Received: 27 December 2021 / Accepted: 13 April 2022 / Published online: 30 April 2022

DOI 10.34689/SH.2022.24.2.001

UDC 614.2:615.47:616-036.21:005.932(574)

ANALYSIS OF THE SUPPLY OF MEDICAL DIAGNOSTIC EQUIPMENT DURING THE PANDEMIC IN KAZAKHSTAN

Zhandulla Nakipov[1], https://orcid.org/0000-0001-5528-693X
Gaukhar Dauletova[1], https://orcid.org/0000-0002-1621-8149
Karlygash Tebenova[2], https://orcid.org/0000-0003-0648-7828
Serik Abdiraimov[1], https://orcid.org/0000-0001-6435-3401
Zaituna A. Khismetova[3], https://orcid.org/0000-0001-5937-3045
Assiya K. Turgambayeva[1], https://orcid.org/0000-0002-2300-0105

[1] NJSC «Astana Medical University», Department of Public Health and Management, Nur-Sultan, Republic of Kazakhstan;
[2] Academician E.A. Buketov Karaganda University, Department of Special and Inclusive Education, Karaganda, Republic of Kazakhstan;
[3] NJSC «Semey medical university», Semey, Republic of Kazakhstan.

Abstract

Background. Approximately 14% of people with COVID-19 develop a serious illness requiring hospitalization and oxygen support, 5% need hospitalization in the intensive care unit. At the beginning of the pandemic, countries faced a shortage of such specialized equipment. A complete oxygen system should consist of the following elements: oxygen sources, delivery devices, control and conditioning devices, and patient monitoring devices.

Objective. To assess the supply of medical equipment during the pandemic in Kazakhstan.

Materials and methods. We conducted a review of empirical studies, statistical data and case studies, reports of the World Health Organization, the United Nations and the World Bank, studies of public spending, the Global Health Expenditure Index. By the method of sales analysis based on a marketing plan, a mathematical model has been developed that allows optimizing sales surcharges and service fees in the implementation.

Results. There is a surge in demand for medical equipment. The release of some diagnostic devices is carried out on JSC “Aktyubrentgen”. Pulsed X-ray machines have become widespread. 132 city and regional hospitals and 53 rural ones are equipped with the necessary diagnostic equipment. There is a 2.5-fold increase in investment.

Conclusion. Timely adopted resolutions and the creation of customs-free conditions gave a positive result on deliveries. To improve the process of Kazakhstan's medical devices entering the international market, a step-by-step algorithm should be developed that would include marketing steps and follow-up actions to promote medical equipment.

***Keywords**: medical equipment, X-ray machine, MRI, Covid-19, supply.*

Резюме

АНАЛИЗ ПОСТАВКИ МЕДИЦИНСКОГО ОБОРУДОВАНИЯ ДИАГНОСТИКИ ВО ВРЕМЯ ПАНДЕМИИ В КАЗАХСТАНЕ

Жандулла Б. Накипов[1], https://orcid.org/0000-0001-5528-693X
Гаухар Ш. Даулетова[1], https://orcid.org/0000-0002-1621-8149
Карлыгаш С. Тебенова[2], https://orcid.org/0000-0003-0648-7828
Серик Абдираимов[1], https://orcid.org/0000-0001-6435-3401
Зайтуна А. Хисметова [3], https://orcid.org/0000-0001-5937-3045
Асия К. Тургамбаева[1], https://orcid.org/0000-0002-2300-0105

[1] НАО «Медицинский университет Астана», Кафедра общественного здоровья и менеджмента, г. Нур-Султан, Республика Казахстан;
[2] Карагандинский университет им. Е.А. Букетова, Кафедра специального и инклюзивного образования, г. Караганда, Республика Казахстан;
[3] НАО «Медицинский университет Семей», Кафедра общественного здоровья, г.Семей, Республика Казахстан.

Актуальность. Примерно у 14% людей с COVID-19 развивается тяжелое заболевание, требующее госпитализации и кислородной поддержки, а 5% нуждаются в госпитализации в отделение интенсивной терапии. В период начала Пандемии страны столкнулись с нехваткой такого специализированного оборудования, что привело

системы здравоохранения в коллапс. Полная кислородная система должна состоять из следующих элементов: источников кислорода, устройств доставки, устройств регулирования и кондиционирования и устройств наблюдения за пациентом.

Цель. Оценка поставки медицинского оборудования в период пандемии в Казахстане.

Материалы и методы. Проведен обзор эмпирических исследований, статистических данных и тематических исследований, отчетов Всемирной организации здравоохранения, Организации Объединенных Наций и Всемирного банка, исследований государственных расходов, Индекс глобальных расходов на здравоохранение. Методом анализа продаж, основанного на маркетинговом плане разработана математическая модель, позволяющая оптимизировать надбавки к продажам и платы за обслуживание в реализации.

Результаты. Наблюдается резкий рост спроса на медицинское оборудование. Выпуск некоторых диагностических приборов осуществляется на АО "Актюбрентген". Импульсные рентгеновские аппараты получили широкое распространение. Необходимым диагностическим оборудованием оснащены 132 городские и областные больницы и 53 сельские. Наблюдается увеличение инвестиций в 2,5 раза.

Выводы. Своевременно принятые решения и создание беспошлинных условий дали положительный результат по поставкам. Для улучшения процесса выхода казахстанских медицинских изделий на международный рынок необходимо разработать пошаговый алгоритм, который включал бы маркетинговые шаги и последующие действия по продвижению медицинского оборудования.

