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AUTOMATION OF THE PROCESSES BASED ON MACHINE LEARNING FOR TELEMEDICINE INFORMATION SYSTEM

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The integration of Machine Learning into Telemedicine Information Systems has revolutionised remote healthcare delivery, optimising patient monitoring, diagnosis, and treatment processes. However, challenges persist in automating these systems, particularly in areas of data interoperability, security, and scalability. The research explores the role of ML-driven automation in overcoming described challenges, analysing current trends, obstacles, and research gaps. The study notices technologies predictive analytics and image recognition are advancing telemedicine capabilities, while issues like fragmented data, lack of standard protocols, and privacy concerns remain. It emphasises the need for robust frameworks that integrate ML techniques to enhance the reliability and efficiency of TIS, especially in resource-constrained settings. By combining the latest findings, the work demonstrates the importance of adopting complex automation strategies enhanced via ML tools for developing future innovation in the telemedicine field.

Keywords: telemedicine, medical information system, machine learning, healthcare information system, remote patient monitoring.

АВТОМАТИЗАЦИЯ ПРОЦЕССОВ НА ОСНОВЕ МАШИННОГО ОБУЧЕНИЯ ДЛЯ ТЕЛЕМЕДИЦИНСКОЙ ИНФОРМАЦИОННОЙ СИСТЕМЫ

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Интеграция методов машинного обучения в информационные системы телемедицины произвела революцию в области дистанционного оказания медицинской помощи, оптимизируя процессы мониторинга пациентов, диагностики и лечения. Тем не менее, автоматизация таких систем по-прежнему сталкивается с рядом проблем, особенно в сферах совместимости данных, безопасности и масштабируемости. В исследовании рассматривается роль автоматизации, основанной на машинном обучении, в преодолении указанных вызовов, проводится анализ современных тенденций, препятствий и существующих исследовательских пробелов. Отмечается, что технологии прогнозной аналитики и распознавания изображений значительно продвигают возможности телемедицины, однако сохраняются такие проблемы, как фрагментированность данных, отсутствие единых стандартов и вопросы конфиденциальности. Особое внимание уделяется необходимости создания надежных архитектур, интегрирующих методы машинного обучения для повышения надежности и эффективности информационных систем телемедицины, особенно в условиях ограниченных ресурсов.На основе анализа последних достижений работа подчеркивает важность внедрения комплексных стратегий автоматизации, усиленных инструментами машинного обучения, для стимулирования инноваций в области телемедицины.

Ключевые слова: телемедицина, медицинская информационная система, машинное обучение, система медицинской информации, дистанционный мониторинг пациентов

ТЕЛЕМЕДИЦИНАЛЫҚ АҚПАРАТТЫҚ ЖҮЙЕ ҮШІН МАШИНАЛЫҚ ОҚЫТУҒА НЕГІЗДЕЛГЕН ҮДЕРІСТЕРДІ АВТОМАТТАНДЫРУ

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Машиналық оқыту әдістерінің телемедицина ақпараттық жүйелеріне интеграциялануы қашықтықтан медициналық көмек көрсетуді түбегейлі өзгертті, бұл пациенттерді бақылау, диагноз қою және емдеу үдерістерін оңтайландырды. Дегенмен, мұндай жүйелерді автоматтандыруда деректердің үйлесімділігі, қауіпсіздік және ауқымдылық секілді салаларда әлі де бірқатар қиындықтар бар. Зерттеу машиналық оқытуға негізделген автоматтандырудың осы қиындықтарды шешудегі рөлін қарастырып, қазіргі үрдістерді, тосқауылдарды және зерттеу алшақтықтарын талдайды. Болжамдық талдау мен кескіндерді тану технологиялары телемедицинаның мүмкіндіктерін кеңейтуде, бірақ деректердің шашыраңқылығы, бірыңғай стандарттардың болмауы және дербес деректердің құпиялылығы сияқты мәселелер өзекті болып отыр. Зерттеуде әсіресе ресурс шектеулі жағдайларда телемедицина ақпараттық жүйелерінің сенімділігі мен тиімділігін арттыру үшін машиналық оқыту әдістерін біріктіретін мықты архитектуралардың қажеттілігі атап өтіледі. Соңғы жетістіктерді талдай отырып, бұл жұмыс телемедицина саласындағы болашақ инновацияларды дамыту үшін машиналық оқыту құралдарымен күшейтілген кешенді автоматтандыру стратегияларын енгізудің маңыздылығын көрсетеді.

