Applying a modified care delivery value chain for procurement strategy development (the case of anti-HIV/AIDS institutions)

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Introduction

Among the Sustainable Development Goals (SDGs) adopted by the United Nations in 2015 ([UN, 2015]), there is Goal 3: "Ensure healthy lives and promote well-being for all at all ages". In turn, amid the targets of Goal 3, there is target 3.3: "By 2030, end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, water-borne diseases and other communicable diseases".

In this paper, we discuss the peculiarities of application of the value chain (VC) methodology, proposed by M. Porter, to countering the spread of HIV/AIDS and tuberculosis (TB). As of now, the value chain methodology is one of the key instruments of strategic planning of activities in companies and/or their strategic business units (hereafter, SBU; see [Hall, 1978]).

The value chain approach was proposed by M. Porter in the mid-1980s ([Porter, 1985, p. 38]) to determine the success of a business as based on the excess of the value (accumulated in the process of passing a product or service through a sequence of interrelated activities of the business) over the costs (accumulated in production/delivering of this product or service). Since that time, the approach has been actively used by companies operating in various sectors of the economy.

Twenty years later, M. Porter co-authored in extending of the original VC methodology by proposing a care delivery value chain model (CDVC) (see [Porter, Teisberg, 2006]). The CDVC model has the following peculiarities:

a) It structures the provision of medical care for a certain pathology, dividing it into stages (links of the chain): diagnosis, preparation, intervention, rehabilitation, and post-treatment interaction.
b) It considers the contribution of activities performed at each stage to creating value for the patient, which consist of providing access to medical care, measuring the parameters of the patient's health status, and the corresponding informing of the patient.
c) It measures the success of care delivering by means of health outcomes per unit of costs.

Thus, the CDVC framework, first, describes the current care delivery process (see item a) that is typical for the clinician-driven models [Park, 2020, p. 459]; second, it pays a great attention to structuring and understanding of patient value (see item b) that is typical for the patient-driven models (Ibid); third, and more importantly, it analyzes the ways how to apply hospital activities to increase the value of services for the patients (see items a-c) so it can be classified as the patient-centered

model [Carey, 2016, p. 46] and, at the same time as the value (for patient)-based model [Porter, Teisberg, 2006, p. 98].

Since the research objects of this paper are the HIV/AIDS and tuberculosis institutions that are usually public institutions or, as minimum, public bodies, we consider value chain methodology as an innovative tool of the New Public Management – an international ideology aiming to increase the effectiveness of public services through managerial means [Diefenbach, 2009].

The application of the methodology opens such diverse opportunities for improving the effectiveness and efficiency of healthcare organizations (primarily by enhancing the quality of medical care) that, by now, value chains have been built for many pathologies.

However, as to paper's research objects the academic literature has an abundance of papers that discussing CDVC in the case of HIV/AIDS ((see [Rhatigan et al., 2009; Osunyomi, Grobbelaar, 2015; Rhatigan et al., 2018])) and deficiency of them in the case of tuberculosis (see Section 2 for details) (Gap 1).

Another direction of the value chain methodology application is strategic planning in healthcare organizations or their SBUs – care delivery departments. Usually, such a hospital department is responsible for care delivery to patients with various medical conditions and for the corresponding activities that are reflected in different CDVCs. Maybe that's why the issue of CDVC applying for development of hospitals or their departments strategies, how informed are the authors, does not consider in the academic literature (Gap 2). Even in the latest papers concerning the hospitals' strategic planning, the CDVC model may not be mentioned at all [Liff, Andersson, 2021], and, if patient-centered CDVC is mentioned, then the Porter's VC model that can be classified as clinician-driven one, is actually discussed [Ramsdal, Bjørkquist, 2020, p. 1722].

In this paper, the gap is partially closed for some cases when the department or, moreover, the hospital, at large, counteracts a single disease. To stress this feature, we sometimes will call such institutions "mono-hospitals". Examples of mono-hospitals are HIV/AIDS and tuberculosis institutions, COVID-19 hospitals, perinatal centers, and some other. All the above-mentioned organizations have a common feature – they can be considered as so-called *integrated practice units* (IPU) whose value chains consist of all or almost all the links specified above (see, for example, [Porter et al., 2021]). In this case, application of Porter's methodology is especially seminal, since "care over full care cycle is tightly coordinated, and patient information is extensively and seamlessly shared" [Porter, Teisberg, 2006, p. 203].

Health care organizations have traditionally concentrated their management work on those activities which they are reimbursed for – office visits, medical tests, procedures, etc. Thus, managers readily focus on the steps immediately before and after these activities (i.e., getting patients in and letting them out), but generally do not take much responsibility for meeting the needs of the patients

over the entire cycle of care [Porter et al., 2021]. Thus, value chain methodology requires from the IPU leaders a holistic view on care delivering.

And last theoretical gap that is discussing in this paper relates to CDVC model *per se*. On the one hand, all chain links in the CDVCs considered in academic literature consist of medical activities (see item *a* in the model description above) that a little bit different depends on pathology and do not include some other links presented in Porter's CV model, for example, logistics and marketing. This circumstance obviously makes it difficult to use the model for strategic planning, since logistics and marketing activities significantly affect the value of the health care and the corresponding costs. On the other hand, all components of patient's value (see item *b* above) are the same in different papers discussing different pathologies. The question is, does the list of patient's value components closed.

Thus, specific objectives of this paper are: (1) to develop a CDVC framework for the TB pathology; (2) to justify and suggest some improvements into the CDVC model that open up the applying it to the monohospital strategy planning more effective way; (3) to apply modified model for increasing performance of the institutions countering HIV/AIDS and TB by means palanning their procurement practice. The ultimate goal of this paper is to provide relevant recommendations for practitioners and public policy improvement in the field of countering the spread of HIV/AIDS and TB.

To illustrate how the performance of the corresponding medical institutions (and, thus, the patients' value of health care delivery) can be enhanced in the context of countering suppliers' collusion at medical products procurement auctions, we collected procurement data on all Russian medical institutions countering HIV/AIDS (38 567 records) and tuberculosis (148 720 records) over 2017-2020. This information was used to construct quantitative models predicting the potential presence of collusion at an auction.

The paper has the following structure. Section 1 gives the basic notions and ideas related to the value chain methodology and its application to the IPU management. Section 2 provides a review of the studies on the value chain methodology and its applications, as well as specifies the goals for the current research. Section 3 covers the problem and peculiarities of applying CDVC for combating HIV/AIDS, develops CDVC for the TB pathology, discusses some improvements to CDVC that we propose to introduce as well as the experience of practical application of the methodology. In Section 4, on the base of the collected empirical information and constructed models, we demonstrate how procurement actions in the bottom part of the CDVC aimed at *ex ante* and *ex post* counteraction to collusion can increasing performance of the institutions delivering HIV/AIDS and TB. Section 5 concludes.

1. The value chain methodology

The emergence of the value chain methodology can be traced quite accurately. In the first of his fundamental monographs ("Competitive Strategy…" ([Porter, 1980]) published by M. Porter, the term "value chain" is never found[1], while in his next monograph ("Competitive Advantage…", [Porter, 1985]), the concept of value chain appears already in its final form.

The following three ideas constitute the essence of the concept.

1. The activity of a company (production of goods or provision of services) is presented as a set of relatively independent but interrelated sub-activities – the primary ones (implemented in the company's units that produce goods or provide services) and the supporting ones (conducted by the company to support such units). Thus (see Fig. 1), M. Porter directly introduced the list of primary and supporting activities that turn out to be independent of the company's industry, thus ensuring the universal application of the methodology created.

2. In the process of conducting the primary activities (links in the value chain) – with contribution of the supporting ones, – on the one hand, value for potential consumers is accumulated, and, on the other hand, company's costs are accumulated, too.

3. The success of the company is determined by whether the willingness of consumers to pay for the value created in the production process is higher than the corresponding company's costs.

On the one hand, M. Porter's model gave rise to a method of strategic planning for the company's – or its SBUs in the case of a multibusiness firm[2] – development associated with a consistent consideration of activities implemented within the links of the value chain in terms of their contribution to creating value for the buyer (in healthcare – the patient) or reducing the company's costs. This approach allows making an appropriate contribution to the formation of the SBU's functional strategies (production, marketing, personnel), along with one from the analysis of its environment.

