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MASTER'S THESIS

IMPROVING INFORMATION SYSTEM OF KBC REBRO BY USING ARTIFICIAL INTELLIGENCE

Ljubljana, November 2025 BERNARD UDOVIČIĆ

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ABSTRACT

In this thesis, I explore the integration of artificial intelligence (AI), specifically solutions that can be achieved through AI, into the existing hospital information system (HIS) at KBC Rebro to enhance communication between doctors-specialists and patients, as well as optimize the scheduling of appointments to have a reduced number of failed show-ups by patients. Through an analysis of current system capabilities, the research showed that there is a lack in HIS. In the examples that are provided in this thesis, I found that there is an issue in hospitals where people do not show up for scheduled appointments. I wanted to investigate why this is happening and what the motives are for that. In some cases, as provided in this thesis, I found out that there are around 30% of patients who do not show up for their scheduled appointments. The reasons are various, but the one for which I wanted to find a potential solution is that they simply forget if this appointment is scheduled for a longer period. By introducing an AI agent (chatbot), which will at first raise awareness of scheduled appointments, and just by that the percentage of show-ups will increase. Then, afterwards, the patient would also have the possibility to ask questions about the checkup (such as the location, the requested arrival time before the appointment, and preparation instructions, etc.). This will increase the willingness to attend the checkup, and people will feel less nervous about preparing for the checkup.

This will not only remind patients but also save time for the specialists because there will be fewer of them without a reduced percentage of people who do not show up for the appointment. Additionally, the benefit of it is that if a certain patient cannot come to the scheduled appointment, with this alert and reminder, this appointment can be assigned to somebody else. In general, the integration of such an AI solution is something that will have a positive impact because, as is described later in the case studies, people tend to forget appointments that are not scheduled in a short-term period. And such implementation would have a positive impact on further processes and would save precious time for the specialists. And patients would also have the possibility to get informed about what they could expect from the checkup and reduce the fear of unknown expectations.

KEY WORDS: hospital information system, artificial intelligence, clinical decision support systems, hospital information systems, management information systems, Central Health Information System of the Republic of Croatia

SUSTAINABLE DEVELOPMENT GOALS:



POVZETEK

V magistrskem delu raziskujem integracijo umetne inteligence (UI), zlasti informacijskih rešitev, ki jih je mogoče vzpostaviti z uporabo UI, v obstoječi bolnišnični informacijski sistem (HIS) v KBC Rebro za izboljšanje komunikacije med zdravniki-specialisti in pacienti ter optimizacijo načrtovanja terminov, da bi zmanjšali število neodločenih prihodov pacientov. Z analizo trenutnih zmogljivosti sistema je raziskava pokazala, da v HIS obstajajo pomanjkljivosti. V primerih, ki so navedeni v tem magistrskem delu, sem ugotovil, da obstaja težava v bolnišnicah, kjer se ljudje ne pojavijo na dogovorjenih terminih. Želel sem raziskati, zakaj se to dogaja in kakšni so motivi za to. V nekaterih primerih sem ugotovil, da se približno 30 % pacientov ne pojavi na svojih dogovorjenih terminih. Razlogi so različni, vendar sem želel ugotovite, če morda preprosto pozabijo, v primeru, da je ta termin načrtovan po daljšem obdobju. Z uvedbo agenta UI (klepetalnega robota), ki bo ljudi ozaveščal o njihovem dogovorjenem terminu, bi se lahko povečal odstotek prihoda ob dogovorjenem terminu.

To ne bo samo opomnilo pacientov, temveč bo prihranilo čas specialistom, saj se bo zmanjšal odstotek ljudi, ki se ne pojavijo na terminu. Poleg tega je prednost ta, da določen pacient ne more priti na dogovorjeni termin, s tem opozorilom in opomnikom pa se lahko ta termin dodeli nekomu drugemu. Na splošno je integracija takšne rešitve z umetno inteligenco nekaj, kar bo imelo pozitiven vpliv, saj, kot je opisano kasneje v študijah primerov, ljudje pogosto pozabijo na termine, ki niso predvideni v kratkem času. Takšna implementacija bi pozitivno vplivala na nadaljnje procese in bi specialistom prihranila dragoceni čas.

KLJUČNE BESEDE: bolnišnični informacijski sistem, umetna inteligenca, sistemi za podporo kliničnemu odločanju, bolnišnični informacijski sistemi, upravljavski informacijski sistemi, Centralni zdravstveni informacijski sistem Republike Hrvaške

CILJI TRAJNOSTNEGA RAZVOJA



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LIST OF ABBREVIATIONS

AI – Artificial Intelligence

CDSS – Clinical Decision Support System

CEZIH – Central Health Information System of Republic of Croatia

CPOE - Computerized physician order entry

CRM – Customer Relationships management

EHR – Electronic Health System

GDPR – General Data Protection Regulation

HIS – Hospital Information System

IS – Information Systems

LIMS – Laboratory Information Management System

LLM – Large Language Model

OCR – Optical character recognition

RIS – Radiology Information System

1 INTRODUCTION

In the rapidly evolving landscape of modern healthcare, the integration of advanced information systems (IS) and artificial intelligence (AI) technologies has become essential for delivering efficient, high-quality patient care. These digital solutions serve as the backbone of healthcare institutions, enabling streamlined operations, improved decision-making, and enhanced patient safety (HIMSS, 2021). The concept of healthcare information systems (HIS) encompasses a broad range of technological components, from electronic health records (EHRs) and computerized physician order entry (CPOE) systems to specialized modules such as radiology information systems (RIS) and laboratory information management systems (LIMS). These components work cohesively to ensure the effective management, accessibility, and dissemination of vital health data across various clinical and administrative departments (Ammenwerth et al., 2019).

The significance of these systems extends far beyond mere data storage or digital recordkeeping; they fundamentally transform clinical workflows, facilitate seamless interdepartmental communication, and enable real-time access to critical patient information. This transformation fosters a shift towards evidence-based practices, allowing clinicians to make informed decisions supported by up-to-date, comprehensive data. Furthermore, the integration of management information systems (MIS) within healthcare organizations is pivotal in aligning operational activities with strategic objectives. MIS supports resource allocation, performance monitoring, and quality improvement initiatives, thereby driving enhancements in service delivery, patient satisfaction, and operational efficiency (Kaplan & Harris-Salamone, 2009).

The advent of AI technologies further amplifies the capabilities of healthcare information systems. AI-powered tools provide predictive analytics, risk stratification, natural language processing, and clinical decision support systems (CDSS) that assist healthcare providers in navigating complex clinical scenarios with increased accuracy and speed (Topol, 2019). Automation of routine tasks not only reduces human error but also frees up valuable clinical time, allowing medical professionals to focus more on direct patient care (Esteva et al., 2019). AI applications in healthcare range from diagnostic imaging and personalized treatment planning to administrative functions such as scheduling and supply chain management, highlighting the expansive potential of these technologies (Jiang et al., 2017).

