Original Paper
doi 10.15826/recon.2025.11.4.021
UDC 338.24
JEL P25, L86, O32

Prospects for the development of digital innovations in public healthcare

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ABSTRACT
Relevance. The transition to a platform-based model in the public sector depends on stakeholders developing interoperability skills and a flexible technological infrastructure. Yet, the adaptation of industry-specific technologies to such platform architectures remains an open research question.
Research objective. The study aims to define the current state of digital healthcare and provide an evidence-based rationale for its development prospects in an emerging healthcare platform.
Data and methods. Topic modeling was applied to a dataset of 60 digital innovations from 56 Russian regions, implemented between 2019 and 2024 as part of regional projects for a unified digital healthcare contour. Findings were further validated using factor analysis and clustering, incorporating official statistics and data on technical and regulatory aspects of innovation adoption across regions.
Results. Collaborative business models involving all healthcare actors and remain low-priority in public health governance. Statistical analysis confirms the high importance of economic and regional aspects, while regulatory aspects that determine the order of administration and technical interaction between stakeholders also have a moderately positive impact.
Discussion. Digital innovations in public health were qualitatively and quantitatively assessed through the prism of the concept of responsible healthcare. Findings exposed a disparity: while digital innovations prioritized economic and healthcare outcomes, they consistently overlooked collaborative governance models. The results provide a foundation for future research on how innovation providers and public sector actors have adapted their business models to ensure transparency, accountability, and collaboration.

KEYWORDS
digital innovations, responsible innovations, digital platform, regional healthcare, topic modeling, factor analysis

FOR CITATION
Lisitskii, N. N., Maximova, T. G. (2025). Prospects for the development of digital innovations in public healthcare. *R-Economy*, 11(4), 391–405. doi: 10.15826/recon.2025.11.4.021

Определение перспектив развития цифровых инноваций в государственном секторе здравоохранения

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АННОТАЦИЯ
Актуальность. Институционализация платформенной модели функционирования в государственном здравоохранении требует от заинтересованных сторон развития компетенций в области взаимодействия и гибкой технологической базы. Измерение уровня адаптации отраслевых технологий к архитектуре экосистемы остается нетривиальной исследовательской задачей.
Цель исследования. Установить статус-кво цифрового здравоохранения для научного обоснования перспектив развития в контексте формирования платформы здравоохранения.
Данные и методы. Применен метод тематического моделирования для изучения данных о 60 цифровых инновационных решениях из 56 регио-

КЛЮЧЕВЫЕ СЛОВА
цифровые инновации, ответственные инновации, цифровая платформа, региональное здравоохранение, тематическое моделирование, факторный анализ

нов России, реализованных в период реализации региональных проектов по формированию единого цифрового контура в сфере здравоохранения в 2019–2024 годах. Результаты тематического моделирования были верифицированы посредством факторных нагрузок и кластеризации с использованием официальной статистики и данных о технических и нормативных аспектах внедрения инноваций в регионах.
Результаты. Цифровые инновации ориентированы на обеспечение устойчивости здравоохранения и экономическую эффективность в большей степени, чем на вопросы здоровья. Институализация моделей взаимодействия, направленных на вовлечение всех субъектов здравоохранения остаются низкоприоритетными в государственном здравоохранении. Факторный анализ подтверждает высокую значимость экономических и региональных аспектов в эффективности цифровизации здравоохранения. Умеренное положительную значимость имеют регуляторные аспекты, определяющие порядок административного и технического взаимодействия между заинтересованными сторонами.
Обсуждение. Цифровые инновации государственного здравоохранения были качественно и количественно оценены через призму концепции ответственного здравоохранения.
Результаты демонстрируют, что цифровые инновации сосредоточены на обеспечение экономических и управленческих результатов, тогда как принцип совместного создания инноваций систематически игнорируется. Результаты закладывают основу для будущих исследований того, как поставщики инноваций и государственные акторы адаптировали свои бизнес-модели для обеспечения подотчетности и сотрудничества.

ДЛЯ ЦИТИРОВАНИЯ
Lisitskii, N. N., Maximova, T. G. (2025). Prospects for the development of digital innovations in public healthcare. *R-Economy*, 11(4), 391–405. doi: 10.15826/recon.2025.11.4.021

确定公共卫生领域数字创新的发展前景

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摘要
现实性：在公共卫生领域实现平台化运作模式的制度化，要求相关方提升协作能力并建立灵活的技术基础。衡量行业技术对生态系统架构的适应程度，仍是具有挑战性的研究课题。
研究目标：建立数字医疗的发展现状基准，为卫生平台建设背景下的发展前景提供科学依据。
数据与方法：采用主题建模方法，研究了2019–2024年俄罗斯56个地区在实施区域医疗卫生数字化一体化项目期间，60项数字创新解决方案的数据。通过因子负荷和聚类分析，结合官方统计数据以及各地区创新实施的技术和规范方面的数据，对主题建模的结果进行了验证。
研究结果：数字创新的主要侧重点在于保障医疗系统的稳定性与经济性，而非健康议题本身。旨在吸纳所有医疗主体参与的互动模式的制度化建设，在公共卫生体系中仍处于较低优先级。因子分析证实，经济与区域因素对医疗数字化的成效具有高度影响力；而监管因素——即界定相关利益方在行政与技术协作的相关因素——仅呈现中等程度的正向显著性。
结论：通过负责任医疗保健的概念，对公共卫生领域的数字创新进行了定性与定量评估。研究结果表明，数字创新主要聚焦于实现经济效益和管理成效，而创新共创原则却被系统性地忽视。这些发现为未来研究奠定了基础，有助于深入研究创新供给方与公共行动者如何通过调整其商业模式来确保问责落实与协同合作。

关键词
数字创新、负责任创新、数字平台、区域医疗、主题建模、因子分析

供引用
Lisitskii, N. N., Maximova, T. G. (2025). Prospects for the development of digital innovations in public healthcare. *R-Economy*, 11(4), 391–405. doi: 10.15826/recon.2025.11.4.021

Online ISSN 2412-0731

Introduction

National development priorities in digital technology are focused on advancing sector-specific digital platforms[1]. However, technologies introduced over the past decade have accumulated significant legacy constraints that often limit their adaptability to the platform paradigm. This issue is particularly evident in highly regulated sectors such as healthcare, where compliance requirements reinforce dependence on legacy systems. As a result, assessing technological readiness and adaptability to platform paradigms within the public sector represents a promising direction for further research.