On the other hand, comparing its activities with the ones of its competitors in the framework of industry analysis, the SBU can determine its strengths and weaknesses as internal factors that determine its advantages or the advantages of its competitors in implementation of this or that link of the value chain.

There are various VC-methodology applications in the manufacturing industries ([Acharyulu et al., 2015], [Aitken, 2016]), as well as in service delivering ([Pathak, Pathak, 2010], [Dorri et al., 2012]). This paper contributes to further development of the VC-methodology in healthcare.

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[1] Perhaps, only the phrase "Value added can also be enhanced by forward integration from manufacturing into distribution or retailing" ([Porter, 1980, p. 208]) carries the germ of the future value chain concept.

[2] Firm that operates in different geographical and/or product markets (see [Chandler, 1991, p. 33]).

Value chain construction for a specific industry (in our case, healthcare) starts with splitting of the “Operations” link (see Fig. 1) into several typical interconnected activities. The corresponding links of the chain can be identified by means of analysis of the healthcare business landscape structure which, according [Inamdar, 2007, p. 1695], gives us seven separate business areas (see Table 1).

The hospital’s scope of activities is defined as a range of businesses in which it chooses to compete. Thus, there emerges a multibusiness health care firm that can be called “integrated health care delivery system” (IHCDS) (see [Inamdar, 2007, p. 1691]).

There are two ways in which such a firm contributes to health care effectiveness and efficiency. First, its integrated nature overcomes the fragmentation of care and makes IHCDS accountable for health outcomes. Second, the multi-business approach decreases the average expense due to lowering (1) average fixed costs (keeping administrative costs relatively unchanged); (2) average variable costs (due to the effects of scale or diversity, if any).

However, managing IHCDS is more complicated as compared to the one of a single-business company and, thus, demands a holistic view on its strategy development. The basis for such a view has been developed by M. Porter and his colleagues starting from a seminal book by M. Porter and E. Teisberg (see [Porter, Teisberg, 2006]) up to the most recent publications (see [Porter et al., 2021]).

The developed concept of value-based health care:

- puts the patient with a specific medical condition (pathology) in the center of care delivery;
- introduces the term of *integrated practice unit* (IPU) – the dedicated multidisciplinary team that is organized around the needs of patients with a specific medical condition over the full cycle of care (see [Porter et al., 2021]);
- constructs the care delivery value chain (CDVC) that connects the structured activities of IPU with their contribution to the patient value;
- establishes the health outcomes per unit of costs as a crucial criterion of IPU’s health care delivery performance.

The care delivery value chain for a typical IPU is given in Fig. 2.

The CDVC is organized the following way. There are six typical links of the value chain: monitoring and preventing; diagnosing; preparing; intervening; recovering and rehabbing; monitoring and managing. This list is usually customized for concrete medical conditions. Comparing Fig. 1 and Fig. 2, we can see that M. Porter's CDVC is actually a fragmentation of the "Operations" VC link and does not contain other links of VC.

At the bottom of CDVC, each chain link represents a mix of departmental and other hospital facilities and, if any, outsourced health care activities. Thus, CDVC structures the value generated by the activities (listed at the CDVC bottom) within the value components located at its top left corner: ensuring access to medical services, measuring patient health indicators, informing the patient. All

published CDVC-cases corresponding different pathologies (Section 2) contain this list unchangeable. The top part of CDVC is filled in as given in Table 2.

According to M. Porter's approach, the top part of CDVC contains prescriptions on that hospital must doing to secure a contribution to the components of patient value (Fig. 2, Table 2) thereby the quality and safety of medical care is ensuring. However, from the strategic point of view, such a model does not allow reflecting the contribution of individual medical actions to one or another component of patient value.

Over the last fifteen years, the value chain methodology in healthcare has been developed in different directions that are considered in the following section.

2. Literature review and paper goals

As mentioned above, the value chain methodology was formulated in well-known publications [Porter, 1985] and [Porter, Teisberg, 2006] and since then has been mainly developed by M. Porter and his colleagues up to the present moment (see [Porter, Lee, 2013]; [Rhatigan et al., 2018]; [Porter et al., 2021]; [Reitblat et al., 2021], etc.).

Ever since it was invented, the value chain methodology has been successfully applied in medical practice for improvement of care delivery quality for various pathologies: breast cancer, kidney disease, and stroke [Porter, Teisberg, 2006]; urology [Reitblat et al., 2021]; HIV/AIDS [Rhatigan et al., 2009; Fiori et al., 2016; Berk et al., 2020; Gilenko et al., 2021a]; orthopedics [Kaplan, Porter, 2011], and some other.

This paper is dedicated to improvement of care delivery quality in medical institutions that counteract the HIV/AIDS and TB diseases. Unlike the application of CDVC to counteract spreading of the HIV/AIDS infection, which has been developed with an extensive participation of M. Porter himself, the case of TB is substantially less covered in the academic literature ([Dubois et al., 2020]). To the best of our knowledge, there have been no attempts in the literature to construct a CDVC for TB – so, *one of our goals* in this research is to develop a CDVC for TB counteraction.

~~While the list of value chain links is usually modified in the literature (relative to the one given in Fig. 2) in accordance with the peculiarities of a specific pathology, the set of key components of patient's value (informing, measuring, and accessing – see Table 2) has remained the same.~~

The value chain concept has been extensively applied for hospital strategy development on each level of strategy planning: corporate, business, and functional ([Ginter et al., 2018]).

The first one (corporate level) sets the institution boundaries. Inamdar (2007) examines how the range and types of businesses in which the hospital chooses to compete (see Table 1) are related to its financial performance. The research gives evidence that under high Medicaid and low commercial insurance (that is typical for HIV/AIDS and TB care in many countries), firms with the largest business scope demonstrate the best performance.

Now, let us consider how the value chain methodology can contribute to strategy development on the business and functional levels. CDVC aims to provide a holistic view on managing the treatment of a particular pathology in the framework of IPU (~~integrated practice units~~). So, its application to development of a strategy for the whole hospital (IHCDS) or its departments responsible for providing care for *many* pathologies represents a certain challenge and has been largely neglected in the academic literature.

However, there is a lot of institutions that can be considered as IHCDS and IPU at the same time, including the ones that we focus on in this paper – TB dispensaries and hospitals, as well as

HIV/AIDS prevention and control centers[3]. These institutions are administered through functional departments (clinical operations, marketing, human resources and so on) and, thus, their managerial structure can be identified as a functional one (see [Chandler, 1991, p. 32]).

There exists a standard algorithm of strategy developing for the functional structure institution that encompasses the following steps [Jauch, Glueck, 1988, p. 7]:

- setting up the institution's goals;
- defining the institution's external environment;
- analyzing this environment;
- applying the analysis results to construction of hierarchy connected hospital strategies – growth strategy, competitive strategy, and complex of functional strategies (for medical institution – clinical operations, marketing, human resources, and may be, R&D).

The value chain methodology contributes to this algorithm as follows.

As it was mentioned in Section 1 (Fig. 2), an IPU's performance is measured as health outcomes per unit of costs. We'll assume that the activity of each HIV/AIDS or TB institution is aimed at improving the value of this indicator.

The CDVC model allows identifying the brand and product (industry) competitors as those that use a similar value chain (see [Ferrell et al., 2022]). However, for HIV/AIDS and TB institutions, the competition on the corresponding markets is weak or completely absence. Market failures, distributional issues, and other inefficiencies are the primary reasons for government intervention in the health care markets [Watts, Segal, 2009]. It is a common practice in most markets, but in the markets in question, governments make interventions by means of direct funding of public and/or private organizations to support provision of health care and medicines to patients. Thus, since each HIV/AIDS or TB institution possesses a monopoly power on care delivering, it has no brand, product (industry), and/or form[4] competitors.

