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Systematized review of the innovative Russian IT-solutions for the optimization of drug information in the circulation of medicines

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ABSTRACT
An increase in the number of new drug products (DPs) leads to the growth in the associated information. To improve the efficiency of medical and pharmaceutical care, IT-products are created. In this review, we attempt to systematize innovative domestic IT-solutions (dITSs) for the optimization of remote data management of medicines. We have conducted a systematized search over the past 5 years in accordance with the PRISMA framework. eLibrary, CyberLeninka, and Google were utilized as search engines. 18 out of 312 results met the preset criteria. 23 dITSs were extracted. 18 used big data as the main technology, 2 blockchains, 2 artificial intelligence, and 1 continuous acquisition and lifecycle support/product lifecycle management. The innovations point towards the optimization of drug information in medical organizations (16/23) and pharmacies (6/23). In practice, the dITSs are mainly used as databases (10/23), decision support systems (9/23), and automated analytics (6/23). Specific products are infrequently and not comprehensively assessed in scientific papers. It is more efficient to search them on particular sites dedicated to IT-projects. Today's reasons for the development of the innovative dITSs to optimize information management within the lifecycle of medicines are a necessity to trace each DP and automate the analysis of related information.

INTRODUCTION

Background

Under current conditions of the information revolution and scientific and technological progress (Gruzina, 2020; The Eurasian Economic Union, 2022; United Nations Industrial Development Organization, 2021), pharmaceutical companies around the world are actively investing in research and development (R&D) of medicines (Armstrong, 2022; Assis, 2022; Atradius, 2022; Buntz, 2022; Citeline, 2021; Congressional Budget Office, 2021) [a compound annual growth rate (CAGR) of new drugs in pipeline, calculated according to Pharmaprojects data (2001–2021), is 5.53% (Citeline, 2021)]. Consequently, in the pharmaceutical market, the number of drug products (DPs) is rapidly increasing [a CAGR of first approved DPs by the Food and Drug Administration, calculated according to the Center for Drug Evaluation and Research (2008–2021), is 5.38%] (Mikulic, 2022; Center for Drug Evaluation and Research FDA, 2022). No doubt, this trend is favorable for pharmacotherapeutic medical care (PhTMC), but it is obvious that in the pharmaceutical market, quantity does not always result in quality.

Since the rise of DPs leads to the growth of its information, it will be more difficult for the workers of the pharmaceutical product lifecycle (PhPL) to process this amount of data and make the right decisions in their work. Without convenient IT-solutions (ITSs), there is a high probability of reduced quality of PhTMC.

Purpose and objectives

Our aim is to systematize innovative domestic IT-solutions (dITSs) for the optimization of remote control (RC) of drug

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information (DI) that is generated through the PhPL. To achieve the goal, we set the following tasks: determine the key terms, define a literature search strategy, find the dITSs that allow to optimize DI on the PhPL stages and describe the results in a tabular form.

MATERIALS AND METHODS

This review tends to be systematized due to the presence of a search strategy, a narrative synthesis with tabular accompaniment, and an analysis of what is known and what is uncertain [Table 1 where the criteria of compliance were checked according to SALSA framework utilized by Grant and Booth (2009)].

The search for dITSs consisted of three parts and was conducted on November 26, 2022, in Russian and in accordance with the search settings specified for each search engine (Table 2).

Initially, we carried out a literature search via eLibrary and CyberLeninka. The exclusion criteria at the screening step were: publications earlier than 2018 (5-year relevance), limited access (paid, on request), a foreign language, and a mismatch of titles and/or abstracts to the purpose of the review. The exclusion criterion at the eligibility assessment step was an absence of reference to the specific dITSs for the DI optimization within the PhPL.

The second part of the search was done through the Russian patent database provided by eLibrary. The exclusion criteria at the screening step were next: records earlier than 2018 and a mismatch of titles to the purpose of the review. The

Table 1. Checking the review for the systematized review criteria of compliance (according to SALSA framework utilized by Grant and Booth (2009).

Systematized review criteria	Comprehensive search	Quality appraisal	Narrative synthesis with tabular accompaniment	Analysis
Systematized review	May or may not include	May or may not include	Must have	What is known, uncertainties, methodological problems
Present review	Includes	Doesn't include	Has	What is known, uncertainties
Criteria compliance visualization	+	+	+	+ + –

Table 2. Search settings by the search engine.

