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Experimental auction design: Enhancing procurement efficiency in Ukraine's healthcare sector

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Abstract. The relevance of this study arises from the urgent need to optimise resource allocation and improve procurement procedures in Ukraine's healthcare sector, particularly under martial law conditions, which underscore the importance of efficient and transparent use of financial resources. This study aimed to conduct a comprehensive investigation and objective assessment of the effectiveness of auction-based mechanisms for procuring medical equipment within the Ukrainian healthcare system, taking into account the specific features of the sector. A comprehensive approach was employed, including systemic and comparative analysis of existing auction models and their implementation in the healthcare systems of various countries. Using methods of formalisation and generalisation, an experimental auction model was developed, incorporating multi-attribute evaluation. Statistical methods enabled a quantitative analysis of the proposed model's effectiveness. The findings indicated that introducing auction mechanisms into Ukraine's healthcare procurement system holds significant potential for enhancing the efficiency and transparency of medical equipment procurement. The developed experimental model of multi-attribute evaluation, combined with a sealed-bid auction format, allows for the consideration of not only price but also other important criteria, such as the technical specifications of the equipment, warranty period, service conditions, and the presence of additional benefits. A detailed analysis was conducted to assess the impact of each of these factors on auction outcomes. The study demonstrated that the proposed approach enables the selection of suppliers offering the best overall value, considering the balance between cost and quality of medical equipment. The research findings make a significant contribution to the advancement of both the theory and practice of auction applications in the healthcare sector, broadening the understanding of how auction mechanisms function within the medical field

Keywords: tender bidding; medicine; experiment; healthcare; efficiency; price; quality

Introduction

Like many other countries, Ukraine's healthcare sector continuously faces the challenge of allocating limited resources efficiently and fairly. This issue is particularly pressing as public demand for medical services continues to grow while the state's financial capacity remains constrained – conditions further intensified by the ongoing

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war. Traditional procurement methods, often marked by a lack of transparency, bureaucratic hurdles, and vulnerability to corruption, have proven inadequate in ensuring the optimal use of resources or meeting the evolving needs of the healthcare system. In the search for more effective solutions, auction-based mechanisms are gaining increasing traction in the medical field. Due to their ability to enhance transparency, promote competition, and establish market-based pricing, auctions represent a powerful tool for improving the allocation of resources within healthcare. They offer opportunities to attract a wider range of suppliers, encourage fair competition, and achieve better value for medical goods and services.

The literature on auction design in the healthcare sector, although a relatively recent area of research, is developing rapidly and attracting growing interest from both scholars and practitioners. As noted by R. Malani (2020), this interest stems from the potential of auction-based mechanisms to address key challenges facing modern healthcare systems, such as inefficient resource allocation, limited access to medical services, and high costs. Several studies, including those by V. Pitkänen *et al.* (2020) and A. Hortaçsu & I. Perrigne (2021), have confirmed the potential benefits of applying auctions in healthcare. For instance, the study by V. Pitkänen *et al.* (2020) argued that introducing a capacity-rule of acceptance in medicine could, on the one hand, lead to significant public budget savings and ensure higher-quality medical care. On the other hand, it could also require many patients to change service providers and travel longer distances to receive treatment. In their article, G. Németh *et al.* (2023) presented a concept for designing multi-winner tenders for pharmaceuticals, with a focus on supply and distribution guarantees, cost-effectiveness, and equitable access. The authors advocate for the development and implementation of multi-winner tenders for medicinal products, arguing that such mechanisms promote long-term competitiveness in pharmaceutical markets and reduce the risk of supply shortages. Auctions can also contribute to improving access to healthcare services, particularly under conditions of limited resources. Research by J.D. Moody-Williams *et al.* (2024) explored the use of auctions in the allocation of organs for transplantation, demonstrating how this approach can support a more efficient and equitable distribution of life-saving resources. A. Arshad *et al.* (2019) examined the advantages of presumed or deemed consent for organ donation compared to explicit consent, highlighting how this model could enhance the development of a more competitive organ transplantation system.