Let us consider an institution's *growth* strategy – the top-level one in the strategies hierarchy. There are three options when the growth strategy is selected: *expansion*, *stability*, and *retrenchment* [Jauch, Glueck, 1988, pp. 204-210]. In the general case, the implementation of the first and last of the strategies is associated either with a significant change in the volume of services provided in the markets served, or with the exit (leaving) of the organization to new geographical and product markets. The last alternative is not possible for the organizations in question since the geography of

[3] It is worth noting that this may not be true for standalone TB organizations (dispensaries, hospitals, sanatoriums): for example, a TB sanatorium – responsible for the rehabilitation of TB patients only – is obviously only a part of the corresponding IPU.

[4] A "form competitor" of the SBU satisfies the same need for a product/service, but by means of an alternative technology, and, correspondingly, has a different value chain.

service and treatment methods for them are precisely determined by corresponding authorities. Thus, from four product-market strategies – market penetration, market and product development, and diversification (see [Ansoff, 1957, p. 114], Table 3) – only the first one is relevant for the considered institutions.

I. Ansoff defined market penetration as an effort to increase company sales without departing from an original product-market strategy [Ibid.]. In the research context, we assume that market penetration aims at institution's health care quality improvement and costs optimization.

In the absence of competition, the strategy choice depends mainly on the morbidity dynamics. For example, the global TB incidence rate (new cases per 100 000 population per year) declined of about 2% per year for most of the previous 2 decades, and the net reduction from 2015 to 2021 was 10% [Global Tuberculosis Report 2022, p. 17] [5]. Thus, for the countries with the same tendency, the choice of *retrenchment* strategy by TB institutions seems to be the most relevant.

Table 4 illustrates the spread of HIV/AIDS and TB diseases in Russia in recent years (2010-2019). The data give evidence that for HIV/AIDS institutions the *retrenchment* alternative is not relevant while for TB ones the same is for an expansion alternative.

Let us move down to the next level of strategies hierarchy – to the competitive strategy that must be developed to secure a fit the goals established in the growth strategy. There are again three options when the competitive strategy is selected: overall cost leadership, differentiation, and focus [Porter, 1980, pp. 35-39]. However, due to their monopoly power the HIV/AIDS and TB institutions can avoid of selection one of three alternatives[6] and may combine measures aimed at the care quality improvement with ones aimed at costs optimization securing obtaining the goals of market penetration strategy.

Let us move on the lowest level of strategies hierarchy – to the functional strategies and confine the discussion two of them – production and marketing. The value chain methodology explicates the value that consumers and organizations gain at each stage of the chain ([Pitta, Laric, 2004, p. 451]; Fig. 2). It is possible to gradually consider value chain links assessing the contribution of medical actions in each of them into the creation the additional value for patients in three fields –accessing, measuring, informing. However, it is hardly possible to reflect these contributions in the Porter's CDVC *per se* (Fig. 2). We will try to close this gap in the next section developing a corresponding modification of the CDVC model.

Since there is no need to save their patients from the competitors or capture competitors' ones the institutions production strategy of HIV/AIDS and TB is much more demanded than the marketing

[5] However, it rose by 3.6% between 2020 and 2021 due to COVID-19 pandemic [Ibid.].
[6] They are not in danger to be "stuck in the middle" [Ibid., p. 41].

one. However, marketing efforts still can effectively contribute to the effectiveness of care delivering by establishing strong and flexible contacts with various patient groups (for the case of HIV/AIDS, see [Gilenko et al., 2021a, p. 49]). Below, we will concentrate on production strategy development assuming that it aims at health care quality improvement and costs optimization – to obtain the aims of higher-level strategy. It is worth noting that for an multibusiness organization (according to [Chandler, 1991, p. 33]) its procurement strategy, as a rule, is developed on the corporate level to satisfy its SBUs' needs in a more effective way, while for a functional organization its procurement strategy can be considered as a part of production strategy [Tkachenko et al., 2018].

Finally, we modify CDVC model and apply modified one to enhance the hospital procurement contribution into the obtaining of both above-mentioned production strategy aims. More precisely, we will connect the procurement actions with their contribution into the patient value components and then examine how hospital's anti collusive measures can increase the value of crucial criterion of IPU's health care delivery performance – health outcomes per unit of costs.

In the examining the problem of suppliers' collusion, this paper, on the one hand, is in line with the studies that highlight the importance of tender design in reducing the opportunities for an anti-competitive agreement ([Klemperer, 2002]; [Kovacic et al., 2006]; [Albano, Santocchia, 2022]) – so-called, *ex ante* collusion counteraction. On the other hand, this research contributes to the development of applied empirical methods for collusion detection – so-called, *ex post* collusion counteraction.

The range of methods of detection of bid-rigging/price fixing cartels varies substantially: from simple statistical screening to quite advanced approaches of the modern time-series econometrics. For example, Esposito and Ferrero (2006) analyze the Italian gasoline and baby food markets using the simple mean and the standard deviation for price description. They find that the prices under collusion are higher**,** and that the variance of these prices is lower. Imhof (2017) applies simple statistical screens to a bid-rigging cartel in Switzerland and shows how well the screens detect it by capturing the impact of collusion on the discrete distribution of the bids.

Bolotova et al. (2008) demonstrate the impact of the lysine cartel and the citric acid cartel by analyzing the price evolution with ARCH and GARCH models. Tas (2017) designs a method to identify and test for the presence of bid rigging in procurement auctions with limited information. Huber and Imhof (2019) combine machine learning techniques with statistical screens computed from the distribution of bids in tenders within the Swiss construction sector to predict collusion brought by bid-rigging cartels.

Besides other methods, recently, construction of logistic regression models based on positive-negative ([Hastie et al., 2017]; [Gilenko et al., 2021b]) or positive-unlabeled data ([Bekker, Davis, 2020]; [Goryunova et al., 2021]) has become quite popular. This paper also contributes to this

research direction using as empirical base procurement data on all Russian medical institutions countering HIV/AIDS (38 567 records) and tuberculosis (148 720 records) over 2017-2020.

Thus, in the rest of the paper:

- the CDVC for the case of TB are developed,
- the CDVC model is modified to be more effective one for institution strategy planning,
- the CDVC for the case of HIV/AIDS are modified and applied,
- hospital's anti collusive measures that must increase the value of health outcomes per unit of costs in the HIV/AIDS and TB institutions are suggested and justified.

3. Care Delivery Value Chain: the current and possible ways of application

The HIV/AIDS Care Delivery Value Chain (see Fig. 3) was one of the first CDVCs constructed for medical pathologies [Rhatigan et al., 2009; Porter, 2010]. In this section we will briefly cover the current ways of CDVC application and discuss some improvements to it that we propose to introduce.

3.1. CDVC: the current outlook and ways of application

The CDVC model contributes a lot to the management of HIV/AIDS care delivery.

~~First, it identifies relatively independent links of the entire HIV/AIDS value chain – "Screening", "Diagnosing/Staging", etc. (see Fig. 3), compared to their standard set for a typical IPU (Fig. 2).~~

First, it substitutes a standard set of chain links for a typical IPU – "Monitoring and preventing", "Diagnosing", etc. (see Fig. 2) with the set for HIV/AIDS care delivery (see Fig. 3) – "Screening", "Diagnosing/Staging", etc. (see Fig. 2).

Second, this CDVC's bottom part consists of the measures that are to be taken in each CDVC link in the HIV/AIDS case thereby ensuring the necessary level of quality of medical care from the care provider's perspective.

Third, the managers acquainted with the CDVC can look beyond the limits of their own units or organizations and see themselves as part of a larger system (IPU). Managing interdependencies becomes as important as managing within the organization's walls [Porter et al., 2021].

Fourth, in the case of HIV/AIDS care delivery, the model specifies what patients need to be educated about ("Informing"); what information about patients' health status need to be collected ("Measuring"); and where patient care activities take place ("Accessing") – thus, ensuring the necessary level of quality of medical care from the patient's perspective.

To the best of our knowledge, no CDVC for tuberculosis has been so far developed in the literature except a specific CDVC for a pediatric HIV/TB care that can be classified as clinician-oriented model in contrast to Porter's patient-oriented one [Dubois et al., 2020, p. 8]). Hence, closely following Porter's methodology (see above First, Second, Forth), we propose a CDVC for tuberculosis[7] (see Fig. 4).

The model given in Fig. 4 demonstrates a practical contribution to the quality management of TB care delivery in a way similar to the one reflected in Fig. 3 for the case of HIV/AIDS. Let us discuss how these two models can be used in the strategy developing process of the studied medical institutions.

