



# Medical Equipment Cost Assessment in the Conditions of Intensive Technological Changes

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**Abstract:** *The purpose of the article is to consider the theoretical and methodological foundations of equipment assessment, in particular, the features of medical equipment assessment. The novelty of the study is associated with the fact that equipment assessment is considered by researchers, as a rule, as a stage in assessing the value of an industrial enterprise, that is, to a greater extent, production equipment is considered. Given the rapid development of biomedical engineering, the novelty of the study is related to the consideration of the features of medical equipment assessment. The article substantiates the relevance of medical equipment assessment and analyzes the use of different approaches to medical equipment assessment. Based on the analysis of scientific literature and expert survey, the characteristics of different approaches to medical equipment assessment are presented; cost factors, as well as advantages and disadvantages of various assessment methods, are indicated.*

**Keywords:** *medical equipment, equipment cost, equipment cost assessment, approaches to equipment cost assessment, equipment cost assessment methods.*

## I. INTRODUCTION

The modern development of the economy, science and technology indicates the need to use new theoretical approaches and applied tools that ensure effective adaptation of subjects to the dynamic market environment. Determining the value of both business entities and individual objects allows entering successful transactions in the market and carrying out effective activities.

Equipment, being an integral part of movable property, has several features that must be considered when determining its value. These features differ, depending on the application. In particular, the assessment of medical equipment is an important component of the market entities management and one of the aspects of providing medical services of appropriate quality and cost, which requires further research

and deepening of the theoretical and applied aspects of determining the cost of medical equipment.

## II. LITERATURE REVIEW

Among authors considering the assessment of these objects, it is necessary to note such researchers as A.N. Asaul [1], N.V. Veig [2], A.N. Reneva [3], etc. Issues of the purposes of the assessment and classification of equipment [4], types of its depreciation and ways of its calculation and compensation [5], methods of cost assessment of machines and equipment and their restoration, as well as the increase of efficiency of use have been considered.

Despite the thorough study, the proposed methods of assessment of existing machinery and equipment are controversial and have certain drawbacks. Some methods are too labor-intensive while some are insufficiently substantiated or are based on conditional and subjective indicators. Moreover, the vast majority of existing methods are designed to assess a fairly simple universal equipment and do not provide correct results in the case of assessing the cost of specialized equipment, especially specialized medical equipment.

According to V.N. Baranov, medical equipment is a wide range of equipment, the purpose of which is to provide optimal conditions for patients and medical staff in the implementation of diagnostic and treatment measures and patient care. Medical equipment represents the fixed assets of a medical institution and may also be owned by individuals [6].

According to A.V. Shulaev, the features of medical equipment assessment include the following:

- a large variety of types and models of medical equipment;
- a wide range of prices for identical products in connection with the implementation of different pricing strategies;
- the need to take into account the completeness of the subject property, since the absence of an important element can reduce the price of equipment to the level of prices of secondary materials;
- the life cycle of medical equipment is often short, with a life cycle stage having a significant impact on the price;
- it is mandatory to account for obsolescence, since the equipment may be subject to permanent obsolescence;
- it is necessary to take into account the degree of maintainability of medical equipment (repair capabilities and spare parts availability) [7, 8].

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According to G.M. Gaidarov, with the overall high growth rates of sales in the market of medical equipment and the expansion of the range of these products, especially rapid growth is observed in the field of high-tech products. This applies to medical gadgets and mobile devices connected by wireless communication, their software and services that allow doctors to receive information from gadgets and make decisions based on it [9]. Such technologies increase patients' access to diagnosis, treatment and preventive care, as well as reduce health care costs [8].

Unfortunately, the production of medical equipment in Russia is limited and is at the initial stage of its development [10, 11]. Entering the market and putting into operation high-tech and mainly imported medical equipment puts forward new requirements for the competence of experts.

Research hypothesis:

1. Assessment of equipment as an element of movable property is important in modern conditions of market relations and has certain features, in particular, this concerns medical equipment assessment;

2. Most often, when assessing medical equipment, methods of comparative approach with the adjustment of relevant characteristics are used and it is necessary to pay attention to those characteristics that are essential for medical equipment. It is advisable to use the cost approach for unique equipment created with own resources.

### III. PROPOSED METHODOLOGY

#### A. General description

To achieve this goal, the method of analysis of scientific literature was used to determine the main approaches and methods of assessing the cost of medical equipment.

The sources of data included works by Russian and foreign researchers and peer-reviewed publications in scientific journals.

The study also used the method of an expert survey to analyze the features of the cost of medical equipment, preferred approaches and methods of its assessment.

The online expert survey was attended by 25 experts, including employees of companies for the independent assessment of medical equipment (12 people), employees of administrations of medical institutions (7 people), employees of suppliers of medical equipment (6 people).