Түйін сөздер: телемедицина, медициналық ақпараттық жүйе, машиналық оқыту, денсаулық сақтау ақпараттық жүйесі, болжамдық аналитика, қашықтан пациентті бақылау.

Introduction. Over the last decades, telemedicine information systems (TIS) have noticeably transformed the healthcare field via the deployment of remote doctors' consultation, medical diagnosis, and patient management services [1]. Integration of machine learning (ML) technologies presents further opportunities to enforce TIS systems through predictive analytics, natural language processing (NLP), and patient image recognition. These features can enhance the telemedicine usage performance efficiency and adaptability to user needs [2,3]. However, critical barriers remain in automating core processes of TIS, especially in ensuring seamless interoperability, robust data security, and adaptability across different healthcare settings [4,5]. These challenges become a crucial issue due to the heterogeneous nature of healthcare data and the absence of standardised data exchange protocols [6].

The research work shows a review of ML technologies' role in automation TIS system processes. It consists of an empirical investigation based on healthcare professionals' thoughts, analysed via mixed-method approaches. The work adopts a broader perspective, synthesising insights from diverse studies to identify trends and challenges in the telemedicine domain. This study focuses on how machine learning-based automation can be applied to address the primary challenges of the telemedicine platform, with particular attention to developing secure, scalable, and user-centred design strategies. Understanding of these aspects is essential for effectively integrating ML features into TIS systems and for informing future developments in the ehealth field. Moreover, the integration of ML technologies with other innovations, namely blockchain network, offers promising avenues for improving data integrity and patient privacy in telemedicine applications [7-9]. While prior works have examined individual ML and blockchain applications, the research proposes an architecture that is able to combine the noted technologies in a modular framework for low-resource settings.

Additionally, the study proposes an enhanced system architecture by ML tools, blockchain technology, and secure interoperability standards. The results highlight major concerns, namely, data fragmentation, lack of standardisation, and security risks, which the proposed model aims to mitigate. The outcome of the article informs possible future design, implementation, and policy development for telemedicine systems. What differentiates this study from prior literature is the integration of technical and user-centred perspectives through a

mixed-methods study, which supports the design of a new modular system architecture. Rather than solely reviewing trends, this work formulates a forward-looking implementation framework rooted in both literature and stakeholder insights.

Materials and methods. In this section, a set of articles relevant to the research topic was systematically reviewed and analysed. The primary sources for the literature search included academic databases, namely, Google Scholar, Scopus, and ScienceDirect. The inclusion criteria required that the publication has to reference specific keywords such as telemedicine, medical information system, healthcare remote technologies, medical information systems, and related digital health infrastructures. Studies that did not directly engage with these themes were excluded. Applying the inclusion criteria, the research review aims to offer a comprehensive overview of the current state of research, emphasising major advancements, emerging trends, and persistent challenges in the field. This approach ensures a conceptual foundation for understanding the broader implications of TIS in the scope of the modern healthcare service.

Analysis of publications related to the TIS system shows diverse significant outcomes depending on the context of implementation. Firstly, the adoption of TIS platforms has been associated with improvements in clinical decision-making, reducing medical errors and optimising treatment plans [10,11]. As an illustraion, the integration of Electronic Health Records (EHR) illustrated error reduction in the medical process [12,13]. Additionally, the implementation of Clinical Decision Support Systems (CDSS) within TIS frameworks helps medical staff by offering evidence-based treatment recommendations and computer diagnostic accuracy [14].

Contrastingly, other works present that the effectiveness of using TIS systems often faces foundational challenges. There are low levels of infrastructure, limited internet connectivity, unqualified training for healthcare workers, and financial constraints. These factors reflect the scalability and sustainability of telemedicine integration [15]. Moreover, a systematic review emphasised the absence of clear guidelines and investment can increase the possibilities of successful TIS integration [16].