[7] Fig. 4 reflects Russian practice of care delivery, however, as to tuberculosis care, it entire corresponds to the international one [____].

As mentioned above, in the case of HIV/AIDS and, with some extra comments, in the case of TB, the corresponding medical institutions match the respective integrated practice units, and, thus, the problem of their strategy development is relevant. However, the direct application of the CDVC model here is hardly possible due to the following reasons.

First, each CDVC reflects, before all, *medical* actions that can be taken in the corresponding CDVC links, however, the distribution of *paramedical* supporting activities across them may be problematic.

Second, it was mentioned above, the question "Is the list of patient value components complete?" is still open.

~~Third, the top part of CDVC undoubtedly represents a great step toward the patient-oriented health care, however, though it consists of medical actions, it does not directly reflect their contribution and the contribution of actions from the bottom part of CDVC to the patient value.~~

Third, the top part of CDVC undoubtedly represents a great step toward the patient-oriented health care, however, it consists of prescriptions for care delivery and does not reflect the contribution of actions from the bottom part of CDVC to the patient value components.

4.2. CDVC: recommendations on improvement

Hence, we suggest introducing the following modifications to the discussed model to make it more applicable for the strategy development process.

Recommendation 1*: Add the "Inbound Logistics" link (see Fig. 1) to the list of CDVC links*.

Before all, implementation of this recommendation will help better reflect the contribution of procurement measures that would cut costs or create additional value for the patients. In Fig. 5 we demonstrate the corresponding contribution for the case of ~~Russia~~ HIV/AIDS care.

Recommendation 2*: Add the "Patient's well-being" link into the list of patient value components*.

Having analyzed various CDVCs, we found that some medical/paramedical actions do not fall into any of the components of the patient value (Accessing, Measuring, Informing) but clearly improve the patient's well-being. The HIV/AIDS and TB care, as a rule, implies psychologist's participation in the care delivering process (as reflected in Fig. 4 and Fig. 5) which directly improves the patient's well-being but in no way contributes to Accessing, Measuring, or Informing. In a similar way, measures aimed at normalizing the patient's blood pressure, relieving their pain, etc., contribute to the patient's value by means of improving the patient's well-being.

Recommendation 3*: Concentrate all performing activities of the healthcare institution in the bottom part of CDVC and reflect their contributions to the patient's value in the top part of CDVC*.

As it was mentioned above, the activities reflected in the top part of M. Porter's CDVC describe the actions of the medical institution (where the services are provided; what parameters of the

patient's health are to be measured; what the patient should be informed about) and do not reflect their specific contribution to creating value for the consumer. We suggest concentrating all the performing activities in the CDVC's bottom part and using the CDVC's top part to connect the performed actions with their contributions to the patient's value.

Recommendation 4*: Give CDVC the outlook of an MS Excel spreadsheet*.

Fig. 5 illustrates how the proposed modifications can be implemented for the HIV/AIDS Care Delivery Value Chain – with some elements of the HIV/AIDS CDVC (as given in Fig. 3) that are not relevant to this illustration of the suggested modifications being omitted.

The modified CDVC can be used in the framework of strategic planning in the following manner. Let us consider the Inbound Logistics (procurement) link.

HIV/AIDS care delivery is about providing patients with special medicines. In the Russian Federation, the necessary medicines can be bought by: (a) the medical institution itself; (b) the corresponding regional public authority; (c) the Ministry of Health of the Russian Federation (MHRF).

But in all these cases the medical institution needs to: (1) predict its demand for the medicines (cell A5), (2) prepare the corresponding claim for the medicines and get it approved by MHRF (A8); (3) develop such a design of the procurement tender that, on the one hand, would ensure suppliers' competition and, on the other hand, would prevent them (as much as possible) from colluding (A10).

Having been implemented, these measures contribute to the patient's value in the following ways: (1) ensure that the demand for the medicines will be meet (A5, A8 $\rightarrow$ A3), (2) improve the procured medicines' quality (A10 $\rightarrow$ A4). In a similar way, more elaborate development of procurement tenders' design to ensure demand for consumables (A9) must improve the diagnostics quality (A9 $\rightarrow$ A3).

4.3. CDVC: experience of application

The value chain methodology itself and all its above-mentioned improvements have been tested and successfully applied in the projects of top-managers and owners of different Russian healthcare institutions that they were developing during their study at the retraining program "Healthcare management" of our university[8] (we will later specify the name of the university) over 2020-2022.

~~Our retraining program "Healthcare management" is certified by the Global Educators Network for Health Innovation Education (http://www.thegeniegroup.org/programs) in line with 17 other programs from world-known universities.~~

[8] The program is certified by the Global Educators Network for Health Innovation Education in line with 17 other programs from world-known universities.

Table 5 in Appendix presents eight examples of such projects illustrating various possible directions of application of the proposed modifications to CDVC. Most of the projects (#1, 2, 5, 6 and 8) were aimed at healthcare quality improvement by means developing the corresponding CDVC.

In some projects, the value chain methodology was used to construct the strategy of a mono-hospital (#1 and 6); a hospital department (#5 and 8); supporting activities (#2), and even for development a growth strategy of a pharmaceutical company (#7).

In projects #3 and 6, the proposed methodology was applied to introduce changes in a regional healthcare system, while in project #4 a similar thing was done for alternating a hospital structure.

It is worth mentioning that the theoretical findings of this paper were thoroughly tested in the process of developing the projects, thus ensuring integration of research, education and business.

4. Suppliers' collusion counteraction as a way to enhance performance of HIV/AIDS and tuberculosis institutions

~~In this section, as a concrete illustration of further application of the discussed methodology, we show how cells in Fig. 5 can be influenced to enhance the patient's value of health care delivery.~~

In this section, as a concrete illustration of further application of the discussed methodology, we show how the contribution of medical actions placed in cells of the bottom-part of HIV/AIDS CDVC (Fig. 5) into enhancing of patient's value can be reflected in the CDVC's top part. In greater detail, we will consider the procurement measures that can decrease suppliers' incentives to collude and, correspondingly, improve the quality of procured goods and services and/or decrease the respective costs for the public buyer. It should be noted that reflection of the influence of procurement efforts on the costs of care delivery in the modified CDVC is beyond the scope of this paper.

So, here we address the problem of impact of suppliers' collusion in procurement procedures on the performance of HIV/AIDS and TB institutions, and, thus, on the patient's value. We propose some approaches to improve procuring of medicines and medical consumables (filling in cells A9 and A10, see Fig. 5) that are expected to decrease suppliers' incentives to collude (correspondingly, decrease procurement costs) and, thus, increase patient's value (see cells A2 and A4 in Fig. 5).

Some of these measures (such as prediction of occurrence of collusion at an auction) can be classified as *ex ante* counteraction, while others (such as the proposed conditions for collusion detection) – as *ex post* counteraction. The consideration of the issue will be provided on the Russian experience of public procurement regulation and procurement practice of healthcare institutions.

5.1. Theoretical grounds

Being public organizations, HIV/AIDS and tuberculosis institutions must procure in accordance with the Russian public procurement regulation. The latter put certain restrictions on tender design development making it difficult for the so-called *ex ante* counteraction to collusion.

~~Below, we demonstrate how information on tender's results can be used to discover suppliers' collusive behavior. This decreases the incentives to collude, thus, contributing to the *ex post* counteraction to collusion.~~

Below, we demonstrate how information on tender's results can be used to discover suppliers' collusive behavior what can be classified as ex post counteraction to collusion. At the same time, such cases having become public decrease the incentives to collude, thus, contributing to the *ex ante* counteraction to collusion.

The development of countries implementing intensive economic reforms is objectively accompanied by corruption growth [Huntington, 1968, p. 59]. Since the authorities consistently seek to increase transparency of the public procurement system, many corruption cases are covered in the

media. In such situations, developing countries very often form their public procurement policies to restrict contracting authorities' discretionary power, preventing them from rent-seeking behavior, and to strengthen the institutions [Nemec et al., 2020]. In other words, the policies aim at controlling the three necessary conditions of corruption behavior [Aidt, 2003, F633]:

1. discretionary power: the relevant public official must possess the authority to design or administer regulations and policies in a discretionary manner;
2. economic rents: the discretionary power must allow extraction of (existing) rents or creations of rents that can be extracted;
3. weak institutions: the incentives embodied in political, administrative, and legal institutions must be such that officials are left with an incentive to exploit their discretionary power to extract or create rents.