eLibrary (https://www.elibrary.ru/querybox.asp)			
Search settings			**Interpretation**
What to search (in Russian, transliteration given)	информац* технолог* лекарственн* (средств* препарат*)	informats* tekhnolog* lekarstvenn* (sredstv* | preparat*)	Retrieves sorted by descending relevance open full-text records containing keywords starting with "informat", "technolog", "drug" or "medicine" in the title, abstract and keywords section of journal articles and conference papers that were published in 2018–2022
Where to search	title, abstract, keywords		
Publication type	journal articles, conference papers		
Theme	–		
Authors	–		
Journals	–		
Search in a compilation	–		
Parameters	open full-text available		
Years of publication	between 2018 and 2022		
Received	for all the time		
Sort	by relevance		
Order	descending		
CyberLeninka (https://cyberleninka.ru)			
Search settings			**Interpretation**
Search query	информационные технологии лекарственные средства препараты	informatsionnyye tekhnologii lekarstvennyye sredstva preparaty	Retrieves records containing keywords (considering different word forms) "information", "technology", "drug", "medicine" that were published in 2018–2022
Year	between 2018 and 2022		
OECD[a] category	health science		
Scientific database	HAC[b], RSCI[c]		
Journal	–		

Continued

eLibrary patents (https://www.elibrary.ru/patents.asp)			
Search settings			**Interpretation**
Patent type	computer program, database		Retrieves sorted by descending publication date computer programs and databases patents in Russia containing keywords starting with “drug” in the title, abstract and description
Patent number	–		
Keywords	лекарств*	lekarstv*	
Search in	title, abstract, description		
Author	–		
Patentee	–		
Year	–		
Country	Russia		
IPC[d]	–		
Sort	by publication date		
Order	descending		
Google search (https://www.google.ru)			
Search settings			**Interpretation**
Query 1	(информационные технологии фармация) телефармация	(informatsionnyye tekhnologii farmatsiya) telefarmatsiya	Retrieves records containing keywords (considering different word forms) “information”, “technology” and “pharmacy” all together or only “telepharmacy” that were published in 2018–2022
Parameters	in Russian between 2018 and 2022		
Query 2	medtech инновации	medtech innovatsii	Retrieves records containing keywords (considering different word forms) “medtech” and “innovations” that were published in 2018–2022
Parameters	in Russian between 2018 and 2022		
Query 3	(электронный фармация) (цифровой лекарственные препараты) (мобильное приложение лекарственные препараты)	(elektronnyy farmatsiya) (tsifrovoy lekarstvennyye preparaty) (mobilnoye prilozheniye lekarstvennyye preparaty)	Retrieves records containing keywords (considering different word forms) “digital” and “pharmacy” or “digital” and “medicines” or “mobile”, “application” and “medicines” all together that were published in 2018–2022
Parameters	in Russian between 2018 and 2022		

[a]Organization for Economic Co-operation and Development. [b]Higher Attestation Commission (state scientific authority). [c]Russian Science Citation Index. [d]International Patent Classification.

exclusion criterion at the eligibility assessment step was an absence of the patent’s description.

The third part was a Google search. We did not include web pages further than the 10th search result [onwards the value of the results significantly drops, which is associated with Google search algorithms (Chitika, 2013; Google, n.d.; Google Help, n.d.)]. The exclusion criteria at the screening step were the following: publications earlier than 2018, a limited access, a foreign language, and a mismatch of titles and/or snippets to the purpose of the review. The exclusion criterion at the eligibility assessment step was a mismatch between the web page’s full text and the purpose of the review.

As the search was over, we formed a PRISMA flowchart (Fig. 1). All the included records of the search are summarized in Table 3. The key terms are introduced in the authors’ interpretation. The synthesis was done narratively with a tabular appendix (Table 4).

RESULTS AND DISCUSSION

Key terms

In the study, we have identified and defined the following terms. DI: any information about a drug, pharmaceutical information: any information related to pharmaceutical and medical activities within the circulation of medicines, ITSs for the optimization of information RC: automated information systems (IS) to save consumer resources for information search and processing, automation: the act of changing processes in order to reduce the human participation (both the developer’s and the user’s), optimization: the act of modifying a process to achieve its better efficiency and innovation: a new product (idea, method, item, device, etc.) or the act of innovating (i.e., creating an innovation).

Output of the systematic search and innovation vector

Out of 312 search results, 18 (5.77%) were included in the review. 23 dITSs were extracted from the studied resources. Some of them are multifunctional and solve several problems, use a combination of ITs, are used in several fields, and are developed jointly by several teams from different geographical centers.

The vector of dITSs is aimed at optimizing DI in medical organizations (16 out of 23, 69.6%; the PhPL has nothing to do with it) and in retail (6 out of 23, 26.1%). We have identified 37 directions in total, while the predominant directions are still the same (Fig. 2). The remaining directions are distributed approximately evenly across the PhPL except for