Ключевые слова: *медицинское оборудование, рентгеновский аппарат, МРТ, Covid-19, поставка.*

Түйіндеме

ҚАЗАҚСТАНДАҒЫ ПАНДЕМИЯ КЕЗІНДЕГІ ДИАГНОСТИКАНЫҢ МЕДИЦИНАЛЫҚ ЖАБДЫҚТАРЫН ЖЕТКІЗУДІ ТАЛДАУ

Жандулла Б. Накипов[1], https://orcid.org/0000-0001-5528-693X
Гаухар Ш. Даулетова[1], https://orcid.org/0000-0002-1621-8149
Карлыгаш С. Тебенова[2], https://orcid.org/0000-0003-0648-7828
Серик Абдираимов[1], https://orcid.org/0000-0001-6435-3401
Зайтуна А. Хисметова [3], https://orcid.org/0000-0001-5937-3045
Асия К. Тургамбаева[1], https://orcid.org/0000-0002-2300-0105

[1] КеАҚ "Астана медицина университеті" КЕАҚ, Қоғамдық денсаулық және менеджмент кафедрасы, Нұр-сұлтан Қ., Қазақстан Республикасы;
[2] Е.А. Букетова атындағы Қарағанды университеті, Арнайы және инклюзивті білім беру кафедрасы, Қарағанды қ., Қазақстан Республикасы;
[3]КеАҚ «Семей медицина университеті», Қоғамдық денсаулық кафедрасы, Семей қ., Қазақстан Республикасы.

Өзектілігі. COVID-14 бар адамдардың шамамен 19% ауруханаға жатқызуды және оттегі қолдауын қажет ететін ауыр ауруды дамытады, ал 5% - реанимация бөліміне жатқызуды қажет етеді. Пандемия басталған кезде елдер Денсаулық сақтау жүйесін құлдырауға алып келген осындай мамандандырылған жабдықтардың жетіспеушілігіне тап болды. Толық оттегі жүйесі мынадай элементтерден: оттегі көздерінен, жеткізу құрылғыларынан, реттеу және кондиционерлеу құрылғыларынан, және пациентті бақылау құрылғыларынан тұруы тиіс.

Мақсаты. Қазақстандағы пандемия кезеңінде медициналық жабдықтарды жеткізуді бағалау.

Материалдары мен әдістері. Эмпирикалық зерттеулерге, статистикалық мәліметтерге және кейс-стадияларға, Дүниежүзілік денсаулық сақтау ұйымының, Біріккен Ұлттар Ұйымының және Дүниежүзілік Банктің есептеріне, мемлекеттік шығыстарды зерттеуге, денсаулық сақтаудың жаһандық шығыстарының индексіне шолу жасалды. Маркетингтік жоспарға негізделген сатылымдарды талдау әдісі сатылымдар мен сату қызметтері үшін төлемдерді оңтайландыруға мүмкіндік беретін математикалық модель жасалды.

Нәтижелері. Медициналық жабдықтарға деген сұраныстың күрт өсуі байқалады. Кейбір диагностикалық аспаптарды шығару "Ақтөберентген" АҚ-да жүзеге асырылады. Импульсті рентген аппараттары кең таралды. Қажетті диагностикалық жабдықтармен 132 қалалық және облыстық ауруханалар мен 53 ауылдық ауруханалар жабдықталған. Инвестициялардың 2,5 есе өсуі байқалады.

Тұжырымдар. Уақытылы қабылданған шешімдер және бажсыз жағдайлар жасау жеткізілімдер бойынша оң нәтиже берді. Қазақстандық медициналық бұйымдардың халықаралық нарыққа шығу процесін жақсарту үшін маркетингтік қадамдарды және медициналық жабдықты ілгерілету жөніндегі кейінгі іс-қимылдарды қамтитын қадамдық алгоритм әзірлеу қажет.

Түйінді сөздер: *медициналық жабдықтар, рентген аппараты, МРТ, Covid-19, жеткізу.*

Bibliographic citation:

Nakipov Zh., Dauletova G., Tebenova K., Abdiraimov S., Khismetova Z.A., Turgambayeva A.K. Analysis of the supply of medical diagnostic equipment during the pandemic in Kazakhstan // *Nauka i Zdravookhranenie* [Science & Healthcare]. 2022, (Vol.24) 2, pp. 6-14. *doi 10.34689/SH.2022.24.2.001*

Накипов Ж.Б., Даулетова Г.Ш., Тебенова К.С., Абдираимов С., Хисметова З.А., Тургамбаева А.К. Анализ поставки медицинского оборудования диагностики во время пандемии в Казахстане // Наука и Здравоохранение. 2022. 2(Т.24). С. 6-14. *doi 10.34689/SH.2022.24.2.001*

Накипов Ж.Б., Даулетова Г.Ш., Тебенова К.С., Абдираимов С., Хисметова З.А., Тургамбаева А.К. Қазақстандағы пандемия кезіндегі диагностиканың медициналық жабдықтарын жеткізуді талдау // Ғылым және Денсаулық сақтау. 2022. 2 (Т.24). Б. 6-14. *doi 10.34689/SH.2022.24.2.001*

Introduction

A new coronavirus, designated COVID-19, appeared in Wuhan, China, in December 2019, causing respiratory, digestive and systemic problems affecting human health [1,2]. WHO announced the beginning of a pandemic and many states closed their borders. The reason was that in a short period of time the virus caused not only fever, cough, nasal congestion, fatigue and respiratory problems, but also caused a sharp increase in the number of deaths.

Although the COVID-19 pandemic has placed unprecedented demands on modern healthcare systems, the industry's response has clearly demonstrated its resilience and ability to bring innovations to market quickly. But the crisis is most likely far from over, and the innovative capabilities of the sector must continue to meet the challenges associated with both COVID-19 and the economic consequences of its spread. While many industries are facing unprecedented shocks, medicine and healthcare have been particularly affected, given the nature of this crisis [3,4].