As to the Russian Federation, such public procurement policy was formed by 2005. However, due to the lack of experience in the public procurement area, to achieve the above-stated objectives, the legislative authorities and the government chose tools that were rarely used in international practice. In order to minimize the discretion power of the contracting authority, the English auction with sole price criterion was selected as the main procurement method that was to be applied for procuring of goods and services from a specified list (the, so-called, Auction list[9]). It is worth to note that about the all procurement of medical institutions (medicines, consumables, medical equipment) is included in the Auction list.

Application of the English auction in procurement means that the price successively drops down from the initial contract price (ICP; designated in the solicitation to the auction) until only one bidder remains [McAfee and McMillan, 1987, p.702]. If we recall that a supplier's *reserve price* at such an auction is the minimum price until which the supplier is ready to participate in the auction, we can identify the English auction as a second-price auction, because it stops when the auction price falls to the reserve price of the last supplier that quits bidding, and this price is next to the overall minimum reserve price at the auction. Thus, at this kind of auction, the contract (final) price is higher than the winner's reserve price.

It is worth noting that there are two types of first-price auctions – the Dutch auction and the request for quotations – that (under some assumptions) allow to reveal the reserve price of the winner [McAfee and McMillan, 1987, p.702]. In the *Dutch auction*, the price goes up from zero (or another small price that cannot satisfy any bidder) and the auction stops when some bidder accepts the current price. With the *request for quotations*, each potential supplier submits a single bid, and the bidder with the lowest price in the bid is awarded the contract for the price of their bid.

[9] Formally speaking, request for quotations and single-source procurement are also applicable to the goods and services from the Auction list if the contract size is relatively small.

From the point of view of several authors, the development of procurement procedure design should begin with an examination of potential collusion between the suppliers [Klemperer, 2002; Kovacic et al., 2006]. And, if such information is available, the English auction is least preferable option as compared to the Dutch auction, the scoring auction (a procurement method where suppliers bid both on price and quality criteria; see [Asker, Cantillon, 2010]) or the request for quotations [Kovacic et al., 2006; Marshall, Marx, 2007]. However, the Dutch auction cannot be used in the Russian public procurement at all, as the initial contract price must go down, not up; scoring auctions are not permitted for medical institutions; the request for quotations is only applied for relatively small (in price and volume) contracts.

Now, let us move on to the *ex post* counteraction to suppliers' collusion and analyze a couple of situations at the English auction when suppliers' collusion may be considered proven.

According to the current Russian public procurement legislation, the algorithm for conducting public procurement of an indivisible product/service via an electronic English auction implies interaction of the following three principal parties – the public buyer, the electronic trading platform (ETP), and the potential suppliers – and is implemented in the following steps.

1. The public buyer places a solicitation to the auction in the Russian unified information system (RUIS), specifying the ICP, information on the procured products/services, and some other details of the future contract.
2. Potential suppliers send their applications to the chosen ETP. A supplier's application comprises two parts: the first part contains the information on the proposed product/service while the second one has details on the supplier itself.
3. The ETP sends the first parts of the collected applications to the public buyer. The public buyer examines them and composes an application selection report where the total number and coded IDs of the potential suppliers approved for participation in the auction are reflected[10]. This report is then sent back to the ETP to be published in the RUIS. So, before the auction begins, potential suppliers know the information on the number of companies approved for participation in the auction, as well as the dates/times of their application submission.
4. The ETP conducts the electronic auction if the number of approved bidders is two or more. At the auction, the contract price consecutively falls by the step that is legislatively allowed to vary from 0.5% to 5% of the ICP.
5. The auction stops if there was no new bid for 4 minutes either from the beginning of the auction or since the last submitted bid.

[10] When a single supplier submits to and is approved for an auction, the contract goes to them at the ICP if the second part of their auction application is also approved by the public buyer.

6. As a result of the auction, a formal report on its procedure is published by the ETP, which reflects the ICP decrease proposals made by each of the participants.

In the general case, it is quite challenging to prove suppliers' collusion based on the information on their bidding behavior during the auction. However, when at the auction the price decrease (PD) is small, it can be easily done. Below, we consider two such cases.

Case 1: PD = 0% of ICP. According to the current Russian public procurement legislation, this case is possible – if during the auction the contract price does not decrease at all, the contract is signed with the supplier whose application was the first to be submitted and approved. This implies that at the auction there was at least one bidder who: (1) spent some money/time to prepare for participation in the auction; (2) had information that it was impossible to win the contract without an ICP decrease; (3) actually, didn't decrease the initial price. Such irrational behavior cannot be explained anyhow else but by presence of suppliers' collusion at the auction ■

Case 2: PD = 0.5% of ICP. According to the auction algorithm stated above, in this case there was a single (winning) bid that decreased the ICP by 0.5%. Let us assume that this (winning) bid was submitted *not* at the very beginning of the auction and consider the behavior of the losing participants.

Since the losing participant(s) didn't decrease price by 1% of ICP, it means that the reserve price of these participants is more than 99% of ICP, so, each of the losing participants knows that it is impossible to win a contract if some of the competitors submit a bid first.

In the setup of this case, it means that there is at least one bidder who: (1) spent some money to prepare for participation in the auction; (2) knew that he/she must be the first to submit a bid; (3) did not submit the bid at the very beginning of the auction. Such irrational behavior of the losing participant(s) cannot be explained anyhow else but by presence of suppliers' collusion at the auction[11]

■

Then the final question here is what does it mean "not to submit a bid at the very beginning of the auction"? Our extended discussion with the experts in the field of public procurement resulted in an understanding that the *first 20 seconds* of an auction is sufficient time for a supplier to place a bid if they actually want to be ahead of their competitors.

To summarize, in this subsection we proposed two *ex post* conditions for automatic collusion detection at auctions with insubstantial ICP decrease. In the next subsection we will demonstrate approaches to ex ante collusion identification.

[11] A more rigorous proof for these two cases can be found in [Ivanov et al., 2021].

4.2. Empirical analysis

In this section, we describe the sample collection process and the approaches adopted to construct classifiers to predict collusion in auctions on the *ex ante* basis.

4.2.1. Sample collection and descriptive statistics

We collected the procurement data of all Russian HIV/AIDS and TB institutions over the period 2017-2020 and selected from them only price auctions[12]. As a result, we obtained 38 567 records on HIV/AIDS institutions and 148 720 records on TB institutions.

After cleaning the data (for missing values, etc.) and selecting only those auctions:

- that fell into the category "English price electronic reverse auction";
- where were at least 2 approved participants (as we needed auctions with competition);
- that were held at the Sberbank-AST ETP (as this ETP publicly provides the full information on the auctions in a user-friendly form);

we were left with 3 096 data points on HIV/AIDS and 19 783 data points on TB institutions. We marked as collusion-positive those auctions where the initial price (ICP) either was not decreased at all or decreased insignificantly due to the irrational behavior of some of the participants. When marking such auctions, we used the principles described in subsection 5.1.

Based on the collected information, we have developed a list of variables (features) to be used further in our prediction algorithms. The variables and their descriptive statistics are given in Table 6. As we seek to construct classifiers based on the *ex ante* information, it is worth mentioning that the values of the variables in Table 6 (except the outcome variable) are publicly known before the auction begins.

4.2.2. Classification results

In this subsection we describe the results of our empirical experiments. The aim of such experiments is to identify the possibility for effective pre-marking auctions where the authorities[13] should expect collusion to occur before the bidding even begins. The idea is to train a model on a training sample, then obtain its predictions for auctions using the features (variables) from the test sample and compare these predictions with the actual auction classes from the test sample.

Four machine learning algorithms – Random Forest, Gradient Boosting, SVM, and Linear Regression – were used in calculations. The corresponding models were optimized via randomized

[12] In the Russian public procurement legislation, the auction with the single (price) criterion is the dominant procurement method [Berezinets, Ivanov, 2019].