Also, existing studies provide valuable advantages of integration of TIS systems in the medical field, they often overlook non-clinical applications, including public health monitoring and policy development. Additionally, there is research addressing the socio-economic factors influencing TIS adoption in resource-limited settings. It underlines the necessity of deep studies in the telemedicine area [17].

CDSS has demonstrated the potential to enhance patient outcomes by reducing medical errors, particularly those related to drug interactions and diagnostic inaccuracies [18,19]. Institutions have successfully implemented CDSS to bolster patient safety measures [20]. This indicates that while CDSS offers potential benefits, its success is contingent on clinician engagement and the system' s alignment with the workflow.

Various methods and technologies have been deployed in TIS for the improvement of business processes. The innovative approaches in telemedicine systems, mobile health (mHealth), and medical information platforms have successfully improved many healthcare settings [21]. These systems have helped in healthcare operations, reduced operational costs, and increased the efficiency of medical service delivery.

Recent advances and integration of blockchain technology in telemedicine have able to get higher security standards and improved data-sharing capabilities. Other methods, namely, machine learning algorithms could be used for predictive analytics in healthcare, assisting in decision-making and early disease diagnosis [4,5,8].

CDSS can be categorised into knowledge-based and non-knowledge-based systems. Knowledge-based systems rely on rules and guidelines derived from medical literature, while non-knowledge-based systems use machine learning and statistical pattern recognition. Most of today's CDSS are knowledge-based, utilising if-then rules to trigger

alerts for issues such as duplicate test orders or drug interactions. However, advancements in artificial intelligence have led to more sophisticated CDSS, which can learn from past data and provide supportive clinical support [1]. While the integration of these IT solutions gives a chance of successful usage, the whole concerns about transparency and trust have limited their adoption [20-22].

B. *Identifying* Research Gaps

Several issues remain in current TIS research. The one of the significant areas is the under-researching of TIS adaptability in low-resource settings. Although TIS has been established sufficiently in healthcare systems, there is still incomplete research on how telemedicine system can be fully optimized in developing territories [21]. While studies have highlighted the importance of management skills within TIS, there is limited research on the integration of artificial intelligence tools in the telemedicine ecosystem for real-time knowledge processing.

Despite the proven benefits of CDSS, research presents application limitations in some critical areas. One of them is the lack of large-scale, systematic studies examining CDSS effectiveness in real-world settings outside of controlled environments excluding academic medical centres. Additionally, while much attention has been given to CDSS for healthcare management, less research has focused on their use in diagnostic decision-making, particularly in general practice [19,22].

The current research is able to address these gaps by focusing on how TIS can be better tailored for resource-constrained environments and identifying the best practices for integrating cutting-edge technologies with existing systems or by focusing on the real-world implementation of CDSS in diverse healthcare environments, examining factors such as user interaction and integration with existing workflows.

The connection diagram illustrates how a set of research papers addresses the core issues of interoperability and data security within the TIS framework. It shows how studies join/differ from one another in their approaches to solving the challenges [23-25].

- Concentration on challenges related to interoperability and heterogeneous data formats.

- Exploration of the influence on healthcare expenses and patient care.

- Discussion of the benefit of AI and blockchain for providing security aspects.

The figure (Figure 1) presents pointers between the reports to spotlight the advancement of ideas over the term. It shows where the last studies build on older findings.