The most effective response to the virus is quarantine and limiting the chances of the virus spreading. At the same time, quarantine measures had a negative impact not only on the delivery of medicines, medical equipment, but also made adjustments to usual life.

In patients with symptoms, clinical manifestations of the disease usually begin within a week. The virus also appears in patients who have no symptoms, and they are quite difficult to quantify.

The main sign of hospitalized patients with COVID-19 is pneumonia. Among the most noticeable signs of this pneumonia are a decrease in oxygen levels, gas deviations in the blood or changes visible on chest X-rays [5,6,7].

Approximately 14% of people with COVID-19 develop a serious illness requiring hospitalization and oxygen support, and 5% need hospitalization in the intensive care unit. At the beginning of the pandemic, countries faced a shortage of such specialized equipment, which led health systems to collapse.

A complete oxygen system should consist of the following elements: oxygen sources, delivery devices, regulation and conditioning devices, and patient monitoring devices.

Therefore, this study is very relevant, since the analysis will allow us to develop recommendations and actions in the future for any more severe infectious diseases.

The aim of the study was an assessment the supply of medical equipment during the pandemic in Kazakhstan.

Research objectives:

1. To analyze the literature on diagnostic equipment used during the pandemic;

2. to determine the regulatory documents and procedures for the delivery of medical equipment to Kazakhstan;

3. to make recommendations to improve the procedure for the delivery of medical equipment.

The primary data were taken based on the analysis of the portal of public procurement of equipment by medical institutions. The principles of SWOT and PAST analyses were taken as a basis, since the supply of equipment was not only a necessity, but also a political goal.

The object and subject of the study was diagnostic medical equipment, which was most in demand during the pandemic in Kazakhstan. First of all, these are X-ray equipment, computed tomography and magnetic resonance imaging equipment.

Materials and Methods

Literature review based on integrative processes: analysis of empirical literature and global cost structures for the purchase of diagnostic equipment during the COVID-19 pandemic, analysis of country-specific case studies and recommendations.

The data is based on previous empirical findings, theoretical foundations, statistics, and country-specific case studies from reliable research papers, reports from the World Health Organization, the United Nations, and the World Bank, previous empirical studies of government spending and pandemics, the Global Health Expenditure Index, and recent articles written during the COVID-19 time [8,9,10].

By the method of sales analysis based on a marketing plan, a mathematical model has been developed that allows optimizing sales surcharges and service fees in the implementation. It is confirmed that it is possible to obtain optimal values of the sales allowance and service fees for JSC «Aktyubrengen», which seeks to maximize profits. The results obtained show that the model is amenable to financial analysis and computer automation.

Practical significance of the work included following. The recommendations developed based on the results of the analysis were submitted to the national chamber "Atameken" for structuring practical experience.

Results

The situation with the volume of the medical diagnostic equipment market

In the beginning of April 2020, the European Commission (EU) decided to waive duties and value-added taxes (VAT) for a number of medical devices and personal protective equipment arriving from outside the EU during the coronavirus pandemic.

This measure concerns testing kits, ventilators and other medical equipment and will be valid for six months.

This decision was made by the EU against the background of an acute shortage of protective equipment for doctors, as well as equipment that is extremely necessary for the treatment of patients with COVID-19 [11,12].

Supplies of medical equipment/components necessary for the production of medical devices were interrupted because many countries were blocked. Forced quarantine in China has hit supplies the hardest. As the country has become a key player in the production of low-cost medical devices for high-quality ones.

There are more than 60 manufacturers of necessary medical equipment with headquarters in the USA and manufacturing enterprises in China. The situation has been aggravated by the fact that more than 10 leading manufacturers of medical equipment have manufacturing facilities in China.

Due to the huge increase in demand for certain medical devices that are vital in the fight against the outbreak [13,14].

At the end of January 2021, ProClinical portal published a rating of the largest manufacturers of medical equipment. Experts based the report on the sales volumes of companies in 2019 [12,13].

The volume of the medical devices market in 2020 reached almost $456.9 billion in 2019, having increased with an average annual growth rate (CAGR) of 4.4% since 2015. The market is expected to shrink from $456.9 billion in 2019 to $ 442.5 billion in 2020 at a rate of -3.2%. The decline is mainly due to blockages imposed by governments around the world that have hindered the supply chain in the medical device manufacturing industry. Nevertheless, there has been an exceptional increase in the production of ventilators that are used to treat patients with COVID-19. The medical equipment market is expected to recover and grow at an average annual growth rate of 6.1% from 2021 and reach $603.5 billion in 2023. This is due to the fact that, as already mentioned, after 2020, the increase in the number of infectious and chronic diseases will stimulate the growth of the market. Analysis of the medical equipment market by country shows that North America accounts for about 39%, this is the largest share in the world market [15,16,17].

Global trends in the medical equipment industry driving this growth include companies that have begun to repurpose their production lines for the production of medical products in high demand for the fight against coronavirus, such as hand sanitizers, face masks, personal protective equipment (PPE), ventilators, etc. For example, the alcoholic beverage company AirCo has shifted the focus on its production facilities to the production of hand sanitizers. New alcohol brands Bev and Endless West have also joined the production movement.

Similarly, in Canada, the startup INKSmith, which made design and technical tools accessible to children, switched to creating face shields. 3D printing companies such as Markforged and Formlabs from Massachusetts produce personal protective equipment such as face shields, as well as nasal swabs for testing for COVID-19. In addition, large-scale investments in health monitors and related mobile applications from medical device manufacturers, technology companies and other investors also help the market, and medical device manufacturers should cooperate with such technology companies to develop and sell monitoring and tracking devices. human health for more effective diagnosis and treatment of patients.