[13] By the term 'authorities' we mean a contracting authority or a public procurement monitor. In Russia, the contracting authority itself cannot cancel the results of a tender even if the presence of collusion is obvious.

search over their hyper-parameters and validated using a 5-fold cross-validation with respect to the F1-score metric[14].

The stability of classification quality metrics for the optimized models was evaluated by random subsampling (see [Dubitzky et al., 2007]), with the corresponding datasets being split into the training (80% of all observations) and the test (20% of all observations) subsamples. The values of the classification quality metrics were calculated *on the test subsamples* over 1000 runs of random subsampling and averaged.

Let us now briefly discuss the obtained classification results.

For *the HIV/AIDS dataset*, as it can be seen from Table 7, the best performance is demonstrated by the models based on ensemble methods, namely, Random Forest and Gradient Boosting. Random Forest has the highest recall score (0.973) meaning that 97.3% of all auctions with identified collusion were predicted correctly. It is worth mentioning that Support Vector Machine and Linear Regression has significantly worse scores on all metrics.

Averaged scores of classification metrics for each model on the TB dataset are shown in Table 8. Here, Random Forest and SVM demonstrate quite similar results with only a slight difference in precision. Again, Random Forest outperforms Gradient Boosting in terms of recall, while the latter has the best precision and F1-score values among the models – 0.212 and 0.345, respectively. Interestingly, the predictive power of SVM is substantially better for the TB dataset than for the HIV/AIDS dataset and, thus, has very varying results on different datasets as also indicated by Rodríguez et. al. (2022).

The obtained results clearly indicate the fact that the use of formal prediction models can indeed provide an effective way for automatic pre-identification auctions with expected presence of collusion. Active use of such approaches on the *ex ante* basis will help the authorities later run a more thorough check on such auctions.

4.3. Implications for practitioners

The obtained results for our HIV/AIDS and TB datasets (are given in Tables 7 and 8) illustrate the following. Overall, it can be seen that on these datasets for all constructed models recall is substantially larger than precision, which means that the "positive" class (the auctions with identified

[14] In this research, the class of auctions with identified collusion is the "positive" class, the rest are the "negative" class. For our classification algorithms, we use the following classification quality metrics:

Precision = TP / (TP + FP); Sensitivity (Recall) = TP / (TP + FN); Specificity = TN / (TN + FP);

F1-score = 2*Precision*Recall / (Precision + Recall); Balanced Accuracy = (Sensitivity + Specificity)/2;

where

TP – true positive (the correctly predicted positive class outcome of the model),

TN – true negative (the correctly predicted negative class outcome of the model),

FP – false positive (the incorrectly predicted positive class outcome of the model),

FN – false negative (the incorrectly predicted negative class outcome of the model).

collusion) is comparatively *over-predicted* (the number of false positive observations is much larger than the number of false negative ones).

On the one hand, this stems from the fact that our datasets have a prominent class imbalance – the observations from the "positive" class constitute only about 7% in the corresponding samples (see Table 6). But we intentionally did not balance the training samples, as (1) balancing may introduce bias to the data; (2) the test sample remains imbalanced anyway. These issues are very well covered in the literature (see, for example, [Gilenko, Mironova, 2017]).

On the other hand, specifically, in our case, this may not be that big a problem, because our algorithms over-predict the "positive" class – the auctions with identified collusion. This means that for the authorities such algorithms may become effective support tools for *preliminary* decision making – with the final decision on the presence of collusion in an auction made based on extra information from the auction.

From the practical point of view, here we put forward the idea that, using the information available *before* the auction begins, such tools indeed can substantially increase the effectiveness and speed of collusion pre-identification.

5. Conclusion

Ensuring healthy lives and promoting well-being for people is a very challenging task. In this research we addressed some issues related to countering the spread of HIV/AIDS and TB.

In this paper, we:

- propose such a modification of the value chain methodology that can be applied for development of a mono-hospital's strategy;
- develop a CDVC for TB and modify the CDVC for HIV/AIDS to improve the quality-of-care provision by the corresponding institutions;
- illustrate how to contribute to enhancement of performance of the above-mentioned institutions and the patient's value of health care delivery by proposing certain measures for countering suppliers' collusion at auctions on the *ex ante* and *ex post* basis.

We see further development of the research in modification of the value chain methodology in such a way that will be aimed at applying it for the development of strategies of hospitals and/or their departments that incorporate many CDVCs. Another challenging direction of the further research can relate to the construction and applying of education delivery value chain (EDVC).

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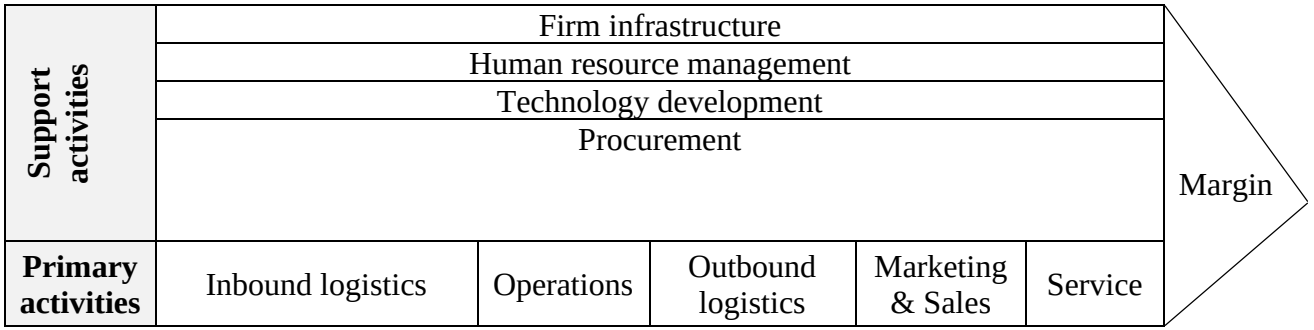
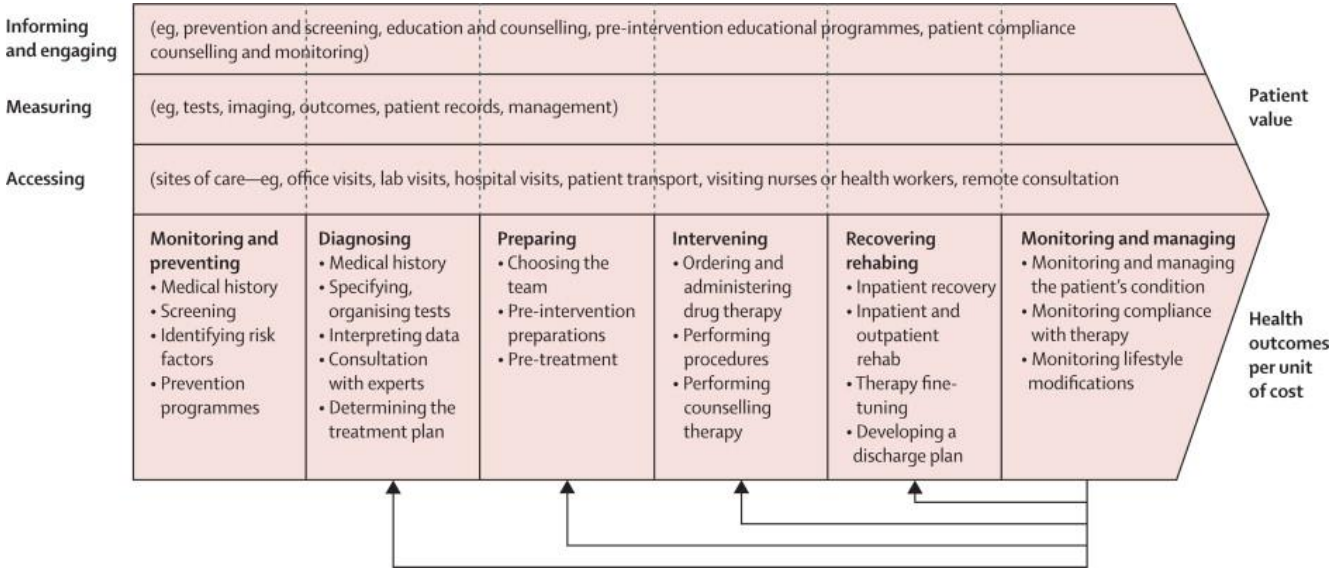
Appendix