The success of federal initiatives largely depends on the effectiveness of regional governance systems and the reliability, completeness, and adequacy of data generated by information systems. Regional authorities, often operating under resource constraints, are responsible for ensuring the comprehensive implementation of measures that yield tangible benefits for the population.

Variations in regulation and healthcare practices across countries shape how digital technologies deliver value. In Russia, the coexistence of diverse medical systems and digital solutions from multiple vendors, combined with federal initiatives implemented across regions, highlights the need for uniform criteria to assess the effectiveness of digital solutions.

While platform approaches are often examined from technical and systemic perspectives, they also encompass economic and social dimensions of value creation (Frishammar et al., 2023). In digital healthcare, however, the external, platform-mediated interactions that enable such value remain relatively underdeveloped (Hermes et al., 2020).

Against this background, this study seeks to identify the current state of digital healthcare to provide an evidence-based rationale for its development prospects within the emerging healthcare platform. The research tasks are as follows:

1. To evaluate how the value generated by digital innovations aligns with the principles of responsible innovation in healthcare;

2. To identify and assess the gaps and catalysts in the development of regional digital healthcare.

This study applies the concept of Responsible Innovation in Health (RIH) to examine key value domains, including public health, the healthcare system, economics, organization, and the environment. Using topic modeling of implemented innovations and statistical evidence, it investigates responsible practices, identifies factors that support their institutionalization, and explores potential development pathways for digital health in Russia. The central hypothesis is that the dominance of administrative actors in public health constrains platform development, suggesting that multi-stakeholder collaboration is needed to overcome these limitations.

To address this hypothesis, the following research questions were formulated:

RQ1: How can digital innovations in the public health sector be characterized?

RQ2: How do the values underlying responsible innovation manifest themselves in the public health sector?

RQ3: What factors influence the presence or absence of responsible practices?

By examining these questions, the study moves beyond conventional assessments of digitalization efficacy and aims to identify prospects for a platform-based model in Russian digital healthcare.

Theoretical Framework

Technologies driving the digital transformation of industries, including the modernization of business processes, are key pillars of innovative development[2]. In healthcare, digital innovations are continuously developed, piloted, and adopted, encompassing new or significantly improved products, services, processes, and organizational frameworks[3]. When implemented effectively, these innovations generate the greatest value, un-

[1] Decree of the President of the Russian Federation № 309 dated 05.07.2024 "On the National Development Goals of the Russian Federation for the Period until 2030 and for the Future until 2036" [Electronic resource]. Retrieved from: http://www.kremlin.ru/events/president/news/73986 (date of access 10.12.2024).

[2] Decree of the Government of the Russian Federation dated October 28, 2020 № 1750 "On Approval of the List of Technologies Used in the Framework of Experimental Legal Regimes in the Field of Digital Innovation" // Collection of Legislation of the Russian Federation of 2020, № 44, art. 7003 (date of access 16.01.2025).

[3] Federal Law № 258-FZ dated 07/31/2020 "On Experimental Legal Regimes in the Field of Digital Innovations in the Russian Federation" // Collection of Legislation of the Russian Federation dated 2020, No. 31, art. 5017 (Part I)

Online ISSN 2412-0731

derstood as outcomes unique to each stakeholder, including the benefits of products and services and their performance in practice (Starkbaum et al., 2024; Greenhalgh et al., 2017).

Pacifico Silva and colleagues (2018) define responsible innovation in healthcare as a collaborative effort among health actors to uphold ethical, economic, social, and environmental values throughout the development, financing, dissemination, use, and discontinuation of socio-technical solutions that address health system needs. In Responsible Innovation in Healthcare (RIH) research, innovations are often treated as a generalized set of products and technologies (Lehoux et al., 2018; Van Oudheusden, 2014). By contrast, the original concept of Responsible Innovation (RI) focuses on market-based products perceived as socially useful and economically beneficial (Blok & Lemmens, 2015). While RI provides a common value framework, its application requires adaptation to specific healthcare domains, such as pharmaceuticals, clinical innovations, and digital health. Current research remains limited in domain-specific studies, with notable exceptions in medical neuroimaging and cases involving nanotechnology or artificial intelligence in healthcare (Arentshorst et al., 2016; Jansma et al., 2022; Alami et al., 2020). The main focus of this research area is to clarify the core values of responsible healthcare innovations across specialized domains and develop methodologies to assess their outcomes (MacNeil et al., 2019; Miller & Lehoux, 2020).

Implementing Responsible Innovation in Healthcare (RIH) requires policies that go beyond technology. Addressing complex societal challenges demands an active government role throughout the innovation cycle (Lehoux et al., 2023) and a clear framework for distributing risks and benefits among diverse healthcare stakeholders.

Regional economic, social, governance, and regulatory factors strongly influence the success of digital health interventions (Kim & Backonja, 2025; Hartley, 2010). It is essential to gain a better understanding of these contextual conditions to design, implement, and sustain innovations that reflect responsible principles (Verzilin et al., 2015; Alami et al., 2024).

