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Master Thesis

MANAGEMENT OF THE INTERNET OF THINGS IN HEALTHCARE ORGANIZATIONS' STRATEGIES

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Master in Management:

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АННОТАЦИЯ

Автор	Дворецкая Анастасия
Название ВКР	Управление интернетом вещей в стратегиях медицинских организаций
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Научный руководитель	Иванов Андрей Евгеньевич, к.ф.-м.н., Доцент кафедры государственного и муниципального управления
Описание цели, задач и основных результатов	Цель данного исследования – сформулировать рекомендации по разработке стратегии внедрения решений Интернета медицинских вещей в деятельность российских организаций здравоохранения. В качестве методологической основы диссертации была использована концепция цепочки добавленной стоимости (М. Портер). На основе концепции цепочки добавленной стоимости в работе рассматривается деятельность трех клиник Санкт-Петербурга (ведомственной, частной, государственной) по внедрению решений интернета вещей в сфере оказания медицинских услуг. Результаты исследования обобщены в виде рекомендаций по совершенствованию содержания и методов разработки стратегии развития организаций.
Ключевые слова	Интернет вещей, интернет медицинских вещей, здравоохранение, госпитальные стратегии, разработка стратегии организации, цепочка добавленной стоимости

ABSTRACT

Master Student's Name	Anastasia Dvoretskaya
Master Thesis Title	Management of the Internet of Thing in healthcare organizations' strategies
Educational Program	Master in Management
Main field of study	International business
Year	2020
Academic Advisor's Name	Andrey E. Ivanov Associate Professor, Department of Public Administration
Description of the goal, tasks and main results	The goal of this research is to formulate recommendations for the development of a strategy for implementing the Internet of Medical Things solutions in the activities of Russian healthcare organizations. As a methodological basis of the thesis the modified concept of the value-added chain (M. Porter) was used. Based on the value-added chain concept, the paper examines the activities of three St. Petersburg clinics (departmental, private, state) to implement the Internet of Things solutions in the provision of medical services. The results of case studies are summarized as recommendations for improving the content and methods of hospital strategy development.
Keywords	Internet of Thing (IoT), Internet of Medical Things (IoMT), healthcare, organizational strategy development, hospital strategies, value-added chain model

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INTRODUCTION

A significant part of modern patients (often, for example, yuppies – young urban professionals (J. Algeo, 1991) don't have the time to be sick or to waste on unnecessary services, but rather need the medical service to be given a personalized character. The Internet of medical things makes this possible. Large volumes of data collected by body sensors facilitate the personalization of the healthcare experience. In the future, each patient will be treated using more flexible clinical standards, which are formed using data about the patient, and not just based on average indicators.

The doctor-patient relationship will shift from generalization to personalization (deduction will be replaced by induction). Patient information will become more accessible, allowing practitioners to find the right treatment options much faster.

For instance, according to a study by PricewaterhouseCoopers (PwC), the overall economic effect of the introduction of "Internet of things" technologies in the administration and management of medical organizations, as well as in the diagnosis, treatment and care of patients, in the future until 2025 will amount to 536 billion rubles (PwC, 2017). However, it is not used by healthcare organizations, clinics and hospitals in proper extension, especially in Russia and in order to adopt new IoT technologies, healthcare organizations need to know which ones they actually need and how they will affect their primary and supporting activities.

Despite the fact that nowadays IoT is being actively adopted by many healthcare organizations, there are still not much researches done on this topic. There is no framework that Russian healthcare organizations can rely on when it comes to IoT adoption, as all of the foreign studies do not consider the specificity of healthcare in the Russian Federation.

The goal of current research is to formulate recommendations for the development of a strategy for implementing IoMT in the activities of Russian healthcare organizations. As a methodological basis of the thesis, the concept of the value-added chain (M. Porter) was used. This model structure the organization in a set of interrelated primary (implemented in the framework of the strategic business units) and supporting (implemented by the organization against its strategic business units) activities.

Based on the value-added chain concept, the paper examines the activities of three St. Petersburg clinics (departmental, private, state) to implement IoMT solutions in the provision of medical services. The results of case studies are summarized as recommendations for developing strategies for implementing the Internet of Medical Things in the activities of healthcare organizations.

CHAPTER 1. HEALFCARE ORGANIZATIONS AND INTERNET OF THINGS

The first chapter provides the context of the research. The following literature review is conducted to understand the phenomena, namely the potential ability of the Internet of Things to change the healthcare organizations' strategy. To create a detailed picture of how activities of healthcare organizations and the Internet of Things are linked to each other, it is important to review both Russian healthcare system specifics and key IoT applications. Firstly, it provides the theoretical background of the healthcare system in Russia, healthcare organizations' activities and strategies, which could be influenced by the Internet of Things. Second, there is a theoretical context to the Internet of Medical Things (Internet of Things in healthcare organizations). Key aspects of the Internet of Things are discussed, and how the system works. Ultimately, a correlation between healthcare organizations' strategy and the Internet of Things is demonstrated by evaluating potential benefits from the Internet of Things adoption and barriers for it, as well as by the world and Russian practices of Internet of Medical things adoption. As a result of the literature review, a potential research gap is formed.

1.1. Healthcare organizations

To start with, we need to clarify terminology of the topic. To help us to do so, we need to answer the question “What types of organizations are included in the system of healthcare?”. The system of health care institutions consists of three types of health care institutions:

- Treatment-and-prophylactic institutions;
- Institutions of the state sanitary and epidemiological service;
- Pharmacy institution.

Each type consists of several types of health care facilities.

Treatment-and-prophylactic institutions include:

1. Hospitals (regional, regional, Republican, district, district, district hospitals; hospitals, medical and sanitary units, specialized hospitals-infectious, tuberculosis, psychoneurological, etc.; centers-drug rehabilitation, rehabilitation therapy, occupational pathology, etc.);
2. Special type of health care institutions (Bureau of forensic medical examination, Bureau of medical statistics, pathology Bureau; leper colonies; hospices; disaster medicine centers-Federal, regional, territorial; centers for medical prevention, etc.);
3. Dispensaries (medical and physical, oncological, neuropsychiatric, anti-tuberculosis, etc.);

4. Outpatient clinics (city and district clinics; children's clinics; specialized clinics-consulting and diagnostic, dental, physiotherapy; paramedic and obstetric centers; centers-diagnostic, rehabilitation treatment for children, physical education and sports medicine, etc.; outpatient clinics, hospitals);

5. Emergency medical facilities and blood transfusion facilities (blood transfusion stations, emergency medical services);

6. Maternity and child protection institutions (children's homes, women's clinics, dairy kitchens, maternity homes, etc.);

7. Sanatorium-resort institutions (balneological hospitals, mud baths, resort clinics, sanatoriums (resorts), health resorts, children's health resorts, year-round health camps, etc.);

8. Clinics (clinics of higher medical educational institutions, clinics of medical scientific organizations).

Institutions of the state sanitary and epidemiological service include:

1. Sanitary and epidemiological institutions (disinfection stations, anti-plague centers (stations), centers of state sanitary and epidemiological supervision in the subjects of the Russian Federation, cities and districts, administrative districts and districts in the city, and others);

2. Institutions of preventive medicine (center for hygienic education of the population in Moscow, etc.).

Pharmacy institutions include pharmacies of medical institutions, medical warehouses, control and analytical laboratories, centers for quality control and certification of medicines. (Federal Law No 323-FZ, 2011).

Another term should be mentioned as well. Medical organization — an organization that performs activities in the field of health or medical services that support the development of medicine as a science, and is engaged in measures to maintain health and provide medical care to people through the study, diagnosis, treatment, and possible prevention of diseases and injuries; a legal entity or individual entrepreneur that performs medical activities and has the appropriate license for this (Government decree No 30, 2007).

Thus, from now and henceforth, by “healthcare organizations” we mean treatment-and-prophylactic institutions or medical organizations only (healthcare organization, clinic and hospital we consider as synonyms). Further in this chapter we explored types of activities in healthcare organizations, discussed how healthcare market looks like in the Russian Federation and determined current international and national Internet of things practices.

1.2. Business processes and strategic business units in healthcare organizations

Business process is a regularly repeated sequence of interrelated activities (operations, procedures, actions) that use the resources of the external environment, create value for the consumer, and give them a result (in our case, it is medical service).

The core business processes are processes focused on the production of goods or services, which are the target objects of creating an enterprise and providing income. So, for a medical institution, the main business process is to provide the patient with quality medical care (quality medical services). Those include medical activities and supporting medical processes.

Supporting processes form the infrastructure organizations, in a medical facility-create conditions for performing the diagnostic and treatment process. In our classification those are supporting administrative activities and economic activities.

By analyzing business processes in healthcare organizations, we can see that, first of all, there are four types of activities: basic medical activities, auxiliary medical processes, supporting administrative activities, economic activities. Out of those, primary activities are in fact basic medical activities and supporting activities are the rest three. Let's take a deeper look at all four types of business processes healthcare organization normally have.

Medical activities

Medical activities are activities that affect the life and health of a person. Accordingly, the organization and the specialists who conduct them must meet a certain set of requirements. Have a permit or license for the work. In this context, we will consider the types of medical activities that are subject to mandatory licensing, and the specifics (according to the law) of the process of obtaining a license.

First, we need to understand what medical activity is. Here is how it is explained by Russian legislation: these are works and services that are included in the list attached to the Regulation on licensing of medical activity (approved by the government of the Russian Federation No. 291, the last version of the document was made in 2016).

Types of medical activities are divided according to the General classification (All-Russian classifier of types of economic activity, 2014):

- Health resort activities;
- High-tech medical care;
- Specialized ambulance or an air ambulance;
- Specialized medical activities;
- Medical care for women both during pregnancy and during childbirth;
- Inpatient medical care;
- Medical primary care;

– Outpatient activities;
– Pre-medical care.

Medical activities are the core activities for healthcare organizations. Core activities directly add value to the final product (we will discuss value chain more later in paragraph 1.3. Value chain in healthcare organizations). However, if we are examining medical activities from the point of view of value chain, those can be divided into further business processes:

3. Processes related to the provision of outpatient medical care in a consulting clinic:
   a. Patient registration and appointment;
   b. Processes related to the activities of specialists of the consulting clinic;
4. Processes related to the provision of inpatient replacement medical care in a polyclinic or hospital:
   a. The processes of the day hospital at the clinic;
   b. Day care processes in the hospital;
5. Processes related to the provision of inpatient medical care:
   a. The processes associated with the activities of the receiving Department:
   b. Account of movement of patients in the steady state;
   c. Processes related to activity of the medical Department;
   d. Processes related to activity of the intensive care unit;
   e. Processes related to the operation activity:
   f. Processes for providing medication treatment;
6. Processes related to the provision of emergency and emergency medical care:
   a. Accounting for the activities of specializations-visiting teams;
   b. Emergency medical services assistance by mobile teams.

Supporting medical processes

In order to proceed proper medical activities, hospitals need supportive medical processes to be done. Supporting medical processes:

1. Processes related to paraclinic activity:
   a. Processes related to treatment paraclinic activity;
   b. The processes associated with the Advisory activity of the medical specialists;
   c. Performing instrumental diagnostics;
   d. Conducting laboratory research;
   e. Processes of the pathology service;
2. Processes of clinical and expert activity:
   a. Processes related to the activities of medical commissions;
   b. The processes of examination of disability;

c. Examination of the quality of medical care;

3. Other supporting medical processes:
   a. Processes of the Department of medical nutrition;
   b. Rehabilitation and rehabilitation treatment;
   c. The processes of the division of blood transfusion;
   d. The processes of the center for organ donation.

Supporting administrative activities

Supporting administrative activities are the processes of professional operational daily organizing and regulating influence on public relations, solving general, group and private cases on the basis of and for the implementation of management decisions. Specifics of supporting administrative activities differ from sphere to sphere, from organization to organization. In case of healthcare organizations supportive administrative activities include:

1. Administrative and managerial activities:
   a. Managing the activities of a medical organization;
   b. The processes of the office;
   c. Personnel records;
   d. Organizational processes.
2. Financial and economic activities:
   a. Accounting;
   b. Planning and economic activity of a medical organization;
   c. The subject matter of the contract;
   d. Settlements with contractors for render service;
3. Medical statistics and archive of medical documents:
   a. Generating medical statistics and other reporting;
   b. Maintaining a medical archive;

Economic activities

In this context by economic activity we consider the activity of providing property for use, selling goods, performing works, providing services, carried out for the purpose of making a profit or without such a purpose. In healthcare organizations economic activities include:

1. Material support of the medical and diagnostic process;
   a. Provision of medicines and medical devices;
   b. Personalized accounting of direct material costs;
2. Ensuring warehouse accounting:
   a. Purchasing processes;
   b. Material accounting of medicines and pharmaceutical products;

c. Material accounting of food products;
d. Material accounting of medical devices;

3. Accounting for a set of technical means;
4. Accounting and maintenance of medical equipment;
5. Processes of the central sterilization department.

Those business processes that were defined were used further in the application of value chain model to our cases in the third chapter of the research. As a rule, a business process coincides with a chain link, but more often there are several business processes in the link.

Strategic business unit (hereinafter – SBU) is an economic organization that produces a clearly defined list of goods and services sold to a certain homogeneous group of buyers, and deals with a specific group of competitors (F. Borch, 1970). In the context of healthcare organization, SBU might be explained from patient's side. Customer (or patient) has a specific problem. This problem can be solved by getting a specific service (treatment, diagnosis, etc.). The patient can get the service in the relevant department of the clinic. This department is in fact the SBU.

1.3. Value-added chain model

In further research, we chose one SBU in each of the organizations in order to examine it with value-added chain (hereinafter – VAC) model application. Here we will briefly discuss the concept of value chain (deeper discussion of the model application in healthcare you may find in the second chapter).

The concept of value chain was introduced in 1985 by Michael Porter in the book "Competitive advantage" (Porter, 1985). The value chain is a model that helps to understand and model activities of organization and choose right management decisions. It describes all the activities carried out by an organization to create a service or a product. The key idea is to define strengths and weaknesses of organization, including comparison with industry competitors (organizations with similar value chains). Based on the chain elements, we can compare with competitors, analyze and determine ways to improve.

Value – the amount that the buyer is willing to pay for what the company provides. A value chain is an interconnected set of activities that create value, ranging from the delivery of basic source materials from suppliers to the delivery of the final product or service to the customer. Activities are not a set of independent components, but are a system of interrelated stages in which the results of one of them affect the costs of others.

Methodology for building and applying the value chain:

– Identify the company's value chain;
– Specify costs, revenues, and assets for value-creating activities;

– Establish the cost-forming factors that regulate each type of economic activity;

– Create a competitive advantage by better managing costs and / or reconfiguring the value chain.

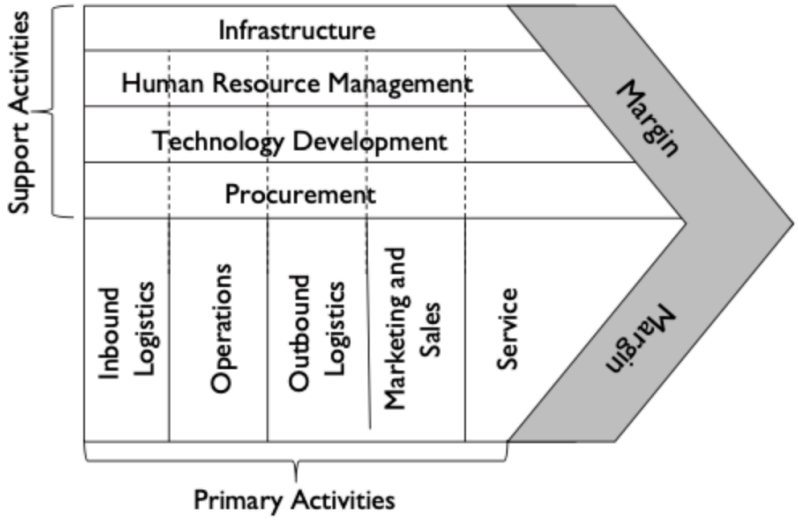

Figure 1 *Generic value chain model template (Porter, 1985)*

Historically, the concept of "value chain" was developed for industrial organizations (Figure 1), but it can be successfully applied in the field of services, including medical ones. This approach allows to more clearly separate the main and supporting processes, make more explicit the places in the organization's activities where value is formed, and fix its value using certain indicators. The value chain method allows us to more effectively solve the task of monitoring and measuring processes, which is key in quality management, by more clearly identifying the main tasks and processes and determining their value.