The literature also highlights several challenges and risks associated with the use of auctions in healthcare. One of the key issues is the problem of information asymmetry, where auction participants possess differing levels of knowledge regarding the quality of medical goods or services. This can lead to adverse selection, with lower-quality providers winning contracts simply because they can offer lower prices. Research by D. Powell & D. Goldman (2020) emphasised a positive correlation between the generosity of health insurance coverage and the level of healthcare consumption, while also pointing to th problem of adverse selection within the health insurance market. Another significant challenge is the risk of collusion among auction participants, which may result in artificially inflated prices or restricted competition. The study by L. Siciliani *et al.* (2022) stressed that proximity to the provider remains a key factor in a patient's choice of healthcare facility. At the same time, demand for medical services varies considerably depending on the quality of care delivered. There are ethical considerations associated with the use of auctions in healthcare, particularly when it comes to the allocation of life-saving resources or services. For example, the articles of M. Gawronski *et al.* (2022) and F.J. Esplugues *et al.* (2024) argued that, even under the general EU directives, the diversity of tendering methods and the wide range of public procurement criteria across individual countries prevent the consistent application of a uniform logic – even within a relatively homogeneous legal framework. Given the inherent complexity of any tendering process, such issues should not be interpreted as evidence of poor governance or deficient procurement practices. Corruption risks are also common in such procurement processes. The research group led by O. Onwujekwe *et al.* (2020) highlighted widespread pharmaceutical corruption in English-speaking sub-Saharan Africa, particularly in Nigeria. The studies by O. Dluhopolskyi (2024), O. Dluhopolskyi *et al.* (2024), and O. Dluhopolskyi & O. Myronenko (2024) analysed corruption risks using various indicators across different countries, with particular attention to Ukraine, where progress has been observed in certain anti-corruption reforms, while regression has occurred in others.

In the Ukrainian context, research into auction mechanisms in healthcare remains at an early stage. However, recent reforms in the sector, aimed at improving efficiency and transparency, have created favourable conditions for exploring and implementing auction-based approaches. It is worth noting that many of the challenges related to public procurement in Ukraine are, in one way or another, connected to the healthcare sector. V. Datsenko (2022) highlighted the crucial role of the online platform Prozorro in ensuring an effective public procurement process for Ukraine's reconstruction. Amid the full-scale war waged by Russia against Ukraine from 2022 to 2024, the challenges surrounding auctions in the medical field have become even more acute. This study aimed to analyse the specific characteristics of Ukraine's healthcare sector and to identify the auction formats most likely to prove effective in this context.

Materials and Methods

A wide range of academic methods was employed to conduct a comprehensive study of the application of auction mechanisms in Ukraine's healthcare sector. Systems analysis enabled the consideration of auction mechanisms as an integral part of the Ukrainian healthcare system, taking into account its complexity and the interconnections between its various components. This approach helped to

identify the key factors influencing the effectiveness of auctions, as well as to examine the potential risks associated with their implementation.

Comparative analysis was used to evaluate different auction formats employed in healthcare and to determine their advantages and disadvantages within the Ukrainian context. The use of auctions in the medical sectors of various countries – such as the USA, Australia, and EU member states – was examined to identify best practices. The formalisation method was applied to develop a mathematical model of an auction based on multi-attribute evaluation, allowing consideration of not only price but also other important criteria in selecting the winning bidder.

The formalisation of the proposal evaluation process ensured objectivity and transparency. The generalisation method enabled conclusions to be drawn regarding the effectiveness of auction use in Ukraine's healthcare sector, based on the analysis of hypothetical cases and theoretical models. The synthesis of research findings allowed for the formulation of recommendations for the implementation of auction mechanisms within the Ukrainian healthcare system. Simulation modelling was employed to create a hypothetical case of medical equipment procurement using a sealed-bid auction. This simulated model made it possible to analyse various scenarios and assess the effectiveness of the proposed procurement approach.