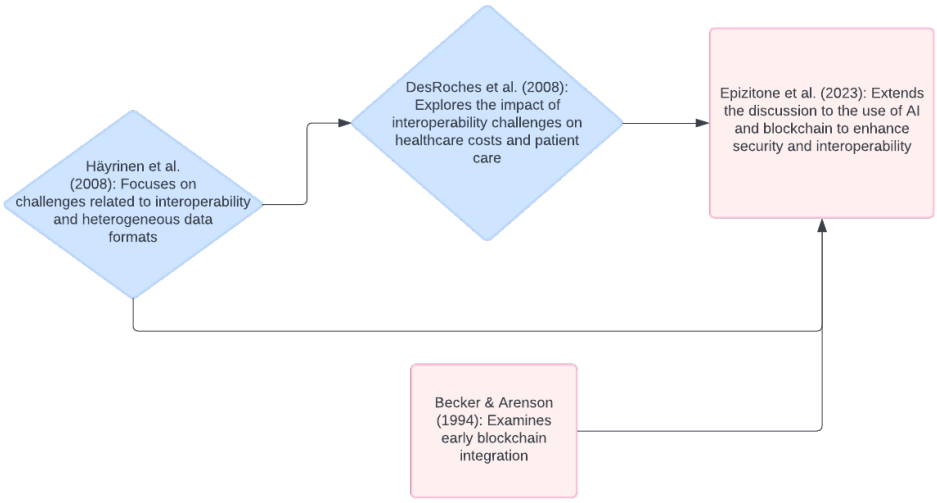


Fig.1 - Graphical representation of source

The above diagram presents how interoperability barriers have evolved from early discussions of data formats and communication protocols [25]. They lead to modern solutions involving AI and blockchain [21]. Each study concerns previous findings, gradually introducing more advanced technological keys to solve essence difficulties in Medical Information Systems

Table 1 is a comparative table with specific columns. The content of the table consists of methods, advantages, and limitations of different studies on TIS. It helps summarise how different authors approached common challenges and what results they reported.

Table 1 - Description for TIS approaches

Study	Year	Method Used	Advantages
Häyrinen et al.[24]	2008	Data format standardisation	Data format standardisation
DesRoches et al.[23]	2008	TIS implementation	Reduced patient wait times
Epizitone et al.[21]	2023	AI and blockchain integration	Enhanced security, automated decision-making
Liu et al. [5]	2020	Blockchain for security	Strong encryption and distributed access control
Ahmad et al. [7]	2021	Blockchain in telehealth	Tamper-proof logging and improved patient privacy

Graph represents a progression of research publications on TIS syste, implementation and AI in Healthcare from 2000 to 2020 (Figure 2). The blue line represents the increasing number of publications focused on TIS implementation. The green line represents the rise in publications related to AI tools in Healthcare.

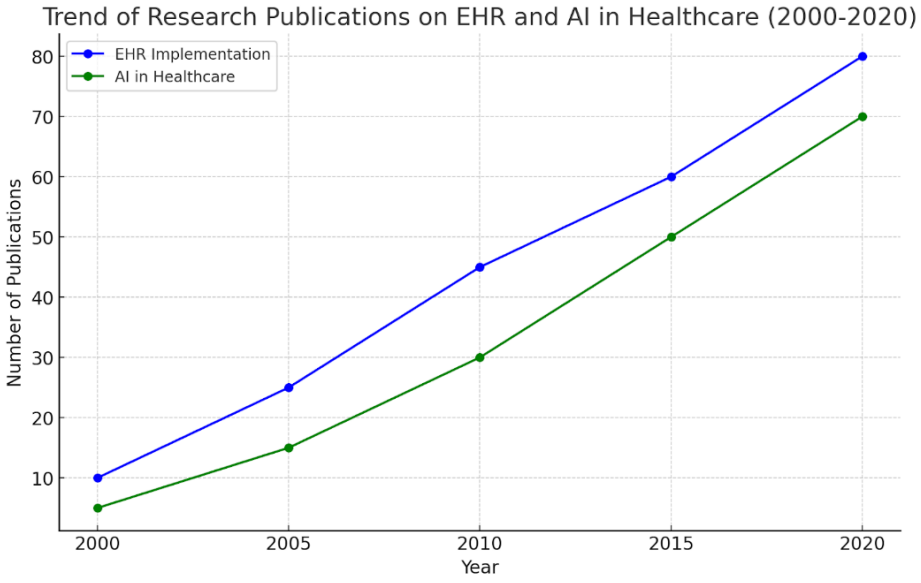


Fig.2 - Progression of research publications on TIS implementation

The review set highlights that EHR-s are not only repositories of structured clinical and administrative information but also function as tools for decision support, communication, and quality improvement. The authors emphasise that while EHR implementation has the potential to enhance healthcare efficiency and patient safety, success depends heavily on standardization, user training, and system integrations.