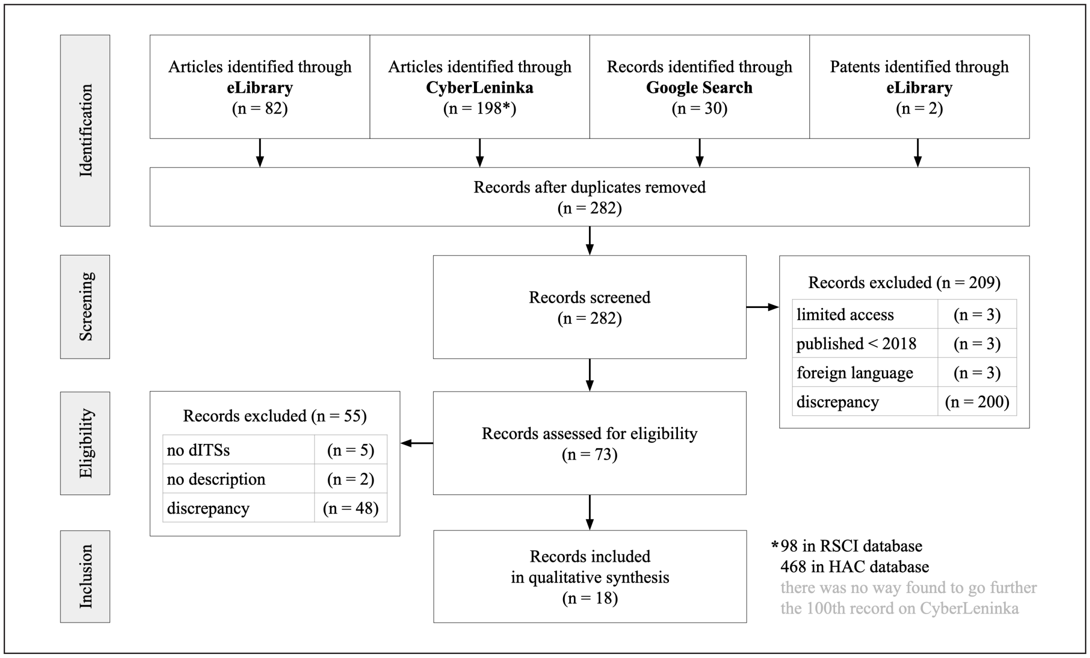

Figure 1. PRISMA flowchart of the search.

Table 3. Included recordings on the dITSs topic.

No	The name of SE	YP[a]	Contributors (authors or a publisher) & Title	Key findings
1	eLibrary	2018	Karpov O. E., Nikitenko D. N. Automation of the medical supply system. Database of medicinal means of a multi-disciplinary medical organization.	“Medicinal products” and “DPs”—databases for effective integrated control of the drug supply process in a medical organization.
2	eLibrary	2018	Kurbesov A.V., Kalugyan K.KH. Relevance of use of technology blockchain in questions of provision of medicines of citizens.	The blockchain technology for EDM (including digital health records with prescribed medicines) within a medical organization.
3	eLibrary	2022	Loginovskaya O.A., Kolbatov V.P., Sukhov R.V., Ryavkina M.S., Kolbin A.S. New technologies in digital pharmacovigilance systems for marketing authorisation holders.	Flex database—the IS that utilizes AI to automate pharmacovigilance processes.
4	eLibrary	2018	Koshechkin K.A. Creation of an IS for managing the activities of testing laboratories of an expert institution in the sphere of medicinal products circulation.	LIMS—the LIMS based on CALS/PLM technology for the optimization of drug trials.
5	eLibrary	2019	Koshechkin K.A., Preferansky N.G., Preferanskaya N.G. The use of blockchain-technology for maintaining the State register of medicines.	The blockchain system for EDM and information exchange of data on biologically active substances.
6	eLibrary	2021	Sychev D.A. Information technologies’s role in optimizing the application of drugs in clinical practice: a view of a clinical pharmacologist.	“Element” (https://element-lab.ru) and “Digital clinical pharmacologist” (https://www.ecp.umkb.com)—the comprehensive DSSs for doctors integrated into medical ISs of medical organizations.
7	eLibrary	2019	Lebedev G.S., Fartushniy E.N., Shaderkin I.A. *et al*. Bilding of the medical DSS on the basis of providing medicine based on evidence-based medicine.	“Sechenov DataMed” (www.datamed.pro)—the national medical DSS based on the principles of evidence-based medicine.
8	eLibrary	2019	Andreev D.P., Kozlovich A.V. Conceptualisation of an information analytical database of reference standards.	The database of reference standards of medicinal products to improve the efficiency of testing laboratories aimed at evaluation of medicines’ quality, efficacy and safety.
9	CyberLeninka	2021	Lysykh E.A., Ekusheva E.V., Chefranova ZH.YU. *et al*. Secondary prevention of ischemic stroke in gerontological practice by using digital technologies.	“Stroke platform”—the system of remote monitoring and drug provision of stroke patients.