Methodologically, research on digital health frequently employs topic modeling to uncover latent structures in user-generated content or electronic health records. Applications include telemedicine platforms, mental health apps, and diabetes management systems (Martin et al., 2025; Yi et al., 2022; Ossai & Wickramasinghe, 2023; Chiu et al., 2023; Dinsa et al., 2024). Typically, studies focus on data generated by specific digital products, forming case studies. Alongside quantitative analyses of secondary data, this approach constitutes the core of scholarly work in the field (Nielsen & Sahay, 2022).

However, the meta-level characteristics of innovations corresponding to their fundamental attributes remain largely unexplored. Addressing this gap, particularly in public health, requires new conceptual frameworks and methodological approaches that can capture both innovation outcomes and the institutional, social, and economic conditions that shape them.

Methods and Data

The research is based on a text corpus describing 60 innovative healthcare solutions from 56 Russian regions, incorporating technologies such as digital transformation tools, big data, artificial intelligence, human–machine interaction, and neurotechnology.

The corpus was compiled from two main sources, covering 48 and 12 innovations respectively:

– *Best practices in regional healthcare*: Selected by the Ministry of Health in accordance with official recommendations for identifying best practices in regional projects[4]. The dataset includes review articles and presentation materials on regional digital innovations[5].

– *Practical solutions posted on the "Polezny Orgzdrav" portal*: Administered by the Central Research Institute of Healthcare Organisation and Informatization, this source includes solutions addressing organization, health econom-

[4] Letter of the Ministry of Health of the Russian Federation dated October 20, 2021 № 29–3/I/2–17134 On Methodological Recommendations on the Procedure for Determining Best Practices in the Implementation of Regional Projects of the National Healthcare project [Electronic resource]. Retrieved from: https://base.garant.ru/402964714/?ysclid=mc4gjcwycv921429176 (date of access 16.01.2025).

[5] Website of the Ministry of Health of the Russian Federation [Electronic resource]. Retrieved from: https://minzdrav.gov.ru/poleznye-resursy/natsproektzdravoohranenie/praktiki (date of access 16.01.2025).

Online ISSN 2412-0731

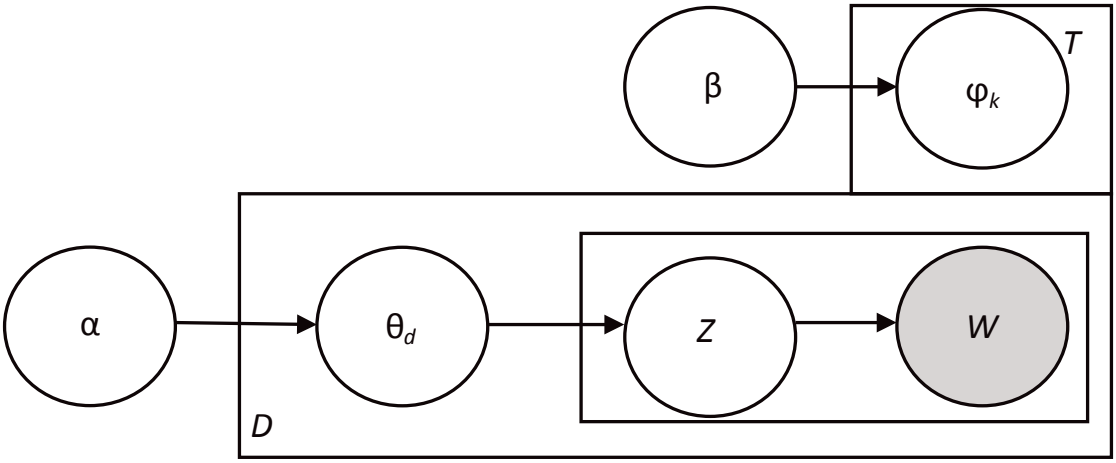

Figure 1. *The process of generating the LDA model*
Source: compiled from the materials by Blei & co-authors (2003)

ics, and digital transformation[6]. Official regional media publications on implemented innovations were also included.

The content and value of these innovations for healthcare stakeholders were analyzed using topic modeling of digital health practices, implemented via the Python library pyLDAvis (Latent Dirichlet Allocation, Blei et al., 2003). This probabilistic model identifies hidden topics through natural language processing (NLP) techniques.

The model optimizes word-topic assignments using the joint distribution of words-in-topics and topics-in-documents. The α and β parameters, controlling the distribution of topics in documents and words in topics, were set automatically to "symmetrical," assuming all topics and words are initially equivalent. The optimal number of topics was determined iteratively, selecting the solution that yielded the most interpretable topics for the research questions.

The general concept of the model is shown in Figure 1, where D is the set of text documents; W is the set of all terms used in them; T is the set of topics; d is the document; θ_d is the probability of topic k appearing in document d; φ_k is the probability of words appearing in topic k; Z is the set of hidden topic assignments for words:

The text corpus was preprocessed using stemming to find word bases, tokenization to split the text, and the introduction of stop words and keywords for document filtering. These procedures were performed using the NLTK (Natural Language Toolkit) library, adapted for the Russian language.

To visualize the topic model, the *pyLDAvis* library was used, which relies on Principal Components Analysis (PCA) to reduce data dimensionality and represent it in two dimensions:

– PC1 (first principal component): the x-axis, explaining the largest share of variance in the data;

– PC2 (second principal component): the y-axis, explaining the next largest share of variance.