The experts were asked questions concerning the use of different approaches to the assessment of medical equipment and methods of its assessment, as well as their advantages and disadvantages.

#### B. Algorithm

The analysis of scientific literature on the problem of existing approaches to the assessment of medical equipment and methods of its assessment was carried out at the first stage of the research.

At the second stage of the study, the expert survey was conducted concerning the advantages and disadvantages of existing approaches to the assessment of medical equipment.

#### C. Flow chart

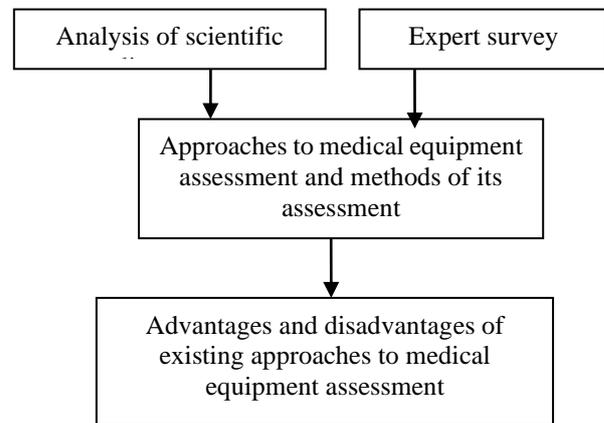


Fig. 1: The algorithm of the study

### IV. RESULT ANALYSIS

As the analysis of scientific literature has shown, in general, comparative, cost and profit approaches are used to assess equipment.

When using the comparative approach, it is possible to assess any object as an element, separate unit or system of equipment. The comparative approach is based on the principle of substitution, according to which, the purchaser of equipment does not pay for the object more than the cost of its purchase in the open and competitive market of new or used (taking into account wear and tear) similar equipment. Typically, there are differences between objects being compared, which are taken into account in determining the cost by adjusting the data [12].

In the assessment of medical equipment, according to the experts, the following methods of the comparative approach are most often used: the method of direct comparison and the method of statistical modeling of prices. The results of the analysis of these methods are summarized in Table 1.

**Table 1: Characteristics of the comparative approach methods to the assessment of medical equipment.**

Name	Cost factors	Advantages	Disadvantages
Direct comparison	1 Analog price; 2 Coefficient of the reduction of the analog cost to the time of assessment; 3 Physical deterioration of the analog; 4 Values of technical parameters of the assessed object and the analog; 5 Coefficient of the difference of commercial appeal; 6 Price of additional devices; 7 Trademark price.	Focus on market data	1 Does not contain recommendations on the choice of basic technical parameters for different types of equipment; 2 Importance of technical parameters is not taken into account; 3 Impossibility of reliable determination of the analog's physical wear; 4 Lack of perfect techniques; 5 Determination of the coefficient of commercial attractiveness and price of the trademark.
Statistical price modeling	1 Average price of similar equipment, established on the basis of its technical parameters using a specific mathematical model; 2 Cost of additional devices.	Can provide a sufficiently accurate value if there are enough analogs	1 Requires a large database of similar objects, containing information about their price and technical characteristics, constantly being updated; 2 Lack of developed mathematical models to assess different types of equipment.

*Compiled by the authors based on the expert survey.*

When using the cost approach, the psychological characteristics of the purchaser of equipment are taken into account. This approach is based on the perception of consumer value as a product of labor, i.e. the cost of equipment is comparable to the cost of its production and sale. The cost of restoration (cost of acquisition of an identical new object) or replacement cost (cost of acquisition of an equivalent replacement) is calculated [13]. This takes into account the average profit in accordance with the characteristic level of profitability for this group of products. In the absence of demand, the cost of equipment is equated to the cost of production or even lower, but not less than the cost of secondary materials minus the cost of liquidation.

However, when calculating the cost, this approach does not take into account the real utility of the equipment for a particular purchaser, which requires adjusting the cost during the sale, taking into account the interests of both parties.

When using the cost approach to medical equipment assessment, according to the experts, the following methods are usually used: analysis and indexation of costs (trend), piecemeal calculation of costs (aggregate, resource and technology), calculation of the price of a homogeneous object.

The main characteristics of these methods of the cost approach to medical equipment assessment are summarized in Table 2.