In March 2020, Medtronic PLC increased the production of ventilators by more than 40% and plans to more than double its capacity for the production and supply of ventilators in response to the demand caused by COVID-19. Medtronic manufactures ventilators for various medical institutions, including for the acute segment (patients in hospitals in intensive care units, emergency departments or on the floors of general medical care) and for the subacute segment (outside the hospital, long-term care facilities. or patients who are on a ventilator at home). The company manufactures Puritan Bennett 980 (PB 980) and Puritan Bennett 840 (PB 840) ventilators in Galway, Ireland, which are primarily intended for seriously ill patients in conditions of high visual acuity [18,19,20].

In April 2020, Royal Philips, a global leader in healthcare technology, announced that the U.S. government and Philips had agreed to team up to increase the production of ventilators for hospitals at their manufacturing sites in the United States. Philips plans to double production by May 2020 and achieve a fourfold increase by the third quarter of 2020 for shipments to U.S. and global markets. Such ventilators are crucial for the treatment of patients with a new coronavirus disease. Philips invests several tens of millions of dollars in the production of ventilators in the USA.

Due to the spread of the COVID-19 pandemic, the demand for N95 masks, PPE kits and ventilators has sharply increased worldwide. This surge in demand has a positive impact on the global market of medical products. The widespread spread of the disease has led to an acute shortage of medical resources on the front line. This shortage of medical supplies around the world has pushed many non-pharmaceutical companies to produce various medical products. For example, in April 2020, SanTan Brewing company from Arizona, USA, repurposed its beer production line for the production of hand sanitizers. In the same month, the company produced 400 gallons of medical grade hand sanitizers. Whereas in March 2020, the Pernod Ricard company in the USA, which eventually produces Malibu coconut rum and Seagram's Rin, began producing 1,000 gallons of hand sanitizer [21,22,23].

Analysis of the supply of diagnostic medical equipment

The results showed that the effectiveness of the supply chain management of medical equipment in public hospitals strongly depends on the practice of procurement, inventory, transportation and warehouse management.

One of the main directions of health policy in Kazakhstan is the creation of favorable conditions for equipping healthcare institutions with modern diagnostic and therapeutic equipment. This will allow the medical equipment market to function more efficiently. Several studies have shown that this market is a steadily developing part of the country's economic complex, which is still in the process of transition to new economic relations. Kazakhstan has already adopted new forms of private ownership and competition, increased the number of enterprises, their volume and product range.

The study of the peculiarities of the medical equipment market in Kazakhstan reveals the development of

integration processes, specialization and fierce competition between enterprises, firms and companies. A characteristic feature of the modern Kazakhstan market is the presence of foreign capital and increasing volumes of imported products. Current sales of imported medical equipment exceed local sales (65% vs. 35%).

We conducted a study of the ratio of medical diagnostic equipment imported to Kazakhstan during the pandemic.

It was found that among the main diagnostic equipment, rengen devices were in the greatest demand Figure 1. It is noteworthy that the release of some diagnostic devices is carried out in the city of Aktobe on Aktyubrengen.

High technologies and processes implemented at the plant include the production of high-tech, ecological and high-quality medical complex. The production of medical equipment consists in the use of unique computer software. This allows medical professionals to synchronize the operation of multiple monitors to get a complete picture of the dynamics of the patient's recovery, as well as access the data stored above.

The accuracy and reliability of the information obtained during diagnostic procedures forms a global approach to the patient's activity and the viability of systems for the staff of JSC "Aktyubrentgen". Therefore, innovations used in technological processes in industrial floor networks guarantee the true accuracy of research results and ensure patient safety. The stability of technical indicators guarantees the accuracy of parameter measurement, automatic adjustment and the absence of risk for patients and laboratory specialists.

The sale of medical equipment is provided to medical workers in connection with preventive maintenance, repair and training. Highly qualified engineers provide expert support to healthcare institutions that want to purchase medical equipment and equip their schools with multifunctional and correct projection equipment.

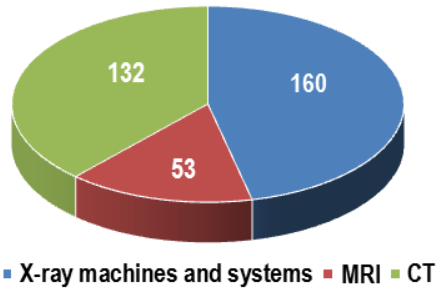

Figure 1. The ratio of purchased diagnostic equipment.

Most of all were purchased X-ray machines - 160, computer tomographs - 132 and magnetic resonance tomographs - 53.

An X-ray machine is an equipment that is used in medicine to obtain analytical data on the patient's condition. Thanks to X-ray radiation, an image is formed that allows you to assess the state of internal organs, the state of bone and muscle tissue and find pathological changes.

The X-ray radiation generated by the X-ray tube is often used in other installations. In particular, the X-ray tube is integrated into a tomograph, introscope and other systems that allow for a comprehensive examination of the object.

There are more than 10 different types of X-ray machines, and each of them performs a specific task. The invention of this equipment made it possible to significantly advance in the field of medicine and save more than one hundred lives.

X-ray equipment is classified by the following: general-purpose X-ray diagnostic device, X-ray computed tomography, angiograph, X-ray therapy apparatus, dental X-ray machine, flaw detection X-ray machine, X-ray mammograph, pantomographic, fluorograph.

MRI is one of the main accurate diagnostic devices. The classification of MRI devices included ultra low-floor tomographs below 0,1 TL, low-floor tomographs from 0,1 TL to 0,5 TL, mid-field tomographs from 0,5 TL to 1,0 TL, high-field tomographs from 0,1 TL to 2,0 TL, ultra high-field tomographs above 2,0 TL.