Continued

No	The name of SE	YP[a]	Contributors (authors or a publisher) & Title	Key findings
10	CyberLeninka	2022	Trapeznikova N.A., Rostova N.B. Information technologies for promoting rational use of medicines.	"AntiVICH-1" (AntiHIV-1)—the DSS aimed at selecting and prescribing the most appropriate combination of antiretroviral medicines for a specific HIV-infected patient taking into account effectiveness and safety criteria.
11	CyberLeninka	2019	Suetina T.A., Kitaeva E.A., Kitaev M.R., Abdulganieva Z.A. Mobile app "The diary of self-control."	The mobile application to increase treatment adherence.
12	CyberLeninka	2020	Tezina N.N. Platform approach to creating regional e-health systems.	The accounting system for drug provision of cancer patients and centralized database of medical images.
13	Google	2019	Chesnokova N.N., Kononova S.V. Application of information technologies in pharmaceutical consulting.	The software for standardization and optimization of pharmaceutical consulting on the treatment and prevention of lower extremity varicose vein disease.
14	Google	2022	MCHI, LLC[b] "MedikBuk." MedicBK.	The DSS for cardiologists (http://medicbk.com).
		2019	MCHI, LLC "Softmedica." Softmedica.	The software to optimize drugs procurement (http://soft-medica.ru).
		2022	MCHI, LLC "PharmFrame." PharmFrame.	The software to optimize drugs procurement based on evidence-based medicine (https://pharmframe.ru).
		2022	MCHI, LLC "PharmFrame." MedIQ.	The online evidence-based database (website) that makes it possible to check the effectiveness of prescribed medicines (https://mediqlab.com).
		2018	MCHI, LLC "K-SkAI." Webiomed.	Medical information and predictive analytical DSS (https://webiomed.ru).
15	Google	2021	Russian community, "Znanie." Krasnov G.S. (CEO[c] of LLC "Digital Doctor," PhD student and geriatrician of Samara State Medical University).	The online software to calculate an appropriate drug dosage taking into account patient's individual characteristics (https://dozator.io).
16	Google	2020	LLC "Pervyy elektronnyy retsept" ("First digital prescription"). "Moy retsept" ("My prescription").	The mobile application for storage and use of digital doctor's medicine prescription.
17	Google	2019	LLC "Business Media Holding," LLC "Medical Systems." Vitakit.	The mobile application for storage and use of digital doctor's medicine prescription.
18	Google	2018	National digital marking system "Chestny ZNAK" ("The Honest Mark"). IS "Medications traffic control."	The governmental IS for digital marking of medicines to ensure the traceability and safety of products.

[a]Year published. [b]Limited liability company. [c]Chief Executive Officer.

Table 4. The dITSs for the optimization of DI RC and their supposed application on the stages of the PhPL.

No	The name of the dITS	The developer of the dITS	Description of the dITS	Key IT	The PhPL stage
1	Medicinal products, DPs	National Pirogov Medical Surgical Center (Moscow)	Databases for effective integrated control of the drug supply process in a medical organization.	Big Data	n/a[a] (field of application—medical organizations)
2	n/f[b]	LLC "Elektronnaya meditsina" (Rostov-on-Don)	The blockchain technology for EDM (including digital health records with prescribed medicines) within a medical organization.	Blockchain	n/a (field of application—medical organizations)
3	Flex databases	LLC "Flex Databases" (Saint Petersburg)	The IS capable of automatically processing RWD on side effects using AI.	AI	Pharmacovigilance
4	LIMS	FSBI[c] SCEEMP (Moscow)	IS for the optimization of drug trials: makes laboratory processes more efficient by computerized management of drug samples, task assignments, documentation storage and management, reports automation, integration with laboratory equipment and more.	CALS/PLM	R&D, preclinical and clinical studies, manufacturing
5	n/f*	FSBI SCEEMP (Moscow), Sechenov University (Moscow)	The blockchain system for EDM and information exchange of data on biologically active substances. It's capable of optimizing the monitoring of registration information, control of procurement and distribution of medicines.	Blockchain	Registration, logistics & wholesale