**Table 2: Characteristics of the cost approach methods to the assessment of the medical equipment cost.**

Name	Cost factors	Advantages	Disadvantages
Calculation of the price of a homogeneous object	1 Price of a homogeneous object; 2 Profitability of homogeneous object production; 3 Average profitability of production equipment, with the level of demand similar to the assessed object; 4 Correction factors and absolute corrections.	Ease of implementation	1 Use of approximate, averaged, biased initial data at each stage of the method implementation; 2 Based on cost indicators; 3 Number and nature of the correction factors are not regulated.
Piecemeal calculation cost	1 Cost of equipment components; 2 Assembly and installation costs.	Provides a fairly accurate result in compliance with the recommendations for use	1 Results of the calculation are the total cost of creating the object, not the cost price; 2 Demand level for equipment is not taken into account; 3 Probability of impossibility to obtain reliable data on the cost of non-standard parts; 4 Use of approximate values of some indicators; 5 Due to the long service life, similar components may not exist on the market.
Cost analysis and indexation	1 Cost of creating the assessed object following the estimate; 2 Indices of changes in prices of structural materials for the period from the creation of the equipment to the moment of its assessment.	Simplicity of calculations in the presence of information	1 Lack of background information; 2 Using estimated average coefficients of indexation.

*Compiled by the authors based on the expert survey.*

The profit approach to medical equipment assessment can be used only when separate equipment or system of equipment (system assessment) provides the possibility of obtaining the result of the provision of paid medical services. Also, the profit approach to the assessment of equipment requires consideration of a large number of random factors provided by a large number of possible areas of use of the assessed

object in different operating conditions.

## IV. DISCUSSION

According to the experts participating in the survey, the use of the methods of the comparative approach requires the identification of analogs and the collection of information on the characteristics of these objects. The information must comply with the following principles: completeness, reliability, relevance, compliance with the assessed object. The formation of the information base is possible based on studying the dynamics of supply prices or sales statistics in this market. For the optimal evaluation process, as the experts point out, it is desirable to form databases with the possibility of automatic selection of analogs, taking into account the degree of mismatch of the composition and numerical values of the main characteristics of analogs and the assessed equipment with regular data updates.

When comparing, the main parameter is the price and it is necessary to take into account not only its level but also the conditions of its formation.

The experts note that it is necessary to pay attention to the following types of prices:

- public reference prices, which are published in specialized publications, are formed on the basis of data from manufacturers and sellers and are an information basis for buyers. Accordingly, prices for individual medical equipment (blood pressure monitors, blood glucose meters, etc.) can be found on the pages of online stores: "Med-magazin.ru", "MET", as well as on the websites of medical companies, such as "Medical Systems and Technologies", "Tech-Med" and universal medical stores ("Medtech"). It is more expedient to find out information about the cost of medical equipment, which is used in medical and preventive institutions, by directly contacting specialized manufacturing companies (Johnson & Johnson, GE Healthcare, Siemens Medical Solutions, Medtronic, etc.), which, however, quite often place information on prices on Internet pages as well.

- prices of offers for buyers of a certain direction are stipulated in the price lists and specialized catalogs, differentiated by the terms of delivery (equipment, place and time of delivery) and payment (payment term, discounts, form and currency of payments). For example, when ordering medical equipment in an online store, the buyer specifies an e-mail for feedback, to which a message is sent containing a list of possible payment options for the goods and delivery methods;

- actual transaction prices for specific buyers are bid prices adjusted during negotiations between the buyer and the seller; however, information about them is inaccessible.

Besides, the experts specify that it should be taken into account whether these prices are domestic trade prices or import-export prices. The latter is formed taking into account international legislation, on the basis of bilateral agreements of states, which should be reflected in the formation of the information base.

Special attention in the analysis of prices for medical equipment, according to the interviewed experts, should be paid to the fact that most medical institutions purchase equipment on a tender basis. The formation of prices based on the results of tenders takes place in conditions of a high-level offer competition, so tender prices are usually lower than prices for analogs sold in the open market.

According to the method of direct comparison, identical objects (with exactly same characteristics), from the perspective of the experts, account for differences in condition (wear level), time of sale (inflation rate) and conditions of sale (contract, type of price, market state, etc.) of the object and analog. Similar facilities, additionally take into account differences in functional, structural and operational characteristics, economy of operation, aesthetics and ergonomics of the equipment.

At the same time, the main characteristics of medical devices include the instrument sensitivity, sensitivity threshold, accuracy, stability, frequency range, lack of noise and unwanted signals and convenience for the patient and their safety. The main characteristics of medical devices are the physical factor intensity, operating frequency, settling time of operating mode, duration of continuous operation and power [14].

So, as the experts specify, when assessing the cost of such device class as semi-automatic tonometers using comparative method, it is advisable to take into account the following characteristics: measurement accuracy, measurement range, arrhythmia indication, presence of a sound signal, presence and amount of memory, nature of power, cuff size, weight, availability and warranty period. At the same time, to assess the cost of electrocardiographs, the accuracy class, warranty period, permissible humidity and temperature in the room, standard sensitivity of the device and option of automatic or manual operation should be taken into account.

One of the possible comparison methods is the price range method. The range, in which the search for solutions is carried out, is the difference between the maximum and minimum values of the transaction price for similar objects. A quantitative account of the impact of certain assessment characteristics is carried out taking into account their proportional impact on the assessment of the object in the identified price range by the algorithm of pairwise comparison, followed by averaging the results. Unfortunately, as the experts note, this method can be used when each characteristic has no more than two values. The cost calculation is significantly more complicated with an increase in the number of deviations in the characteristics of the objects of comparison.