Computer diagnostics is developing extremely dynamically. To date, doctors are already dealing with the 4th generation of devices. The following types of computed tomographs (CT) can be distinguished: spiral with high image quality, multilayer (two or more radiation sensorsality) and MSCT (very high accuracy).

The Covid-19 pandemic, which has accelerated the development of many sectors of the medical device market, will not have a significant impact on the categories of X-ray devices.

Although chest radiography is recommended in hospitals for patients with suspected coronavirus, as well as for patients with serious illnesses, experts call computed tomography of the lungs a sensitive method for diagnosing viral pneumonia. Several studies indicate low sensitivity to radiography when analyzing Covid-19.

On the other hand, the advantage of such devices is their mobility, which allows for an operational examination during patient transportation.

Figure 2 shows the countries producing diagnostic medical devices that were in priority when purchasing X-ray devices. It is gratifying that preference was given to the Aktobe manufacturing plant "Aktyubrengent".

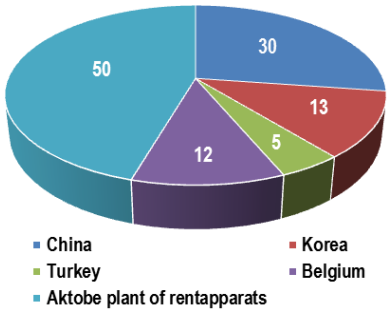

Figure 2. Countries producing X-ray machines purchased during the pandemic.

Currently, pulsed X-ray machines are the most widely used in the Kazakh market, which, in addition to budget cost and convenience in operation, provide the "normative" quality of control of most of the standard ones. All pulse devices are portable and operate in both directional and panoramic modes. At the same time, there are a number of restrictions that do not allow the use of pulse devices at particularly critical facilities.

This is due to the fact that devices of this type do not have voltage regulation, which, combined with the large size of the focal spot, limits their use in nuclear, aviation and other industries that place increased demands on the

quality of radiation monitoring. In addition, pulse devices require a long break between regular exposures and relatively frequent replacement of X-ray tubes.

In the near future, a noticeable growth of the computed tomography market is expected. It is expected that the demand for CT systems will mainly be driven by factors such as the increasing prevalence of chronic diseases, rising healthcare costs and the growing attention of healthcare providers to early diagnosis of diseases for effective treatment. Figure 3 shows data on the countries producing CT scanners.

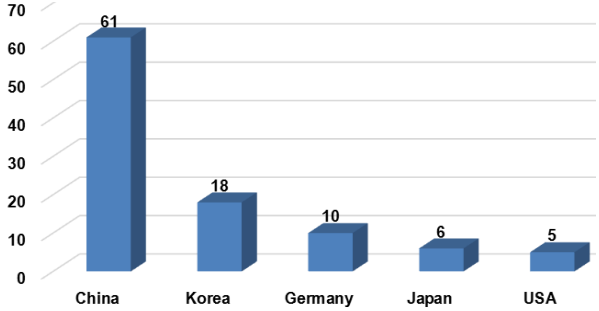

Figure 3. Producer-exporter country of CT for Kazakhstan.

However, it is expected that strict regulations on the production of computed tomography systems will to some extent restrain the growth of the computed tomography market. Since the manufacturers of these systems are required to comply with high quality standards in production, the rules often lead to an increase in the approval time of new products, which further affects the market. In addition, the risks of adverse effects associated with computed tomography, such as exposure to high ionizing radiation, may affect the introduction of these systems in the market.

Exposure to radiation and growing health problems are hindering the growth of the market for computed tomography devices and equipment. Diagnostic imaging procedures use computed tomography devices that emit electromagnetic waves or particles called "ionizing radiation." This radiation coming from artificial sources, such as computed tomography, scanning of nuclear medicine, carries serious dangers and health risks. Low doses can cause cancer in the long run. Cancer is the leading cause of death worldwide, with about 9.6 million people dying from it in 2018. When doses exceed certain levels, it causes skin burns and acute radiation syndrome.

According to the reports, depending on the regions, the global spectral computed tomography market was divided into North and South America, Europe, Asia-Pacific, Middle East and Africa. It is predicted that the Asia-Pacific segment will occupy the largest share of the spectral computed tomography market due to the growing prevalence of cancer, carnivorous diseases, as well as due to the growth of the geriatric population with certain diseases. According to forecasts, America will occupy the second largest market share of spectral computed tomography during the forecast period due to the presence of several medical device companies, innovations in devices to improve the quality of life and reduce healthcare costs.

The European region ranks third in the market of spectral computed tomography due to the growing number of medical equipment manufacturing industries, the growth of per capita income, the increase in consumer spending on healthcare and the presence of developed countries in them. regions are the main growth factor of the spectral computed tomography market in this region.

Prominent key players in the global spectral computed tomography market are focused on developing strategies aimed at increasing the demand for spectral computed tomography. Innovation, product development, mergers and acquisitions are the key strategies of these outstanding players in the global market of spectral computed tomography.

The increasing prevalence of these diseases is expected to play an important role in the growth of the market. Despite the various advantages associated with the MRI system, the costs of purchasing and installing these devices are significant, which, in turn, affects the growth of the market, especially in developing regions. The average cost of a low- and medium-power MRI machine is more than 1 million US dollars. In addition, the increasing need to reduce helium gas deposits to cool the MRI machine leads to an increase in waiting time and a decrease in productivity. Product approval delays and frequent product recalls, mainly due to a strict regulatory framework, also have a serious impact on market growth.

Among the most commonly used screening options for COVID-19, most medical professionals prefer visualization, because it allows you to quickly make an initial diagnosis. All imaging techniques, including magnetic resonance imaging, have been exhaustively used to study COVID-19 and its effects on different patients in each demographic. Improvements in radiological imaging techniques have allowed the industry to create smaller portable MRI with a low magnetic field.