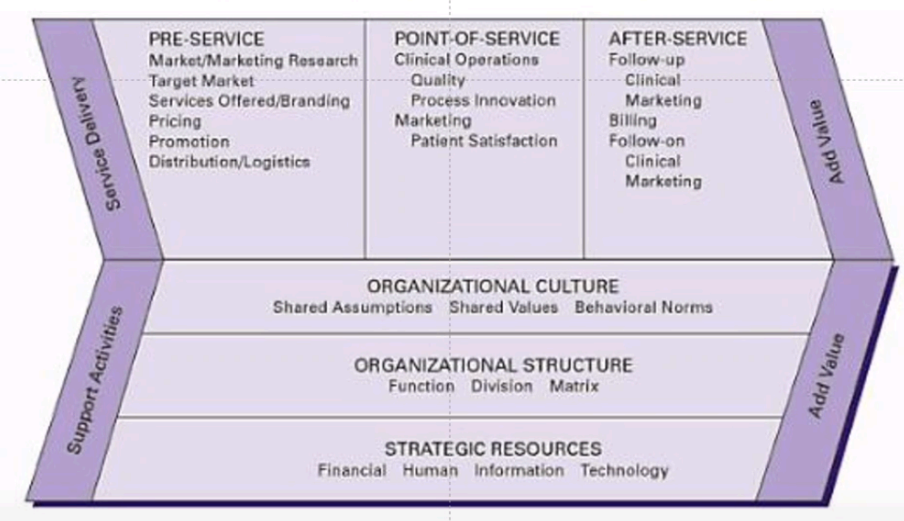

Figure 2 *General value chain model in healthcare (Linda E. Swayne et al., 2006)*

One of the adaptations of the Porter's model to healthcare was made by Linda E. Swayne et al., which can be observed below above – Figure 2. In the paper "Strategic management in health

care organizations" value chain was reformed: primary activities were divided into pre-service (eg. marketing, pricing, promotion), point-of-service (eg. clinical operations) and after-service (eg. follow-up marketing, billing), supporting activities were divided into organizational culture, organizational structure and strategic resources. The location of primary and supporting activities were switched. The value chain model was also adopted to healthcare by M. Porter in 2016. Further, in section 2.2.3, it would be discussed in more details.

Meanwhile, the model is not well used in the world. There are not many pieces of research on the use of the standard Porter model for strategy development in Russia (Verkhovskaya O.V. et al, 2017) nor researches on the use of modified value chain worldwide (Wang J.B. et al., 2018, Raghupathi W. et el., 2014, and etc). Basically, the majority of the papers are not using the value chain model as a tool for strategic planning or developing, but superficially mentioning it in the text. What is more important, there are no cases of value chain model application in healthcare with the Russian context. For instance, after conducting a literature review of management journals "Russian Management Journal" and "Vestnik" that were published since 2015, it was discovered that the value chain model is superficially mentioned only articles, where it is not connected with strategic planning or properly discussed (Dementiev V. E., 2019, Shastitko A. E. et al, 2018, Zenkevich N. A. and Gladkova M. A., 2018, Kolchinskaya E. E. et al, 2019 and etc).

1.4. Healthcare in the Russian Federation

In any country, health care is a social function of society, the purpose of which is to protect and promote human health. Elements of such a system took place even before the first states and ancient civilizations were created by humans. They were expressed in some form of care of the community, family or tribe for their patients, as well as in the measures taken to prevent injuries and diseases. This may include various medical manipulations of healers, their conduct and organization.

Health protection of citizens in Russia is a set of measures of a political, economic, legal, social, cultural, scientific, medical, sanitary-hygienic and anti-epidemic nature aimed at preserving and strengthening the physical and mental health of every person, maintaining their long-term active life, providing them with medical care in the event of loss of health (Federal Law No 323-FZ, 2011).

The number of hospital facilities at the end of 2018 was about 5.3 thousand, hospital beds — 1172.8 thousand (79.9 per 10,000 population). The share of private clinics in Russia is about 5% of their total number. In Russia, 703.7 thousand doctors of various specialties (at the end of 2018). Total health expenditure in Russia in 2018 was 3.2% of GDP (Rosstat, 2019).

1.4.1. Organizational bases of healthcare in the Russian Federation

The main law that regulates healthcare sphere is Federal Law of the Russian Federation of November 21, 2011 No. 323-FZ "About bases of protection of public health in the Russian Federation" (as amended on 27-12-2019).

In accordance with the paragraph 2 of article 41 of the Constitution and article 12-14 of the Fundamentals of Russian Federation's legislation on health protection of citizens in Russia there are three systems of health:

1. State;

The State health system includes Federal Executive authorities and Executive authorities of the subjects of the Russian Federation in the field of health, the Russian Academy of medical Sciences, as well as state-owned medical and preventive, research, educational, pharmacy, sanitary and preventive institutions and some other enterprises, institutions, organizations.

2. Municipal;

The Municipal health system includes local self-government bodies that are authorized to administer health care, and municipal-owned medical, pharmaceutical, and pharmacy organizations.

3. Private.

The private health care system includes therapeutic and pharmaceutical institutions whose property is privately owned, as well as individuals engaged in private medical practice and pharmaceutical activities (Russian Federation Constitution, 1993, Federal Law No 323-FZ, 2011).

It is important to mention that in Saint-Petersburg there are no municipal healthcare system – healthcare organizations have status of regional (state) organizations.

1.4.2. Market overview

Most of the turnover of the medical services market is accounted for by the compulsory health insurance (hereinafter – CHI)) sector-56.8% as of 2018. this is Followed by the budget financing and cash payments sectors, each of which accounts for 15.8%. In 2018, the value of the CHI sector in Russia increased by 17% and reached RUB 1,739. 7 billion. the growth in the segment's turnover was due to an increase in the average per capita standards for financing medical care. The growth of CHI turnover was also facilitated by the development of medical prevention; redistribution of certain types of services from the budget sector to the CHI sector; development of public-private partnership.

Legal commercial medicine, shadow commercial medicine, and Voluntary medical insurance (VMI) are part of the same group of paid medical services. In 2018, the share of legal commercial medicine reached 57% of the entire structure of the paid medical services market.

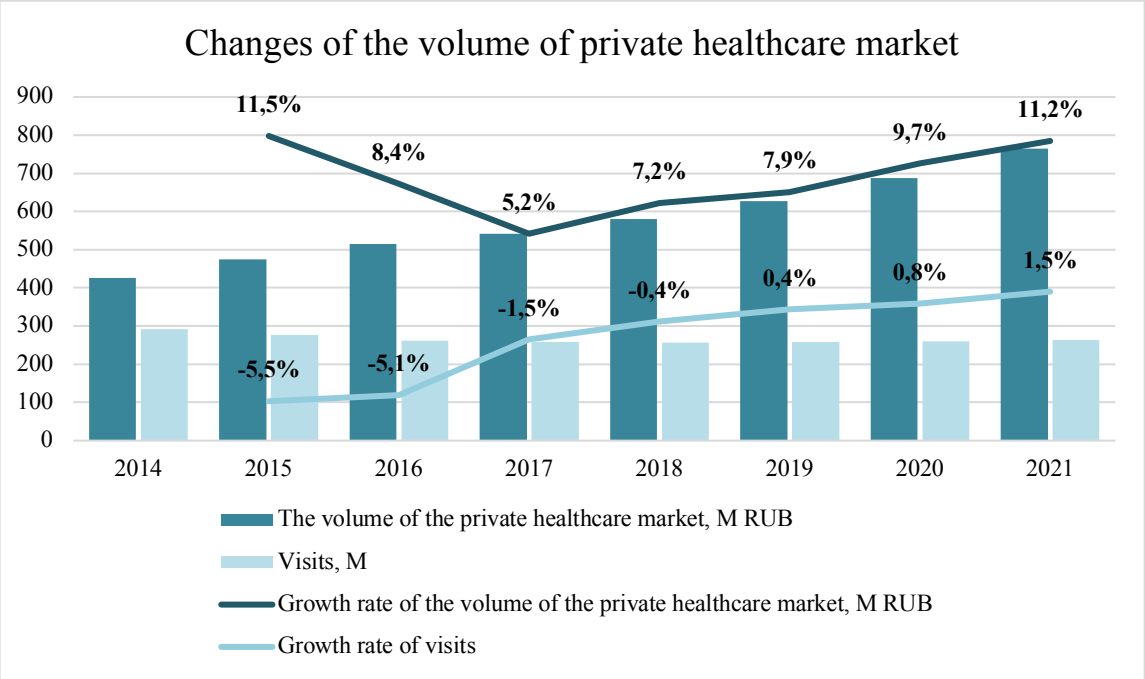

Figure 3 *Changes of the volume of private healthcare market (KPMG, 2017).*

As of 2018, the market for paid medical services in Russia has reached 600 billion rubles. Analysts at Ernst&Young and KPMG predict a CAGR of more than 10% by 2021. The number of visits will remain the same over 250 million visits, but the volume will grow faster than the number of completed receptions. The main factor of volume growth is the increase in prices for medical services.

According to Businessstat, market participants note an increase in demand for MRI diagnostics, as well as services of cardiologists, psychiatrists, otolaryngologists, traumatologists and other specialized specialists. As a result of the optimization of the health care system, it has become more difficult to obtain these services in public health facilities, so patients often turn to private clinics for them. The low level of service in public health due to the increased workload due to the reduction in the number of medical institutions and doctors and, as a result, problems with obtaining medical services at the time of treatment will also contribute to the influx of patients into the commercial sector. Thus, according to the results of a survey of health workers conducted by the “Zdorovye” Foundation in December 2017, 57% of respondents noted a decrease in the quality and availability of medical care for the population.

But, there is a drawback, this is increased price competition, which is especially clearly manifested in the mass and business segments. First of all, this is due to the entry into the market

of paid services of state medical institutions. Receiving support from the budget, they set lower prices compared to private clinics.

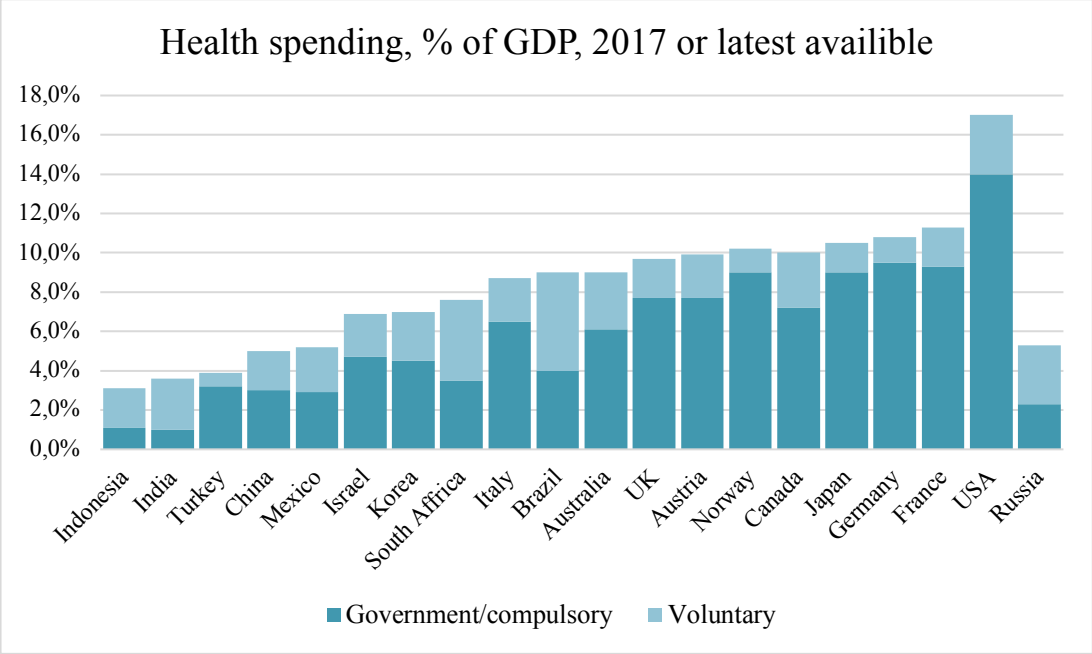

Figure 4 *Health spending, % of GDP (MCClinics, 2019).*

In Russia, the ratio of medical expenses to GDP in 2017 was 3%, which is the average for EM countries, in countries with developed economies (the United States, the European Union, Canada, etc.), this indicator reaches more than 10%.

The market is quite young and new for the Russian Federation, as evidenced by analysts ' forecasts for the growth rate of volumes. The population wants to receive high-quality medical care and will be more active in applying to private clinics.

In Saint-Petersburg, there are 7 Medical Universities are 1 medical scientific center, 30 Federal Medical Centers, 288 city medical hospitals and outpatient centers, 725 offices of general practitioners, 3600 private clinics and outpatient private centers and more that 600 research-production and biological research centers and laboratories (Rosstat, 2019).

1.4.3. Chosen healthcare organizations

For further research three organizations were chosen: The Nikiforov Russian Center of Emergency and Radiation Medicine (hereinafter – NRCERM), EMC Clinic and I.I. Dzhanelidze Research Institute of Emergency Medicine (hereinafter – DRIEM). The choice of clinics is justified by the fact that all of them are considered to be large, but they differ by the mean of typed, legal form, so that the successful application of the value chain model means that it can be applied to a large list of healthcare organizations. NRCERM is a departmental institution that has both emergency and planned care and has inpatient and outpatient departments. EMC is a private clinic which provides only planned care and has only outpatient departments. DRIEM is a state budgetary

institution that has both emergency and planned care and has inpatient and outpatient departments. Further, on each of the organizations an instant look was taken.

The Nikiforov Russian Center of Emergency and Radiation Medicine

The Federal State Budgetary Institute «The Nikiforov Russian Center of Emergency and Radiation Medicine» The Ministry of Russian Federation for Civil Defense, Emergencies and Elimination of Consequences of Natural Disasters is a multidisciplinary medical and diagnostic institution providing specialized high-tech medical care in a polyclinic, day and day hospital, as well as scientific and educational center. Collaborating center of the world health organization for the treatment and rehabilitation of participants in the aftermath of nuclear and other accidents and catastrophes.

NRCERM solves the following main tasks:

– Multidisciplinary specialized high-tech medical care for various diseases, including people affected by radiation accidents, man-made disasters and natural disasters;

– Fundamental and applied research in the field of radiation medicine, radiobiology, occupational pathology. Introduction of new medical technologies; — educational activities in the field of postgraduate and additional professional education (postgraduate, residency, advanced training);

– Registration, recording and dynamic monitoring of victims of accidents, catastrophes and natural disasters;

– Organization of expert work, including the establishment of the causal relationship of diseases with the effects of factors of accidents and catastrophes;

– Cooperation with domestic, foreign and international medical organizations.

NRCERM is staffed with highly qualified personnel, including more than 60 doctors (medical, biological, psychological) Sciences, 35 professors, more than 110 candidates of Sciences. More than 70% of medical personnel have the highest and first qualification category.

20 employees of NRCERM awarded the honorary title "Honored doctor of the Russian Federation", "Honored worker of the health of the Russian Federation", "Honored worker of science of the Russian Federation".

More than 125 doctors, nurses and specialists of NRCERM have been training (training) in leading medical centers of the world (Austria, UK, Germany, Holland, Israel, Spain, Italy, China, Korea, USA, France, Finland, Switzerland, Sweden, India, Czech Republic)

NRCERM highly qualified staff provides more than 5,000 types of medical services using advanced medical technologies and the latest equipment (NRCERM, 2020).