Overall, the application of a comprehensive research framework – incorporating a variety of methods and sources – enabled a thorough understanding of the issues surrounding the use of auction mechanisms in Ukraine's healthcare system. It supported the justification for selecting optimal auction formats and the development of practical recommendations for their effective implementation. One of the key limitations of the study was the restricted availability of data concerning the outcomes of healthcare-related auctions in Ukraine (Advisory Board Sustainability, 2024). The research was based on hypothetical scenarios and theoretical approaches; as such, actual outcomes may vary depending on specific auction conditions and market factors.

Results and Discussion

Auctions have been successfully applied across various sectors of the economy, including telecommunications, energy, and transport. However, the healthcare sector possesses unique characteristics that complicate the direct transfer of practices from other industries. The complexity of medical services, the presence of externalities, information asymmetries, and ethical considerations associated with the provision of care all necessitate a careful approach to the design and implementation of auction mechanisms in healthcare systems. A range of auction formats may be employed in the healthcare sector, each offering specific advantages and limitations. Among the most common formats are the English auction, Dutch auction, sealed-bid auction, and multi-attribute auction (Table 1).

Table 1. Auction formats in healthcare

Auction format	Description	Application in healthcare
English auction	The price starts low and increases incrementally as participants bid. The highest bidder wins	Procurement of medical goods and equipment
Dutch auction	The price starts high and decreases until a participant accepts the current price	Allocation of scarce medical resources (e.g. organ transplantation)
Sealed-bid auction	Participants submit their bids in sealed envelopes. The highest bidder wins	Procurement of complex medical services where quality is difficult to assess in advance
Multi-attribute auction	Bids are evaluated based on price as well as additional criteria (e.g. quality, experience, innovation)	Procurement of healthcare services where quality is a key determinant

Source: developed by the authors

To conduct an in-depth examination of the potential and challenges associated with using auctions in Ukraine's healthcare sector, a hypothetical case study was developed involving the procurement of medical equipment (a computed tomography scanner) through a sealed-bid auction. This auction format was selected for several reasons. Firstly, it enables consideration of factors beyond price, such as technical specifications, warranty period, and service conditions, all of which are essential to ensuring the quality and reliability of the equipment. Secondly, the use of sealed bids makes collusion between participants more difficult, thus promoting fair competition and transparency. Thirdly, this format reduces the risk of purchasing low-quality equipment at an artificially low price, since participants cannot see competing bids and therefore cannot adjust their offers based solely on price. As a result, the sealed-bid auction format presents itself as an optimal choice for ensuring efficiency, transparency, and fairness in the procurement of complex medical equipment.

To enhance the realism of the model, the case study parameters reflected typical conditions for medical equipment procurement in Ukraine, including the number of participants, price offers, and technical characteristics. The information used to construct the case was drawn from open sources (e.g. medical equipment supplier websites, and tender announcements) as well as expert assessments. The simplicity and clarity of the case allowed attention to be focused on the key aspects of the auction application, making it accessible to a broad audience. Case variability was introduced through the development of several scenarios, each differing in the set of evaluation criteria and their respective weightings.

The first scenario (baseline) involved the consideration of all evaluation criteria – price, technical specifications, warranty period, and additional benefits – using a multi-attribute evaluation method. The second scenario took price as the sole criterion for selecting the winning bid. The third scenario demonstrated how changing the weights assigned to the evaluation criteria affected the auction outcome. This approach enabled an analysis of how different factors influence the selection of a winner and justified the use of multi-attribute evaluation in medical equipment procurement auctions. To quantitatively assess the participants' bids and determine a winner in each scenario, a weighted scoring formula was applied:

$$\text{Total score} = (B1 * W1) + (B2 * W2) + (B3 * W3) + (B4 * W4),$$

where $B1$, $B2$, $B3$, $B4$ are scores for each criterion, and $W1$, $W2$, $W3$, $W4$ are their respective weights. The use of this formula enabled a numerical comparison of bids, taking into account the various criteria and their relative importance. The results of these calculations were used to assess the effectiveness of different scenarios and to draw conclusions about the appropriateness of applying a multi-attribute evaluation approach in auction-based procurement. The modelling exercise showed that considering not only price but also other key criteria – such as technical specifications, warranty period, and additional advantages – makes it possible to select the supplier offering the best overall value. This contributes to more efficient use of public funds and ensures that hospitals are equipped with high-quality medical devices. To provide a practical demonstration of the multi-attribute evaluation approach, a hypothetical example is presented below involving three suppliers, whose offers are summarised in Table 2. The table presents three alternative suppliers of medical equipment, each offering differing price proposals, technical specifications, warranty periods, and additional benefits. Supplier A offers equipment priced at 1,500,000 UAH, fully meeting the hospital's requirements. The warranty period is 3 years, and additional benefits include free staff training and servicing throughout the warranty period. Supplier B proposes equipment priced at 1,400,000 UAH, which meets most requirements but with certain limitations. The warranty lasts for 2 years, and the supplier additionally offers a discount on consumables. Supplier C offers the lowest price – 1,300,000 UAH – but the equipment only meets the minimum requirements. The warranty period is just 1 year, and no additional benefits are provided.

Table 2. Comparison of suppliers' offers

Supplier	Price proposal, UAH	Technical specifications	Warranty (years)	Additional benefits
A	1,500,000	Fully meets hospital requirements	3	Free staff training and servicing during the warranty period
B	1,400,000	Meets most requirements, with some limitations	2	Discount on consumables
C	1,300,000	Meets minimum requirements	1	None

Source: developed by the authors

To ensure an objective selection of a medical equipment supplier, the hospital developed an evaluation system that considers not only price but also other important criteria. This system is based on a multi-attribute approach, whereby each criterion is assigned a specific weight reflecting its relative importance. In this case, the criterion price carries a weight of 40%, technical specifications 30%, warranty period 20%, and additional benefits 10%. The higher the score for each criterion, the better the supplier's offer is considered to be. A scoring scale was established for each criterion. Price is assessed on a scale from 60 to 100 points, with the lowest price (1,300,000 UAH) receiving 100 points and the highest (1,500,000 UAH) receiving 60 points. Technical specifications are scored between 40 and 100 points depending on the degree of compliance with the hospital's requirements. The warranty period is awarded 40 to 100 points, in proportion to its length. The presence of additional benefits scores 100 points, while their absence scores 0.

Based on this scoring scale, points were calculated for each supplier, enabling a quantitative comparison and the identification of the auction winner (Table 3). Supplier A achieved a total score of 84, owing to its superior technical specifications, warranty period, and additional benefits. Although its price was the highest, the high quality and advantages offered offset this drawback. Supplier B received 77 points due to a balanced combination of price, technical specifications, warranty, and added benefits. While its price was mid-range, its technical performance and warranty were slightly inferior to Supplier A. Supplier C obtained the lowest total score of 60, as – despite offering the lowest price – its technical specifications, warranty, and absence of added benefits were significantly less competitive.

Table 3. Supplier evaluation

Supplier	Price (40%)	Technical specifications (30%)	Warranty (20%)	Additional benefits (10%)	Total score
A	60 * 0.4 = 24	100 * 0.3 = 30	100 * 0.2 = 20	100 * 0.1 = 10	84
B	80 * 0.4 = 32	70 * 0.3 = 21	70 * 0.2 = 14	100 * 0.1 = 10	77
C	100 * 0.4 = 40	40 * 0.3 = 12	40 * 0.2 = 8	0 * 0.1 = 0	60

Source: developed by the authors

Based on the calculations in Table 3, Supplier A was identified as the auction winner, having offered the best overall value despite submitting the highest price. The experimental approach employed in this study demonstrated that the use of multi-attribute evaluation, in combination with sealed-bid auctions, can serve as an effective tool for the procurement of medical equipment in Ukraine. This approach allows for the consideration of not only price but also other key criteria, such as technical specifications, warranty period, and additional advantages – thereby ensuring the selection of the supplier offering the greatest overall value.