This thesis focuses on the critical role of information systems within KBC Rebro, one of Croatia's leading tertiary healthcare facilities, known for its comprehensive range of specialized services and commitment to innovation. It examines the hospital's current technological landscape, including its strengths and challenges in implementing digital solutions. Particular attention is given to the integration of AI-driven applications aimed at optimizing clinical decision-making and enhancing operational performance. By exploring real-world applications and proposed improvements within KBC Rebro, this thesis

demonstrates how the strategic adoption of an AI chatbot can be very useful in the communication domain. It highlights the intercommunication between patient and doctor (specialist), where wasted time can be saved by just having better organization between the specialist-patient communication.

In recent years, hospitals and healthcare systems have been increasingly adopting innovative technologies to enhance patient engagement and improve operational efficiency. One such advancement is the integration of AI chatbots, which have shown significant potential in streamlining communication between healthcare providers and patients. Despite these technological strides, ensuring patient adherence to scheduled appointments remains a persistent challenge, often leading to missed appointments, inefficient resource utilization, and compromised patient care.

This thesis explores the implementation of an AI-powered chatbot system that utilizes SMS and email notifications to raise awareness among patients about their upcoming medical appointments. By providing timely, personalized reminders through commonly used communication channels, this approach aims to encourage patients to attend their scheduled visits, thereby enhancing appointment adherence rates (Chen et al., 2025).

The primary purpose of this thesis is to evaluate the effectiveness of AI chatbots in improving patient attendance and engagement via automated messaging. The goal is to demonstrate how integrating AI-driven communication tools can reduce no-shows, optimize hospital resources, and ultimately contribute to better healthcare delivery (Chen et al., 2025).

The potential of chatbot interventions has been demonstrated in various areas, such as screening for substance use disorders, supporting patients on waitlists for treatment and helping users manage chronic conditions. In this thesis, I'm highlighting the benefits of implementing AI agents as a tool where the communication relationship between doctors and specialists is improved (Wright et al., 2025).

2 INFORMATION SYSTEMS AS THE FOUNDATION OF MODERN HEALTHCARE

In this chapter, I will try to show and explain the foundations of modern healthcare in order to get more into the information system in general. Additionally, I will attempt to demonstrate how the IS is integrated into hospitals and explain its importance, as well as the roles it plays.

2.1 The concept of Information System in Healthcare institutions

The concept of information, when applied to an organization, is more complex than its everyday use suggests. Every society and organization is an information entity, and information is a fundamental resource alongside materials, money, and personnel (Eaton & Bawden, 1991).

Information can be viewed both as an abstract concept, such as ideas and as a commodity, often taking the form of letters, reports, or data. In today's world, information has become a vital resource, much like energy, playing a crucial role in the success and functioning of both individuals and organizations (Winter et al., 2023).

An Information System (IS) in healthcare institutions refers to a coordinated set of components and processes designed to collect, process, store, and disseminate information to support decision-making, coordination, analysis, and control within healthcare organizations (Almunawar & Anshari, 2012). These systems play a crucial role in improving the quality, efficiency, effectiveness, and delivery of healthcare services. As defined by Winter et al. (2023), a health information system is "the socio-technical subsystem of a health-related setting which comprises all data, information, and knowledge processing as well as the associated human or technical actors."

By enabling accurate data collection and timely access to information, IS support critical healthcare activities such as diagnosis, treatment planning, patient monitoring, and administrative management (Winter et al., 2023). Their integration into healthcare environments continues to transform the way organizations function and deliver patient-centred care.

2.2 The role of Information System

The role of IS is to help organizations manage and utilize data effectively to support their operations, decision-making, and overall goals. IS plays a key role in collecting, processing, storing, and analyzing data to provide valuable insights. They enable organizations to make informed decisions by providing accurate, up-to-date information (Nisrina et al., 2025).

One of the main roles of IS is to improve efficiency. By automating routine tasks and processes, these systems reduce manual work, minimize errors, and streamline operations. This leads to increased productivity and better resource utilization (Hamdat et al., 2024).

Another important role is to enhance communication and collaboration within organizations. IS provide platforms for sharing information across departments or teams, ensuring that everyone has access to the same data. This leads to improved coordination and fewer mistakes due to miscommunication (Bar et al., 2017).

IS also support decision-making at various levels. By gathering and analyzing data, these systems help managers and leaders make better strategic decisions, identify trends, and solve problems more effectively. They also provide decision support tools that can predict future outcomes based on data patterns (Ismail et al., 2025).

Besides that, it is worth mentioning that the key role is to ensure data security. IS manages sensitive data, ensuring it is stored securely and protected from unauthorized access. They help maintain privacy, comply with regulations, and safeguard against data breaches.

IS enables innovation and growth. They help organizations identify new opportunities, improve products and services, and adapt to changing market conditions. By leveraging data, businesses can innovate and stay competitive in a rapidly evolving environment (Quintana et al., 2015). The role of IS is to enhance efficiency, improve communication, support decision-making, ensure data security, and drive innovation within organizations. They play a central part in managing and utilizing information to achieve business objectives (Hamdat et al., 2024).

Another role worth mentioning is supporting customer relationships. Customer Relationship Management (CRM) systems, for example, help organizations gather and manage information about their customers. This allows businesses to offer personalized services, improve customer satisfaction, and build long-term loyalty, which is vital for success in many industries. IS plays a strategic role in helping businesses achieve a competitive advantage. By leveraging data and technological tools, companies can differentiate themselves in the market, find innovative solutions to challenges, and tap into new markets or customer segments (Dhillon et al., 2021).

IS help not only with daily operations but also with long-term strategic planning, performance monitoring, and customer relationships. They are central to sustaining growth, maintaining competitiveness, and driving innovation across organizations.

2.3 Key components of Healthcare Information Systems (HIS)

HIS are comprised of several key components that work together to ensure efficient management of healthcare data and operations. The hardware includes physical devices, such as servers, computers, tablets, mobile devices, and medical equipment, which support the storage, processing, and transmission of data (Winter et al., 2021). Software systems, such as EHRs, are essential for managing and organizing healthcare data, enabling healthcare providers to access and share patient information effectively. The database serves as a structured storage solution for patient records, medical histories, billing information, and other relevant data, ensuring that large volumes of information are organized and accessible (Wager et al., 2022). A secure network connects various devices, departments, and healthcare providers, facilitating seamless communication and data sharing while maintaining security and privacy. The success of an HIS also depends on the people involved, including healthcare providers, IT staff, and administrative personnel, who interact with and manage the system. Processes are crucial, as they define the workflows and procedures for data input, access, and security, ensuring the smooth and compliant operation of the system. Together, these components form the backbone of healthcare IS, enabling effective and secure management of healthcare data (Blobel, 2006).