I.I. Dzhanelidze Research Institute of Emergency Medicine

The I.I. Dzhanelidze Research Institute of Emergency Medicine of Saint Petersburg begins its history in 1919, when the Central emergency hospital was founded, in 1925 it was renamed the Pervukhin emergency hospital, and in 1932 the Institute was established on the basis of the hospital, the scientific Director of which was Professor I. I. Dzhanelidze.

Currently, the Institute of emergency medicine is a multidisciplinary scientific and medical institution with 25 clinics that provide emergency and planned hospitalization, diagnostics and counseling to citizens of the Russian Federation and other countries daily and around the clock.

Services: Dzhanelidze research Institute of emergency medicine provides specialized care for almost all medical profiles and diseases: nervous, endocrine, urogenital, musculoskeletal, respiratory, digestive, circulatory systems, skin and subcutaneous tissue diseases, pregnancy, neoplasms, injuries, poisoning, frostbite, burns, as well as provide high-tech assistance in the following areas: organ transplantation, traumatology and orthopedics, neurosurgery, cardiovascular surgery. Following is the information about the organization and key data from 2019:

Staff:

- About 2100 employees, including 111 researchers;
- 56 doctors of science, including 30 professors;
- 100 candidates of science;
- 513 doctors of various specialties;
- 830 people of secondary medical staff, 330 people of Junior medical staff;
- 4 Laureate of the State prize and RF Government prize, 20 Honored physicians of the Russian Federation, 17 – honors health, 216 specialists with higher and first category, and highly professional nursing staff.

Key performance indicators for the year (DRIEM, 2020):

- The total number of patients taken to the Institute's emergency Department is 78,096;
- 49,284 patients were admitted to specialized departments and clinics of the Institute
- Outpatient care in full with the formation of medical recommendations was provided to 28,812 patients;
- Average annual bed occupancy is 368 days;
- More than 6 million laboratory tests were performed;
- Total number of publications in RSCI – 1816;
- Reports at conferences and meetings of societies – 291.

EMC Clinic

EMC Clinic has gathered a unique international team of experts – more than 600 doctors from the USA, Western Europe, Israel and Russia work together for the benefit of patients. Teamwork is a distinctive feature of EMC, it is an advantage that helps us to achieve excellent results in treatment. The clinic combines experience and knowledge in different areas of medicine to find the right solutions and help patients even in the most difficult cases.

Treatment in EMC is carried out according to modern American and European protocols. Thus, for patients, it is an opportunity to get access to the best world methods of treatment without going abroad.

EMC specialists provide round-the-clock emergency assistance for heart attacks, strokes, complex traumatic lesions of the brain and spinal cord and other urgent conditions. The clinic has extensive experience in conducting complex surgical procedures, provide high-quality postoperative care, conduct timely and comprehensive rehabilitation.

When it comes to a difficult diagnosis, a disease that requires a comprehensive approach, it is important to participate in the treatment of specialists of different profiles. More than 50 medical directions are presented in EMC, the unique centers of competence on assistance to patients with oncological, neurological, cardiovascular and autoimmune diseases, surgical pathologies, injuries of any severity are created.

EMC is a private clinic No. 1 in providing high-tech assistance having the necessary equipment for a comprehensive diagnosis of any disease. The clinic uses the latest medical technologies: molecular imaging, robotic surgery, the latest methods of radiation therapy and radiosurgery, angiographic system of the latest generation to perform endovascular operations.

In the Department of reproduction, EMC helps their patients to find happiness to become parents: the percentage of successful IVF protocols they have is much higher than the average in Russia. EMC cares about the health of the future mother and baby from the first day of pregnancy and after discharge from the hospital. EMC maternity hospital is the experience of the best maternity hospitals in the world in Moscow, obstetricians and gynecologists with many years of experience, comfort and safety of mother and new-born baby.

From the very beginning of the clinic, EMC provides assistance not only to adult patients but also to children. The EMC Children's clinic accepts highly qualified children's doctors with experience in Western Europe and the United States, including doctors of rare specialties. The clinic is equipped with the most modern equipment for the diagnosis and treatment of young patients. EMC is the first paid medical center where a 24-hour children's surgical hospital was organized.

For 30 years EMC has been working at the level of the best international standards, introducing and developing advanced treatments to preserve the health of their patients.

Mission: The European medical center is a territory of health, where each patient receives an individual comprehensive approach and access to the world's best medical technologies.

Vision: EMC is a medical partner for patients throughout their lives. The undisputed leader in the field of comprehensive health care, providing medical services of the highest quality and of any complexity (EMC Clinic, 2020).

1.5. Internet of thing in healthcare

Today, the healthcare sector is a high-tech industry, where transplantology and traumatology, plastic surgery and Oncology, neurosurgery, ophthalmology, gynecology, dentistry and other areas that allow saving the lives of previously hopeless patients are successfully developing. The technical equipment of medical institutions has significantly improved, and it is now possible to diagnose the disease at the earliest stage and quickly restore the efficiency of patients. Minimally invasive procedures using endoscopic equipment, microsurgery and laser vision correction, organ and tissue transplants, correction of congenital and acquired defects have become commonplace. However, some problems still remain relevant. And to solve them, the Internet of things comes to the rescue.

The Internet of Things in healthcare or Internet of Medical Things (hereinafter – IoT, IoMT) is a concept of a network that combines "connected devices" and devices that monitor the state of the human body and its environment, including devices that can interactively influence the prevention, treatment and rehabilitation processes.

The Internet of things is one of the most popular advanced technologies in recent times. The ability to implement practical solutions thanks to the concept of the Internet of things provides advantages in many areas of human activity. Moreover, the Internet of things in medicine is one of the most dynamically developing industries for the its industry. According to the report "IoT Market in healthcare" by the analytical company Meticulous Research, the next few years the medical segment of IoT will grow by 19% annually, by 2025 its global volume will reach $322.2 billion (Meticulous Research, 2019).

Modern medical institutions face a wide range of different challenges, for example, the problems of hospital safety, as well as its employees, the need for constant recruitment of staff to improve performance, constant monitoring of regulatory climate indicators, as well as monitoring the physical performance of patients. And all these problems have a common cause – the lack of a comprehensive solution that will perform constant and continuous measurement and control of environmental parameters, technological processes, the status and condition of patients, staff, medical and other equipment. A syringe pump that is not used regularly, an open refrigerator with heat-sensitive drugs, sporadic ventilation of hospital premises-all this adversely affects the quality of medical services provided.

Modern devices connected to the Internet of things are now becoming an integral part of the life of many medical institutions and significantly help in automating processes and save valuable time for doctors. The use of sensors and remotely operated medical devices will provide patients with access to advanced medical technologies. The development of remote diagnostics (telemedicine) and remote surgery will help to bridge the geographical gap in the provision of medical services, increase the effectiveness of medical care in emergency situations, and significantly reduce the cost of services provided. Medical devices connected via the Internet will be able to collect and transmit patient data over a long distance and in a matter of seconds, which will significantly reduce the number of medical errors.

1.5.1. Applications of IoT in health care

As noted above, the advent of Internet of things technologies has led to exciting developments in the twenty-first century. Experts identified the following options for using IoT in modern healthcare:

1. Remote health monitoring

One of the most obvious and popular applications of Internet of things technologies in healthcare has become remote health monitoring, or telemedicine. In some cases, patients do not need to visit emergency departments or their doctor. The job of medical professionals is usually performed by different devices in a compartment with different applications. Doctors use remote monitoring to draw more informed conclusions about patients' health. Telemedicine reduces the patient's cost of hospital visits.

2. Ensuring availability of critical hardware

Modern hospitals cannot be imagined without next-generation equipment. Some hardware is used to save or maintain people's lives. Like all electronic devices, this equipment is subject to numerous risks - from power outages to system failures. Such cases put the patient on the verge of life or death. The e-Alert system developed by Philips is designed to solve the problem. Instead of waiting for the device to fail, e-Alert predicts possible problems, monitors medical equipment, and alerts hospital staff to possible malfunctions (Philips, 2020).

3. Monitoring staff, patients, and inventory

Ensuring safety is the main concern of any medical institution. In hospitals with multiple buildings and branches, including those with offices in different regions of the world, it is difficult to maintain the maximum level of security without the ability to track assets — employees, patients, and equipment. Real-time location detection systems based on the use of Internet of things technologies make monitoring tasks easier.

4. Reducing the waiting time for a seat

Sinai medical center in New York was able to reduce the waiting time for inpatient placement by an hour for 50% of emergency Department patients. The medical center has 1,1 thousand beds, and doctors receive more than 59 thousand patients annually (about 90% of hospital beds are always occupied).

The medical facility piloted the AutoBed program developed by GE Healthcare. AutoBed's goal is to find affordable beds for patients. AutoBed software can process up to 80 requests for a bed, track the availability of available and occupied places, consider 15 patient needs, for example, the possibility of calling a nurse (Healthcare IT Today, 2020).

5. Improved drug management

New forms of prescription drugs are one of the most exciting advances in medicine that has happened thanks to the IoT. Tablets with the support of microscopic sensors can provide doctors with better information about the state of the patient's internal organs.

For example, the Proteus Discover solution, which uses tablets and built-in sensors, as well as a patch that attaches to the body, provides a more complete picture of the patient's health. The tablets contain a sensor the size of a rice grain. After the pill reaches the stomach, the sensor sends a signal to the patch. The patch is also equipped with sensors that record all the information received and transmit it to the patient and attending physicians (Proteus, 2020).

Also, since 2015, it is known about the development of contact lenses for diabetics. In April 2017, CNBC reported that Apple had hired a team of specialists in the field of Biomedicine. Researchers are developing optical sensors that Shine through the skin to measure sugar levels. Other manufacturers have tried to come up with a similar technology for the prevention and treatment of diabetes (CNBC, 2019).

6. Treatment of chronic disease

By mid-2018, there are several devices and technologies that help treat chronic diseases. In the twenty-first century, it is a combination of technologies, next-generation analytics, and mobile communications. Utilities like Fitbit use IoT to monitor personal health. You can share this information with your doctor in order to get qualified help for a chronic disease (Fitbit, 2020).

By this time, Health Net Connect had created a population diabetes management program. The goal of the program is to improve clinical treatment and reduce patients ' medical expenses. The first results were obtained, but the company is committed to developing the technology (HNC Virtual Solutions, 2020).

1.5.2. Benefits and barriers that affect IoMT adaption in healthcare organizations

Main benefits:

1. Cost reduction

First and foremost, the main benefit from IoT application is cost reduction while maintaining or even enhancing the quality of treatment. IoT technologies requires major investments (especially when it comes to building infrastructure of "smart" hospital from the very beginning), however, in the long term, IoT helps to significantly decrease operational costs in the long term.

2. Simultaneous reporting and monitoring;

Real-time monitoring using connected devices can lead to life in the event of a medical emergency, such as heart failure, diabetes, asthma attacks, etc. When monitoring the condition in real time using an intelligent medical device connected to the smartphone application, the connected devices can collect medical and other necessary medical data and use the connection to the smartphone data to transmit the collected information to the doctor.

The Center for Connected Health Policy conducted a study that found that there was a 50% decrease in the 30-day readmission rate due to the remote monitoring of heart failure patients. The IoT device collects and transmits health data: blood pressure, oxygen and blood sugar levels, weight and ECG. This data is stored in the cloud and can be transferred to an authorized person, who can be a doctor, your insurance company, a participating medical firm or an external consultant to allow them to view the collected data regardless of their location, time or device.

3. End-to-end connectivity and affordability;

IoT can automate patient care workflows with healthcare mobility and other new technologies, as well as next-generation healthcare facilities. The IoT in healthcare provides interoperability, machine-to-machine communication, information exchange and data movement, which makes the provision of medical services efficient.

Connection Protocols: Bluetooth LE, Wi-Fi, Z-wave, ZigBee and other modern protocols, medical personnel can change the way they detect diseases and ailments in patients, and can also introduce revolutionary methods of treatment. Consequently, a technology-oriented installation reduces costs by reducing unnecessary visits, using better resources and improving distribution and planning.

4. Assortment and data analysis;

The sheer amount of data that a medical device sends in a very short time due to their real-time application is difficult to store and manage if cloud access is not available. Even for health care providers, getting data from multiple devices and sources and manually analyzing it is a tough

bet. IoT devices can collect, communicate, and analyze data in real time and reduce the need for raw data storage. All this can happen in overcloud when providers get access only to final reports with schedules. In addition, medical operations enable organizations to receive vital medical analytics and data-based analytical data that accelerate decision-making and are less prone to error.

5. Tracking and Alerts;

Timely notification is crucial in the event of life-threatening circumstances. IoT medical devices collect vital data and transmit it to doctors for real-time tracking, while sending people notifications of critical details through mobile applications and other related devices.

Reports and alerts give a solid view of the patient's condition, regardless of place and time. It also helps to make informed decisions and timely treatment. Thus, IoT provides real-time notification, tracking and monitoring, which allows for practical treatment, increased accuracy, timely medical intervention and improved overall patient care results.

6. Remote medical care;

In case of emergency, patients can consult a doctor who is many kilometers away using smart mobile applications. With mobile healthcare solutions, doctors can instantly check patients and detect diseases on the go. In addition, there are numerous health care delivery chains that predict the development of machines that can distribute drugs based on a patient's prescription and disease-related data available through related devices. IoT will improve patient care in the hospital. This, in turn, will reduce human health expanses.

7. Studies.

IoT for healthcare can also be used for research purposes. This is because IoT allows us to collect a wealth of patient disease data that would take many years if we collected it manually. These data collected in this way can be used for statistical research, which will facilitate the conduct of medical research. Therefore, IoT not only saves time, but also money, which will go to research.

Thus, IoT has a great influence in medical research. This allows the introduction of larger and better medical treatments. IoT is used in a variety of devices that enhance the quality of patient care. Even existing devices are now updated by IoT with the easy use of embedded smart device chips. This chip enhances the care and care that the patient requires.

Challenges:

1. Data Security and Privacy;

One of the most significant threats that IoT poses is data security and privacy. IoT devices capture and transmit data in real time. However, most IoT devices do not have data transfer protocols and standards. In addition, there is considerable uncertainty regarding the regulation of

ownership of data. All of these factors make data very vulnerable to cybercriminals, who can hack into the system and compromise the personal health information (PHI) of both patients and doctors. Cybercriminals can abuse patient data to create fake IDs to buy medicines and medical equipment that they can sell later. Hackers can also file a fraudulent insurance claim in the name of the patient.

2. Integration: Multiple Devices and Protocols;

The integration of multiple devices also creates barriers to IoT adoption in the healthcare sector. The reason for this obstacle is that device manufacturers have not agreed on communication protocols and the standard. Therefore, even if a variety of devices are connected, the difference in their communication protocol complicates and complicates the process of data aggregation. This non-uniformity of protocols of the connected device slows down the whole process and reduces scalability of IoT in healthcare.

3. Data overload and accuracy;

As mentioned earlier, data aggregation is difficult due to the use of various communication protocols and standards. However, IoT devices still record a ton of data. Data collected by IoT devices is used to obtain vital information. Despite this, the amount of data is so huge that it becomes extremely difficult for doctors to draw conclusions on their basis, which ultimately affects the quality of decisions. In addition, this problem grows as more and more devices are connected that record more and more data.

4. Costs.

As it was mentioned, the IoT adoption requires major investments. The boom in health spending is a worrying sign for everyone, especially for developed countries. The situation is such that it spawned “medical tourism,” in which patients with critical conditions gain access to medical facilities in developing countries, which costs them less than one tenth. IoT in healthcare as a concept is a fascinating and promising idea. However, at the moment this has not solved the cost problem. In order to successfully implement the development of IoT applications and achieve their full optimization, stakeholders must make it cost-effective, otherwise it will always remain out of reach of everyone except people from the upper class (Peerbits, 2020).