Topic coherence, which measures the degree to which words within a topic share a common context, was evaluated using the Coherence Score proposed by Röder et al. (2015). This score, calculated with the Gensim library, employs pairwise semantic assessments of words based on vector representations to determine logical consistency within each topic. The mathematical formulation of topic word coherence is as follows:

$$Coh(t) = \frac{2}{N \cdot (N-1)} \sum_{i=1}^{N-1} \sum_{j=i+1}^{i=1} \log \frac{P(w_i, w_j)}{P(w_i) P(w_j)}, \quad (1)$$

where t is the topic; w is the word in the topic, t; N is the number of top words in the topic; $P(w_i)$ is the probability of the word w_i appearing in any document; $P(w_i, w_j)$ is the probability of the words w_i and w_j occurring together in one document (Röder et al., 2015).

The results are also supported by official statistics and documents for the period 2022–2024, key metrics on regional digital infrastructure and sector-specific characteristics. Indicators were se-

[6] *Polezny Orgzdrav* portal [Electronic resource]. Retrieved from: https://praktiki.mednet.ru/ (date of access 18.01.2025).

Online ISSN 2412-0731

lected based on data availability for comparable periods and their relevance to the healthcare sector to ensure accuracy. An additional advantage of the dataset is the combination of infrastructure and human resource indicators (Kurochkina & Golovkin, 2024). Regional-level analysis of the following 2022–2024 indicators was conducted:

– Percentage of healthcare facilities using medical information systems (MIS) for care delivery that are interoperable with the Unified State Health Information System (EGISZ)[7];

– Number of outpatient clinics (year-end)[8];

– Percentage of healthcare organizations with Internet access among all healthcare organizations[9];

– Physician-to-population ratio per 10.000 population (year-end)[10];

– Allocation of federal subsidies to regional budgets for implementing healthcare digitalization projects under the EGISZ, in accordance with period-specific federal budget laws[11];

– Vendor status (0 — single MIS vendor in the region, 1 — multiple MIS vendors in the region)[12];

– Regulation on the State Healthcare Information System (GISZ) — (0 — not adopted, 1 — adopted)[13,14].

Results

The first stage of topic modeling identified five core topics in regional digital healthcare practices, summarized in Table 1. The results indicate an above-average logical coherence of words within topics ($Coh(t)$ = 0.444), reflecting their semantic consistency while also capturing a broad range of thematic content.

Figure 2 presents a graph of intertopic distances based on the topic modeling results. The distribution illustrates the breadth of themes discussed in digital healthcare. Topic 1 is both semantically distinct (positioned far from other topics) and quantitatively dominant (containing the largest token share), highlighting its central role in the corpus. In contrast, topics 2 and 3, which relate to regional project implementation, specialist information support, and local technology adoption, exhibit similar structures, reflecting their frequent co-occurrence in the same context.

The second research stage was dedicated to uncovering evidence of responsible innovation values within regional practice descriptions. For this purpose, a feature for entering keywords was added, which made it possible to focus the LDA model. Document filtering enables the system to focus on processing relevant documents (d) based on keywords and reduces the influence of dominant topics. The keywords were compiled based on the «value domains» of responsible innovation in healthcare (Pacifico Silva et al., 2018). The modeling results and the most interpreted topics are presented in Table 2.

These topic modeling outcomes should be interpreted critically. Core dimensions of digital health innovations include public health, healthcare systems, and their economic foundations. Topics related to emergency care management, drug provision, care for cardiovascular patients, and information system integration align with the objectives of the national project to build a unified digital healthcare framework (EGISZ)[15]. Despite the federal project's goals to engage diverse stakeholders in digital healthcare processes, the prevailing healthcare delivery model remains

[7] Unified Interdepartmental Information and Statistical System (EMISS) [Electronic resource]. Retrieved from: https://www.fedstat.ru/ (date of access 20.04.2025).

[8] Ibid.

[9] Ibid.

[10] Ibid.

[11] Russian Government Portal [Electronic resource]. Retrieved from: http://government.ru/docs/all/ (date of access 10.05.2025). Note: the analysis utilized data on actual subsidy allocations to regions in accordance with federal budget laws for the respective fiscal years

[12] Protocol of the meeting on the implementation of the federal project "Creation of a Single Digital Contour in Healthcare Based on the EGISZ" of the national project "Healthcare" by the subjects of the Russian Federation dated 05/25/2023 № 55/18–5/242 [Electronic resource]. Retrieved from: https://base.garant.ru/407113112/#block_1000 (date of access 10.04.2025).

[13] Ibid.

[14] Methodological recommendations for the development of the NPA of the supreme executive authority of the subject of the Russian Federation on the GISZ of the subject of the Russian Federation and the regulations on the GISZ of the subject of the Russian Federation [Electronic resource]. Retrieved from: https://portal.egisz.rosminzdrav.ru/materials/4281 (date of access 10.04.2025).

[15] Passport of the federal project "Creation of a Unified Digital Contour in Healthcare Based on the Unified State Information System in the Field of Healthcare (EGISZ)" [Electronic resource]. Retrieved from: https://static-0.minzdrav.gov.ru/system/attachments/attaches/000/046/712/original/FP_Cifrovoj_kontur_zdravooxraneniya.pdf?1565344851 (date of access 20.12.2024).