Health information technology involves both software and hardware that deals and help with storage and maintenance, sharing and use of all information, as well as knowledge for decision-making and communication (Almunawar & Anshari, 2012).

2.4 Types of Information Systems in healthcare

In healthcare, several types of IS are utilized to streamline operations, improve patient care, and enhance decision-making. One such system is the EHRs, which serves as the digital version of a patient's paper chart. EHRs provide real-time access to crucial patient data, including treatment history, laboratory results, and medications, allowing healthcare providers to make more informed decisions (Hossain et al. 2023). Another important system is HIS, an integrated platform that manages both administrative and clinical data within hospitals. It includes modules for patient billing, registration, scheduling, and resource management, helping to improve overall hospital efficiency (Caruana et al., 2023).

The Clinical Decision Support System (CDSS) plays a critical role in assisting healthcare providers with decision-making by analyzing patient data. It offers alerts, reminders, and evidence-based recommendations, ensuring that providers have access to the most up-to-date and relevant information when making treatment decisions (Gholamzadeh, 2023). Similarly, the RIS specializes in managing medical imagery and associated data. It supports tasks such as scheduling, image tracking, and reporting, enabling more effective management of diagnostic imaging processes.

Another vital system is LIMS, which streamlines laboratory operations by efficiently managing samples, test results, and workflows. Telemedicine Systems have become increasingly important in modern healthcare, enabling remote consultations, diagnostics, and treatments via digital communication tools, enhancing access to care for patients, especially in underserved areas. Lastly, Pharmacy IS are used to manage medication inventories, prescriptions, and drug interaction checks, ensuring that patients receive the appropriate medications in the correct order (Romero et al., 2016).

Each of these systems plays a unique and essential role in improving the efficiency, accuracy, and overall quality of healthcare services. HIS are transforming healthcare delivery by improving access to information, enhancing decision-making, and promoting efficient patient care.

At a high level, Healthcare IS are integrated solutions that provide the foundation for data-driven decision-making, efficient workflow management, and better patient care. These systems combine both clinical and administrative information to manage and streamline various aspects of healthcare delivery (Blober, 2000).

2.5 The importance of Information System in healthcare

The importance of IS in general is very high because it helps any organization to store, process, collect and analyze information to make better decisions, improve its effectiveness and efficiency, as well as give a competitive advantage over other organizations. By automating processes, IS increases productivity, reduces errors, and cuts costs (Laudon K.C, Laudon J.P., 2021). They also enhance communication and collaboration within organization, as well as with external stakeholders, through tools like email and customer relationship management systems (CRM). IS also manages and protects data securely, ensuring that sensitive information is safe and backed up (Wager et al., 2022). Organizations that effectively use IS can gain a competitive advantage by quickly adapting to market changes and responding to trends faster than their competitors. Additionally, they foster innovation by uncovering new opportunities and help businesses improve their products and services, as well as their overall growth (Caruana et al., 2023).

When it comes to the importance of IS in healthcare, we can say that IS are essential as they improve patient care, streamlines operations and enhances communication among healthcare providers. They help healthcare professionals access patient records quickly and accurately, leading to better-informed decisions and safer treatment plans. EHRs provide a comprehensive view of patients' history, medication, allergies and test results. HIS also increase efficiency by automating administrative tasks like scheduling, billing and claims processing, allowing healthcare staff to focus more on patient care (Caruana et al., 2023).

They enable better communication and coordination among doctors, specialists, nurses, and pharmacists, ensuring that everyone involved in a patient's care has the same information, which reduces errors and unnecessary tests.

These systems support data analysis and decision-making by helping organizations identify trends and outcomes, leading to evidence-based practices that improve patient care. They also offer patient engagement tools such as portals or apps, allowing patients to access their health records, track appointments, and communicate with their providers, which improves patient satisfaction and involvement in their own health management (Aljarboa et al., 2022).

Additionally, IS helps reduce costs by increasing operational efficiency and minimizing errors. They protect sensitive patient data through secure systems and ensure compliance with privacy regulations, helping to prevent breaches and maintain trust. Telemedicine platforms supported by healthcare IS also provide remote consultations, diagnosis, and monitoring, improving access to care, especially in underserved areas (Arifah et al., 2024).

3 ARTIFICIAL INTELLIGENCE TECHNOLOGIES IN BUSINESS AND HEALTHCARE

3.1 Introduction of AI technologies in business

AI technologies in business refer to the use of machine learning, data analysis, and automation tools to improve business operations, enhance decision-making, and create innovative solutions. These technologies enable businesses to process large amounts of data quickly, automate repetitive tasks, personalize customer experiences, and make more informed, data-driven decisions (Badmus et al., 2024). From chatbots handling customer service inquiries to AI systems predicting market trends, AI is revolutionizing industries by increasing efficiency, reducing costs, and offering new opportunities for growth and innovation. The adoption of AI helps businesses stay competitive and adapt to the ever-changing market landscape (Gomes et al., 2022).

One of the most transformative applications of AI lies in the automation and optimization of business processes. From intelligent workflows to predictive maintenance and robotic process automation, AI is actively reshaping how businesses operate. A systematic review by Gomes highlights the growing application of AI-driven methods such as process mining and optimization algorithms in business operations, demonstrating measurable gains in productivity, accuracy, and cost reduction (Gomes et al. 2022).

3.1.1 Example of AI technologies in business

C3 AI, an Enterprise AI software company, in 2022 announced a groundbreaking achievement in collaboration with Shell, marking the successful deployment of an AI-powered predictive maintenance program on a global scale. This program, now monitoring over 10,000 critical pieces of equipment in Shell's upstream, manufacturing, and integrated gas assets, represents one of the largest deployments in the energy industry. By leveraging advanced AI technology, Shell can detect equipment degradation and potential failures before they occur, enabling proactive measures to prevent costly downtime, production interruptions, and safety risks. CEO Thomas M. Siebel praised Shell's achievement, emphasizing the economic, environmental, and safety benefits derived from the partnership with C3 AI.

The technical infrastructure supporting the program processes a staggering 20 billion rows of data weekly, trains thousands of machine learning models, and generates millions of predictions daily. Looking ahead, Shell plans to expand its predictive maintenance initiative while exploring other AI use cases such as asset integrity, production optimization, and sustainability. Additionally, Shell has commercialized its AI predictive maintenance applications developed with C3 AI software through the Open Energy AI initiative, aiming to advance AI adoption across the energy sector. This collaboration underscores the strategic

partnership between Shell and C3 AI, as they continue to drive innovation and excellence in predictive maintenance and beyond (C3 AI, 2022).

