condition in hospital settings.

## DISCUSSION

The study identified key features and trends in the management of patients with PHPT. It was found that this condition primarily affects women, particularly in the age range between 60 and 74 years. As patients age, there is an increased likelihood of surgical intervention, which becomes more prevalent in patients over the age of 75. Complications such as osteoporosis and bilateral nephrolithiasis occur in a substantial proportion of patients, significantly influencing the choice of treatment approach. The analysis of pharmacotherapy revealed frequent uses of cardiovascular drugs and vitamin supplements in patients with PHPT. The economic aspect of treatment is also significant, as

conservative treatment without complications is significantly more expensive than surgery, particularly in cases with complications. These findings underscore the importance of an individualized treatment approach for PHPT patients and the need to optimize therapy costs based on each patient's specific clinical case.

### Gender Differences in PHPT

Studies have consistently shown that PHPT affects women more frequently than men, with a ratio of 3-4:1 [2, 11, 12, 30]. In our study, women represented 82.0% of patients, with a female-to-male ratio of 4.6:1. This gender disparity is further corroborated by other studies indicating that the incidence of PHPT among women is approximately three times higher than in men [15, 31].

### Age and Treatment Methods

PHPT is more common in individuals over 50 years of age, with the incidence increasing to 2% or more [13]. The average age of diagnosis is typically between 54 and 59 years [11], which aligns with our study's findings of an average age of 58 years. As patients age, the likelihood of undergoing surgical treatment increases, reaching 100% for those over 75 years [2]. Our findings confirm this trend, with a notable increase in surgical interventions among older patients.

### Complications

Complications such as osteoporosis and nephrolithiasis are prevalent in PHPT patients, occurring in 47.8% and 20.0% of cases, respectively [32]. Our study supports these findings, showing that these conditions frequently accompany PHPT. A co-occurrence of osteoporosis and nephrolithiasis was found in 41.5% of patients.

### Treatment Approaches

Treatment of PHPT includes both surgical and conservative methods. Our study indicates that 45.6% of patients underwent surgical intervention, while 54.4% received conservative treatment. Conservative therapy is often used for mild forms of PHPT or when surgery is contraindicated or declined [33, 34]. Commonly prescribed medications include cardiovascular drugs (33.5%) and vitamin supplements (25.1%), with colecalciferol, bisoprolol, and cinacalcet being the most frequently used [35].

### Pharmacological Treatment

Pharmacological management of PHPT may involve various drugs, including antiresorptive agents, calcimimetics, and estrogens [20, 21]. Calcimimetics are widely used for preparing patients for surgical intervention and treating inoperable elderly patients [36, 37].

### Economic Aspects

The cost of PHPT treatment varies significantly between conservative and surgical methods. Surgical treatment without complications costs approximately 353.2 rubles, while conservative treatment costs 773 rubles. The cost of conservative treatment increases substantially in cases with osteoporosis, reaching 8701.1 rubles compared to 971.8 rubles for surgical treatment. In patients with bilateral nephrolithiasis, the cost difference between conservative and surgical treatment is minor [38-43].

## CONCLUSIONS

Today, the management of patients with PHPT is guided by the severity of their clinical manifestations, presence of complications, and chosen treatment approach. In this study, the majority of PHPT patients were women, particularly those aged 60-74 years. The incidence of the condition is highest in this age group. As patients age, the likelihood of undergoing surgery increases, particularly for those over 75 years of age, who also tend to spend less time in hospital-based treatment.

Most patients experience complications, with osteoporosis and bilateral nephrolithiasis being the most common. Treatment options vary depending on the individual patient's circumstances and may include both conservative and surgical approaches. The specific treatment method and associated costs depend on the presence or absence of complications, as well as the duration of hospitalization. Pharmacological treatment for PHPT typically involves the use of medications from various classes, with frequent prescriptions for cardiovascular drugs and vitamin supplements. Conservative treatment without complications is generally more expensive than surgery, particularly in cases where complications such as osteoporosis are present. Based on these factors, we constructed mathematical models to forecast the cost of hospital pharmacotherapy for PHPT. Using linear regression and correlation-regression analysis, we obtained the following regression equations:

Cost of pharmacotherapy ( $Y$ ) depending on patients' age ( $X$ ):

$$Y = 3,359.343 - 16.71X. \quad (1)$$

Cost of pharmacotherapy ( $Y$ ) depending on duration of hospitalization ( $X$ ):

$$Y = 8,076.520 - 96.36X. \quad (2)$$

Cost of pharmacotherapy ( $Y$ ) depending on the cost of treating PHPT complications ( $X$ ):

$$Y = -3,525.500 - 272.73X. \quad (3)$$

These equations provide a tool for predicting the expenses of treating PHPT and justifying funding for pharmacotherapy in a hospital setting.

### Study Strengths

The research was conducted at the I. M. Sechenov First Moscow State Medical University and encompassed a substantial volume of data. This study could serve as a foundation for further research aimed at optimizing the prediction of the cost of hospital therapy for PHPT.

### Study Limitations

The present study is constrained by the time frame from 2020 to 2023. The research is based on data from two hospitals, which complicates the generalization of results to a broader population. There is a possibility of insufficient representation of the research group. Some important factors influencing the development and treatment of PHPT may have been missed within the study, potentially limiting the comprehensiveness and accuracy of the analysis. Data on pharmacotherapy gathered from a limited number of sources provide an

inadequate representation of the variety of medications used, which could affect the completeness of treatment effectiveness assessment.

**Author contributions:** **OZ & AL:** project administration; **OZ:** conceptualization; **AL & OK:** writing–review & editing; **AL:** data curation; **YG & OK:** visualization; **YG:** formal analysis; **OK:** funding acquisition; **ZM, LG, & MB:** methodology and writing–original draft. All authors have agreed with the results and conclusions.

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**Declaration of interest:** No conflict of interest is declared by the authors.

**Data sharing statement:** Data supporting the findings and conclusions are available upon request from the corresponding author.

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