Online ISSN 2412-0731

Table 1

Key topic categories of regional digital healthcare practices

№	Topic category	Key words	% of all tokens
1	Organization and provision of medical care	Organization, medical, system, information, primary, consultation, assistance, government	23.1
2	Implementation of regional healthcare projects and their monitoring	project, clinic, monitoring, implementation, regional, indicators, patient	22.7
3	Information support for specialists at the municipal level	Informational, assistance, research, provision, specialist, district, municipal	18.7
4	Electronic healthcare in the activities of medical organizations	patient, electronic, record, implementation, cabinet, department, healthcare	17.9
5	Physician-patient interaction through information technology	physician, patient, consultation, booking, referral, population, health, digital	17.7

Source: calculated by the authors based on the text corpus

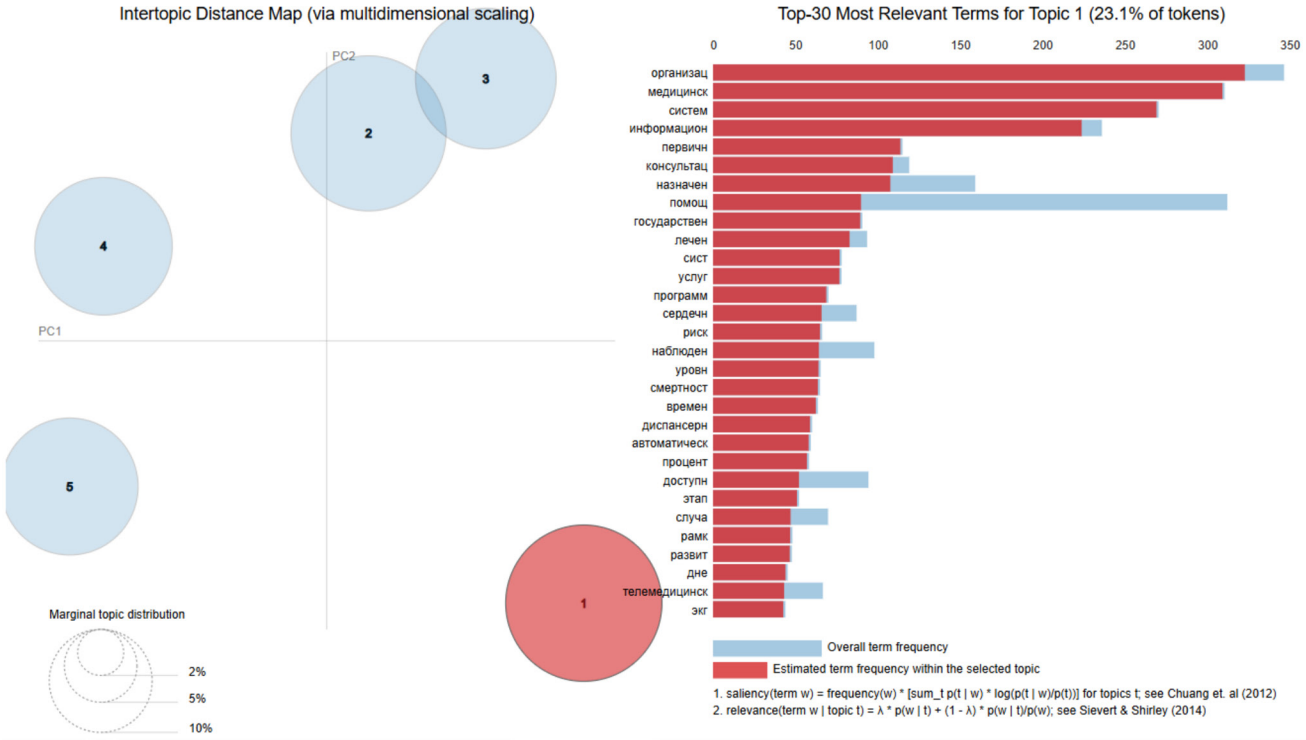

Figure 2. *Intertopic distance map of regional digital innovation practices*

Source: calculated by the authors based on the text corpus

traditional, primarily focusing on physician-patient interactions. At the same time, the terms "physician" and "patient" represent the most frequently occurring lexical items across the entire text corpus, particularly in topic categories 2, 4, and 5. This establishes the central narrative of the analyzed documents: digital health projects enhance healthcare accessibility for patients, while technology implementation helps streamline the work of medical professionals and the healthcare system as a whole.

The search for environmental narratives was not successful because the results did not match the search parameters. Currently, the environmental domain of technology is the least relevant in the field of digital healthcare due to the urgent need to ensure medical effectiveness, the complexity of an objective assessment of such technologies and the limited number of potential vendors of such technologies (Alami et al., 2023). Meanwhile, innovations aimed at improving the environment are allocated as a separate expense item for organiza-

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Table 2

Results of topic modeling on the manifestation of responsible innovation aspects in regional practices

Value domain / Coherence score	Keywords for filtering the text corpus	Number of topics for the model	Topic categories
Population health / 0.552	health, risk, improvement, quality, ethics, legal, legal, social, inequality, accessibility	7	Improving the efficiency of health services; Implementing projects in the field of children's healthcare; Organizing medical care for patients at high risk of cardiovascular diseases; Managing the availability of the regional health system.
Health system / 0.680	Inclusivity, accessibility, efficiency, dynamism, speed, level, quality, sustainability	8	Quality management of medical services and integration of information systems; Improving the operational efficiency of services through digital technologies; Treatment and risk management during hospitalization; Models of organization of medical care; Accessibility and satisfaction with the quality of care; Ensuring the operation of medical institutions; Monitoring the condition of patients and the drug provision.
Economic / 0.721	Frugality, resources, efficiency, optimization, economics, finances, costs, innovation	6	Optimization of costs and resources via digital technologies; Investing financial resources in the organization of emergency care; Improving the efficiency of services through information support; Financial and human resources for the implementation of projects.
Organizational / 0.353	business, platform, model, organization, vendor, company, value, users, social, needs	7	Physician's work and interaction with the patient; Organization of remote medical care; Public health status and disease monitoring.
Environmental / 0.345	negative, emission, ecological, environment, sustainable,	5	Follow-up of patients with cardiovascular diseases; Diagnosis of cardiovascular diseases.