1.5.3. IoMT market overview

According to analysts' forecasts, the volume of the Internet of things market in medicine will exceed about $158 billion by 2022. The average market growth rate (CAGR) in the period from 2016 to 2022, market Research Engine experts estimated at 30.8% (E. Semenovskaia, 2018).

The key players in the segment are Medtronic PLC (USA), Royal Philips (Netherlands), Cisco Systems (USA), IBM Corporation (USA), GE Healthcare (USA), Microsoft (USA), SAP

SE (Germany), Qualcomm Life (USA), Honeywell Life Care Solutions (USA) and Stanley Healthcare (USA).

The main drivers of the development of the Internet of things market in the field of healthcare are: the development of IoT solutions to reduce the cost of medical care, the development of artificial intelligence technologies, increased investment in medical IoT solutions, increased efficiency of network technologies, the growing penetration of connected devices in the health sector, as well as the potential of developing countries.

Analysts attributed the lack of skills to deploy solutions based on Internet of things technologies, compatibility and security issues, as well as the lack of management standards to the factors hindering market growth.

In general, the range of applications of IoT in medicine is wide: from remote monitoring of patients to smart sensors and medical gadgets, such as fitness bracelets and miniature devices designed for diagnosis and treatment. According to analysts, the number of connected devices and the huge amount of information they collect can be a real challenge for hospital its departments. Typical IoT problems are the risk of data leakage, as well as the search for an effective method of data processing.

1.5.4. Wearable technologies

Wearable medical devices are one of the biggest parts of Internet of medical things. In order to proceed closer to analytical part, we will take a closer look at wearables, its typology and best practices in healthcare organizations.

Wearable technology is an electronic device that people carry on their bodies to collect various types of data for different purposes. These wearable devices are absolutely convenient to use and barely noticeable, as they are worn as accessories or sometimes as implants. The field of industrial application of wearable technology is already quite extensive. Wearable devices are used by many companies in order to:

- Ensuring safer working conditions and predicting employee injuries and fatal accidents due to fatigue or other factors;
- Customer service improvement;
- Increase efficiency and productivity.

However, the widest use of such gadgets can be observed in healthcare and medicine. Wearable health monitoring devices contribute to the creation of a special healthcare industry - telemedicine.

Telemedicine is an interdisciplinary field related to the development and application of modern computing and telecommunication technologies in the healthcare sector to monitor people's well-being and provide them with remote medical care and treatment.

The chart below shows a significant increase in the global number of patients using wearable devices from 2013 to 2018.

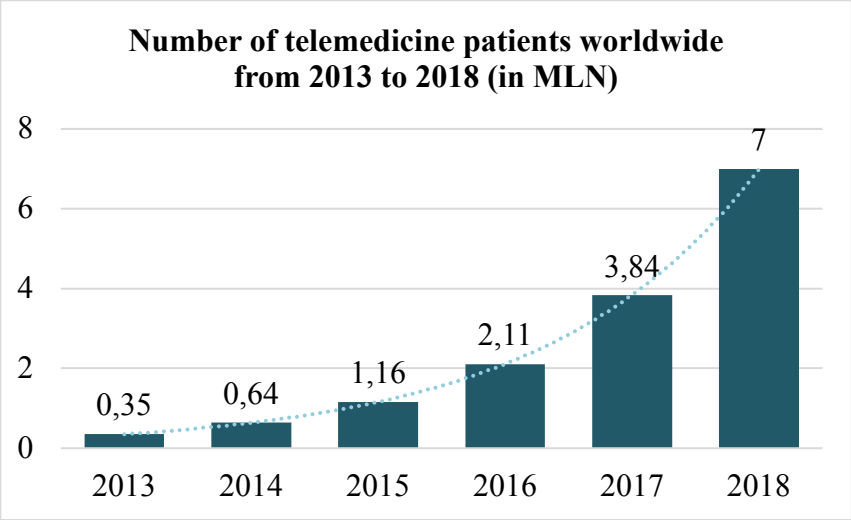

Figure 5 *Number of telemedicine patients worldwide (Statista, 2018).*

Research company MarketsandMarkets predicts that the global market for wearable devices in healthcare will reach $ 14 billion by 2022, compared with $ 6 billion in 2017. Such rapid growth is due to technological advances in medical equipment and the ubiquity of smartphones, followed by the creation of mobile medical applications. Another reason is that people become more aware of their health and are ready to use wearable devices in their daily lives (MarketsandMarkets, 2020).

Wearable medical technology has a great impact on both doctors and patients, as they can be in constant contact. Patients have the opportunity to monitor their health 24 hours a day, without leaving home and not distracting from work, as well as receive real-time feedback from doctors. This allows patients to avoid unnecessary hospitalizations or frequent visits to the doctor's office and, as a result, reduces stress and costs (Grand View Research, 2019).

There are many different classifications for wearable medical devices. For instance, those can be classified depending on (SaM Solutions, 2019):

1. Clinical aspects of application:

– Diagnostic (tonometer, urine analyzer, ultrasound apparatus, glucose meter, thermometer, uroflowmeter, and more.);

– Preventive – for maintaining a healthy lifestyle (wellness) (fitness tracker, scales, etc.);

– Medical (insulin pump, "smart" tablet that controls the intake of drugs, and more.);

– Rehabilitation services.

2. Type:

– Fixed (weather Station);
– Portable (Portable urinary analyzer);
– Wearable (Fitness tracker);
– Implantable ("Smart" tattoo).

3. Devices by target user groups

– Medical — the main users are medical professionals (doctors, paramedics, nurses, etc.);
– Home appliances – the main users are patients and people who want to lead a healthy lifestyle;
– Professional – the main users are athletes, security personnel, military, firefighters, employees of remote drilling stations, drivers.

4. Based on body parts they are used:

– Head (immersive helmets, smart glasses);
– Ear (hearing aids, headphones, ear-worn trackers);
– Eyes (smart eyewears, contact lenses);
– Body (smart clothes, skin patches, chest straps);
– Arms (arm-worn trackers);
– Wrist (smartwatches, wrist-worn trackers);
– Legs and feet (smart footpads, socks, footwear, bracelets);
– Other (implantable, multi-location sensors).

1.5.5. Practices of IoT devices usage in healthcare organizations

As it was mentioned before, one of the biggest uses of wearable medical devices is telemedicine, as during online medical services. However, those are also well-used among healthcare organizations – hospitals, clinics and etc. Now we will take a look at the best practices of wearables' usage in the world in general and in Russia in particular.

International practices:

1. Florida Hospital Celebration Health;

Florida Hospital Celebration Health has been actively using badges for five years to track the movements of medical staff and patients around the clinic. Data is used for different purposes. By tracking the movements of medical professionals, analysts understand how to organize the clinic space so that everyone is comfortable — for example, where it is better to place cabinets

with supplies of medicines. With the help of data, the clinic administration can understand in advance when a particular health care worker or nurse will finally get tired of doing routine (apparently, this is judged by repeated routes) and in time offer him or her a little change of environment — for example, go to advanced training courses.

Badges are also issued to patients of the clinic. People who come to the hospital to visit a relative can always look at the electronic scoreboard and find out where he or she is at the moment — in the operating room, ward, or somewhere else. The information appears next to the patient's last name.

In some clinics, badges are also attached to medical equipment so that they can always be found — for example, on defibrillators, infusion pumps, and wheelchairs (Forbes, 2014).

2. Hand washing control;

Hundreds of papers have been written about the problem of hospital infections. According to researchers, up to 100,000 people die from them every year in the United States. Clinics incur losses of billions of dollars. One of the main causes of hospital infections is dirty hands.

Over the past few years, several companies have offered to solve this problem using the Internet of things. The solutions differ in detail, but the principle is the same-sensors installed on containers with liquid soap and disinfectant lotion monitor their consumption and the time spent by the employee on washing. To do this, you need to take into account how many employees visited the premises. Different companies solve this problem in different ways. Someone sets up sensors at the entrances to the room where the patients are located and counts how many people entered and left. Someone gives all employees badges or bracelets — when a person goes to the sink, the sensor on the soap container determines who the employee is and monitors how much time, soap or alcohol they spent washing their hands. Data from the sensors is sent to the server and analyzed. Administrators look at which departments carefully wash their hands, and in which — not so much. Some systems also remind employees to wash their hands.

3. BEDDIT (Espoo, Finland);

Beddit (owned by Apple) aims to enhance quality of sleep with its app-driven and bluetooth-connected sleep monitor, which tracks breathing, heart rate, snoring (it also can be connected with CPAP machines) and sleep environment. It analyzes the data collected to determine the best rate action for better sleep.

4. HONEYWELL (Morris Plains, New Jersey);

Honeywell Genesis Touch communicates with remotely located healthcare providers who receive biometric data through the patient’s dashboard. The GT can also accept video visits,

provide several providers with access to patient vital statistics, and be integrated with an oximeter, blood pressure monitor and precision health scale.

5. AVA (San Francisco (US Headquarters) + Zurich (Global));

Ava is a night-only device that helps women naturally track their cycles in order to better understand their fertility, pregnancy and overall health. In addition to simply tracking symptoms, ovulation and period, wearable tracks and logs of sleep, stress levels and heart rate at rest, all in the Ava app. According to a clinical study conducted at the University Hospital of Zurich, Ava determined "an average of 5.3 fertile days per cycle with an accuracy of 89 percent."

6. MOTIV (San Francisco, California);

Despite the fact that wearable fitness and health devices in the form of watches are widespread these days, Motiv does things a little differently. Motiv Ring is worn on the user's finger to control activity, sleep, and heart rate. The ring app allows users to track and adjust their goals.

7. TEMPTRAQ (Westlake, Ohio);

TempTraq is a control sensor for infants and children that monitors temperature during illness. The bluetooth sensor is a soft patch placed under the child's arm and sends the temperature to mobile devices so that parents can track it without repeatedly manually measuring the temperature. The sensor allows parents to monitor several children and warns them of dangerous temperatures, without disturbing the work of the owner. When TempTraq was tested on pediatric cancer patients at the Cincinnati Children's Hospital, the device detected a fever and temperature changes that episodic monitoring missed (Built in, 2019, 2020).

Practices in the Russian Federation:

1. Pilot of the Ministry of health

If the Internet of things in medicine is developed abroad on the initiative of both private and public organizations, in Russia the advantage is on the side of the latter. So far, the largest existing IoT project in the country is a pilot project of the Ministry of health of the Russian Federation to introduce remote monitoring of patients with arterial hypertension in a number of regions, who have a very high risk of developing cardiovascular complications (the Ministry of health Order No 2276, 2017).

During the pilot, patients were given a telemedicine kit — a tonometer with GSM communication, which itself transmitted data over the cellular network to the Federal remote monitoring center. If the participants ' health indicators deteriorated, the center's staff contacted the patient and urged them to call an ambulance or contact their doctor. As a result, for example,

according to the Ministry of health of the Belgorod region, remote monitoring has reduced the number of such patients ' requests for medical care in the region by 40%, and by another 17% — the number of ambulance's calls with a diagnosis of "hypertension" (RBK, 2019).

2. Center of Innovation and the Internet of things in Healthcare

In 2019 in "SKOLKOVO" has opened a Center of Innovation and Internet of things in Healthcare. The center will become a platform for combining the experience and efforts of business, government, scientific institutions and startups, healthcare institutions and medical associations. Its work is intended to contribute to the transformation and development of the healthcare system in Russia.

The center for Innovations and the Internet of things in Healthcare is being created with the support of the Ministry of health of the Russian Federation. It coordinates therapeutic areas and will help bring information about the therapeutic solutions presented in the Center to medical organizations.

The center will create and implement innovative developments in four therapeutic areas with the greatest contribution to the structure of morbidity: cardiology - acute coronary syndrome (ACS), Oncology – lung cancer, endocrinology – type 2 diabetes, pulmonology – bronchial asthma.

In addition, the Center offers special services for each group of diseases:

– Modern technologies of screening programs with the use of low-dose CT and the ability to process information using artificial intelligence will allow detecting lung cancer at an earlier stage. Innovative solutions based on modern endoscopic techniques, digital technologies in morphological diagnostics, and new approaches in the field of molecular genetic testing will lead to improved quality and reduced time for diagnostics in Oncology.

– Technologies for screening with the help of electronic questionnaires and medical decision support systems will help to conduct pre-medical rapid diagnostics to detect diabetes and possible complications, as well as to assess cardiovascular risk.

– The Central control room will help to shorten the path of a patient with a myocardial infarction from the moment of initial medical contact to the operating room with percutaneous coronary intervention. The system of location tags will reduce intrahospital time loss, as well as innovative solutions for vascular centers and telemedicine technologies to help patients at the outpatient stage.

– Technologies for improving the verification of bronchial asthma, determining the degree of control and severity of the disease, optimizing the patient's route to specialized specialists for effective medical care.

In the future, it is planned to expand the solutions presented in the Center in other therapeutic areas (Skolkovo Foundation, 2019).

1.6. Research gap

Modern medicine is difficult to imagine without the latest technologies, which are becoming one of the main tools of today's healthcare system. The digital world has brought medical innovations that can radically change the system of medical care and disease prevention. This area was one of the first to use the capabilities of the Internet of things, and all sorts of "smart" devices have already become an integral part of the functioning of many clinics and hospitals. However, some problems still remain relevant. And to solve them, the Internet of things comes to the rescue.

The market of IoMT is growing at a fast rate, healthcare organizations, clinics and hospitals are starting to adopting the IoT solutions. Most of reliable organizations (PwC, BCG, McKinsey, major banks and etc.) highlights the rising importance, advantages and urgency of IoT adoption, including healthcare industry. However, there are practically no researches on this topic in terms of strategy planning, especially with the context of Russia. Particularly, in the process of literature review, it was discovered that:

1. Not many researches on the impact of IoMT adoption on strategies of healthcare organizations worldwide (Abramson E.L. et el., 2016, Sympson J.L. et el., 2017, Meigs S. and Solomon M., 2016, and etc.);
2. Not many researches on the use of the standard Porter model for strategy development in Russia (Verkhovskaya O.V. et al, 2017);
3. Not many researches on the use of modified value chain worldwide (Wang J.B. et al., 2018, Raghupathi W. et el., 2014, and etc);
4. No cases of value chain model application in healthcare in Russia.

Thus, the research gap was formulated as followed:

Even though nowadays IoT is being actively adopted by many healthcare organizations, there are still not many researches done on this topic. There is no framework that Russian healthcare organizations can rely on when it comes to improve hospital strategies with IoT adoption, as all of the foreign studies does not consider specificity of healthcare in the Russia Federation.

The goal of current research is to investigate strategies for implementing IoMT solutions in clinics and summarize the results as recommendations for improving the content and methods of hospital strategy development. As a methodological basis of the thesis the concept of the value-added chain (M. Porter) was used. This model structure the organization in a set of interrelated

primary (implemented in the framework of the strategic business units) and supporting (implemented by the organization against its strategic business units) activities.

Based on the value-added chain concept, the paper examines the activities of three St. Petersburg clinics (departmental, private, state) to implement IoMT solutions in the provision of medical services. The results of case studies are summarized as recommendations for developing strategies for implementing Internet of Medical Things in the activities of, which can be illustrated on the figure below.

Thus, the research question is:

How can the modified concept of value chain be applied in order to develop strategies for implementing Internet of Medical Things in the activities of Russian healthcare organizations?

CHAPTER 2. RESEARCH METHODOLOGY

The second chapter is dedicated to the description of the methods and tools used in the research. The research design and data collection process are introduced. Eventually, the developed framework is explained, the context of the case organizations that was gathered in the process of in-depth interviews is provided and the choice of divisions that were analyzed in the research is explained.