Continued

No	The name of the dITS	The developer of the dITS	Description of the dITS	Key IT	The PhPL stage
6	Element	LLC "Element Laboratory" (Moscow)	The database to support doctor's decision on pharmacotherapy. Constantly updates based on world-class peer-reviewed scientific articles. Takes into account patient's individual characteristics, DDI[d] and more.	Big Data	n/a (field of application—medical organizations)
7	Digital clinical pharmacologist	JSC[e] "Socmedica" (Moscow)	The database to support doctor's decision on pharmacotherapy. Unlike "Element," has additional packages for managers of medical organizations (planning, control, economics, statistics, etc.).	Big Data	n/a (field of application—medical organizations)
8	Sechenov DataMed	Sechenov University (Moscow), FSBI FRIHOI[f] (Moscow)	The database to support doctor's decision on pharmacotherapy and pharmacist's recommendations on nonprescription medicines, as well as providing reliable information to health-conscious patients.	Big Data	n/a (field of application—medical organizations), retail, application
9	Database of reference standards	FSBI SCEEMP (Moscow)	The database that provides digital directories about drugs' reference standards and working templates to testing laboratories.	Big Data	R&D, preclinical and clinical studies, manufacturing
10	Stroke platform	Belgorod National Research University (Belgorod), Belgorod Regional Clinical Hospital of St. Joasaph (Belgorod), Institute for Advanced Studies of the FMBA[g] (Moscow), Pavlov University (Saint Petersburg)	The system capable of storing and transmitting data on computer tomograms between medical organizations, assessing individual risk factors, treatment adherence (including pharmacotherapy) and outcomes along with creating analytical reports on the situation with strokes in the region.	Big Data	n/a (field of application—medical organizations)
11	AntiVICH*	Perm State Pharmaceutical Academy (Perm)	The database to support doctor's decision on the antiretroviral combined pharmacotherapy. Shows personalized set of drugs, taking into account patient's characteristics, effectiveness and safety criteria.	Big Data	n/a (field of application—medical organizations)
12	The diary of self-control	Kazan National Research Technical University (Kazan), Rybno-Slobodsky district Central hospital (Rybnaya Sloboda)	The mobile application to input, store and exchange of health parameters, doctor's appointments (including prescribed medicines), etc. The application is able to demonstrate the dynamics of parameters, remains (to increase treatment adherence), communicate remotely with a doctor and more.	Big Data	n/a (field of application—medical organizations)
13	n/f	Novosibirsk State University of Economics and Management (Novosibirsk)	The accounting system for drug provision of cancer patients.	Big Data	n/a (field of application—medical organizations)
14	Pharmacist's assistant	Privolzhsky Research Medical University (Nizhny Novgorod)	The database to support pharmacist's decision on the treatment and prevention of lower extremity varicose vein disease.	Big Data	Retail
15	MedicBK	LLC "MedikBuk" (Novosibirsk), MCHI (Moscow)	The database to support cardiologist's decision. The software is capable of identifying individual risk factors and contraindications, evaluating effectiveness and safety of drugs and interventions.	Big Data	n/a (field of application—medical organizations)
16	SoftMedica*	LLC "Softmedica" (Moscow), MCHI (Moscow)	The program to automate ABC-, VEN- and DDD-analysis of drug consumption at the state, regional and medical organization levels.	Big Data	n/a (field of application—medical organizations)
17	PharmFrame	LLC "PharmFrame" (Moscow), MCHI (Moscow)	The program to automate ABC-, VEN-analysis of drug procurement based on evidence-based medicine.	Big Data	Logistics & wholesale, retail
18	MedIQ	LLC "PharmFrame" (Moscow), MCHI (Moscow)	The free and open online database to check an active substance (drug or BAA[h] that are registered in Russia) for effectiveness. The database is constantly updated by experts, who assess world-class peer-reviewed scientific articles in Cochrane Library, PubMed, the WHO[i] and RxList.	Big Data	Application (conscious consumption), retail (pharmacist's DSS), n/a (field of application—medical organizations)

Continued

No	The name of the dITS	The developer of the dITS	Description of the dITS	Key IT	The PhPL stage
19	Webiomed	LLC "K-SkAI" (Petrozavodsk), MCHI (Moscow)	Multifunctional AI-based medical information and predictive analytical system for supporting medical (considering DI) and management decisions (DSS) and RWD mining for research and insurance organizations (https://webiomed.ru).	AI	n/a (field of application—medical organizations)
20	Medicine dispenser	Krasnov G.S. (CEO of LLC "Digital Doctor," PhD student and geriatrician of Samara State Medical University)	The online software to support doctors on the calculation of appropriate drug dosage (e.g. anticoagulants, hypotensive medicines) based on patient's individual characteristics and scientific approach to calculation method. New calculators are being added.	Big Data	n/a (field of application—medical organizations)
21	First digital prescription	LLC "Pervyy elektronnyy retsept" (Yekaterinburg)	The mobile application for patients to store and use their digital doctor's medicine prescription. Integrates with medical and pharmaceutical ISs. Has the feature to find out the cost of medicines and their availability at pharmacies, as well as book or order them.	Big Data	n/a (field of application—medical organizations), retail
22	Vitakit	LLC "Medical Systems" (Kazan)	The mobile application for patients to store and use their digital doctor's medicine prescription. Integrates with medical and pharmaceutical ISs. Has the feature to find out the cost of medicines and their availability at the nearest pharmacy, as well as book or order them.	Big Data	n/a (field of application—medical organizations), retail
23	IS "Medications traffic control"	The Centre for Research in Perspective Technologies (Moscow)	The IS that stores information about the whole path of a DP from its manufacturing till patient's purchase. Technology bases on the cryptographic labelling.	Big Data	GXP[j]

[a]Not applicable, [b]Not found, [c]FSBI, [d]Drug-drug interactions, [e]Joint stock company, [f]Federal Research Institute for Health Organization and Informatics, [g]Federal Medical and Biological Agency, [h]Biologically active additives, [i]World Health Organization, and [j]Good … practice (e.g., GMP—good manufacturing practice)—quality control system, *no data on launch found (the development may be still in progress).