Another example of using AI software in their business is DHL company. DHL, one of the world's leading logistics companies, is continually innovating to enhance its operational efficiency and customer experience. One of their advanced technological solutions is OptiCarton, an AI-powered software designed to optimize packaging processes.

OptiCarton uses AI and machine learning algorithms to determine the most efficient way to pack goods into cartons. The software analyzes the size, weight, and shape of items to minimize the number of cartons used, reduce packaging material, and improve load stability. This optimization not only helps DHL decrease shipping costs but also reduces environmental impact by minimizing packaging waste.

A DHL fulfilment centre receives a large order consisting of various items of different sizes and weights. Instead of packing each item separately, DHL uses OptiCarton to streamline the process. The software analyses each item's dimensions and weight, then determines the optimal way to pack them together into the fewest possible cartons. For example, if the order includes small electronics, clothing, and accessories, OptiCarton calculates the best arrangement to fit all items securely and efficiently. It suggests the ideal carton sizes, positions each item accordingly, and provides packing instructions. As a result, DHL can significantly reduce the number of cartons needed, lowering shipping costs and minimizing packaging waste (DHL Supply Chain, 2022).

This automated optimization speeds up the packing process, reduces errors, and ensures that products are well-protected during transit. Customers benefit from faster delivery times and more sustainable shipping practices.

The last example I want to show is the study from Wardle, which aimed to explore people’s usage and perception of AI and voice-assisted technologies when looking for health information and evaluating whether these tools are upgraded from classic traditional patterns of health information seeking for credibility assessment.

They conducted detailed qualitative research, including 27 participants aged 19 to 80 years, using a think-aloud protocol. Participants searched for health-related information across three platforms: Google, ChatGPT, and Alexa, verbalizing their thought processes throughout. The prompts included both a standard hypothetical scenario and a personally relevant health question. Sessions were recorded, transcribed, and analyzed through reflexive thematic analysis to identify patterns in search behaviour, perceptions of trust and usefulness, and differences across platforms and demographic groups (Wardle et al., 2025).

Participants often incorporated AI tools into their overall search routines rather than relying solely on them. ChatGPT was appreciated for its clarity, quick responses, and ability to generate keywords or summarize complex topics, even by users who questioned its accuracy.

Trust and perceived utility did not always align; participants frequently used ChatGPT despite concerns about source credibility and bias. Caution was also observed with Google's AI Overviews, which many participants skipped to focus on traditional search results. Alexa was considered convenient but limited, especially for more detailed health inquiries. Platform selection was influenced by the seriousness of the health issue, the context of use, and prior experience. Nearly a third of participants were multilingual, facing challenges related to voice recognition, cultural relevance, and data provenance.

Overall, users demonstrated sophisticated "mix-and-match" behaviours, selectively using multiple tools based on context, urgency, and familiarity.

These findings highlight the need for further research into how search behaviours are becoming increasingly dynamic and context-dependent in the age of AI and voice-assisted technologies. Although the sample size was small, participants chose tools based on perceived usefulness rather than trustworthiness alone, questioning the assumption that credibility is the main factor in adopting these technologies. The results emphasize the importance of digital health literacy initiatives to help users better evaluate the strengths and limitations of emerging tools. As search technologies continue to evolve rapidly, longitudinal and real-time observational studies are crucial for understanding how AI-driven tools are reshaping HIS (Wardle et al., 2025).

3.1.2 Advantages of AI technologies in business

AI technologies offer businesses a wide array of benefits that go beyond traditional methods. By automating repetitive tasks, AI improves operational efficiency, allowing employees to focus on more high-value, strategic activities. This automation can drastically reduce human error and lead to faster decision-making across departments (Paiva et al., 2022). AI's ability to analyze massive datasets quickly and accurately gives businesses valuable insights into customer behaviour, market trends, and business operations, empowering them to make smarter, data-driven decisions (Badmus et al., 2024).

AI also helps personalize the customer experience by delivering tailored recommendations and content, improving customer satisfaction and loyalty. In addition, businesses can cut costs by streamlining processes, minimizing waste, and optimizing resources (Badmus et al., 2024). For customer service, AI tools like chatbots and virtual assistants offer around-the-clock support, answering queries and resolving issues efficiently, all while maintaining a high level of customer engagement. When it comes to security, AI plays a critical role in detecting potential threats and fraud in real-time, giving businesses a proactive approach to safeguard sensitive data. In supply chain management, AI's forecasting capabilities enable companies to predict demand, optimize inventory, and improve delivery efficiency, which leads to significant cost savings and better overall management (Paiva et al., 2022).

AI also fosters innovation by enabling the creation of new products, services, and business models that might not be feasible with conventional approaches. With AI's ability to quickly

adapt to changing market conditions, businesses can stay ahead of the curve and maintain a competitive edge. Furthermore, by providing real-time insights, AI aids in more informed decision-making, improving business outcomes (Badmus et al., 2024).

AI technologies are transforming businesses by enhancing productivity, reducing operational costs, improving customer satisfaction, and driving innovation. Businesses that adopt AI can gain a significant advantage in today's fast-paced, data-driven market, positioning themselves for long-term growth and success (Paiva et al., 2022).

3.1.3 Disadvantages of AI technologies in business

While AI technologies offer significant advantages, they also come with a few drawbacks that businesses need to consider. One major disadvantage is the high initial cost of implementing AI. For smaller businesses, expenses such as purchasing software, integrating AI systems, and training employees can be a significant barrier. AI also has the potential to cause job displacement. Automating tasks traditionally performed by humans can lead to job losses or shifts in workforce demands. Although new roles may emerge, employees might need to reskill or upskill to remain relevant in an AI-driven environment. Another concern is data privacy and security. AI systems depend heavily on large amounts of data, often personal or sensitive, which raises privacy issues. If these systems aren't properly secured, businesses face the risk of data breaches that could damage their reputation and customer trust. Additionally, there are bias and fairness issues to be aware of. AI algorithms are only as good as the data they are trained on. If that data is biased or incomplete, AI systems could make decisions that are unfair or discriminatory, which may lead to legal complications or harm a company's reputation (Jafer et al., 2024).

Implementing and maintaining AI systems can also be complex and resource-intensive. Businesses often need specialized expertise to set up, manage, and optimize AI technologies. Furthermore, AI models require regular updates to stay accurate and relevant. AI can also lack the human touch. In industries where empathy, intuition, and emotional intelligence are key, such as healthcare or customer service, AI's inability to replicate these human qualities could limit its effectiveness. Over-relying on AI can also be risky. If technology fails or experiences a disruption, businesses could be vulnerable to operational breakdowns, especially when decisions are largely driven by AI (Trigo et al., 2025).

Lastly, ethical dilemmas surrounding AI are becoming more prominent. There are questions about accountability and transparency in decisions made by AI, particularly in areas like hiring, loan approvals, or criminal justice. Poorly designed AI systems could unintentionally perpetuate biased outcomes (Jafer et al., 2024).