Figure presents (Figure 3) a bar chart displaying the primary challenges associated with the realisation of TIS technologies. It was identified across multiple studies. The most frequently reported issues are the following:

- interoperability. A notable amount of healthcare institutions emphasise difficulties in blending heterogeneous systems and data formats;

- data security. It emerges as another vital consideration with more than half of the surveyed institutions expressing suspicions about safeguarding patient information;

- high implementation costs. It poses a considerable barrier, particularly in low-resource settings, where budget regulations limit the scalability of digital health solutions.

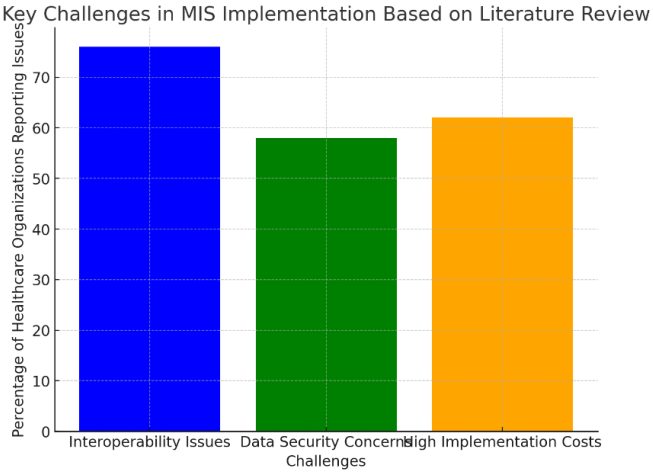


Fig.3 - Key challenges in TIS implementation

The visual representation actually underlines these key challenges, strengthening prevalence and impacting the existing literature.The charts and visual materials in this paper are based on reliable sources and real-world studies related to EHR and TIS technologies. These visuals help explain the main challenges and trends in telemedicine in a clear and accessible way.

- Interoperability: The data demonstrates a different researcher attempts for solving the intercommunication and data exchange among different programes. There are even some progress has been made. A number of healthcare systems still struggle to share data smoothly. The evidence from studies merges and diverges in work approaches to embarking on the complex problem.

- Data Security: Information breakings and the use of blockchain make it clear why protecting patient information is so important. As more additional, healthcare systems go digital, consequently, it is necessary to develop more reliable and secure tools. These visuals highlight how new technologies are helping to keep patient data safe.

- System Adoption: The review presents how TIS and CDSS are used to reveal success relies on the local context. Factors, namely, staff training, technical readiness, and budget all play a role. These insights show why it’ s important to adapt systems to each specific environment.

Results and discussion. The study uses mixed (qualitative and quantitative) research methods.

The methods demonstrate a description of the usage of TIS applications and challenges in TIS implementation. Approaches are made to examine both clear and measurable patterns. Additionally, it is modest and experience-based insights. The work' s main focus area includes a user' s satisfaction with TIS deploying. Particularly, it touches on assessments, namely, data protection, system integrity in daily routines, and efficiency of usage. Participants are chosen randomly from healthcare institutions. The medical centres have already used medical information systems with any telemedicine functionalities. The work is aimed to gather feedback from a variety of medical professionals from different departments, and levels of experience. It helps to capture a full picture of the analysis and avoid biased insights. The result has different viewpoints included in the analysis.

The analysis focuses on three main aspects of research:

- User Satisfaction. Measurement of using a scale (from 1 to 5), and through yes/no responses.

- Data Security. Evaluation of users' safety feelings about patient' s data is.

- Workflow Integration. Assessment of the usability of TIS system fitted into daily work processes.

Responses are gathered via an online survey using Google Forms. The survey was accomplished remotely and participants were able to fill it when it was most convenient for them. It was made to diminish of interrupting participant' s work. The questions covered key areas, namely, a system usability, security consideration, and TIS integration in their institutions.

Each questionnaire question was carefully developed to match the objectives of the study. It used rankings scores and open-ended questions to collect a broad range of data. Some questions are requested by parties to rate TIS usage via their satisfaction. Others are asked their thoughts about data security.

This metric captures the perceived efficiency and usability of the TIS platforms and was analyzed alongside data security and workflow integration variables to identify correlations. Limitations of the study, such as potential biases in questionnaire analysis, were noted and reduced its risks. The assessment steps were taken to mitigate through anonymising responses and conducting the survey remotely.