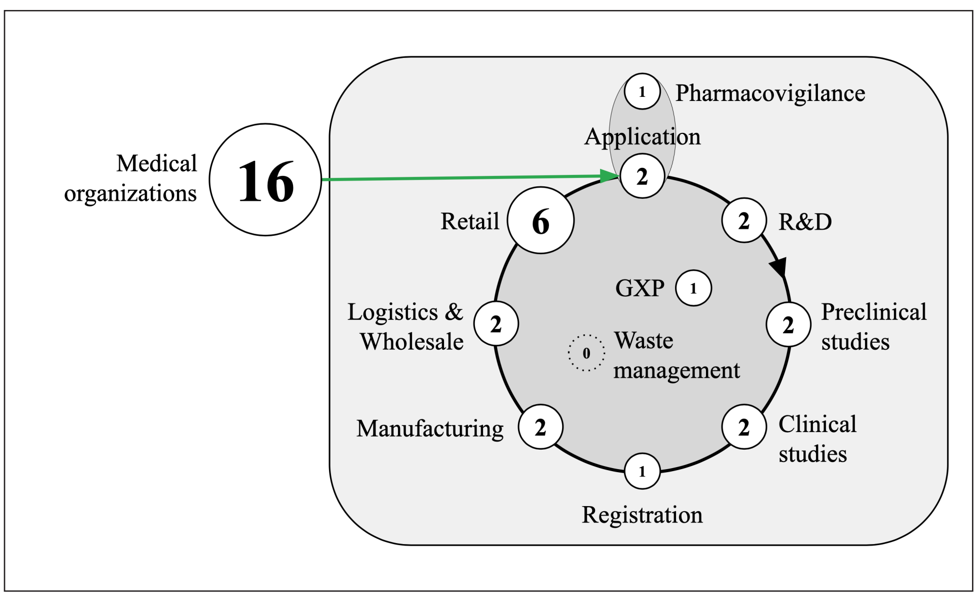

Figure 2. The number of innovative dITSs applied to the PhPL (2018–2022).

the stage of disposal and waste management. Our review found no innovation in this sector. To identify the stages of PhPL, we have turned to the textbook "Pharmaceutical Informing" (under the editorship of Svistunov and Tarasov, 2020) and looked through the paper of Pyatigorskaya *et al*. (2020).

Utilized technologies and their practical applications

18 out of 23 (78.3%) dITSs used big data as the main technology, 2 (8.7%) blockchain, 2 (8.7%) artificial intelligence (AI), and 1 (4.3%) continuous acquisition and lifecycle support/product lifecycle management (CALS/PLM)

(Fig. 3). When selecting and describing ITs, we relied on the works of Vardomatskaya and Lilyukhin (2020), Salimjanova and Dyachuk (2021). However, as the complex CALS/PLM technology was difficult to define in one of the groups given in the works above, so we have singled it out.

It is important to understand what these technologies are. Big data can be defined as a technology for processing (collecting, analyzing, and visualizing) large and complex datasets. In pharmacy, this technology is particularly useful for extracting data from arrays of electronic medical records of patients and clinical trial participants. The technology helps to accelerate the development of new drugs and make data-driven decisions for healthcare practitioners.

Blockchain is an encrypted storage technology. It stands up for a decentralized database consisting of algorithmically linked blocks of information that are simultaneously stored on multiple computer devices connected via a mutual network. The key advantage of the technology is the transparent tracking of data that cannot be altered without leaving a trace. This is particularly important to stand against counterfeit pharmaceutical products and for monitoring healthcare practitioners' prescriptions.

AI is a technology that imitates human intelligence to solve human mind-dependent ("sapiodependent"—authors' expression") tasks based on preset self-improving algorithms. AI can accelerate diagnosis and prescription of personalized pharmacotherapy (including genetic features). AI can be one of the methods of big data technology (we assume to call it "technology within technology").

CALS/PLM according to Koshechkin (2018) is a combination of CALS technologies, which include technologies for continuous information support of supply and product lifecycle, and PLM, which is an organizational and technical system for managing product-related information throughout its lifecycle (from R&D to market exit).

Our research showed the following forms in which these technologies are utilized: databases (10 out of 23, 43.5%), decision support systems (DSS; 9 out of 23, 39.1%), automated analytics (6 out of 23, 26.1%), electronic document (EDM; 2 out of 23, 8.7%), and DI management systems during the lifecycle (1 out of 23, 4.3%), as well as improving accounting systems (1 out of 23, 4.3%).

Based on the articles included in the review, we can synthesize the definitions of each extracted form. Database refers to a structured dataset stored electronically. DSS acts as a computer program that processes data to provide useful information for decision-making. Automated analytics may be defined as interactive data visualization software or cloud-based services (graphs, charts, maps, schemes, etc.). EDM (as well as DI management) system is a software or cloud system aimed at storing and organizing digital documents. Finally, accounting systems are computer programs to track and manage processes (tasks, medical interventions, financial data, etc.).