While AI offers numerous benefits, businesses must carefully navigate these potential disadvantages, such as high costs, job displacement, data privacy concerns, and ethical issues.

A balanced approach is needed to ensure that AI enhances operations without introducing new challenges.

3.1.4 Predicting potential health risk

While AI brings numerous advantages, its integration into everyday life and business also raises several potential health risks that need careful consideration. One of the main concerns is the impact on mental health. Overreliance on AI, particularly in the workplace, can lead to increased stress and burnout. The automation of tasks might create a sense of job insecurity or reduce workers' sense of control, which can negatively affect emotional well-being. Furthermore, constant interactions with AI-driven systems, like social media algorithms or virtual assistants, could lead to feelings of isolation, anxiety, or depression, especially when human connections are replaced by technology. Another significant health risk is related to physical well-being (Xu et al., 2023).

Extended use of AI-powered devices such as smartphones, computers, or wearables can cause digital eye strain, leading to headaches and poor posture. Additionally, the blue light emitted from screens can interfere with the body's natural sleep cycle, contributing to sleep disturbances and poor-quality sleep, which in turn can negatively impact overall health.

AI's role in promoting convenience could also contribute to a more sedentary lifestyle. As AI systems handle more tasks, individuals may become less active, leading to issues such as obesity, cardiovascular problems, and other health complications linked to a lack of physical exercise. The reliance on vast amounts of personal data also raises concerns around cybersecurity and privacy. AI-driven systems can be vulnerable to cyberattacks, leading to identity theft or data breaches. Such events can cause emotional distress for those affected and have long-lasting mental health impacts (Laka et al., 2022).

Over-dependence on AI technologies for decision-making or problem-solving might also erode critical thinking skills, especially if individuals become too accustomed to rely on AI to solve everyday issues. This cognitive shift could impair the ability to make decisions without technological assistance, affecting long-term mental agility (MSTIMES, 2025).

In healthcare, while AI has the potential to revolutionize medical practices, it also introduces the risk of incorrect diagnoses or treatment plans. Faulty algorithms or errors in AI systems could lead to serious consequences, including misdiagnosis or delayed treatments, which could harm patients' physical health (MSTIMES, 2025).

3.2 Vulnerabilities of AI systems in practice

As AI systems become increasingly integrated into healthcare and other critical sectors, their dependence on stable infrastructure, particularly electrical power and network connectivity, presents several practical vulnerabilities. These technical dependencies can significantly

impact the reliability, safety, and effectiveness of AI-based solutions in real-world environments such as hospitals, clinics, and remote medical centers (Frontiers in Medicine, 2025).

One of the primary vulnerabilities lies in the reliance on uninterrupted electrical power. AI systems, especially those used for real-time applications like diagnostic imaging, patient monitoring, and clinical decision support, require continuous power to function effectively. Power outages pose a serious threat, potentially leading to abrupt system shutdowns, data loss, and interrupted medical evaluations at crucial moments. Even brief interruptions can disrupt the functioning of critical AI tools, compromising patient safety (Alwaisi et al., 2024). In order to complete outages, power fluctuations and voltage instability can degrade the performance of AI hardware over time.

Components such as GPUs and servers, which are central to AI computation, are particularly sensitive to these variations. Without proper power conditioning or backup systems like uninterruptible power supplies (UPS) and generators, these fluctuations can lead to hardware failure, corrupted computations, or permanent system damage (Alashwal et al., 2024). Network-related issues present another significant category of vulnerability. AI systems often require high-speed data transfer, particularly when integrated with cloud computing platforms. In such setups, slow or unreliable internet connections can result in high latency or reduced bandwidth, delaying critical tasks such as data processing, image analysis, or the retrieval of patient records. In clinical settings, such delays can lead to diagnostic errors or treatment postponements (HospiInfo, 2023). Total network outages can render cloud-dependent AI systems completely inoperative. This is especially problematic in hospitals that have adopted remote servers or cloud-based decision support tools. Without access to these systems, healthcare professionals may lose real-time insights or the ability to retrieve essential patient data. In regions with less stable internet infrastructure, this limitation can severely undermine the benefits of AI integration (Reuters, 2025).

Security is also a growing concern. Poorly secured networks expose AI systems to cyberattacks, such as ransomware and data breaches. Given the sensitive nature of medical data and the critical decisions AI tools support, such breaches can have both ethical and operational consequences. Notably, ransomware attacks on hospital IT systems have, in the past, resulted in the complete shutdown of services, affecting patient care and institutional operations (Smailhodzic et al., 2024). To mitigate these vulnerabilities, several best practices are recommended. Healthcare facilities should invest in robust backup power systems, including UPS devices for critical machines and on-site generators.

To reduce dependence on cloud connectivity, institutions can adopt edge computing solutions that allow AI to function locally. This ensures that key services remain operational even during network disruptions. Furthermore, implementing resilient network architectures featuring redundant connections, firewalls, and secure protocols can help maintain system uptime and protect against cyber threats. Finally, designing AI systems with local data caching and

synchronization mechanisms allows them to operate offline temporarily and sync data once connectivity is restored (Chowdhury et al., 2025). While AI technologies offer transformative benefits to healthcare, their full potential can only be realized through careful consideration of infrastructural vulnerabilities. Ensuring reliable electricity and secure, high-performance network access is critical for the safe and effective use of AI systems in practice (Gul et al., 2024).

3.3 Example of AI technologies in hospitals

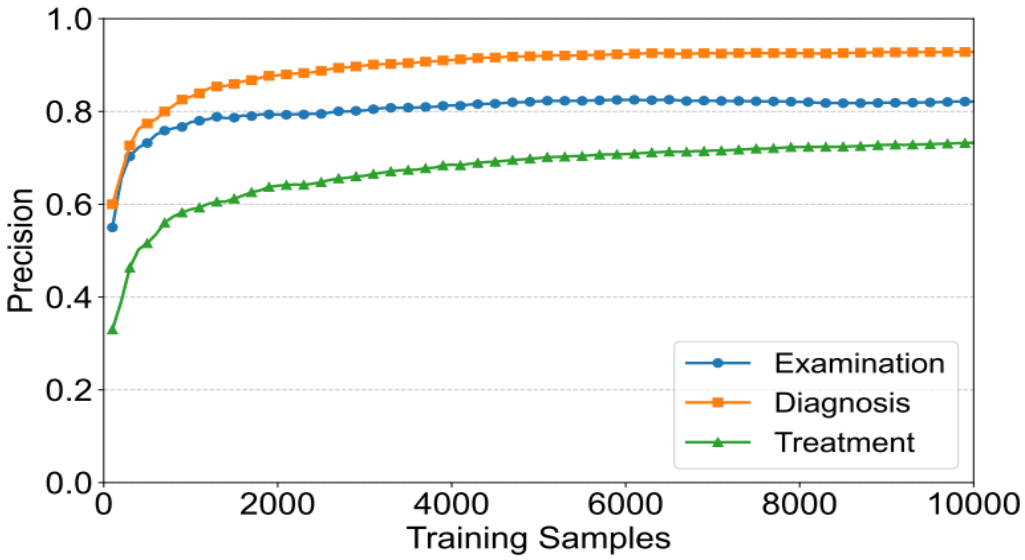
In this subsection, I will provide a few examples of AI usage in hospitals. I decided to use the following examples because I think they describe very well the usage of AI in hospitals that can be very helpful, and by training their models, even better than a doctor. Additionally, I wanted to use this example because I think this is the future of healthcare IS, and this example will show how many benefits they gained by introducing AI tools into their system.