Magnetic resonance imaging is an effective diagnostic device for detecting diseases associated with tumors, stroke and spinal lesions affecting the area of blood vessels and the brain.

Due to significant driving factors such as the provision of specialized medical facilities, increased healthcare costs, strong healthcare infrastructure and a thriving medical technology industry, thanks to the participation of major market players, Europe is the second largest market and holds a fair share of the global market. the market of magnetic resonance imaging systems. In addition, knowledge of the advantages of magnetic resonance imaging systems over radiation imaging and the willingness of residents to diagnose contribute to business development.

The Asia-Pacific region is projected to be the fastest growing region with the most exciting growth prospects. Thus, due to the large number of customers, faster adaptation of medical technologies, government measures to improve the quality of healthcare, the availability of insurance policies for favorable business growth will increase in the forecast period. In addition, due to the lower cost of clinical trials and trials, major players have opened their regional offices and production facilities in Singapore, China, Japan, Korea and Australia, which would make the magnetic resonance imaging systems industry a positive thing. the growth curve in the future.

Mathematical design of sales marketing in JSC "Aktyubrengen"

Aktyubrengen is a company for the production of rengen devices in Aktobe. She sells her products for cash or for free, while the costs are divided into twelve equal

payments. The base sale price is the same in any case, but the service fee as a percentage of the sale price is added to the time-based payment accounts. The production of an X-ray machine (type 1) costs (3265000 tenge), and its selling price is equal to. Business experience shows that the total sales volume is proportional to the price range in question. In addition, the share of total sales, which is a cash sale, is in the find range, as it should be set for maximum profit. The company manages both margin and profit. This dependence can be written as (1).

Business experience indicates the following data in table 1.

$$\wedge 1,000(1+x),\ 0<x\le 1.\ \frac{1}{1+x+x^2}\ \frac{y}{20}+\frac{20-y}{20}\frac{1}{2(1+x)}\ 0\le y\le 20.\ x\ y\ \wedge(x=0.1)\ y=10\% \quad (1)$$

Table 1.

Observed profit ratio, *z:* for *x* and *y* values.

x / y	0	1	2	3	4
0,1	0,0901	0,6036	1,0631	1,4685	1,8198
0,2	0,1613	0,6976	1,1774	1,6008	1,9677
0,3	0,2158	0,7626	1,2518	1,6834	2,0575
0,4	0,2564	0,8044	1,2948	1,7275	2,1025
0,5	0,2857	0,8285	1,3142	1,7428	2,1142
0,6	0,3061	0,8392	1,3163	1,7372	2,1020
0,7	0,3196	0,8401	1,3059	1,7168	2,0730
0,8	0,3278	0,8339	1,2868	1,6864	2,0327
0,9	0,3320	0,8228	1,2619	1.6494	1,9851
1.0	0,3332	0,8082	1,2332	1,6082	1,9332

x / y	5	6	7	8	9	10
0,1	2,1171	2,3604	2,5495	2,6847	2,7658	2,7928
0,2	2,2782	2,5322	2,7298	2,8709	2,9556	2,9839
0,3	2,3741	2,6331	2,8345	2,9784	3,0647	3,0935
0,4	2,4198	2,6794	2,8814	3,0256	3,1121	3,1410
0,5	2,4285	2,6857	2,8857	3,0285	3,1142	3,1428
0,6	2,4107	2,6632	2,8596	2,9999	3,0841	3,1122
0,7	2,3744	2,6209	2,8127	2,9497	3,0319	3,0593
0,8	2,3257	2,5655	2,7520	2,8852	2,9651	2,9917
0,9	2,2693	2,5018	2,6826	2,8117	2,8892	2,9150
1.0	2,2082	2,4332	2,6082	2,7332	2,8082	2,8332

To get the maximum profit, it is necessary that **^(x=0.1)** there was both a surcharge and **y=10%** a service fee. From a mathematical model,

$$S(x)=\frac{1}{1+x+x^2},\ 0<x\le 1. \quad (2)$$

$$D(x,y)=\frac{y}{20}+\frac{20-y}{20}\frac{1}{2(1+x)},\ 0\le y\le \beta=20. \quad (3)$$

$$1-D(x,y)=\frac{20-y}{20}-\frac{20-y}{20}\frac{1}{2(1+x)}. \quad (4)$$

Substituting these values into equations (5):

$$P=\wedge 1,000\alpha\left[\frac{x}{1+x+x^2}+\left(y-\frac{y^2}{20}\right)(x+0.5)\right], \quad (5)$$

$\alpha>0$ and also (6)

$$F(x,y)=\frac{x}{1+x+x^2}+\left(y-\frac{y^2}{20}\right)(x+0.5).\ Solve,\ \max_{x\ge 0,\ y\ge 0} imize\ F(x,y): \quad (6)$$

With a direct approach,

$$\frac{\partial F}{\partial x}=\left\{\frac{1}{1+x+x^2}(1+y-\frac{y^2}{20})-\frac{2x+1}{(1+x+x^2)^2}(x+(y-\frac{y^2}{20})(x+0.5))\right\}=0 \quad (7)$$

$$\frac{\partial F}{\partial y}=\left[\frac{1+0.5}{1+x+x^2}(1-\frac{y}{10})\right]=0\ or\ \left[(1-\frac{y}{10})\right]=0. \quad (8)$$

It follows that $y=10.$ substitution of this value in $\frac{\partial F}{\partial x}=0$ gives a solution to this quadratic equation. Advanced cubic line search algorithm solves equations (9):

$$6x^2+5x-3.5=0\ x=0.453358875\ \underset{x>0,,y\ge 0}{Maximize}F(x,y): \quad (9)$$

It is clear, $x = 0.47$ and $y = 10\%$. therefore, the sale price $\hat{2},940$ should correspond to the 10% the service fee.
Figure 4 shows the graph « x, y against» z , figure 5 shows the graph « x, y against» $F(x,y)$. They confirm that $F(x,y)$ it is right interpolated z.
Consequently, the values x and y are optimal.