2.1 Research design

The purpose of current research is to develop a structure of primary and supporting strategies analysis for healthcare organization with the consequent framework that would support managerial decisions of organization in terms of IoT adaptations. Following are the steps followed in the research:

1. Literature review;
2. In-depth interviews with organizations' representatives;
3. Coding;
4. Interviews with organizations' representatives;
5. Value chain concept development in order to define gaps in primary and supporting activities' strategies;
6. Application of developed framework on chosen cases with further formulation of recommendations for the development of a strategy for implementing IoMT in the activities of the case organizations.

During this study we examined three cases of healthcare organizations: NRCERM, EMC Clinic and DRIEM.

In general, current research can be divided into three parts: creation of theoretical basis, qualitative analysis of organization in order to identify weaknesses that can be improved and strengths that can be enhanced, recommendations and possible solutions suggestion. First part was followed in the first and current chapters of the paper. Literature review was made in order to create theoretical basis of the research. Models and tools used in the second and third part of the paper are described further.

2.2. Selection of methods and tools for organizations' analysis

To identify major weaknesses and key strengths of organizations qualitative analysis should be made. This part of the research consists of three main steps: interview, coding and value chain application. Further, we took a deeper look into each of the steps.

2.2.1. In-depth interviews

As one of the tools of qualitative research, in-depth interview was chosen. In-depth interview is a formalized, directed by the researcher (interviewer) in accordance with a pre-prepared scenario conversation with the respondent, focused on the topic of interest to the researcher (Spradley, 1979). Features of in-depth interviews:

– Conducted in person or by phone, if permitted by the nature of the marketing research;

– Usually involves interviewing one person, less often two or three respondents can be interviewed at the same time;

– Conducted on the basis of the guide-guide, consisting of a list of topics that should be disclosed during the interview;

– Conducted by a qualified specialist moderator;

– Can last from 30 minutes to several hours;

– Usually recorded on audio media.

Advantages of in-depth interviews as a qualitative research method:

– Opportunity to openly discuss any topics and issues;

– The opportunity to hear the opinion of all, even the most modest and shy respondents;

– Many degrees of freedom in terms of determining the time and place of the interview – you can adjust individually for each respondent (Belk, Fischer, & Kozinets, 2013).

In the case of this research three representatives of three healthcare organizations are chosen to conduct interviews. There was a pool of topics to discuss created in advanced, however, those were unstructured in-depth interviews. The included, but were not limited by the path of the customer, organizations' primary and supportive activities strategies, current usage of IoT in general, current trends in IoMT market, international practices of IoT adoption in healthcare organizations and etc.

2.2.2. Coding

Coding is an element of data processing procedure. In qualitative research after collecting responses during the fieldwork information received in the process (in our case, information gained during three in-depth interviews) is transformed into a set of several key 'issues' - each issue is then given a code. Coding is most often performed on open ended questions so that responses can be quantified. Following is the list of things that should be done in order to use coding method maximum effective:

– Read all the answers in advance. This helps the analyst gain insight into topics recurring in the data set. It will also help the analyst understand how the population responds to a particular survey question. It may be surprising how many people answer an open-ended question in the same way to each other without any guidance;

– Start by creating a large number of categories before narrowing the field. After all categories have been decomposed and initially encoded, begin to further combine the data to limit the analysis to about 8-12 codes;

– Make sure every comment matter. The reporting standard is to create 8-12 comprehensive survey coding categories, even if there are several outliers that are grouped into the "other" category, they should be mentioned and / or provided with footnotes;

– Create accurate and unambiguous codes that cover the answers to which they apply. If someone looked at the name of the code after considering the issue, it would be clear which comments fall under it. This can help create a pop-up in the report with additional code granularity with some explanation;

– Feel free to use more than one code. In many cases, respondents offer some comments on a question covering topics from topic A to topic Z. If the answer were limited to only one code, then the other problem areas of the respondent would be underestimated;

– Consider the coding of % of respondents, not % of responses. This will give equal value to all answers. This does not allow those who express concern in several areas to suppress those who had one code response (Saldana, J., 2009).

Coding helped us to gain some inside knowledge to identify weaknesses that can be improved and strengths that can be enhanced, but what is more important, coding provided us with information for further value chain creation.

2.2.3. Value chain concept application

We have already discussed the value chain concept in the first chapter. Ever since the first mentioning of the value chain, the model was applied to most of the industries. Moreover, in his researches M. Porter narrowed the use of the value chain concept to healthcare in his book "Redefining Health Care: Creating Value-Based Competition on Results" (Porter, 2006). Adapted for the healthcare value chain is presented below in Figure 6.

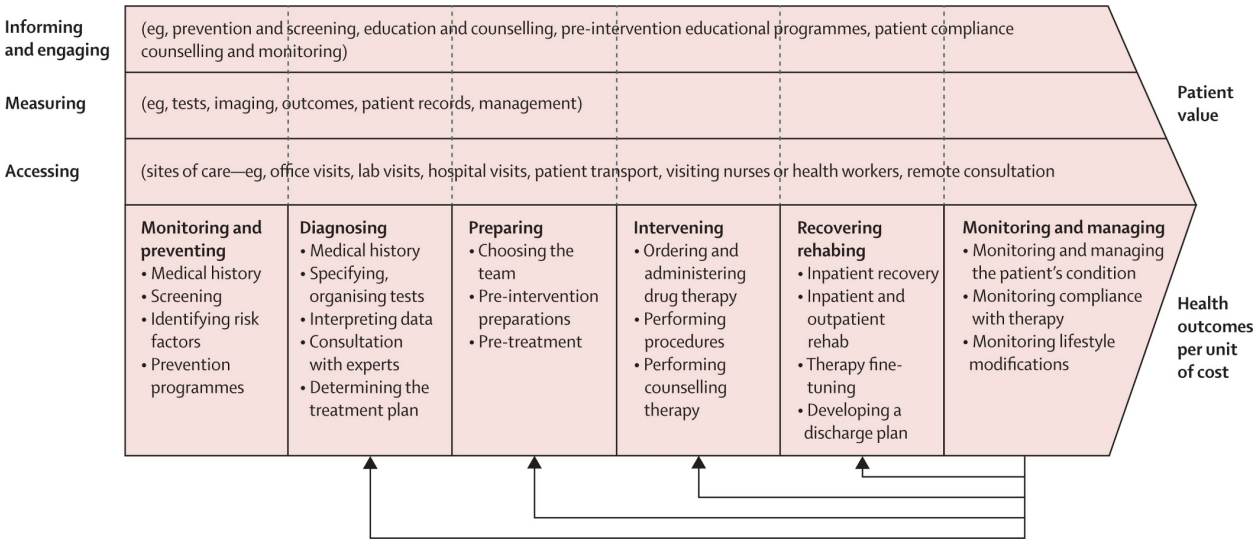

Figure 6 *Value chain in healthcare organizations (Porter, 2006).*

General value chains in healthcare organizations is presented on the picture above. In this chain, the primary and supporting activities were combined, value was structured, and it was defined what happens in the SBU (or in the corresponding department), in other service providers, and in external organizations. It is important to mention that the model outlines the fact that primary activities are not separate, but interconnected, so the structure of the model has matrix characteristics.

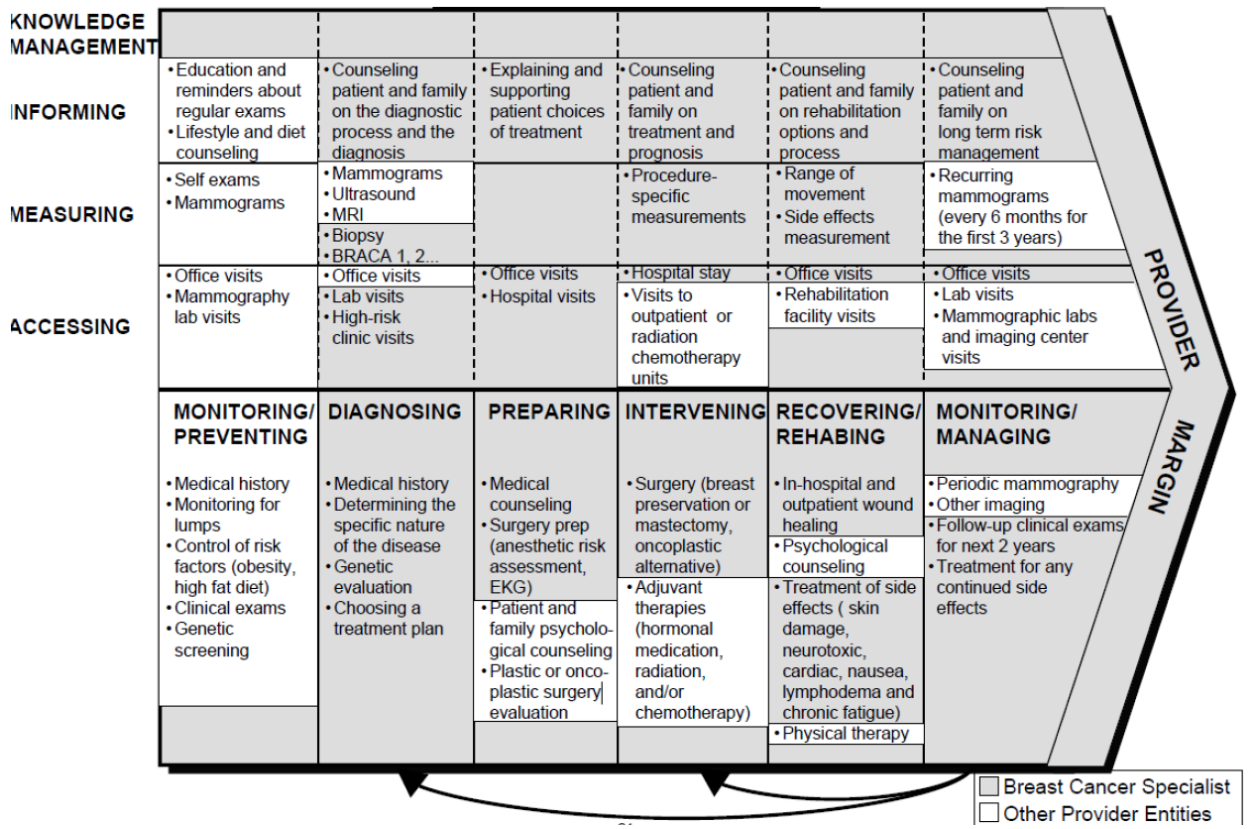

Figure 7 *The Care Delivery Value Chain Breast Cancer Care (Porter, 2006)*

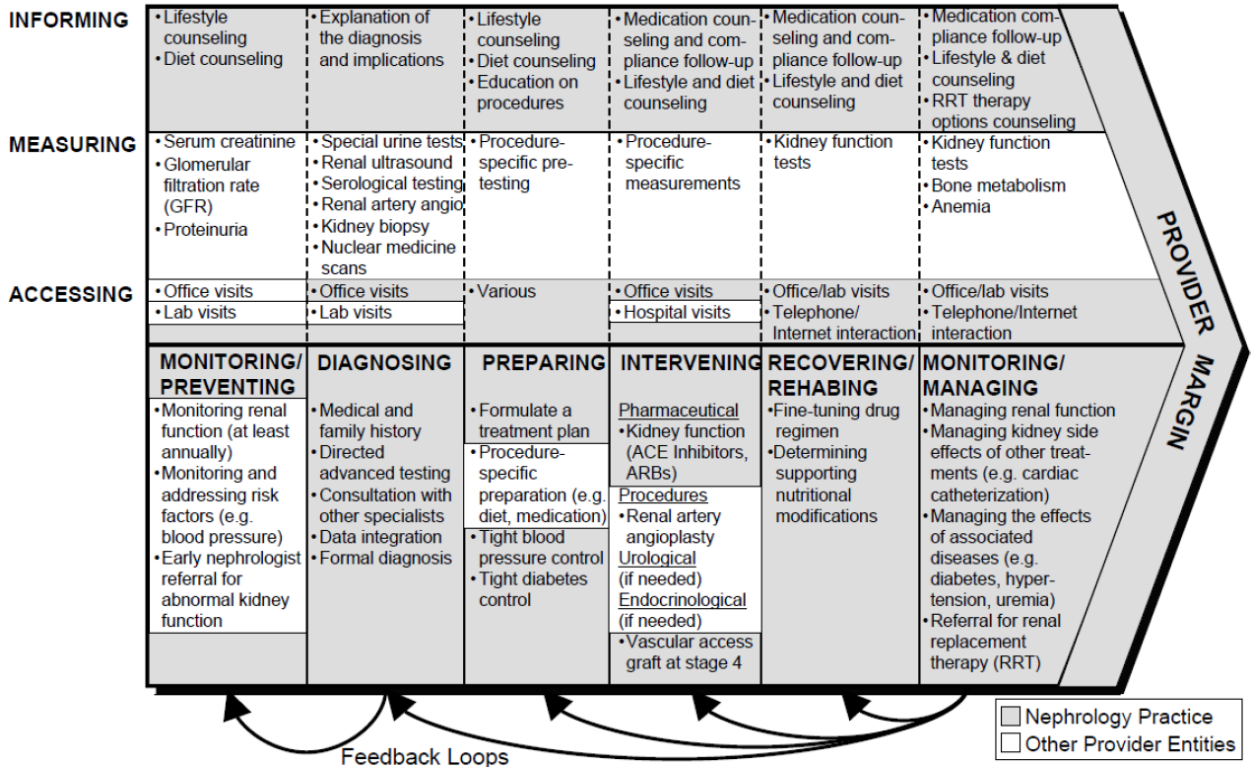

Figure 8 *The Care Delivery Value Chain Chronic Kidney Disease Care (Porter, 2006)*

In his paper, M. Porter provides two examples of value chain model application: in breast cancer care (Figure 7) and in chronic kidney disease care (Figure 8). In the models, M. Porter describes the path patients follow step by step.

In further research in the third chapter, after conducting in-depth interviews and collecting more information about organizations, we created specific value chains for the customers' paths in chosen SBUs in each of the cases.

2.3. Context of the organizations based on interviews results

One of the qualitative data resources were three in-depth interviews with organizations' representatives with on-going consultations during the rest of the research. All of the interviews were held via the phone call. There was a pool of topics to discuss created in advanced, however, those were unstructured in-depth interviews. Each of the interviews took on average about 2 hours and made a great contribution in the research in general – particularly in gathering large background of the current state of the organizations, choice of the business unit to be analyzed, modeling of the value chain and patients' path, problems determination and etc. Further, each of the interviews and some of the findings were discussed in more detail in order to provide the context of organizations.

2.3.1. NRCERM

Representative from NRCERM – Mikhail Yur'evich Bakhtin, Deputy Director of Medical Information Technology (CMIO).

The Nikiforov Russian Center of Emergency and Radiation Medicine or NRCERM is the Federal State Budgetary Institute, a multi-specialty medical and diagnostic facility that provides specialized high-tech medical care in a polyclinic, day and night hospital, as well as a scientific and educational center. It was formed on the basis of the decree of the government of the Russian Federation of March 14, 1997 No. 352-r and became the legal successor of the all-Russian center for environmental medicine, established in 1991, which is the main organization for providing medical assistance to participants in the liquidation of the consequences of the Chernobyl accident and persons resettled from radioactively contaminated areas of Russia.

On the basis of NRCERM, the EMERCOM of Russia Medical register is deployed – a multi-level departmental information and analytical system for providing a combined assessment of the social status, health status and individual professional activity of rescuers of the EMERCOM of Russia for presenting the Ministry's leadership with multi-faceted information for making managerial decisions.

One of the main problems of digitalization and IoT development and adaptation is the absence trend for a healthy living, there is one for younger people, but for the older generation, it is just on the developing stage. There is a strong belief for many people that the responsible one for a persons' health is his/her doctor and only the doctor. Moreover, most people are still sure that medical care must be provided to them free of charge and no less than at the European level. However, it is truer for the older generation, as youngsters tend to adopt a Western attitude to things and are better oriented in the cost of its own health and in the cost of medical services.