Amsterdam UMC hospital has recently implemented a project called AI4AI. Its focus is the interpretation of medical images, such as MRI or CT. The AI is massively helping doctors with the interpretation of medical images, which is greatly lessening the burden on medical staff. In addition, this AI implementation also helped to shorten the waiting list, given its precision and quickness in image analysis. Besides its main goal of medical image interpretation, AI is used for the analysis of stroke and brain tumours, identification of patients with heart disease, referrals for urgent care, screening and triage of threatening visual disorders etc. (Amsterdam UMC, 2023).

Another example is a pilot project in two German hospitals, where TCC Analytics and Telekom have partnered in an AI-based sepsis prevention program. Sepsis is the leading cause of death in intensive care units, with doctors having a very short period to react to blood poisoning. In this project, the AI is helping the doctors by warning them of impending sepsis in a patient. The data from intensive care patients is analysed by an AI algorithm, which can predict the risk of sepsis ten hours before the onset, thus giving the hospital staff enough time to save the patients' lives (Monitor Versorgungsforschung, 2023).

One more example is a virtual hospital developed in China, called the Tsinghua Agent Hospital. It includes 42 AI doctors, capable of treating an astonishing 10,000 patients a day, something it would take human doctors some two years to achieve. Their accuracy rate is at a striking 93,06%. The figure below (Figure 1) shows the virtual doctors' progression in their training course. The more virtual cases the virtual doctor's asses, the more precise and efficient they become in their tasks. Given the great precision rate achieved, these virtual hospitals could become a mainstay in the future. (Li et al., 2024)

Figure 1: Virtual doctors training performance on 3 tasks



Source: Li et al. (2024).

The last example that I will provide to show the impact of using AI software solutions is HCA Healthcare.

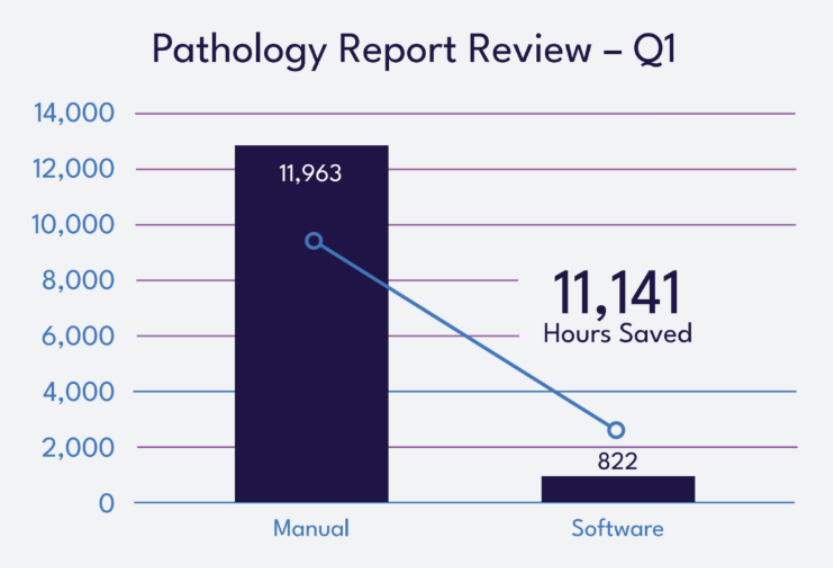
HCA Healthcare, one of the largest healthcare systems in the United States, operates a broad network of hospitals, surgery centers, and other medical facilities across the U.S. and the U.K., with a strong focus on patient care and community health. However, the complexity of managing numerous points of entry, such as pathology reports, physician schedules, and referrals, meant that identifying newly diagnosed cancer patients was a manual, time-consuming process.

This inefficiency led to delays in diagnosis and treatment, negatively impacting patient outcomes and resource allocation. To address this challenge, HCA Healthcare implemented Azra AI, a clinical intelligence platform that uses AI technology to automate oncology workflows. Widely adopted by over 250 hospitals and cancer centers in the U.S., including Inspira Health and the University of Pennsylvania Health System Azra AI offers several critical features. It enables early cancer detection by analyzing pathology reports in real-time, identifies incidental findings in radiology reports, automates cancer registry data entry by extracting key patient information, and integrates directly with HCA's Meditech Electronic Health Record system to support nurse navigators in patient tracking and care coordination (DesignDevelopers, 2024).

The platform also centralizes cancer-related data and provides real-time analytics for better patient volume management. Since adopting Azra AI, HCA Healthcare has reduced the average time from cancer diagnosis to first treatment by six days and saved over 11,000 hours previously spent manually reviewing pathology reports. The care team can now dedicate 65%

more time to patient navigation and coordination, enabling HCA to onboard more than 10,000 new oncology patients within just 14 months (DesignDevelopers, 2024).

Figure 2: Decrease in time of diagnosis



Source: Design Developer (2024).

In Figure 2 we can see enormous decrease in time spent on diagnosis by using Azra AI software. They saved more than 11 thousand hours. That means that such work can be done more precisely and faster just by using AI tools.

3.4 Introduction to AI chatbots

AI chatbots, also known as conversational agents, are software applications designed to simulate human conversation using natural language processing (NLP), machine learning (ML), and, more recently, large language models (LLMs). Their development spans from early rule-based systems with scripted responses to advanced generative models capable of producing contextually relevant and human-like dialogue (Brandtzaeg & Folstad, 2017). Recent advancements in transformer-based architectures, such as GPT, have significantly enhanced the fluency, coherence, and adaptability of chatbot responses.

Chatbots are widely deployed across domains. In healthcare and wellness, they are used to promote physical activity, support dietary change, deliver mental health support, and aid behaviour change interventions. A systematic review by Krämer et al. (2025) found that while chatbot interventions often/ showed positive outcomes for physical activity promotion, evidence was mixed in areas such as diet and weight loss. In education, chatbots serve as virtual teaching assistants, answering student questions, providing personalized support, and facilitating access to educational content. Other sectors using chatbots include customer

service, tourism, and enterprise-level workflows, where they streamline communication and reduce operational costs (Brandtzaeg & Folstad, 2017).