Source: calculated by the authors based on the text corpus

tions[16]. Healthcare organizations mostly carry out "healthy" innovations voluntarily (31 organizations) in order to comply with environmental legislation (35 organizations). At the same time, the main goal of eco-friendly innovations was to reduce noise levels, soil, and water or air pollution, which is applicable only to medical devices used directly in the treatment of diseases.

Despite the high coherence score for economic topics, the organizational domain, reflecting a business's intent to generate societal value, is largely absent. Within the public health paradigm, innovation value is primarily realized through government provision. Other stakeholders, such as IT solution providers, pharmaceutical and specialized technology companies, social and educational organizations, and non-core government agencies, remain largely outside the discussion.

The topic modeling results can be cross-validated with statistical data and official documents describing regional infrastructure and health IT regulations, which govern interoperability with medical information systems, pharmaceutical organization systems, other information systems, information interaction participants, and data composition.

To reduce the dimensionality of the indicator space, factor analysis with Varimax rotation was applied. During the study period, the identified factors explained, on average, 60 % of total variance. The Mann–Whitney U test showed comparable factor load matrices across study periods, demonstrating the stability of indicators over time:

– Matrix2022 and Matrix2023: p-value = 0.399;

– Matrix2022 and Matrix2024: p-value = 0.594;

– Matrix2023 and Matrix2024: p-value = 0.749.

[16] Website of the Federal State Statistics Office. Information on the use of digital technologies and the production of goods and services related to them (results of statistical observation on F. № 4-innovations) [Electronic resource]. Retrieved from: https://rosstat.gov.ru/statistics/science (date of access 20.04.2025).

Online ISSN 2412-0731

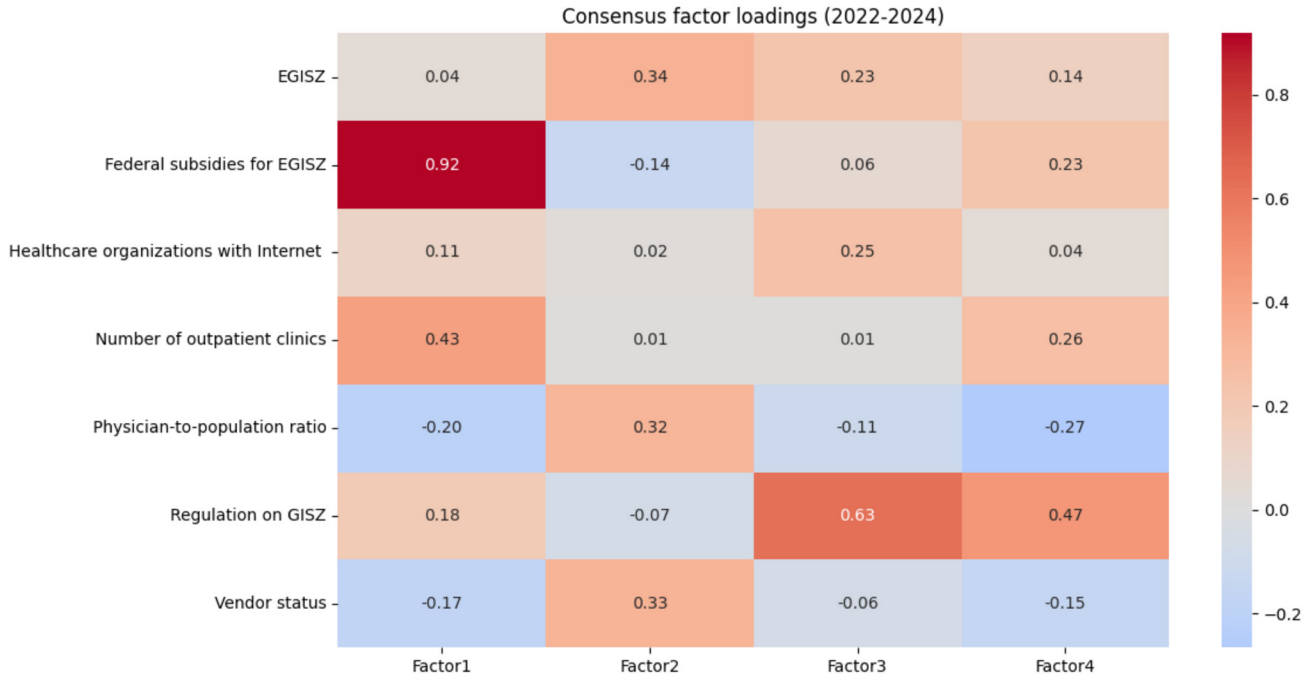

Figure 3. *Consensus factor loadings of selected indicators (2022–2024)*
Source: calculated by the authors based on statistical observations and administrative records

Table 3

Cluster analysis using Gaussian mixture model

Indicator	Matrix2022	Matrix2023	Matrix2024	Indicator retention stability
EGISZ	Cluster 0	Cluster 0	Cluster 1	2/3
Vendor status	Cluster 0	Cluster 1	Cluster 0	2/3
Healthcare organizations with Internet	Cluster 0	Cluster 0	Cluster 0	3/3
Regulation on GISZ	Cluster 0	Cluster 0	Cluster 0	3/3
Physician-to-population ratio	Cluster 1	Cluster 0	Cluster 0	2/3
Number of outpatient clinics	Cluster 2	Cluster 2	Cluster 0	2/3
Federal subsidies for EGISZ	Cluster 2	Cluster 2	Cluster 2	3/3

Source: calculated by the authors based on factor loadings

Figure 3 shows the consensus (average) factor loadings, indicating the degree of correlation between indicators and factors.