Y. Abdulsalam & E. Schneller (2019) noted that supply-related expenses represent the second-largest cost category in hospitals after payroll, yet they offer greater potential for improving cost efficiency. This area of expenditure remains underexplored in the academic literature on health economics. Their research found that, on average, supply costs account for approximately 15% of a hospital's total expenditure; however, in institutions with a high case complexity index – particularly surgical hospitals – this figure may reach 30%-40%. E. Peters *et al.* (2023) highlighted that within the Dutch healthcare system, a significant mismatch was identified between the levels of containment and anticipation strategies: while containment was implemented at the network level, forward-looking strategic planning at that same level was lacking. As a result, the response during the COVID-19 crisis proved to be improvised, placing considerable strain on individual institutions. The study by E. Peters *et al.* (2023) also demonstrated that trust and stable working relationships are critical for effective coordination. However, due to the lack of pre-pandemic collaboration, such relationships had to be established during the crisis itself. The absence of a clearly defined command structure, limited experience within key public institutions, and mistrust towards formal leadership undermined the efficiency of supply network management. The conclusions drawn by the researchers appear well-founded, as this study likewise highlights the need for a structured and proactive approach to procurement in the healthcare sector. Emphasis should be placed on transparency, multi-dimensional proposal evaluation, and the consideration of quality – principles that align with critiques of improvised strategies and underscore the importance of trust and systematic preparedness in times of crisis.

Despite the availability of international research on the use of auctions in the healthcare sector, including the study of L. Knight (2023), such approaches cannot always be directly applied to the Ukrainian context due to differences in legislation, the level of development of the healthcare market, and the specifics of local conditions. As noted by B. Tip *et al.* (2022), this may result in certain mechanisms that function successfully in other countries proving less effective in Ukraine. The evaluation of healthcare services through auction-based mechanisms may also raise ethical concerns, particularly in cases where cost or other criteria take precedence over the quality of medical services. Additionally, issues of accessibility for the most vulnerable population groups may arise, as lower-priced offers may fail to meet required quality standards. It is therefore important to consider the experience of other countries that have already successfully implemented auction mechanisms in healthcare and to adapt these practices to the Ukrainian context. The experience of EU countries is particularly relevant, where auctions are widely used for the procurement of medicines and medical equipment. Adapting this experience may involve the introduction of unified standards for the quality and safety of medical products, the harmonisation of public procurement legislation with EU norms, and the establishment of a centralised system for monitoring the prices of medicines and medical equipment. The experience of the USA, where auctions are used for the allocation of organs for transplantation, demonstrates the effectiveness of this procurement model, as shown in the studies by A. Arshad *et al.* (2019) and J. Moody-Williams *et al.* (2024). Adapting this approach in Ukraine could involve the development of clear criteria for organ allocation, the introduction of a patient ranking system, and the implementation of transparent allocation procedures. The experience of Australia is also noteworthy, where auctions are employed to attract private investment in healthcare infrastructure. Adapting the Australian model could include the development of public-private partnership mechanisms in the healthcare sector, with an emphasis on transparency and investor accountability. When adapting to international experience, it is essential to consider the specifics of Ukrainian legislation, the level of competition in the medical goods and services market, and the country's socio-economic context. The use of auction mechanisms in Ukraine holds considerable potential for improving the allocation of medical resources, increasing transparency, and reducing costs. A. Shulika (2022) and V. Kolisnichenko (2022) analysed legislative changes in public procurement introduced during wartime, which, although generally unfavourable to competition, are regarded as a necessary and optimal compromise under the conditions of martial law. The introduction of Prozorro as a mandatory tool for most procurement processes, along with the transition of large-scale privatisation to electronic auctions via this system, illustrates the gradual adaptation of public administration to digital innovation. This shift not only enhances transparency but also promotes more efficient resource use, a key component of sustainable development. The Prozorro e-procurement system has already proven effective in reducing costs for pharmaceuticals and medical equipment. For instance, in her study based on Kyiv School of Economics (KSE) analytics, N. Bihun (2022) demonstrated that transparent tender procedures can result in budget savings of up to 12.4% in the healthcare sector – an especially relevant outcome in wartime conditions. Such an approach supports not only cost savings but also improved accountability and resilience within the healthcare system, directly aligning with the goals of sustainable development. The simplification of procedures and ongoing digitalisation also enable more

agile responses to economic challenges, while maintaining control and accountability – an aspect of particular importance in the post-war recovery context. To further enhance the effectiveness of these mechanisms, it is essential to integrate them with broader healthcare reforms, particularly in strengthening quality control of medical services.