One of IoT adoption cases in NRCERM is therapeutic departments. In the departments of the therapeutic profile, it is necessary to measure the blood pressure regularly (the usual practice is once or twice a day. In cardiology, when selecting medications for blood pressure, measurements are required more often). Traditionally, this is done by post nurses and it takes a significant part of their time. Therefore, automatic blood pressure monitors were installed in the departments. The patient comes to the post to the tonometer, measures the pressure and brings his bracelet with a barcode to the scanner. The tonometer reads the patient's registration number on the wristband and sends information with the patient's blood pressure and pulse to the patient's electronic medical record. In this way, the result is obtained independently of the person (the robot measures) and the person (the nurse) does not get tired. Moreover, the patient has scales and a blood pressure monitor at home (almost the same but cheaper). These devices are connected via Bluetooth to a smartphone that has a patient's personal account. The patient is weighed on a scale and measures the pressure with a tonometer. Both the scales and the tonometer transmit the measurement results to the

personal account on the smartphone, and the smartphone sends the data to the MIS server in the patient's medical record. The patient is at home, and the attending doctor sees the dynamics of both weight and pulse and pressure from his office.

Another interesting case is the pneumatic post. In order to significantly reduce time costs of transfer of materials, analyses, and so on, initiative of pneumatic post was introduced in the organization. The territory of the NRCERM is huge and tubes cover almost all of the building. Pneumatic post allows to send necessary materials (eg. blood samples taken for the analysis) within seconds, which saves time dramatically.

One of the main problems for further better IoT adaptation Mikhail consider low demand formed in Russia. Many supplier companies are trying to bring devices to the Russian market, but the current demand is not enough to get a foothold in it. There is demand for IoT devices from their medical center (and from some other organizations, mostly private clinics), but on the scale of the Russian market, it is not enough for new suppliers to enter.

In the process of communication, it was said that cardiology is one of the most developed in terms of IoT adoption department, as the human heart is the most powerful source of biological electricity and this signal is the easiest to register, transmit, and interpret. This is why, there is a large field for development in NRCERM. Thus, cardiology department was chosen for further analysis in order to provide recommendations that are relevant and useful for the organization.

2.3.2. DRIEM

Representative – Anton Sergeevich Povzun, chief doctor of the Institute's clinics.

Dzhanelidze Research Institute of Emergency Medicine was founded in 1932 (at that time the name was “Scientific and Practical Institute of Emergency Medicine”. Three departments were established — emergency surgery (175 beds), emergency therapy (25 beds) and social pathology. In 1946, the Institute created the Department of burns. With time many other departments were opened. Forms of medical care include emergency, urgent and planned.

This organization turned out to be the least digitalized, as it is a state institution and is funded by the state through the service of patients with mandatory medical insurance. Thus, it does not have such resources as other organizations being analyzed. At the moment, there are no cases of IoT usage.

Another reason for it (it is also the result of the luck of resources) is small Wi Fi coverage – as it turned out, Wi Fi only covers a part of the second floor while DRIEM’s territory is more than 70 thousand square meters. After negotiations, the Internet was provided by MTS on a free basis, as the company has a communication tower on the roof of the DRIEM’s building. Data, instructions, and commands are transmitted and received directly between IoT devices or via a server, so an Internet connection is required.

However, DRIEM was one of the first organizations who adopted telemedicine – there is Baltic telemedicine center. This business unit has the status of a Federal center for emergency telemedicine advice, provides video conferencing with the Ministry of health, Russian Academy of medical Sciences, 11 centers emergency telemedicine advice at the Federal level, the territorial center of medicine of accidents in all regions of Russia.

As it was mentioned in the first chapter, one of the ways of using value chain model in order to analyze current state of hospital's strategy is to compare competitors (organizations with similar value chain). NRCERM considered to be more developed in terms of digitalization and IoT adoption, thus, it was decided to analyze the same SBU of DRIEM – cardiology department.

2.3.3. EMC Clinic

Representative from EMC Clinic – Tatiana Evgen'evna Romanuk, founder and CEO of EMC Clinic.

The company was formed in 1996 as the first private ambulance service in post-Soviet Russia. Later, EMC opened its own multi-specialty outpatient clinic for children and adults. Traditionally, the clinic was focused on children. Not in terms of scale, but in terms of the quality of medical staff, EMC was and still is singled out on the market. Currently, almost all narrow specialists are represented, both adults and children. EMC is a multi-specialty medical company that provides a wide range of medical services to individuals and legal entities. Many employees who were at the beginning of the company's development still work there. The average work experience in the EMC is six years.

The clinic provides comprehensive outpatient services for adults and children – individuals, corporate clients and insured under voluntary medical insurance (VMI) programs. Among the corporate customers are the following organizations – Ford Motor company, PJSC "Lengiprotrans", the chain of gas stations "Phaeton", AtomEnergo, Graduate School of Management, Turkish company "Ichtazh " (developer of the Western High-Speed Diameter of St. Petersburg), and others. VMI is the main revenue source of the company. There are supporting activities, such as cafeteria, which also provides services to the customers, however, it works on the verge of zero profitability solely for improving customer comfort.

Tatiana is a proponent of digitalization of processes and adoption of new technologies, including Internet of Things. For instance, in 2012, when they moved to another building, she stated that there would be no paper patients' medical histories, so they actively digitalized everything and moved away from electronic media in terms of electronic medical histories. However, she highlighted that bureaucratic side of the law is still a big problem (for example, they have to print everything for the insurance companies and afterwards destroy it. She noted that they even have an employee responsible for it). Every patient has a personal account, where he/she can

make an appointment with a doctor, get access to your clinic visits with all the tests, doctor's reports and etc. An app is on development stage at the moment.

Within the staff Tatiana, as a head of the clinic, is trying to instill the culture of using messengers and remote online meetings, which greatly improves performance in terms of time spent. However, what important during digitalization and adaptation of new technologies is the fact that best doctors are usually very conservative, so it is hard for them to adapt. Thus, there are special employees, IT specialists, whose main duty is to help, when doctors are having any technological problems ("most of the times it is really simple mistakes").

At the moment, the focus of technological development of the organization is on online consultations (telemedicine), which is highly relevant in view of the current situation in the world, Russia and Saint Petersburg. However, it is hard to implement due to the limitations introduced in the law, the choice of the platform, disagreements of the staff (because of the uncertainty of the law), knowledge limitations of the patients and etc.

Besides that, EMC Clinic was planning to introduce the department of longevity in April of 2020 (the introduction was delayed for an indefinite amount of time due to the current situation in the world). This is a wide-profile department offering a specially selected set of procedures for each client, in order to conduct diagnostic studies of the patient's body for the preparation of a treatment program and preventive measures. This department was chosen for further analysis, as this direction seems to be the most suitable for adopting the practices of the Internet of things, and the results and recommendations are of particular interest to the clinic and the organization's management (represented by Tatiana).

2.4. Finalization

After following the steps from the second part of the research, application of the value chain concept and qualitative analysis of organizations in order to identify weaknesses that can be improved and strengths that can be enhanced were made and a list of recommendation and IoT solutions were given to organizations' representatives. To help us to pick the right IoT initiatives, in the first part of the paper literature review was made, which includes analysis of international and national practices. Therefore, based on the list of identified gaps in the primary and supporting activities' strategies during the value chain concept application, for each of the cases and each of the gaps a list of recommendations and IoT initiatives was made.

As a result, developed framework of healthcare organizations analysis was applied to real-life cases. Each of the healthcare organizations was provided with the list of recommendation for the development of a strategy for implementing IoMT in the activities.

CHAPTER 3. APPLICATION OF DEVELOPED FRAMEWORK TO CASES OF ORGANIZATIONS

As it was noted earlier, M. Porter introduced value chain model in 1985 in the book "Competitive advantage" (Porter, 1985). Over time, problems of management in health care consideration has taken a special place in research of Michael Porter's and in 2006, the book “Redefining Health Care: Creating Value-Based Competition on Results” comes out, where he modifies the value chain concept, keeping the view of it as accumulating value and costs and defining business success as the difference between them.

The following chapter shows how the concept was applied to our cases. It outlines how the model might be applied to specific problems – lack of digitalization and IoT adoption in healthcare, provides analyze the current state of primary and supporting activities’ strategies of organizations and introduces recommendations of how these strategies (and value chains) might be improved with IoT solutions and not only. Moreover, theoretical contribution, opportunities for future research and limitations are provided in this chapter.

3.1. NRCERM

3.1.1. Value chain application

NRCERM proved to be one of the most developed healthcare organization in the Russian Federation in terms of digitalization and IoT adoption. Cardiology department was chosen for value chain model application. General value chain model in healthcare organization was described in Chapter 2. Further, the findings about a new patient’s path step by step are presented in the Figure 9, where general value chain hypertension care of NRCERM is demonstrated.

	Monitoring & Preventing	Diagnosing	Preparing	Intervening	Recovering Rehabbing	Monitoring & Managing
Informing & Engaging	• Counselling about current health situation	• Explaining choices of treatment and further diagnostic process	• Explaining choices of treatment and further diagnostic process	• Counselling on treatment	• Counselling on treatment	• Counselling about current health situation
Measuring	• Self exam	• Ambulance's initial inspection • Duty doctor's initial inspection	• Attending doctor initial inspection inspection	• Nurse exam / Self exam • Procedure-specific measurements	• Self exam	• Self exam
Accessing	• Office visits • Online consultations	• Ambulance • Inpatient visit	• Hospital stay	• Hospital stay • Visits to outpatient or other SBU	• Hospital stay	• Office visits • Online consultations
Was subject to digitalization and IoT Cardiology department specialist Other provider entities	• Medical history • Blood pressure monitoring • Office visit / Online consultations	• Medical history • Ambulance check (blood pressure check) • Duty doctor check (initial inspection)	• Attending doctor check (initial inspection + additional exams assignment)	• Drip twice a day • Nurse measures blood pressure three times a day • Additional exams • Treatment correction	• Treatment correction (switch from drip to pills) • Patient measures blood pressure twice a day	• Office visit after 2 weeks and 6 months / Online consultations • Treatment correction if needed • Patient measures blood pressure twice a day

Figure 9 *NRCERM. The Care Delivery Value Chain Hypertension Care*

The value chain that is presented above and value chains of DRIEM and EMC Clinic which are discussed further are a modified Porter's models for describing the performance of the corresponding medical service. Bold font represents primary activities (chosen SBU (department), regular font represents supporting activities (other provider entities), red color represents activities that were subject to digitalization and IoT adoption. On the bottom of the model (light grey background) is the path of the patient in the SBU, on the top (white background) is value for the patient in detail. The value chain has matrix character: the element i.j at the intersection of the i-th row and the j-th column (in our case i=1,2,3 (from top down), j=1,...,6 (from left to right) shows what contribution the j-th link in the chain makes to the formation of the i-th value coordinate.

The department receives both patients who already have a diagnosis, and people who have not yet been examined by the heart and blood vessels, have not even been to the cardiologist's office. The main signs of cardiovascular diseases:

- Pressing pain behind the sternum or in the left half of the chest, giving under the shoulder blade, in the left hand;
- Shortness of breath and palpitations;
- Heart failure;
- Permanent edema on the lower extremities;
- Intermittent lameness (intermittent pain in the legs when walking);
- Heart rhythm disorders;
- Increase or decrease in blood pressure;
- Paleness and blueness of the lips and skin of the face.

If such symptoms are present constantly or occur periodically, a person needs to contact a cardiologist, and if he/she has acute pain behind the sternum – urgently call emergency medical care (which is also provided by NRCERM).

Following value chain was made on the example of a person with hypertension (a condition in which the blood pressure is equal to or exceeds 140 mm Hg.) stated by ambulance doctor that was brought to the NRCERM hospital. Examining the patient's path step by step, we gathered the following information:

- *Monitoring and preventing* (medical history, screening, identifying risk factors, prevention programs);

In case if it is not the first visit to NRCERM, this stage is taken place. All of the patients of the center have their own account in the system, where previous visits, analysis and diagnosis are (this information of new patients in not that full amounts are available in the unified state information system). Moreover, patients are able to get access to the system from the website or app, information about upcoming screening appears. Also, most of the patients have at home

“smart” blood pressure monitor and scales, which after measuring sends information to the phone and to the personal account, so the doctor can check it out and advice consultation if some indicator(s) goes beyond the normal values (more about that later).

– *Diagnosing* (medical history, specifying, organizing tests, interpreting data, consultation with experts, determining the treatment plan);

Diagnosis can be divided into two parts: ambulance doctor’s diagnosis and diagnosis by duty doctor at the hospital.

The patient's blood pressure has risen and he has a headache. He called an ambulance, the doctors measured the blood pressure (it is high), injected medication, the pressure does not decrease, so they decided that he needed to be hospitalized, and took him to the hospital.

The patient was brought to the hospital by ambulance. First, the patient is brought to the waiting room, where his data is recorded and a bracelet is printed. The bracelet is used for tests (when taking blood, when it comes to ECG and echo, etc., to mark the material taken), when issuing food (for example, if a special diet) and medications. In general, when allocating some resources to patients. The doctor on duty makes an initial examination and sends it to the inpatient.

The doctor on duty collected complaints (medical history). He completed an initial inspection, listens to the sounds of the heart, measures the pulse rate and respiration, determines blood pressure and blood oxygen concentration using a pulse oximeter, and takes an electrocardiogram (ECG).

– *Preparing* (choosing the team, pre-intervention preparations, pre-treatment);

The attending doctor collects complaints (anamnesis), conducts an initial examination. To clarify the preliminary diagnosis and determine the tolerance to physical activity, the doctor directs the patient to additional examinations, including laboratory blood tests, exercise tests, daily ECG monitoring, ultrasound examination of blood vessels and the heart.

– *Intervening* (ordering and administering drug therapy, performing procedures, performing counselling therapy);

When a patient is admitted to the hospital (before receiving the results of the analysis), he is on a drip twice a day (dosage and medication subscribes duty doctor with attending doctor’s corrections if needed). Besides that, first days, a nurse comes three times a day to measure the pressure and write it in the card (so that the doctor could look at it).

The next day after the patient's admission, the doctor looks at the results of blood tests, and the day after looks at the results of ECG and echo (echocardiogram). Prescribes / corrects treatment. In the treatment, the doctor uses diet therapy, explains the motor mode considering individual tolerance to physical activity, and selects medication therapy.

After the patient gets better, he goes to measure the pressure on the nurse's post. There is a tonometer at the post that reads the barcode on the patient's wristband and sends the measurement results to the patient's personal account and to the medical card in the unified hospital system.

– *Recovering rehabbing* (inpatient recovery, inpatient and outpatient rehab, therapy finetuning, developing a discharge plan);

After 3-5 days, he talks to the patient (explains that it is necessary to regularly measure the pressure, if it rises-you need to contact a specialist) and selects his pills and dosage (the patient is no longer put on a drip and he switches to pills). After that, the patient stays in the hospital for another 3 days to see the reaction to the new drugs. The patient continues to measure the pressure twice a day at the nurse's post. If everything is in order (blood pressure is normal, there are no negative reactions of the body), the patient is discharged home.

– *Monitoring and managing* (monitoring and managing the patient's condition, monitoring compliance with therapy, monitoring lifestyle modifications).

As a rule, the patient must return to the hospital after two weeks for a second examination (to check the progress of treatment, possible adjustments to medications and dosage), and then six months later again.

As it was already mentioned, each of the patients has a personal account, where (if he/she has smart blood pressure monitor and/or scales at home) information of blood pressure, pulse and weight measurements are uploading. In our case, in the morning and evening the patient needs to measure the pressure and sends the results via his personal account.

There is a telemedicine service available for the patient. Telemedicine is not allowed for initial diagnosis, but for subsequent treatment, consultation, and dosage/drug adjustment is possible. The patient is constantly monitored by the doctor through the personal account. He has two included online consultations with the doctor. Besides that, the patient can buy a subscription for online monitoring and consultations (for a month, quarter, year). Thanks to online monitoring, the doctor can adjust prescribed medications and dosages on distance, so the patient does not have to come to the hospital for the offline appointment.