A total of 30 points of practical application were found, grouped, and applied to PhPL (Fig. 4). At the stages of R&D, preclinical and clinical trials, it is possible to use the laboratory information management system (LIMS) and the database of reference standards by Federal State Budgetary Institution "Scientific Centre for Expert Evaluation of Medicinal Products (FSBI SCEEMP). In the next step of registration, another IT by FSBI SCEEMP may be applied—an EDM system based on blockchain technology. The manufacturing stage also involves the application of the LIMS and the database of reference standards. Next, logistics and wholesale are points for the application of blockchain EDM system (FSBI SCEEMP) and "PharmFrame" software to optimize drug procurement. The segment of medicine retail may benefit from "Sechenov DataMed" (DSS for healthcare practitioners), "Pharmacist's assistant" (DSS for a pharmacist), "PharmFrame" and "MedIQ" (both contain evidence-based information on medicines), and "First digital prescription" and "Vitakit" (both are mobile applications to store doctor's prescriptions). After all, at the stage of applying a medication, health-conscious patients can

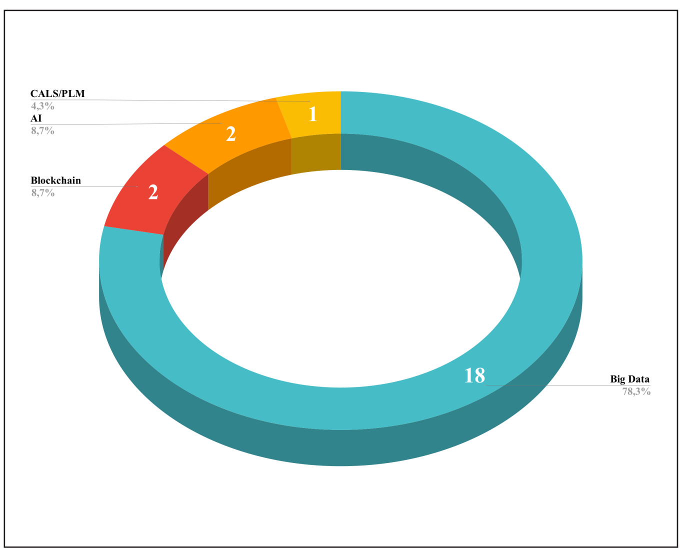

Figure 3. The main utilized ITs.

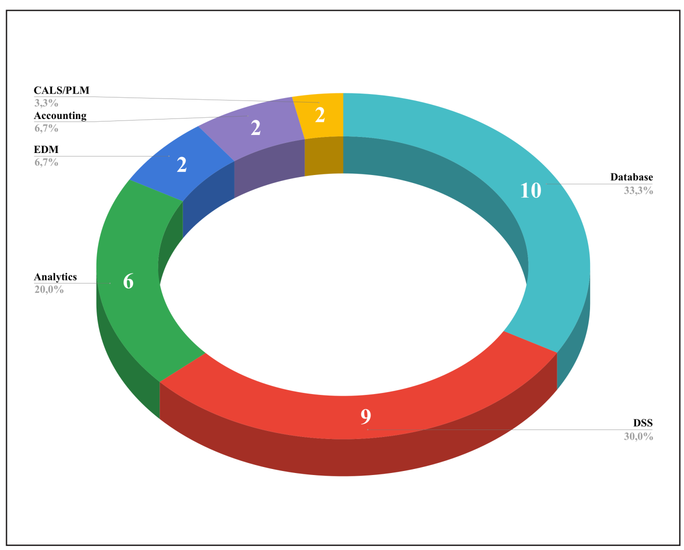

Figure 4. Practical application of the dITSs.

obtain reliable information from "MedIQ" and "Sechenov DataMed" as these services are open-access.

Pharmacovigilance and GXP are at the level of monitoring and control, so they are not depicted as a link in the lifecycle. Nevertheless, they have a direct impact on it. "Flex Database" automatically processes real-world data (RWD) on side effects using AI and therefore applies at the pharmacovigilance stage. The medication traffic control system by the Centre for Research in Perspective Technologies cryptographically stores information about the whole path of a DP and that is the reason for its application in GXP.

Finally, the predominant point of application of the discovered technologies in medical organizations. They are not part of the PhPL, but they are related to one of its stages—the stage of applying medicine. Different technologies are used here in various forms and for various purposes: databases ("Medicinal products" and "DPs," "Stroke platform," "The diary of self-control," "MedIQ," "First digital prescription" and "Vitakit"), EDM systems (LLC "Elektronnaya meditsina"), DSS ("Element," "Digital clinical pharmacologist," "Sechenov DataMed," "AntiVICH," "MedicBK," "Medicine dispenser"), accounting system for drug provision (by Novosibirsk State University of Economics and Management), automated analytics ("SoftMedica"), and multifunctional AI-based system ("Webiomed"). Detailed information is provided in Table 4.