To identify and interpret the factors, we utilized Gaussian Mixture Modeling (GMM), a machine learning technique which calculates the membership probability of each indicator across all factors. The results are presented in Table 3. Further, three GMM clusters were identified, representing the core structure of the indicator data. The average values of factor loads for each GMM cluster and their interpretation (names) are presented in Table 4.

Financial and administrative factors, measured by total subsidies and the number of medical organizations, have a strong influence on digital healthcare. Combined regional characteristics, such as the use of multi-vendor information systems by healthcare organizations, their integration with the unified state information system, and medical staffing levels, play a critical role in shaping the digital ecosystem. Regulatory and technological elements exert a moderately positive effect on these factors. Standardization through regulations supports the implementation of platform principles, accounting for up to 20 % of factor loadings during the study period.

For spatial analysis, hierarchical clustering with the Gower distance metric was applied to assess regional similarities. Three homogeneous

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Table 4

Average factor loads across GMM clusters

GMM cluster	Factor 1	Factor 2	Factor 3	Factor 4
Regulatory and technological elements (0)	–0.0002	0.0044	0.2331	0.0955
Regional features (1)	–0.0417	0.9673	–0.0666	0.0176
Financial and administrative elements (2)	0.8063	–0.1000	0.0360	0.1671

Source: calculated by the authors based on GMM results

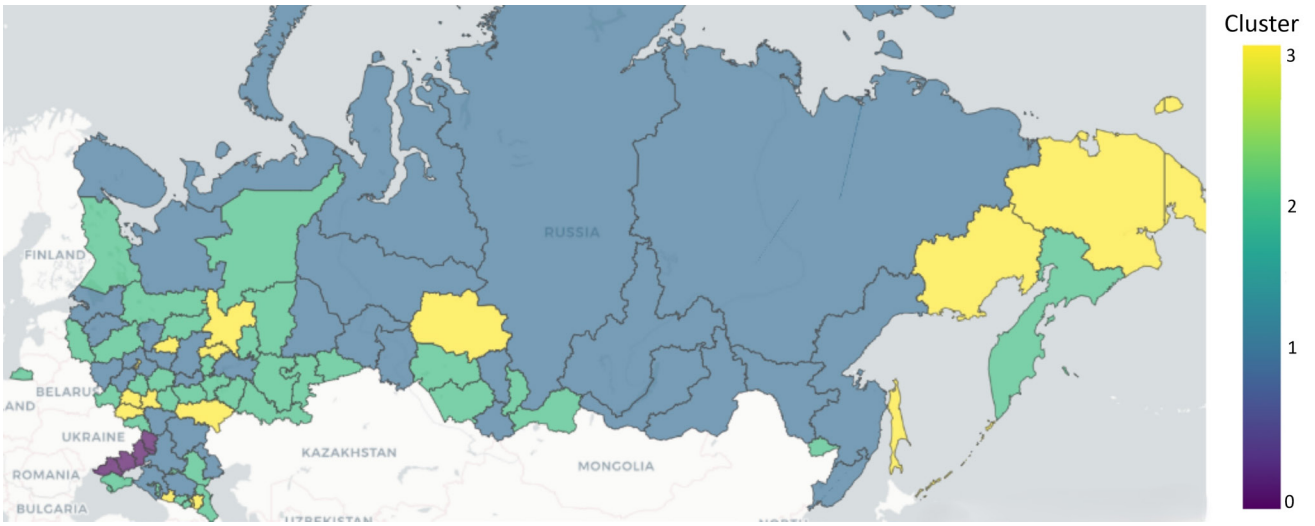

Figure 4. *Spatial representation of hierarchical clustering results*

Source: calculated by the authors based on statistical observations and official documents

Table 5

Results of hierarchical clustering of regions

Indicator	Cluster 1	Cluster 2	Cluster 3
Number of regions	35	34	16
Cluster distance (Gower distance metric)	0.16	0.11	0.19
EGISZ (%, mean)	89.48	91.68	87.30
Number of outpatient clinics (mean)	99.24	53.39	79.38
Healthcare orgs with Internet (%, mean)	93.22	94.42	92.16
Physician-to-population ratio	37.48	36.53	41.19
Federal subsidies (thousand rubles)	81589.46	69752.23	47462.11
Vendor status	0 %	100 %	100 %
Regulation on GISZ	91.4 %	100 %	12.5 %

Source: calculated by the authors based on statistical observations and official documents

clusters were identified, and their spatial distribution is shown in Figure 4[17]. The average values for the clusters are shown in Table 5.

Cluster 1 comprises regions with well-developed medical infrastructure but average digital infrastructure indicators. These regions feature more than one vendor of medical information systems and have the highest average volume of subsidies for implementing regional projects to build EGISZ. This may indicate the economic feasibility of using a single vendor's services. Typical regions include Moscow Oblast, St. Petersburg, Krasnodar Krai, and Tatarstan.

Cluster 2 is characterized by high digitalization and strong workforce capacity. A defining

[17] Regions with missing values for the study indicators are displayed as Cluster 0 in the spatial representation.

Online ISSN 2412-0731

Figure 5. *Factors influencing the presence or absence of responsible practices*
Source: compiled by the authors based on the results of assessments of topic modeling and calculations

feature is the universal adoption of regulations on GISZ and the presence of a single vendor. Typical regions include Belgorod Oblast, Tula Oblast, Samara Oblast, and the Komi Republic.

Cluster 3 comprises crisis regions where digitalization indicators are below average. In the vast majority of these regions, regulations on GISZ have not been approved, which may also indicate the positive impact of regulatory frameworks governing interactions between information systems and healthcare participants. Typical regions include Ivanovo Oblast, Kursk Oblast, Chechnya, and Chukotka. Moscow's inclusion in this cluster appears to be an outlier due to its lack of project implementation subsidies.