3.1.2. Gaps in the primary and supporting activities' strategies

After taking a deep look at the care delivery value chain hypertension care, following gaps in hospital's strategy were considered to be vital to solve:

1. ECG tests (element 2.2)

Electrocardiogram is one of the necessary tests that should be made for a patient with hypertension (more than that, when a patient is suspected of most heart diseases). However, ECG test is made only on stage of diagnosing, when the attending doctor is taking over the patient.

2. NRCERM App (elements 3.1 and 3.6)

When it was decided to build an app for NRCERM patients with the access to their personal accounts, only Android version was created to test the initiative. Over time the app was successfully adopted by customers. However, there is still no iOS version of the app, despite the fact that according to statistics, in Russia the number of people using Android is comparable to the number of people using iOS.

3. On-going blood pressure measurements checks by the doctor (elements 3.1 and 3.6)

As it was mentioned, after discharge from the hospital the patient is constantly monitored by the doctor through the personal account. The blood pressure checks are not automated, the doctor does it independently, often outside of working hours.

4. Interaction with the patient (elements 1.1 and 1.6)

Online interaction with the patient is completely performed by the doctor and administrative staff. It consumes a lot of time of the staff, which they can use more efficiently.

5. Absence of educational programs (elements of row 1)

Value chain reviled the lack of engagement with the patient and the absence of any educational programs. Increasing customer engagement helps create a competitive advantage. Engagement marketing appears when a business has something to say to customers or Vice versa – they want to get a useful feedback. It helps the company to meet the needs of customers, but at the same time solves its own problems

3.1.3. Recommendations

In order to enhance value for patients of the clinic and reduce costs following solutions were chosen:

1. Chat bots

The pieces of chat bots might be inserted in the personal account. It can be used to collect data, answer basic questions, making appointments and etc., so that will save resources of the organization, enhance engagement with patient and create additional value.

2. Education and counselling programs

In order to increase engagement education and counselling programs should be created in personal account. Chat bots can also help with that and simulate additional interaction with patient, which in turn will create additional value for him.

3. Automated system of notifications

Automating blood pressure checks, so that the doctor specifies the minimum and maximum allowable values of indicators for notifications in the system. This system should be created mainly for the doctors, but accompanying a simpler version might be created for patients (eg. alarm that the blood pressure is not in the limits, please contact your doctor). By automating these processes, labor costs will be decreased (eg. doctor's time spent on checks, which they can use for other duties).

4. iOS version of the app

It might seem as an obvious recommendation. However, it is still crucial to create app for iOS. Currently, one of the main trends in digital marketing is the switch of the users from desktop to mobile. Patients with iOS on the phone are a great part of NRCERM, so it is highly important to provide access to the personal account for them.

5. Portable ECG

As it was said, ECG is one of the necessary tests that should be made for a patient with a heart disease. There are portable versions of ECG that can be adopted in ambulance, so that the doctor can make electrocardiogram at the patient's home, on the way to the hospital or in inpatient. Besides that, in the world market of IoMT devices there are different options for simpler portable ECG that patient can have at home in a smaller form or even in a form of mobile phone case (eg. AfibAlert, AliveCor, CardioQvark and other). As a rule, the ECG is measured by putting your fingers to the sensors. The measurement data remains in the smartphone's memory and can be viewed on the computer. In the case of NRCERM, data will be also uploaded to the personal account and unified internal informational system, so doctor can monitor it and correct treatment if needed. By doing this, NRCERM will save time resources of both staff and patient (which will also increase value for them), improve quality of the service, enhance accuracy of treatment's choice.

3.2. DRIEM

3.2.1. Value chain application

As it was mentioned before, cardiology department was chosen for the value chain model application in DRIEM. Figure 10 illustrates how general value chain hypertension care looks like in DRIEM. It can be seen that it is similar to NRCERM's value chain. However, it does not have

any digitalization or IoT touch. Those differences might be considered as strengths of NRCERM and weaknesses of DRIEM. Further, we discuss those parts of value chains in more details.

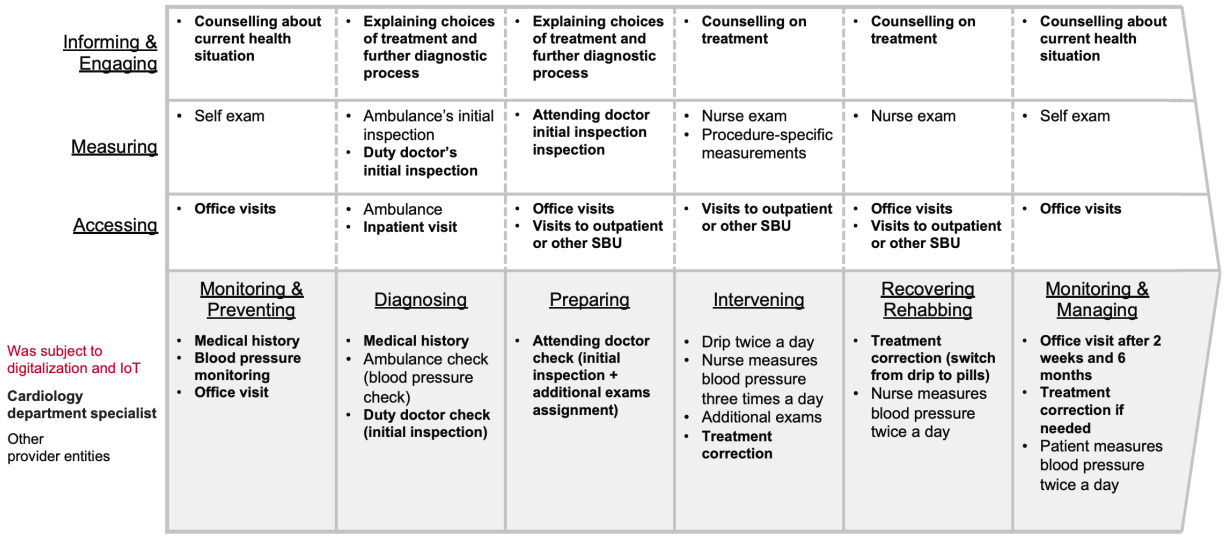

Figure 10 *DRIEM. The Care Delivery Value Chain Hypertension Care*

Examining the patient's path step by step, we gathered the following information:

– *Monitoring and preventing* (medical history, screening, identifying risk factors, prevention programs);

There is no unified internal informational system, all the information flow about patients is made via the unified state informational system. Patients are able to get copies of all the analysis and diagnosis from administrative personnel. Information about appointments can be received via gorzdrav.spb.ru (state portal of electronic services of Saint-Petersburg's healthcare system).

– *Diagnosing* (medical history, specifying, organizing tests, interpreting data, consultation with experts, determining the treatment plan);

Diagnosis can be divided into two parts: ambulance doctor's diagnosis and diagnosis by duty doctor at the hospital.

The patient's blood pressure has risen and he has a headache. He called an ambulance, the doctors measured the blood pressure (it is high), injected medication, the pressure does not decrease, so they decided that he needed to be hospitalized, and took him to the hospital.

The patient was brought to the hospital by ambulance. First, the patient is brought to the waiting room, where his data is recorded. The doctor on duty makes an initial examination and sends it to the inpatient. The doctor on duty collected complaints (medical history). He completed an initial inspection, listens to the sounds of the heart, measures the pulse rate and respiration, determines blood pressure and blood oxygen concentration using a pulse oximeter, and takes an electrocardiogram (ECG).

– *Preparing* (choosing the team, pre-intervention preparations, pre-treatment);

The attending doctor collects complaints (anamnesis), conducts an initial examination. To clarify the preliminary diagnosis and determine the tolerance to physical activity, the doctor directs the patient to additional examinations, including laboratory blood tests, exercise tests, daily ECG monitoring, ultrasound examination of blood vessels and the heart.

– *Intervening* (ordering and administering drug therapy, performing procedures, performing counselling therapy);

When a patient is admitted to the hospital (before receiving the results of the analysis), he is on a drip twice a day (dosage and medication subscribes duty doctor with attending doctor's corrections if needed). Besides that, first days, a nurse comes three times a day to measure the pressure and write it in the card (so that the doctor could look at it).

The next day after the patient's admission, the doctor looks at the results of blood tests, and the day after looks at the results of ECG and echo (echocardiogram). Prescribes / corrects treatment. In the treatment, the doctor uses diet therapy, explains the motor mode considering individual tolerance to physical activity, and selects medication therapy. After the patient gets better, nurse measures blood pressure twice a day.

– *Recovering rehabbing* (inpatient recovery, inpatient and outpatient rehab, therapy finetuning, developing a discharge plan);

After 3-5 days, he talks to the patient (explains that it is necessary to regularly measure the pressure, if it rises-you need to contact a specialist) and selects his pills and dosage (the patient is no longer put on a drip and he switches to pills). After that, the patient stays in the hospital for another 3 days to see the reaction to the new drugs. The nurse continues to measure the pressure twice a day. If everything is in order (blood pressure is normal, there are no negative reactions of the body), the patient is discharged home.

– *Monitoring and managing* (monitoring and managing the patient's condition, monitoring compliance with therapy, monitoring lifestyle modifications).

As a rule, the patient must return to the hospital after two weeks for a second examination (to check the progress of treatment, possible adjustments to medications and dosage), and then six months later again.

It is recommended to the patient to keep measuring blood pressure twice a day. In case if the results of the measuring are not normal values, he should make an appointment and visit a doctor, so he can correct the treatment, adjust dosage/drug prescription.

3.2.2. Gaps in the primary and supporting activities' strategies

It can be noticed that there is low level of processes digitalization in the organization and no use of Internet of Things. After taking a deep look at the care delivery value chain hypertension care, following gaps in hospital's strategy were considered to be vital to solve:

1. Dependence on Unified State Informational System

There is no unified internal informational system and state unified information system is still on the stage of development, so data collection takes time and received medical histories are not always full and correct. It takes some time to improve and correct it.

2. Interaction between DRIEM and a patient (elements 3.1 and 3.6)

There is almost no interaction between the hospital and the patient. Moreover, the interaction that takes place is mostly offline, which brings highly inconvenient for the patient, so it decreases the value of the service for him.

3. Blood pressure tests (elements 2.1, 2.4, 2.5 and 2.6)

Every day, a nurse spends over an hour to measure blood pressure to every patient in the department. As it can be seen on the example of NRCERM practices, this time might be spent more efficient.

3.2.3. Recommendations

Since DRIEM does not actually have digitalization and adoption of IoT devices, the organization has a large field to work with. The following solutions were chosen as the beginning of building a smart hospital:

1. Creation of the unified internal informational system

Having an internal system optimizes the process of accessing medical history of a patient, improves accuracy of data gathering and analysis and raises efficiency of doctors' work when it comes to deciding on treatment and correcting it.

2. Creation of access for patients to their medical history

After creating informational system within the DRIEM, the next step would be to provide the access for patients to it (eg. create opportunity for them to observe their medical history, make appointment and etc.). It was suggested to add personal accounts on the website and in the long term create an app with the same features. It will enhance engagement with patients and create additional value for them.

3. Use resources of Baltic Center of Telemedicine

Resources of the Baltic Center might be used for connecting not only doctors, but doctors with patients as well. It will help to decrease the costs on offline consultations and create additional value of the service delivery that is being examined to the patients, moreover, it will create new service for customers.

4. "Smart" tonometer

Successful implementation of this practice by NRCERM (and other clinics in the world) showed how a healthcare organization can benefit from "smart" tonometer adoption. It will decrease the costs (eg. nurses' time spent on measurements, which they can use for other duties) and enhance accuracy.

3.3. EMC Clinic

3.3.1. Value chain application

As it was mentioned in Chapter 2, longevity department was chosen for further analysis. This is a wide-profile department offering a specially selected set of procedures for each client, in order to conduct diagnostic studies of the patient's body for the preparation of a treatment program and preventive measures. This department was chosen for further analysis, as this direction seems to be the most suitable for adopting the practices of the Internet of things, and the results and recommendations are of particular interest to the clinic and the organization's management (represented by Tatiana). Figure 11 illustrating general value chain for patient in longevity department is presented below.

	Monitoring & Preventing	Diagnosing	Preparing	Intervening	Recovering Rehabbing	Monitoring & Managing
Informing & Engaging	• **Counselling about current health situation**	• **Explaining further diagnostic process**	• **Explaining further diagnostic process**	• **Counselling on treatment**	• **Counselling on treatment**	• **Counselling about current health situation**
Measuring	• Self exam	• **Doctor initial inspection**	• Self exam + doctor assessment	• Procedure-specific measurements • Self exam + doctor assessment	• Self exam + doctor assessment	• Self exam + doctor assessment
Accessing	• **Office visits** • **Online consultations**	• **Office visits**	• **Office visits**	• **Office visits** • **Visits to outpatient or other SBU**	• **Office visits**	• **Office visits** • **Online consultations**
Was subject to digitalization and IoT **Longevity department specialist** Other provider entities	• **Medical history** • Weight and physical activity monitoring • **Office visit / Online consultations***	• **Medical history** • **Doctor check (initial inspection + additional exams assignment)**	• Physical activity tracking • **Genotype and phenotype research** • **Adjusting the list of further tests**	• Additional exams (eg. stress test) • Physical activity tracking • **Treatment prescription (balance of food, nutrients, medicine and etc.)**	• **Treatment correction (changes based on new analysis results if needed)** • Physical activity tracking	• **Office visit monthly / Online consultations** • **Treatment correction if needed** • Weight and physical activity monitoring

Figure 11 *EMC Clinic. The Care Delivery Value Chain Longevity Department*

Examining the patient's path step by step, we gathered the following information:

– *Monitoring and preventing* (medical history, screening, identifying risk factors, prevention programs);

In case if it is not the first visit to EMC Clinic, this stage is taken place. All of the patients of the center have their own account in the system, where previous visits, analysis and diagnosis are (this information of new patients in not that full amounts are available in the unified state information system). Moreover, patients are able to get access to the system from the website, information about upcoming screening appears there (besides that, administrators call and/or send SMS in advance to notify about it).

– *Diagnosing* (medical history, specifying, organizing tests, interpreting data, consultation with experts, determining the treatment plan);

The patient has decided to prolong his life. He made an appointment in the EMC Clinic with therapist of longevity department. During the first meeting, the doctors collects complaints (anamnesis), makes initial inspection and prescribes additional tests. Besides that, he asks the patient to measure his weight and track his daily physical activity.

– *Preparing* (choosing the team, pre-intervention preparations, pre-treatment);

The doctor studies patient's genotype and phenotype. Based on received medical history and test results he adjusts the list of further tests. The patient does not stay in the clinic, but comes for the tests' appointments.

– *Intervening* (ordering and administering drug therapy, performing procedures, performing counselling therapy);

The patient passes additional examination (eg. stress test). With the help of modern methods and examinations on the latest equipment, multi-sided diagnostics is performed. Only after carefully studying and comparing the data obtained, a diagnosis is made. The doctor notifies the patient of the results of the examination and prescribes treatment (eg. balance of food, nutrients, medicine and etc.). The patient keeps measuring his weight and track his daily physical activity.

– *Recovering rehabbing* (inpatient recovery, inpatient and outpatient rehab, therapy finetuning, developing a discharge plan);

After receiving tests results and collecting new data, the doctor might adjust treatment. For the entire period of treatment, the patient's condition is carefully monitored – the impact on the body of prescribed medications and procedures is controlled. He also keeps measuring his weight and track his daily physical activity.

– *Monitoring and managing* (monitoring and managing the patient's condition, monitoring compliance with therapy, monitoring lifestyle modifications).

As it was already mentioned, each of the patients has a personal account, where now he adding manually information of weight measurements and daily physical activity tracking. There is a telemedicine service available for the patient. Telemedicine is not allowed for initial diagnosis, but for subsequent treatment, consultation, and dosage/drug adjustment is possible. The patient is constantly monitored by the doctor through the personal account. Thanks to online monitoring, the doctor can adjust prescribed medications and dosages on distance, so the patient does not have to come to the clinic for the offline appointment.