Conclusions

The study confirmed that auction-based mechanisms hold significant potential for improving efficiency, transparency, and fairness in the allocation of resources within Ukraine's healthcare sector. The use of auctions can help reduce procurement costs for medical goods and services, stimulate competition among suppliers, enhance the quality of healthcare provision, and broaden access for the population. The findings demonstrated that applying multi-attribute evaluation in combination with sealed-bid auctions can serve as an effective tool for procuring medical equipment in Ukraine. This approach enables supplier selection to be based not only on price, but also on other key criteria such as technical specifications, warranty period, and additional benefits – ensuring the selection of the offer that provides the best value for money.

Auctions have the potential to become an important instrument for enhancing the efficiency and transparency of Ukraine's healthcare system. Their successful implementation requires a comprehensive approach that takes into account all aspects of the medical sector and ensures a balance between economic and social objectives. Only under such conditions can auctions make a meaningful contribution to improving the quality and accessibility of healthcare for the population of Ukraine. The future development of auction mechanisms in Ukraine's medical sector depends on continued reforms within the healthcare system. Key steps include refining the regulatory framework, expanding the use of electronic auctions across all stages of procurement, and strengthening training among auction participants. These measures would help reduce the impact of bureaucracy and corruption while making the system more transparent and effective. Further research in this area should focus on examining the long-term effects of auctions on the quality and accessibility of healthcare services in Ukraine, as well as developing recommendations for improving auction design and adapting it to the specific characteristics of different segments of the medical market.

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Conflict of Interest

None.

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Експериментальний дизайн аукціонів: підвищення ефективності закупівель у медичній галузі України

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Анотація. Актуальність дослідження обумовлена нагальною потребою в оптимізації розподілу ресурсів та удосконаленні процедур закупівель в медичній галузі України, особливо в умовах воєнного стану, що актуалізує питання ефективного та прозорого використання фінансових ресурсів. Метою дослідження було всебічне вивчення та об'єктивна оцінка ефективності застосування аукціонних механізмів для закупівель медичного обладнання в українському секторі охорони здоров'я з урахуванням специфіки галузі. В роботі застосовано комплексний підхід, що включав системний та компаративний аналіз існуючих моделей аукціонів та практики їх застосування в охороні здоров'я різних країн. Методами формалізації та узагальнення було розроблено експериментальну модель аукціону з урахуванням багатоатрибутної оцінки, а статистичні методи дозволили провести кількісний аналіз ефективності запропонованої моделі. Встановлено, що впровадження аукціонних механізмів в систему охорони здоров'я України має значний потенціал для підвищення ефективності та прозорості закупівель медичного обладнання. Розроблена експериментальна модель багатоатрибутної оцінки в поєднанні з аукціоном із запечатаними ставками дозволяє враховувати не лише ціновий фактор, але й інші важливі критерії, такі як технічні характеристики обладнання, гарантійний термін, умови сервісного обслуговування, наявність додаткових переваг тощо. Проведено детальний аналіз впливу кожного з цих факторів на результати аукціонів. Дослідження показало, що запропонований підхід забезпечує вибір постачальника, який пропонує найкращу загальну цінність, враховуючи співвідношення ціни та якості медичного обладнання. Результати дослідження вносять вагомий внесок у розвиток теорії та практики застосування аукціонів в сфері охорони здоров'я, розширюючи розуміння особливостей функціонування аукціонних механізмів в медичному секторі

Ключові слова: тендерні торги; медицина; експеримент; охорона здоров'я; ефективність; ціна; якість