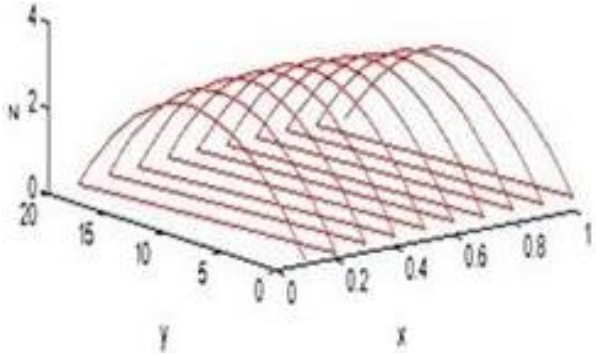

Figure 4. Graph of available data points.

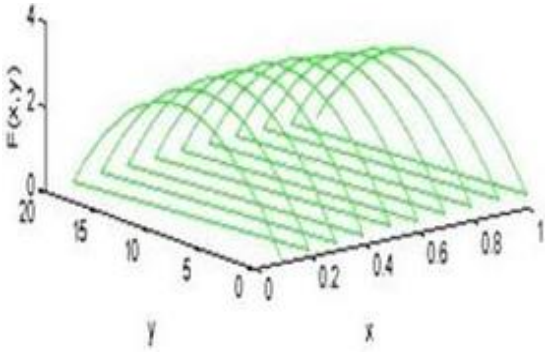

Figure 5. Graph of model data points (functions).

Calculated results show that the model for optimizing the sales allowance and service charges is accurate and easy to implement. The possibility of obtaining optimal values of the sales allowance and service fees for the company "Aktyubrengen", seeking to maximize profits, is confirmed. The results obtained show that the model is amenable to financial analysis and computer automation.

Discussion

In 2015, the Ministry of Finance of the Republic of Kazakhstan launched an electronic public procurement system. On the portal, anyone can unpack machine-readable procurement data on a variety of samples, such as contracts and plans, customers and suppliers, regions and dates. And already in 2020, this largely helped to ensure full transparency of coronavirus procurement, when Kazakhstan declared a state of emergency and adopted a special procurement regime to combat COVID-19. Then the state customer was able to promptly purchase the necessary medical equipment and protective equipment from certain sources. No country in the world could avoid the mandatory procedure. President K.Tokayev addressed a message in which he spoke about the need to build a hearing state. Therefore, in order to ensure transparency and openness, each ministry on its page accepts citizens' appeals and responds promptly. For example, an anti-corruption agency has been created, aimed at ensuring openness. In the public procurement system of Kazakhstan, it has become possible to quickly filter out contracts concluded in the fight against COVID-19. The Anti-Corruption Service holds public procurement procedures, so the director of the Zertteu anti-corruption research, Sholpan Aitenova, conducted research on the reaction of social networks to public procurement during the pandemic. Open and readable data has become an excellent basis for this.

During emergencies, it is possible to conclude direct contracts. But governments should do everything possible to make these purchases as open as possible and gradually return to the competitive field.

In Kazakhstan, as in many countries in Eastern Europe and Central Asia, so far all public procurement within the framework of the fight against COVID-19 takes place without supplier competition, but directly.

Kazakhstanis rely on medical devices to maintain and improve their health and well-being. Kazakhstan has one of the few medical device regulatory systems in the world with some of the strictest requirements. IC "Pharmacy" is a reliable supplier of medicinal products, and certain requirements are set for equipment suppliers to guarantee uninterrupted high-quality operation of diagnostic equipment.

The Government of Kazakhstan is taking steps to further ensure the safety, effectiveness and quality of medical devices used by Kazakhstanis.

To improve the process of Kazakhstan's medical devices entering the international market, a step-by-step algorithm should be developed that would include marketing steps and follow-up actions to promote medical equipment.

In addition, the procedures for emergency anti-science public procurement should be improved on the basis of international experience and better planning

The set goals and objectives have been fully fulfilled, since the analysis of medical equipment supplies showed that Kazakhstan has directed its efforts not only to treatment, but also to correct diagnosis, since the success of treatment depends on accurate diagnosis.

This purchased equipment is based on modern manufacturers, that is, the best manufacturers have presented diagnostic equipment.

The research conducted on the literature review allowed us to conclude that not only our republic made purchases of diagnostic equipment, but also almost all countries. A special trend was used by rengen equipment and computed tomography.

We have analyzed the regulatory documents according to which the purchase of this equipment was made. Undoubtedly, the resolutions on the Customs Union played a great role in the rapid delivery and purchase of equipment. These resolutions made it possible by creating a "green corridor" to speed up the delivery of equipment without bureaucratic delays.

In general, the following recommendations for improvement can be made:

- the creation of a register of bona fide suppliers on this issue will allow for the prompt selection and purchase of the necessary equipment according to the required parameters;
- a clear organization of experts who determine the parameters for the purchased equipment will simplify the procedure for providing characteristics and prices of equipment for selection;

- to leave under special attention customs agreements on the supply of diagnostic and other medical equipment, since timely delivery will reduce the time between waiting, and timely treatment will allow for a quick recovery.