Fig. 1. M. Porter's value chain model



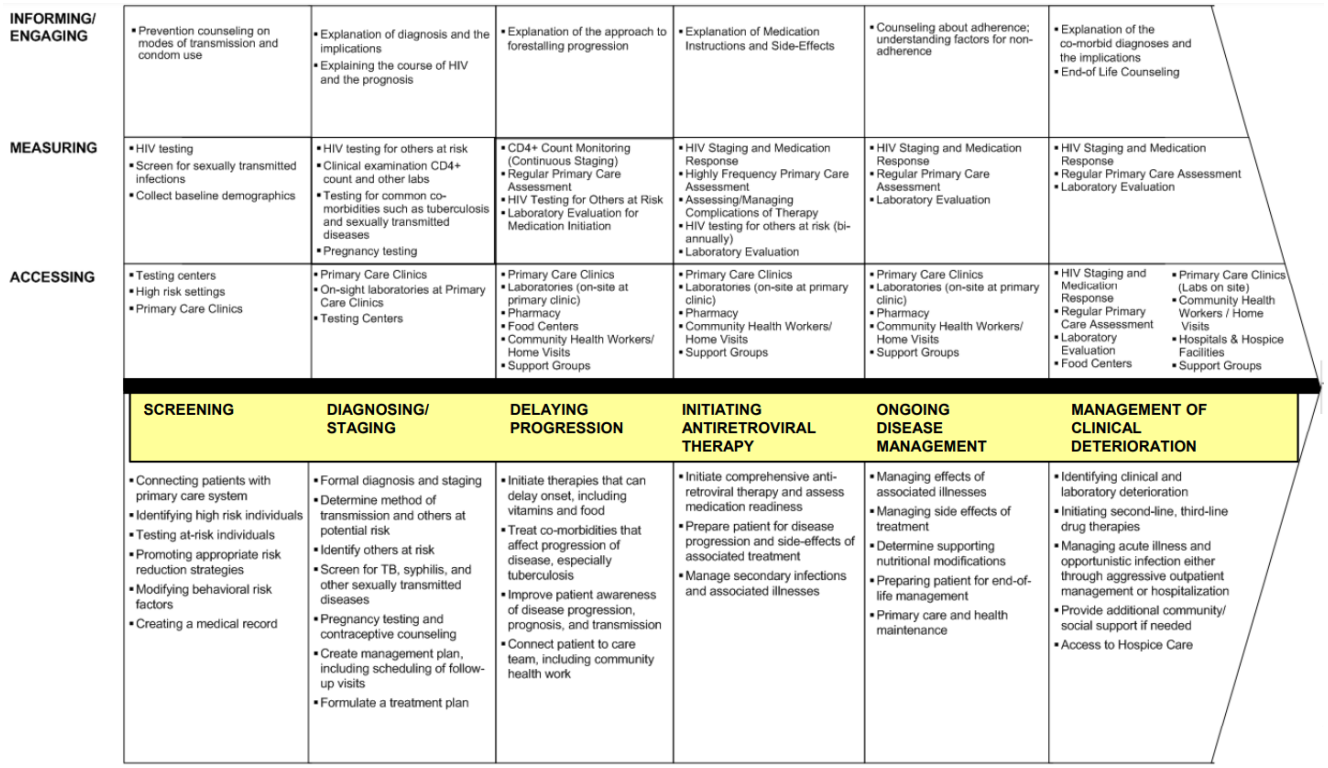
Source: [Porter, 1985, p. 37].

Fig. 2. The care delivery value chain (CDVC) for a typical IPU



Source: based on [Porter, Teisberg, 2006, p. 204]

Fig. 3. The HIV/AIDS Care Delivery Value Chain



Source: [Porter, 2010].

Fig. 4. The Tuberculosis Care Delivery Value Chain

Informing	Lifestyle consulting	Lifestyle consulting Informing about the course of TB and prognosis	Lifestyleconsulting Informing about the diagnosis and its consequences	Explaining instructions for use and side effects, tuberculosis treatment plan	Lifestyle consulting
Measuring	Examination for tuberculosis (Photofluorography) Assessment of lung damage	Examination for tuberculosis (Photofluorography) Diagnosing the patient (establishing the form of the disease) Clinical examination, determination of the resistance profile of Mycobacterium TB and other laboratory studies Testing for comorbidities	Analysis of concomitant diseases and their treatment by patient Socio-psychological assessment of the patient's adherence to the risks of therapy (medical, social)	Monthly monitoring of bacterial excretion Continuous evaluation of the effect of therapy Monthly laboratory and instrumental evaluation of treatment	Determination of functional disorders because of TB Determination of the socio-psychological consequences of TB for the patient TB testing of contact persons (twice a year) Laboratory assessment of the condition (1 time in 3 month)
Accessing	Meeting with patients at high risk of contracting TB General medical network (outpatient hospitals) photofluorography centres, field fluorographic installations	TB dispensaries TB hospitals TB departments of general/specialized hospitals Tuberculosis bacteriology laboratory	TB dispensaries TB hospitals TB departments of general/specialized hospitals Patient Schools, Laboratories Pharmacies, Home visits	TB dispensaries TB hospitals TB departments of general/specialized hospitals TB sanatoriums Support groups, Patient Schools, Laboratories, Pharmacies	TB dispensaries TB sanatoriums Support groups Patient Schools Laboratories
Main activities	**Prevention and examination of TB**	**Diagnosis of TB**	**Preparation for TB treatment**	**TB treatment**	**Rehabilitation**
Description of activities used to provide medical care	Determining the groups of people at a high risk of contracting TB Testing of people at high risk of contracting tuberculosis Encouraging appropriate strategies to reduce the risks of TB Changing behavioural risk factors of TB	Diagnosing the patient Screening close contacts of a patient Creating a patient treatment plan Creating preventive treatment for patients' contacts	Formulation of the treatment plan Informing the patient about the treatment side effects Psychological testing for treatment adherence Determining possible interactions between antituberculosis and other drugs taken by the patient Raising the patient's awareness of TB, its treatment methods and prognosis Connecting the patient to social health workers and psychologists	Providing antitubercular therapy Prescribing a diet Management of adverse events during therapy (e.g. negative side effects) Ensuring that the patient adheres to the treatment plan Therapy of concomitant diseases affecting the progression of TB	Vocational rehabilitation Functional rehabilitation Conducting a control examination (laboratory and X-ray)

Source: composed by authors

Fig. 5. The Modified HIV/AIDS Care Delivery Value Chain

Columns		A	B	C	D	Rows
Components of value for patients	Informing		Using the optimal informing channel (10) Improving information quality (8)	Objective information of stage of the disease (7)		1
	Measuring	Improving the quality of diagnostics (9)	Determining the presence of HIV infection (5, 6, 9)	Extensive health screening (7)		2
	Accessing patient care elements	Ensuring that the demand for medicines will be met (5, 8)	Facilitate access to diagnostics (9)	Opening access to the dispensary care (6, 7) Opening access to the dispensary care (8)	Obtaining medicine (8)	3
	Patient's well-being	Improving the quality of drugs (10)	Informing on the absence of HIV infection	Informing on the easy stage of HIV infection, if any (5)	Use of medicine (8) Obtaining psycho-logical assistance (5)	4
Value chain links		Inbound logistics	Monitoring / Preventing	Diagnosing	Intervening	
Performing activities		Forecasting the need for consumables and medicines	Mandatory medical examination	Identification of HIV infection: ELISA/CLIA	Infectious disease doctors' and other specialists' appointments	5
		Preparation of a state assignment	Voluntary medical examination	Dispensary registration	Laboratory and instrumental research methods	6
		Drawing up an annual procurement schedule	Organization and implementation of preventive measures	Detection of the stage of the disease: appointments of medical specialists, usage of instrumental research method	Organization of education for patients	7
		Preparation of an application to MHRF for provision of medicines	Preparation and distribution of information materials	Issuance of an opinion on the presence of HIV infection	Distribution of medicines	8
		Purchases of consumables (by the Center and authorized organ.)	Medical examinations in the course of off-clinic events	Determining the presence of HIV infection Establishing the stage of the disease		9
		Purchases of medicines (MHRF, region)	Marketing efforts to establish channels with target groups			10

Notes: (1) MHRF stands for the Ministry of Health of the Russian Federation

(2) Fig. 5 uses the HIV/AIDS case to reflect the authors' contribution to further development of the value chain methodology. The complete version of HIV/AIDS CDVC requires merging of the chains in Fig. 3 and Fig. 5.