The research work meets ethical requirements. It was obtained by informing all participants as well as their private information was secured. The participants were informed about the purpose of the research, confidentiality, and the anonymity of their responses.

Data sharing is one of the primary keys of the study. It does not occur seamlessly across systems, which the majority of organisations mentioned in the survey. The proposed architecture can be framed in an integration engine and API gateway for standardisation of the communication channels between the internal modules (TIS, CDSS, Analytics) and external systems (laboratory, pharmacy platforms). Elimination of data fragmentation helps ensure continuous patient care by removing repeated activities in the medical workflow process. Users have expressed in a survey about dissatisfaction with fragmented workflows in domestic medical information systems. It means that ensuring the data sharing process in real-time between all parties TIS system might improve the overall efficiency of the system work.

According to the findings, 72% of users determined data breaches and unauthorised access as the most crucial threats in existing systems. To address this, the proposed architecture includes a multi-layered security approach using OAuth 2.0, encryption, anomaly detection, and audit logs to protect sensitive patient data from login to storage.

Additionally, integrating a blockchain ledger will strengthen the system by improving transparency and keeping with MIS standards. The current security measures directly align with the survey findings. The users will feel confident in system security, resulting in higher levels of satisfaction.

The research indicates one of the main obstacles for deploying telemedicine systems is incapacity for scaling, especially in low-resource

environments. To overcome the current issue, the proposed infrastructure should contain load balancer components and auto-scaling tools. A such technologies allow the system to automatically adapt to changing workloads while maintaining strong performance.

This is especially important during periods of high demand, especially in health emergency situations. In this case, the system must remain available and responsive. This approach directly addresses a common weakness found in many existing systems, as noted in previous studies.

The survey outcomes reveal current systems are commonly adequate, but many users still face difficulties due to poor levels of usability and unproductive workflows. For eliminatation this case, the proposed model should possess interactive dashboards for different user roles. Particularly, it could be a patient portal, a clinical dashboard and an administrative dashboard. This role-based approach ensures a more personalized and user-friendly experience for each user type. Furthermore, the dashboards is able to allow users do rapid data-driven decisions.

The findings display that poor and fragmented data management remains a major issue. One of the possible ways for improvement is designing a specific data layer. The layer can be proposed for handling different types of medical data in a well-organised and efficient way. For instance:

- database will store structured data such as patient records;

- data Warehouses will gather long-term information for analytics and reporting;

- file Storage will manage unstructured data (e.g. medical images with a variety of resolutions).

Combining all the above aspects into a unified system, healthcare providers will gain quick and reliable access to medical information. This will help reduce delays and support more accurate, personalised, and timely patient care.

Conclusion. The findings of this study confirm that Telemedicine Information Systems (TIS) play an important role in improving healthcare processes and outcomes. Nevertheless, key challenges continue to restrict its full potential scaling. Quantitative data revealed that the majority of users identified interoperability issues, while others expressed to anxieties over data security. The results were sustained by qualitative feedback demonstrating that user satisfaction with existing systems remains moderate level. Due to there were usability limitations and security shortcomings.

For overcoming the issue, the study presents an improved system architecture description that highlights data exchange through integration engines and API gateways. They can have a capability for reducing workflow fragmentation. It also introduces robust security mechanisms, including OAuth 2.0, encryption, blockchain integration, and anomaly detection to sustain user trust and ensure data protection principles. Furthermore, the architecture presented mechanisms for scalable applications during periods of high demand.

Through implementation-specific dashboards, administrators, and patients are able to reveal the significant distinguish in usability and align with the diverse their needs. Lastly, the architecture could adopt a structured data management model that unifies databases, data warehouses, and file storage for developing clinical decision-making and long-term analytics.

In contrast to traditional literature reviews, the article contributes new approaches for system architecture that synthesise cutting-edge ML and blockchain technologies with empirical survey findings. This mixed method maintains the practical relevance of the design for ensuring alignment among technical requirements and user satisfaction.

The proposed architecture not only mitigates the well-documented challenges in TIS implementation but also introduces an innovative, integrative model combining ML, blockchain, and modular design—unlike current fragmented solutions. Planned validation and comparative testing will further substantiate its real-world applicability, paving the way for future adoption in scalable digital healthcare deliver services.

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