Conclusion

Timely adopted resolutions and the creation of customs-free conditions gave a positive result on deliveries. 132 city and regional hospitals and 53 rural ones are equipped with the necessary diagnostic equipment (100%). There was an increase in investments in this direction by 2.5 times. It is confirmed that it is possible to obtain optimal values of the sales allowance and service fee for JSC Aktyubrengen, which seeks to maximize profits on exports.

The conducted research leads to the following recommendations:

1. To improve the process of Kazakhstan's medical devices entering the international market, a step-by-step algorithm should be developed that would include marketing steps and follow-up actions to promote medical equipment.

2. It is necessary to improve the procedures for emergency "anti-covid" public procurement based on international experience and better planning.

Acknowledgement

Declaration of conflicting interests: *The authors declare that there is no conflict of interest in the present study.*

Funding: *None.*

Author contribution statement:

All authors were equally involved

References:

1. *Nvaeze E., Isienii S., Chzhengue L.* Advanced cubic line search algorithm for solving multidimensional nonlinear optimization problems // Journal of the Nigerian Mathematical Society. 2013. 32(3):185-191.

2. *Mettler F., Tomadsen B., Bkharvagan M., Gilly D., et al.* Medical radiation exposure in the USA in 2019: preliminary results // Health Phys. 2008. 95: 502–507.

3. *Hricak H., Brenner D.J., Adelstein S.J., Frush D.P., et al.* Managing the use of radiation in medical imaging: a multifaceted task // Radiology. 2018. 258: 889–905.

4. *Van Randen A., Bipat K., Winderman A., Ubbink D., et al.* Acute appendicitis: meta-analysis of the diagnostic effectiveness of CT and ultrasound with stepwise compression depending on the prevalence of the disease // Radiology. 2018. 249: 97–106.

5. *Rosen M.P., Sands D.Z., Longmaid H.E., Reynolds K.F. et al.* The effect of abdominal CT on the management of patients admitted to the emergency department with acute abdominal pain // AJR Am J Roentgenol. 2017. 174: 1391–1396.

6. *Rosen M.P., Siver B., Sands D.Z., Brumberg R., et al.* The significance of computed tomography of the abdominal cavity in the emergency department for patients with abdominal pain // Eur Radiol. 2018. 13. 418–424.

7. *Smith-Bindman R., Miglioretti D.L., Johnson E. et al.* Use of diagnostic imaging studies and associated radiation exposure for patients included in large integrated healthcare systems, 2010-2018 // JAMA. 2018. 307: 2400–2409.

8. 2020 Diagnostic Imaging Equipment Service Outlook// Des Plaines, IL: IMG Medical Information Division, 2020. P.236.

9. *Fasel R., Krumholz H.M., Wang Y., Ross J.S., et al.* Exposure to low doses of ionizing radiation during medical imaging procedures // N Engl J Med. 2019. 361: 849–857.

10. *Metler F.A., Bhagavan M., Faulkner K., Gilley D.B., et al.* Research in the field of radiology and nuclear medicine in the USA and around the world: frequency, radiation dose and comparison with other radiation sources - 1950-2007 // Radiology. 2019. 253: 520–531.

11. *Metler F.A., Uist P.V., Liukin J.A.* CT scan: usage patterns and doses // J Radiol Prot. 2017. 20: 353–359.

12. *Schauer D.A., Linton O.V.* The report of the National Council for Radiation Protection and Measurements indicates a significant increase in medical exposure // Radiology. 2019. 253: 293–296.

13. *Tsapaki V., Ahmed N.A., Al-Suwaidi J.S., Beganovich A. et al.* Radiation exposure of patients during interventional procedures in 20 countries: first results of the IAEA project // AJR Am J Roentgenol. 2019. 193:559–569.

14. *Mettler F.A., Bhargavan M., Tomadsen B.R., Gilly D.B. et al.* The impact of nuclear medicine in the USA, 2015-2017: preliminary results // Semin Nucl Med. 2008. 38: 384–391.

15. *Heiken J.P., Peterson C.M., Menias C.O.* Virtual colonoscopy for colorectal cancer screening: current status. Cancer visualization // Specification. 2015. S:133 – 139.

16. *Henschke K.I., Yankelevich D.F., Libby D.M., Pazmantier M.V. et al.* Survival of patients with stage I lung cancer detected by CT // N Engl J Med. 2016. 355: 1763–1771.

17. *Dempster B.* National normalization of MRI in Australia affects the use of CT // BMJ. 2015. 346: f3929.

18. *Freudenberg L.S., Beyer T.* Subjective perception of radiation risk // J Nucl Med. 2015. 52: 29C – 35C.

19. *Royal H.D.* Low-level radiation effects - what's new? // Semin Nucl Med. 2018. 38: 392–402.

20. *Chen SY.* Decision making for late-phase recovery from nuclear or radiological incidents // Health Phys. 2015. 108, 161 – 169. (doi:10.1097/hp. 0000000000000233).

21. *Kardis E., Vrijheid M., Blatner M. et al.* Joint study of cancer risk among radiation industry workers in the nuclear industry in 15 countries: assessment of radiation-related cancer risk // Radiat Res. 2017. 167: 396–416.

22. *Brenner D.J., Hall E.J.* Computed tomography is a growing source of radiation exposure // N Engl J Med. 2017. 357: 2277–2284.

23. *Berrington de Gonzalez A., Mahesh M., Kim K.P., Bhagavan M., et al.* Predicted cancer risks based on computed tomography scans performed in the USA in 2007 // Arch Intern Med. 2019. 169: 2071–2077.

Corresponding Author:

Assiya K. Turgambayeva - PhD, Associate professor, NJSC «Medical University Astana» Head of the Department of Public health and Management;

Mailing Address: 010002, Nur-Sultan, Kazakhstan, Tashenov str. 17.

E-mail: tak1973@mail.ru

Phone: +7 701 887 62 73