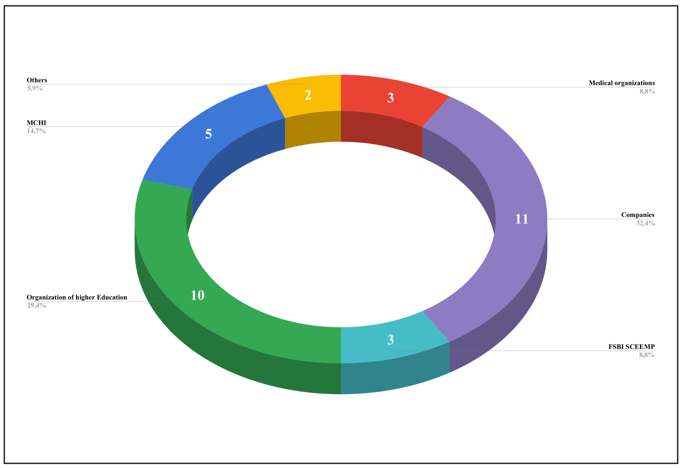

Figure 5. The main developer groups.

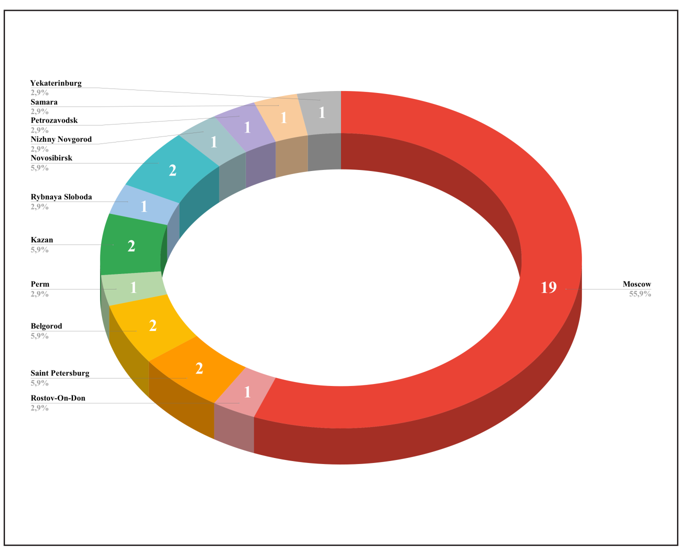

Figure 6. The major geographical centers of the dITSs in Russia.

Developers and geographical centers

The majority of dITSs were developed with the participation of commercial organizations (11 out of 23, 47.8%), higher education institutions (6 out of 23, 30.4%), and the Moscow Center for Innovative Technologies in Healthcare (2022); 5 out of 23, 21.7% (MCHI). Most of the dITSs were proposed with the participation of the MCHI (5 out of 23, 21.7%) and FSBI "SCEEMP" (The Ministry of Health of the Russian Federation; 3 out of 23, 13%). A total of 34 developers were found (4 of them occur more than once). Commercial organizations (11 out of 34, 32.4%), higher education institutions (10 out of 34, 29.4%), and the MCHI (5 out of 34, 14.7%) were most often involved in the development (Fig. 5).

The main geographical center of innovation is the capital of Russia, Moscow (it occurs 19 out of 34 times, 55.9%) (Fig. 6).

CONCLUSION

When distributing dITSs through the PhPL, we faced the fact that most of the dITSs do not apply to the lifecycle, since they are associated with the optimization of DI RC in medical organizations. In this regard, it seems reasonable to consider the lifecycle of DI as an add-on to the PhPL in further research.

Also, during the screening of resources, we noticed that scientists pay much attention to discussing the problems and prospects of ITs, putting forward proposals and methods, while almost no experience in the use of already implemented and pilot ITSs to optimize DI RC in Russia is observed. This indicates that such innovations are hard-to-find in research papers and, if found, they are insignificantly described. Therefore, it is more productive to seek them through project aggregators and accelerators and business or investment reports. This is confirmed by the successful result of our predictive decision to conduct several search queries on Google—almost half (10 out of 23, 43.5%) of innovative dITSs were found this way. In the future, it is necessary to understand the reason for the lack of dITSs at the stage of disposal and waste management. To do this, we suppose to study the information structure and the needs of specialists in this field. Perhaps, this line of business needs optimization and innovation.

After all, based on the results of the review, one may see the drivers of the innovation vector in the studied issue for the next few years. These include traceability and control of DI to improve the quality of PhTMC and automation of RWD analysis with the help of AI to make faster and better medical, pharmaceutical, and management decisions.

LIMITATIONS

The review design is a "systematized review" according to review typology by Grant and Booth (2009). Thus, quality assessment was not included. This sets the stage for further studies.

AUTHOR CONTRIBUTIONS

All authors made substantial contributions to the conception and design, acquisition of data, or analysis and interpretation of data; took part in drafting the article or revising it critically for important intellectual content; agreed to submit to the current journal; gave final approval of the version to be published; and agree to be accountable for all aspects of the work. All the authors are eligible to be an author as per the international committee of medical journal editors (ICMJE) requirements/guidelines.

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The authors report no financial or any other conflicts of interest in this work.

ETHICAL APPROVALS

This study does not involve experiments on animals or human subjects.

DATA AVAILABILITY

All data generated and analyzed are included in this research article.

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