Discussion

In addressing *RQ*1, the identified topics in descriptions of innovative practices cover diverse aspects of the healthcare system, including care delivery optimization, technology implementation, and monitoring of innovation project outcomes. The comparable distribution of token shares across topics confirms the structural diversity and multi-topical nature of digital health innovation descriptions. These categories also align with the objectives of creating a digital healthcare framework aimed at improving system efficiency through digital technologies.

For *RQ*2, we found a fundamental distinction between the contexts of innovation development and implementation, reflecting the dominant role of key drivers, primarily government or business. Economic aspects of innovation and overall healthcare system performance are strongly emphasized, consistent with the government's mission to protect citizens' health and ensure access to quality care[18]. Organizations, including in the field of healthcare, using sustainable business models ("hybrid" organizations), are focused primarily on health goals rather than economic benefits, and represent high value to stakeholders (Haigh & Hoffman, 2012). Government institutions are the closest to this format, yet topic analysis shows that organizational factors play a minor role in actual digital health innovation cycles.

The translation of innovation value largely occurs through government-led efforts, observable across all analyzed domains. However, the responsibility for implementing technologies and the potential for digitalization also depends on vendor priorities, which are often overlooked in evaluations of healthcare technologies (Lehoux et al., 2025; Thapa & Iakovleva, 2023). In oligopolistic digital health markets, where developers define customer needs, proprietorial innovations may undermine organizational factors.

Currently, there is no clear consensus on the measures required to establish a highly productive ecosystem of medical innovations. As noted, the conditions under which innovations are de-

[18] Federal Law № 323-FZ dated 21.11.2011 "On the Basics of Public Health Protection in the Russian Federation" // Collection of legislation of the Russian Federation of 2011, № 48, art. 6724

Online ISSN 2412-0731

veloped and applied significantly affect their social value. Topic modeling and statistical analysis identify critical institutionalization factors for responsible public sector practices, providing an evidence-based response to *RQ*3 (Figure 5).

The lack of platform-level interaction among stakeholders across the healthcare system limits the effectiveness of innovative development. This can lead to fragmented initiatives, conflicting stakeholder interests, reduced innovation activity, and low implementation efficiency. Solutions often remain isolated with limited application, diminishing the synergistic effects of interinstitutional collaboration and increasing transaction costs.

Effective communication within the ecosystem relies on mutual benefit among stakeholders. The technological infrastructure that supports these communication channels enables participants to create unique offerings for one another, accumulate knowledge about stakeholder needs and broader market challenges, scale implemented decisions and technologies, and increase transparency of market actions.

Research limitations

For the portion of the textual corpus derived from the "Polezny Orgzdrav" portal, official regional media publications were used to supplement innovation-related information. This approach may limit the representation of alternative perspectives. The statistical data analyzed covered only part of the implementation period for the digital healthcare contour project. Nevertheless, it incorporated indicators from official project meeting protocols, which are considered more reliable than open-source data. The ecological value domain in the context of digital innovations remains largely unexplored in routine practice, representing a frontier in fundamental research. However, its relevance is likely to grow, as collaboration will become critical in addressing environmental challenges.

Conclusion

The quantitative assessment of value alignment (Task 1) revealed that the organization and provision of medical care is the primary focus of digital innovations, accounting for 23.1 % of all tokens. Topic modeling further showed that economic and systemic (sector-wide) value domains were dominant, with coherence scores of 0.721 and 0.680, respectively. Project-related patterns even surpassed health-specific values (coherence score 0.552). Coordination of efforts and platform-based interaction received the lowest score (0.353), indicating minimal interaction between healthcare stakeholders, while environmental considerations proved largely irrelevant.

For Task 2, identifying and assessing development gaps and catalysts, financial and administrative factors demonstrated the greatest significance (factor loading 0.8063). Regional digital differentiation, which is expressed through digital infrastructure, vendor services, and medical staffing, ranked second in importance (factor loading 0.9673). Even under government-led management, regulated interactions between stakeholders and digital services were the third most important factor for digitalization effectiveness. Regions with low regulation of interactions (16 out of 85) exhibited lower digitalization success, whereas 35 leading regions using multi-vendor services achieved comparable digitalization rates, albeit with costs 71.9 % higher, highlighting the economic rationale for system unification to support platform goals.

Thus, the theoretical significance of the work is to confirm the applicability of the concept of responsible innovation to the context of the administrative economy, and not just market systems. The work enriches the research of areas of values at the meta-level of innovation, rather than narrow cases, and their manifestation in public health. In the healthcare system, financial and economic efficiency can conflict with platform openness, as public systems are optimized for reporting and fund disbursement rather than generating cooperative health value. Consequently, RIH principles are refracted through the specific governance context of public health.

Practically, the study identifies a development perspective for digital innovations, emphasizing the advisability of digital unification policies for regional clusters and their economic justification. Proper regulation of interactions between stakeholders and digital services is highlighted as a necessary step. Regional governments must adapt locally used innovations to enable platform expansion. Currently, the focus remains on physicians and patients, while the potential range of participants, including management bodies, related industries, and niche digital solution vendors, remains underutilized. Given the diversity of dig-

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ital solutions across regions, formal coordination mechanisms are necessary to maximize stakeholder value. This is particularly relevant for crisis regions, where information interaction is underdeveloped. These findings open avenues for future research on how public-sector innovation providers adapt business models to ensure transparency, accountability, and cross-regional collaboration.

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Online ISSN 2412-0731

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ARTICLE INFO: received July 24, 2025; accepted November 07, 2025

ИНФОРМАЦИЯ О СТАТЬЕ: дата поступления 24 июля 2025 г.; дата принятия к печати 07 ноября 2025

Online ISSN 2412-0731