Despite their potential, AI chatbots face several challenges. One significant concern is bias and fairness. Chatbots based on large-scale language models can perpetuate harmful stereotypes or generate misleading content due to biases in their training data (Bender et al., 2021). Ethical concerns also emerge from the opaque nature of these models, making it difficult for users to understand how responses are generated. Additionally, data security and privacy are critical issues, as chatbots may be vulnerable to adversarial attacks or data leaks if not properly secured.

Reliability is another limitation, especially in high-stakes contexts such as healthcare. Chatbots may offer inaccurate or overly simplified advice, which can mislead users if not carefully monitored (Krämer et al., 2025). Moreover, many systems still struggle with multi-turn conversations, user personalization, and domain adaptation (Brandtzaeg & Folstad, 2017).

Emerging trends are reshaping the field. The introduction of LLMs has expanded chatbot capabilities, enabling more fluid and dynamic interactions. At the same time, researchers are examining the psychological and social effects of chatbots. Xu et al. (2023) found that users who perceive chatbots as more human-like are more likely to trust them and report positive engagement, particularly in health and wellbeing contexts. Furthermore, scholars have called for standardized frameworks to assess chatbot usability, effectiveness, and user satisfaction across studies (Krämer et al., 2025).

In conclusion, AI chatbots are evolving into sophisticated tools with significant applications in health, education, and service industries. However, their development and deployment require careful attention to ethical, technical, and social implications. Continued interdisciplinary research will be essential to maximize their benefits while mitigating associated risks.

4 USING ARTIFICIAL INTELLIGENCE IN KBC REBRO

This research adopted a mixed-methods approach combining both qualitative and quantitative data collection. The primary aim was to explore how employees at a hospital perceive the current state of their IS and how they view the potential introduction of AI tools, such as chatbots, to improve hospital workflows and communication with patients. Interview was conducted with an employee working directly within the hospital's administrative or IT department. The goal of the interview was to collect detailed, first-hand information about current status with IS in the hospital, also the employee’s experience with AI tools and general opinion on introducing more AI in the hospital.

A structured survey was distributed among employees from different departments within the hospital, including administration, medical staff, and support services. The survey focused on currently use of the IS in the hospital, potential challenges of introducing AI tools, and willingness to adopt new technologies.

4.1 Information System in KBC Rebro

KBC Rebro, in medical research, is actively involved, particularly in the field of molecular medicine. The hospital's Department of Pathophysiology has made very significant contributions to the understanding of disease mechanisms and the development of diagnostic tools. For instance, Professor Stjepan Gamulin's work in molecular medicine has been instrumental in integrating molecular diagnostics into clinical practice, enhancing the hospital's research capabilities (Gamulin, 2003).

KBC Rebro has faced challenges, including a significant cybersecurity incident in June 2024, where the hospital's IT infrastructure was targeted by a cyberattack. The attack led to a temporary shutdown of its IS, disrupting operations. Although emergency services and medical laboratories continued to function, the incident highlighted vulnerabilities in healthcare IS and emphasized the critical need for robust cybersecurity measures in medical institutions. Worth mentioning is that KBC Rebro is actively engaged in medical research, particularly in molecular medicine. The hospital's Department of Pathophysiology has made notable contributions to understanding disease mechanisms and developing new diagnostic tools. Professor Stjepan Gamulin's work, for example, has been instrumental in integrating molecular diagnostics into clinical practice, advancing the hospital's research capabilities (Gamulin, 2003).

KBC Rebro exemplifies a comprehensive healthcare model that integrates high-quality patient care, medical education, and research. The hospital's advanced IS, commitment to enhancing cybersecurity, and active involvement in medical research have helped it maintain its status as a leading healthcare institution in Croatia. While challenges like cybersecurity incidents highlight areas for improvement, the hospital continues to evolve and implement measures to enhance patient care and contribute to scientific advancements (Gamulin, 2003).

4.1.1 Healthcare models in the KBC Rebro

KBC Zagreb (University Hospital Centre Zagreb), located in the Rebro area of the city, is Croatia's largest healthcare institution, providing a broad range of medical services. It is a publicly funded teaching hospital and works closely with the University of Zagreb, contributing significantly to medical education and research.

KBC Zagreb offers specialized care in multiple fields, including its renowned Department of Cardiovascular Diseases. This department is a leading institution in Croatia for cardiology, offering services such as echocardiography, invasive cardiology, and treatment for congenital heart conditions in adults. Additionally, KBC Zagreb is home to Croatia's National Robotic Centre, where advanced robotic surgeries, particularly for prostate cancer, are performed. These minimally invasive surgeries reduce recovery time and enhance precision (Kaštelan et al., 2021).

As a teaching hospital, KBC Zagreb plays a key role in educating medical students and healthcare professionals. It serves as the primary clinical training centre for both the University of Zagreb's School of Medicine and the University of Applied Health Sciences. The hospital also hosts over 70 referral centres in a variety of medical specialties. In 2022, KBC Zagreb signed a EUR 70 million contract to upgrade and expand its facilities. This project includes the construction of a new multifunctional building and a new garage with an emergency Helio drome, aimed at improving patient care and expanding the hospital's capacity (Kaštelan et al., 2021).

KBC Zagreb is a key healthcare institution in Croatia, offering comprehensive medical services across various specialties. In addition to its renowned Department of Cardiovascular Diseases, the hospital provides specialized care in multiple fields. The Oncology and Cancer Care department is one of the hospital's leading areas, offering treatments like surgery, chemotherapy, and radiation therapy for different types of cancer. KBC Zagreb also participates in clinical trials, advancing cancer treatment methods. In Pediatric Care, the hospital provides specialized treatments in podiatric oncology, neonatology, and podiatric cardiology, ensuring comprehensive care for children with serious health conditions. The Neurosurgery department at KBC Zagreb is another standout, focusing on complex surgeries related to the brain, spine, and nervous system, such as brain tumors and spinal cord injuries.

In addition, KBC Zagreb is a key player in Organ Transplantation in Croatia, performing kidney, liver, and heart transplants and training medical professionals for these life-saving procedures. The hospital is also known for its use of state-of-the-art technology, such as robotic-assisted surgery.

This technology allows for more precise operations, reducing recovery times and minimizing complications. KBC Zagreb also invests in cutting-edge diagnostic equipment, ensuring the most accurate diagnoses and treatment options for patients. As a teaching hospital, KBC Zagreb plays an essential role in Croatia's medical education system. It provides hands-on training for medical students, nursing students, and other healthcare professionals, with students from the University of Zagreb rotating through the hospital's various departments. The hospital is also actively involved in medical research, particularly in cardiovascular diseases, oncology, and neurology, contributing to global medical advancements through clinical trials and international collaborations (KBC Zagreb, 2021).