3.3.2. Gaps in the primary and supporting activities' strategies

As it was mentioned before, the longevity department of EMC Clinic has not opened yet due to external circumstance. However, following gaps were found and should be considered:

1. Weight and physical activity monitoring (elements 2.1 and 2.6)

The results of the monitoring are adding manually by the patient to the personal account. This is inconvenient for the patient, takes time and decreases the total value from the service he receives. Moreover, manual input of measurements is inconsistent, entail mistakes (due to human factor) and, as a result, affects data processing.

2. Motivation, Interaction & Data collection (row 1 and elements 1.1 and 1.6 in particular)

There is not much interaction between the clinic and the patient. If only calls from administrators and automatic SMS reminders and notifications in the personal account (and via emails).

3. Personal account access (elements 3.1 and 3.6)

The only way to enter the personal account is via the website. As it was stated earlier, one of the main trends in digital marketing is the switch of the users from desktop to mobile, so the patient is expecting to be able to access his account from the mobile phone.

4. Data processing

Data analysis is made only by the doctor. It takes a lot of his time, which can be spent more efficient.

3.3.3. Recommendations

In order to improve current strategy of the clinic and increase the value for the patient, following suggestions were made:

1. Connection with "smart" scales and watches

Nowadays most of the people already have “smart” scales and watches that track physical activity and pulse. Upgrading system to receive the data from such devices will atomize the process, improve the correctness of data that the patient monitor and upload by himself (it will practically solve the problem of the human factor) and remove extra movements for the client (so the value for him will be increased).

2. Elements of chat bot in the personal account

The pieces of chat bots might be inserted in the personal account. It can be used to collect data, answer basic questions, making appointments and etc., so that will save resources of the organization, enhance engagement with patient and create additional value.

3. Creation of the app

Interaction with clients is really important in any industry, especially in healthcare. Customer interaction is the key to effective online marketing, it is a strategy that companies use to build relationships with their consumers in order to increase brand awareness, satisfaction and loyalty. Properly created mobile version of website and app is a must for customers. Creation of the EMC app will increase engagement and add value (especially comparing to competitors).

4. Analytics of tests results’ dynamics

The analysis of tests results’ dynamics is carried out in four stages: goals definition (for what period to analyze, what data to analyze) and data collection (access unified internal and state informational systems); data processing; performing calculations (visualization of information in graphs and charts for ease of analysis); analysis and summing up. Analytics can be easily applied to the analysis of the weight and physical activity measurement collected from “smart” watches and scales. However, the results of the major tests also can be added in the process of analysis. By doing this, labor costs will be decreased (eg. doctor will spent time usually occupied by these processes on other duties), accuracy enhanced and potentially (in case of creating simpler version of the results visualization) value for customers and engagement with them will be expand.

3.4 Theoretical contribution and practical implication

The value chain as a concept of the methodological level has proved to be effective over time in different industries, and we have used it in this paper as a case study. Modified Porter’s value chain model was used for describing the performance of the corresponding medical service. As an anthological contribution, we applied methodologically a relatively new method and showed that it gives results.

Theoretical contribution of the value chain model usage can provide:

1. Market description

Competitors are identified based on the commonality of activities in the chain (eg. in cases of the study – NRCERM and DRIEM have similar value chains for a Patient with Hypertension, thus in this case they can be defined as competitors).

2. Identification of strengths and weaknesses

Strengths (weaknesses) of SBU are internal factors of organization that ensure the advantage of the SBU over competitors (competitors over the SBE) in creating the value of the service delivered and/or its production costs within the same value chain links. For instance, such activity as blood pressure measuring can be identified as strength of NRCERM, as there is smart tonometer involved in the process, which helps to reduce costs (eg. labor costs) and increase value for the patient. On the other hand, the same activity in DRIEM can be defined as weakness, comparing to its competitor – NRCERM.

3. Development of functional strategies' activities

Traditionally the strategy of an organization consists of growth, competitive and functional strategies. In this research, we defined the impact of the Internet of things on the development of health organization strategies – how IoT implementation affect functional strategies (marketing for connecting with consumers, obtaining information, channels, personnel, finance) and further production strategies (assortment of technologies and services).

As for managerial usage:

1. Gradual and precise examination of all of the service delivery stages

All the stages of the service delivered are being investigated in the process of the value chain model application, which helps not to miss any of them. It helps to conduct deep analysis of the service delivery in order to improve it – reduce costs, enhance quality, add value for customers.

2. Specification of the responsibility for the implementation of activities at each stage of the service delivery

In the process of value chain model application, all of the activities of the service delivered are being defined as primary (activities of the division (SBU) that is being analyzed) or supporting (activities of other providers' entities) activities. Therefore, it allows to specify the responsibility for the implementation of activities (eg. to the head of the division or other providers' entities).

3. Structuring the concept of value for developing current services/creating new ones

Application of the value chain model as a result helps to develop current services (eg. by connecting internal informational system, personal account and smart scales and watches of

customers of EMC Clinic) or even create new ones (eg. using Baltic Telemedicine Center's resources in order to create new service – online consultations).

3.5 Limitations and direction for future research

Several limitations associated with the conducted research can be discussed:

1. The actual quality is not taken into account (quality of medical service cannot be fully evaluated);
2. The value for the customer is evaluated through the perception of the organizations (the main source of collected data is case organizations);
3. No full understanding of the impact of IoMT solution implementation on supporting activity as a whole (the evaluation of supporting actives is based on one SBU perspective).

So, in order to expand the research in further works, following directions can be chosen:

1. Building Customer Journey Map (it would provide an opportunity to take a look from the patient's perspective and compare the results);
2. Application of the framework to other SBUs (eg. NRCERM – Pulmonology department; DRIEM – Therapeutic department; EMC Clinic – Paediatrics department);
3. Analysis of supporting activities management (eg. Human resource management, Logistics of material distribution – it would provide better understanding of the impact of IoMT solutions implementation on supporting activities and organizations strategies);
4. Application to other healthcare organizations (Departmental, State, Private – developed framework might be successfully applied to all the types of healthcare organizations).

CONCLUSION

Despite the fact that nowadays IoT is being actively adopted by many healthcare organizations, there are still not many researches done on this topic. There is no framework that Russian healthcare organizations can rely on when it comes to improve hospital strategies with IoT adoption, as all of the foreign studies does not consider specificity of healthcare in the Russia Federation.

The goal of current research was to investigate strategies for implementing IoMT solutions in clinics and summarize the results as recommendations for improving the content and methods of hospital strategy development. In order to reach the goal, the following research question was formulated – How can the modified concept of value chain be applied to develop strategies for implementing Internet of Medical Things in the activities of Russian healthcare organizations?

To answer the question, as a methodological basis of the thesis the modified Porter's value chain model was used for describing the performance of the corresponding medical service. Based on the value-added chain concept, the paper examined the activities of three St. Petersburg clinics (departmental, private, state) to implement IoMT solutions in the provisions of medical services: NRCERM and DRIEM – cardiology department, EMC Clinic – longevity department. The results of case studies are summarized as recommendations for developing strategies for implementing Internet of Medical Things in the activities of, which can be generally illustrated on the Figure 12 below.

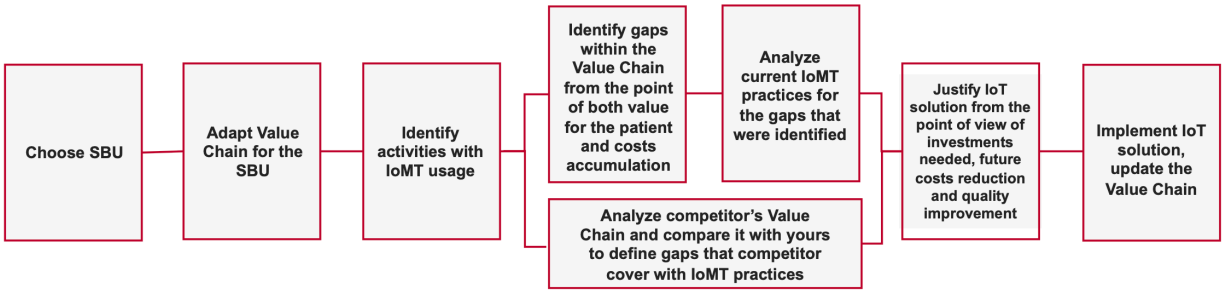

Figure 12 *The process of the strategy development for IoMT implementation*

Moreover, discussed cases will be included in the professional retraining program "Management in healthcare" (Graduate School of Management) and materials of the master thesis will be used for the upcoming publication.

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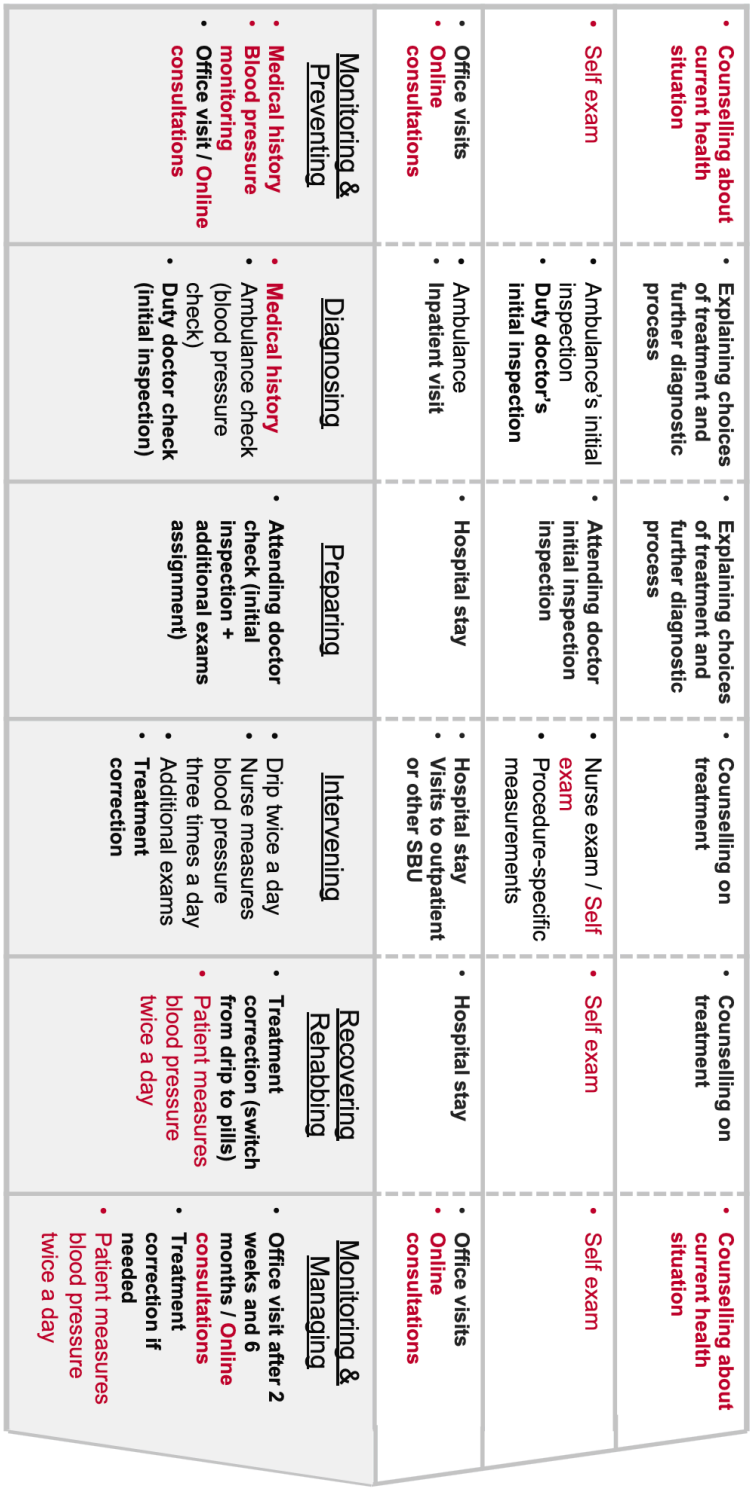
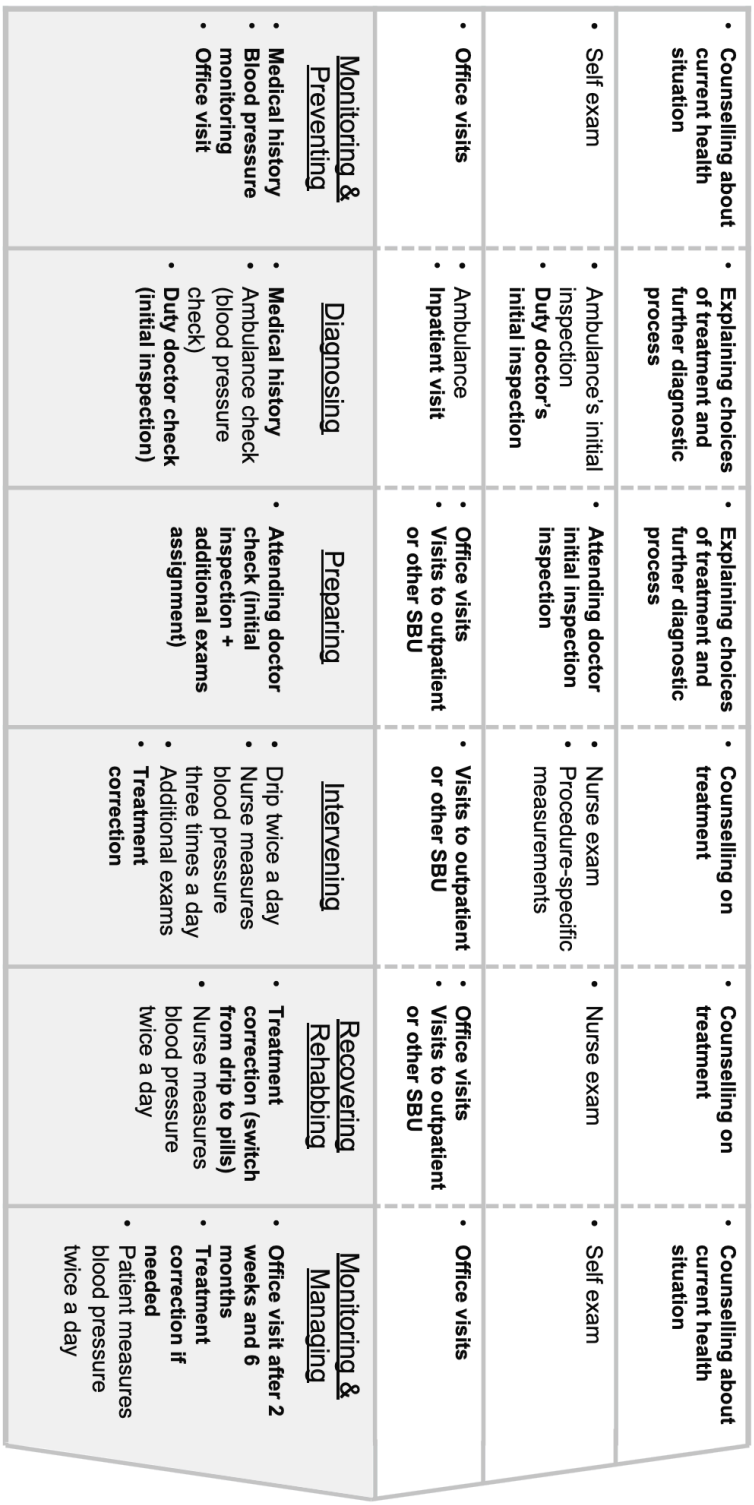
APPENDICES

Appendix 1. NRCERM. The Care Delivery Value Chain Hypertension Care



Appendix 2. DRIEM. The Care Delivery Value Chain Hypertension Care



Appendix 3. EMC Clinic. The Care Delivery Value Chain Longevity Department