Source: authors' analysis

Table 1. Scope of Businesses in Health Care

Scope of Businesses						
Non-Core	Core Businesses			Non-core Businesses		
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Health Plan	Ambulatory Care	Acute Care	Subacute Care	Home Health Care	Other Businesses	Collaborations
Manage care health plans	Preventive, diagnostic, therapeutic and rehabilitative services not classified as inpatient or residents	Hospital facilities that provide inpatient services	Long-term, skilled nursing, behavioral health, psychiatric facilities, and hospice	Physical care and support to patients and their families at home	Businesses that do not provide direct patient care and are owned by the firm (i.e., laboratories, pharmacies, fitness centers, etc.)	External relationships the firm has formed to support or deliver health care services including joint ventures, alliances, and partnerships

Source: [Inamdar, 2007, p. 1695].

Table 2. Patient value components decomposition

Patient value components	What should be pointed out
Informing	What patients need to be educated about
Measuring	What health indicators are to be measured
Accessing	Where patient care activities take place

Source: composed by authors

Table 3. The Ansoff model for expansion strategy options

(1) Market penetration – *a significant increase in the volume of services provided to current consumer groups*.	**(2) Market development –** *provision of current services to new geographic markets and / or new consumer groups.*
(3) Product development – *expansion of the range of provided services*	**(4) Diversification –** *provision of new services to new geographic markets and / or new consumer groups*

Source: [Ansoff, 1957, p. 114].

Table 4. The spread of HIV/AIDS and TB diseases in Russia in recent years (2010-2019)

Year	The number of Russian citizens living with pathology (per 100,000 population)		New registered cases (Russian citizens)	
	HIV/AIDS	TB	HIV	TB
2010	345.8	76.9	58 286	109 900
2011	370.7	104.3	62 385	106435
2012	411.6	97.5	70 832	96740
2013	449.0	90.4	79 810	90531
2014	500.4	87.0	89 728	89327
2015	534.2	84.5	98 037	84515
2016	595.9	78.1	102 277	78121
2017	628.9	70.9	106 072	70861
2018	693.1	65.2	103 506	65234
2019	754.0	60.5	97 176	60531

Sources: RFSMC (2020), Rosstat (2020)

Table 5. Application of the value chain methodology in the diploma projects of hospitals' top-managers at the retraining program "Healthcare Management" (2020-2022)

#	Name	Institution	Position	Project Title	Year
1.	Yuri K.	Dental clinics network	Deputy General Director	Development of a growth strategy of a dental clinics network	2022
	Anastasia K.		Executive Director		
2.	Alexey N.	Proton Therapy Center	Head of the Department of Anesthesiology and Intensive Care	Applying of the value chain methodology to improve the efficiency of anesthesia care for patients in the Proton Therapy Center	2022
3.	Roman K.	Research Institute for Complex Issues of Cardiovascular Diseases	Anesthesiologist-resuscitator	Cardiac surgery for the population during the COVID-19 pandemic	2021
4.	Andrey K.	Center for Emergency and Radiation Medicine	Public Procurement Officer	Establishment of the Public Procurement Service in the Center for Emergency and Radiation Medicine	2021
5.	Konstantin S.	In-patient Hospital	Deputy Chief Medical officer	Development of a full cycle of specialized and high-tech medical care for patients with a cardiological profile in St. Petersburg In-patient Hospital	2021
	Vitaly S.	In-patient Hospital	Neurosurgeon		
6.	Alexander P.	TB dispensary	Chief Medical officer	Reorganization of the St. Petersburg TB service	2021
7.	Olga M.	Pharmaceutical Company	Human Resources Business Partner	Development of a growth strategy for the Pharmaceutical Company	2020
	Dmitry N.		National commercial manager		
8.	Garik K.	In-patient Hospital (Moscow District)	Chief Medical officer	Applying the value chain methodology to develop a strategy for the department of radiological surgical diagnostics and treatment in the City Clinical Hospital	2020

Table 6. Descriptive statistics of the datasets

Variable	Description, measurement units	Rationale of use	HIV/AIDS data (n=3 096)				TB data (n = 19 783)			
			min	median	mean	max	min	median	mean	max
collusion	Binary variable =1 for the auctions with identified collusion; =0 otherwise	Outcome variable	0	0	0.072	1	0	0	0.058	1
ICP	Initial contract price; Continuous variable; thousands of Russian rubles	Higher ICP may provide more incentives to collude.	2.1	317.5	2618.1	710625.7	0.3	199.7	963.9	725628.4
sameBuyOrg	Binary variable =1 if the buyer and the organizer of the auction is the same organization; =0 otherwise	If the buyer and the organizer of the auction are different organizations, this may indicate less incentive to collude.	0	1	0.99	1	0	1	0.99	1
appCollat	Size of collateral for the application submission (% of the ICP, in the range 0%–5% as set by law Continuous variable; thousands of Russian rubles	The larger is the size of the collateral, the more incentives to win the auction, thus, to collude.	0.003	7.73	45.77	21318.8	0	4.03	68.75	36181.2
combined	Binary variable =1 for the auctions run for several buyers simultaneously; =0 otherwise	Combined auctions imply bigger purchases, thus, higher ICPs and more incentives to collude.	0	0	0.15	1	0	0	0.114	1
federalDistrict	A set of binary variables, each corresponding to one of the eight Russian federal districts	Auctions in different federal districts may be differently prone to collusion due to some regional peculiarities.	x	x	x	x	x	x	x	x
n1hour	The number of auction applications submitted within 1 hour (not necessarily the same hour)	An indirect indicator of coordination of actions.	0	0	1.16	24.0	0	0	1.09	23.0
nApproved1	The number of auction applications approved by the first parts	The more approved applications, the more participant in the auction, thus, less possibilities to collude.	2.0	3.0	3.84	33.0	2.0	3.0	4.23	43.0

purchaseType	A set of binary variables, each corresponding to one of types of medical products being bought: (1) medicines; (2) materials used for medical purposes; (3) medical equipment; (4) medical consumables; (5) other (food provision, security services, etc.)	Auctions for different types of medical products may be differently prone to collusion due to product peculiarities.	x	x	x	x	x	x	x	x
limitSmall	A legislative limitation: procurement only from small businesses and socially oriented non-profit organizations Binary variable =1 if the limitation was applied for the auction =0 otherwise	Auctions with such artificially limited competition may be more likely to have suppliers' collusion	0.0	0.0	0.36	1.0	0.0	0.0	0.43	1.0
limitFZ44	Limitations set by art. 14 of the FZ-44 Federal Law. They imply a 15% advantage to the ICP for national producers of the procured products as compared to foreign producers. Binary variable =1 if the limitation was applied for the auction =0 otherwise	Auctions with such artificially limited competition may be more likely to have suppliers' collusion	0.0	1.0	0.52	1.0	0.0	0.0	0.45	1.0

Note: mean values of binary variables show the proportion of "1" (ones) in the sample.

Table 7. Averaged values of classification metrics for the HIV/AIDS dataset

Classification metrics	Random Forest	Gradient Boosting	SVM	Linear regression
Recall	0.973	0.955	0.826	0.900
Precision	0.200	0.204	0.140	0.163
F1-score	0.332	0.337	0.238	0.275
Balanced accuracy	0.836	0.828	0.716	0.771

Source: authors' calculations

Table 8. Averaged values of classification metrics for the TB dataset

Classification metrics	Random Forest	Gradient Boosting	SVM	Linear regression
Recall	0.997	0.924	0.997	0.981
Precision	0.188	0.212	0.186	0.175
F1-score	0.317	0.345	0.317	0.297
Balanced accuracy	0.869	0.844	0.870	0.854

Source: authors' calculations