In assessing special and unique medical equipment, according to the experts, the method of statistical modeling of prices can be used, which is based on the allocation of a typical representative of a certain type of medical equipment. Based on statistical processing of the database, a homogeneous set of analog objects is allocated, for which a mathematical model of the cost dependence on one/several parameters is created and the average price is determined, which is subject to adjustment. The method of analysis and indexation of costs, according to the experts, is used to assess the medical equipment of own production, unique or discontinued. The cost is determined by updating the existing calculations or calculated by enlarged standards. Actualization (bringing the old value to its current level through price indices) is carried out by the main groups of costs that form the cost price.

The method of piecemeal calculation, according to the experts, is applicable when the evaluated equipment can be assembled personally from the components available on the market, the prices of which are known.

The method of calculation of the price of a homogeneous object, as the experts note, is based on the adjustment of the cost of constructively or technologically similar equipment, assuming that the cost of equipment, both analog and assessed, is formed under the influence of common production factors. Accordingly, as noted by the experts, there is a need to find an analog.

The practical application of these models, according to the experts, involves taking into account the depreciation of the assessed object. Wear classification is widely known: physical, functional, economic. When determining the physical depreciation of an object, the life cycle method (the ratio of the actual age of the equipment to the term of its economic life) or the method of integrated assessment of the technical condition (expert assessment of the percentage of wear according to a special rating scale) is usually used.

However, the experts point out that the actual depreciation of medical equipment is precisely obsolescence, which for medical equipment often occurs earlier than physical wear. Therefore, it is advisable to pay attention to the classification of obsolescence, proposed by V.V. Kozlov [15] and adapted to medical equipment:

- the first kind – the loss of equipment cost in case of reduction in the cost of its reproduction;
- the second kind – the loss of utility and market value in the event of the appearance of an analog that more fully meets both public needs (public obsolescence) and the requirements of a specific user (individual obsolescence);
- the third kind – the loss of usefulness and cost of equipment due to the complete or partial disappearance of the need for a service provided using this medical equipment.

At the same time, the experts note that public obsolescence is the loss of usefulness of the equipment for society, which is measured by a decrease in cost when sold in the secondary market. At the same time, this obsolescence increases with the accumulation of similar modern equipment, which displaces the assessed one.

Individual obsolescence does not have a stage of accumulation, is manifested only for a particular buyer or user concerning particular equipment in specific conditions of use and can be measured by reducing the period of its use in the performance of its function. Accordingly, it can be eliminated if used by another owner in other conditions that are more suitable for the use of this equipment. The secondary market makes adjustments to the formation of value because new product prices are set by the manufacturer and the active party in the secondary market is the buyer looking for equipment that best meets the demands on performance in terms of future use, given funding opportunities. When the seller performs the assessment, individual obsolescence can be defined as a decrease in value due to non-compliance with typical operating conditions for the most likely buyers [16].

Determining the obsolescence of the third kind, it is necessary to analyze the potential of the service provided using this equipment. To a greater extent, specialized equipment is subject to this type of obsolescence [17, 18].

According to the experts, each of these approaches has its advantages and disadvantages. Quite often, methods receive different values in calculations made according to different approaches. Therefore, the experts recommend the use of several methods with subsequent statistical processing of the results obtained with different approaches to achieve greater accuracy of the assessment. Some experts believe that it is necessary to choose one method that is most appropriate for the conditions and object of assessment so that it takes into account the availability of information, reliability and significant features of the object of assessment and the conditions for its use, making it better than any other method.

## V. CONCLUSION

The results of the study confirmed the following hypothesis:

- assessment of equipment as an element of movable property is important in modern conditions of market relations and has special features, in particular, this concerns medical equipment assessment;
- most often, when assessing medical equipment, the methods of comparative approach with the adjustment of relevant characteristics are used and it is necessary to pay attention to those characteristics that are essential for medical equipment. It is advisable to use the cost approach for unique equipment created with own resources.

Also, given the above, it can be argued that:

- determination of the depreciation level of objects, especially obsolescence, is relevant in the assessment; however, this aspect is problematic and requires further refinement of the methodology for determining the loss of value of an object due to depreciation;
- significant aspect of assessing medical equipment is that the effectiveness of using individual devices in most cases cannot be measured in monetary terms. For patients, it is an improvement in health status, for medical institutions, it is an improvement in the quality of customer service and, only subject to the provision of paid services, an increase in revenues from the systematic use of equipment. Accordingly, the profit approach is rarely used. However, the time to ensure the growth of competitiveness of manufacturers of medical equipment and medical facilities requires updating medical equipment assessment.

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