To meet growing demands, KBC Zagreb has embarked on a major redevelopment project. This includes the construction of new facilities to enhance outpatient care, diagnostic services, and research. A new emergency Helio drome will improve the hospital's ability to handle critical cases and provide rapid access to emergency medical care. KBC Zagreb's international collaborations with hospitals and research institutions worldwide help maintain its position as a leader in healthcare, fostering the exchange of knowledge and best practices to stay at the forefront of medical advancements. KBC Zagreb exemplifies a comprehensive healthcare

model, integrating high-quality patient care, medical education, and research, and continues to grow to meet the healthcare needs of Croatia and beyond.

4.1.2 Advantages in IS in KBC Rebro

IS plays a crucial role in enhancing the efficiency, productivity, and competitiveness of healthcare institutions like KBC Rebro, as well as other hospitals too.

The implementation of HIS at the KBC Zagreb Rebro has fundamentally transformed both clinical and administrative processes, enabling the hospital to provide more efficient, safer, and higher-quality care. HIS integrates multiple hospital departments including outpatient clinics, inpatient wards, laboratories, radiology, and pharmacies into a single digital platform. This integration streamlines communication, reduces administrative burdens, and ensures that patient information is always accurately and readily available to healthcare providers.

One of the most significant advantages of HIS is the digital management of patient records. Using EHRs, the system consolidates patient medical histories, laboratory results, imaging reports, and treatment plans in a centralized and secure environment. This eliminates the risks associated with paper-based records, such as misplacement, duplication, or illegibility, and ensures that all healthcare professionals have access to the most up-to-date information. For example, a patient undergoing treatment across multiple departments, such as cardiology and endocrinology, benefits from continuity of care because specialists can view the full medical history in real time (KBC Zagreb, 2021).

HIS also brings significant improvements in workflow efficiency. Administrative processes, including patient registration, appointment scheduling, billing, and referral management, are streamlined through the system. Staff no longer need to manage excessive paperwork, which allows them to focus on direct patient care. Laboratory and radiology requests are automatically transmitted electronically, enabling quicker processing of tests and faster delivery of results to treating physicians. In practice, this reduces waiting times for patients, accelerates treatment initiation, and enhances the overall patient experience (KBC Zagreb, 2021).

Another important advantage of HIS is optimized resource management. Real-time monitoring of hospital resources such as bed availability, staffing schedules, and medical equipment usage allows administrators to make informed decisions regarding allocation. This is particularly valuable during peak periods, when patient inflow is high, or during emergency situations. By analyzing historical data and predicting trends, administrators can plan staffing, allocate resources efficiently, and reduce delays, thereby improving patient throughput and reducing bottlenecks (Ministarstvo zdravstva, 2024).

From a clinical perspective, HIS enhances patient safety and quality of care. The system includes clinical decision support tools, which alert healthcare providers to potential drug interactions, allergies, and deviations from recommended treatment protocols. These features

help prevent medical errors and ensure adherence to evidence-based practices. Additionally, HIS enables continuous monitoring of patient outcomes, allowing healthcare professionals to adjust treatment plans in a timely manner and ensuring that care is both initiative-taking and responsive (KBC Zagreb, 2021).

The system also promotes patient engagement and empowerment. Patients can access their medical information, view lab results, track appointments, and communicate with healthcare providers through digital portals. This transparency encourages patients to take an active role in managing their health, improving adherence to treatment plans and fostering trust in the healthcare system. For instance, patients with chronic conditions such as diabetes or hypertension benefit from having immediate access to their records, which helps them manage their treatment more effectively between hospital visits.

HIS further supports interdepartmental coordination and interdisciplinary care. In complex cases requiring multiple specialists, all relevant information is centralized, preventing redundant testing, reducing delays, and facilitating informed decision-making. This integration is particularly important in a large tertiary hospital like KBC Rebro, where patients often require care from various departments simultaneously. The system ensures that all healthcare professionals involved have access to accurate, real-time data, which improves patient outcomes and overall treatment efficiency (KBC Zagreb, 2021).

Data-driven decision-making and hospital planning is another significant advantage. HIS collects and stores vast amounts of data, enabling administrators to monitor hospital performance, identify inefficiencies, and make evidence-based policy decisions. Analytical tools within HIS can provide insights into patient flow, departmental workload, and treatment outcomes, which help optimize hospital operations. Furthermore, this data can support research, quality improvement initiatives, and long-term strategic planning, positioning KBC Rebro as a modern, technologically advanced institution (Ministarstvo zdravstva, 2024).

Finally, HIS ensures compliance with legal and regulatory requirements. Digital documentation and standardized processes simplify reporting to national health authorities and support adherence to privacy regulations. Secure storage and controlled access protect patient data while facilitating authorized sharing among healthcare providers when necessary (KBC Zagreb, 2021).

HIS at KBC Rebro has transformed hospital operations on multiple levels. By improving the accuracy and accessibility of patient information, streamlining workflows, optimizing resource management, supporting clinical decision-making, and enhancing patient engagement, HIS has established a foundation for more efficient and higher-quality healthcare. It not only enhances day-to-day operations but also provides strategic benefits for long-term planning, research, and continuous improvement in healthcare delivery. The experience at KBC Rebro illustrates how technology can be leveraged to modernize healthcare systems while maintaining a patient-centered approach.

4.1.3 Disadvantages in IS in KBC Rebro

While IS provide numerous advantages to institutions like KBC Rebro, they also present certain disadvantages and challenges. One of the most significant drawbacks is the high implementation and maintenance costs. Developing, deploying, and integrating advanced IS require substantial investments in infrastructure, software, hardware, and skilled personnel. Maintaining these systems and ensuring they are up-to-date, secure, and running smoothly requires ongoing financial resources. System upgrades, security patches, and addressing emerging technological requirements contribute to long-term operational costs.

The implementation of the HIS at the KBC Zagreb Rebro has significantly modernized hospital operations and improved access to patient data. However, despite its numerous advantages, the system also presents several notable disadvantages that affect both healthcare providers and patients. One of the most pressing challenges is the frequent downtime and reliability issues. Reports indicate that the HIS experiences periodic outages, during which essential services, such as laboratory testing and imaging, are temporarily unavailable. In some cases, even critical treatments, like radiation therapy, have been disrupted, resulting in delays in patient care and additional stress for healthcare staff, who must revert to manual processes to continue hospital operations (N1 Hrvatska, 2024).

These disruptions highlight the system's vulnerability to technical failures and emphasize the need for continuous monitoring, regular maintenance, and reliable backup solutions.

Data integrity and accuracy are additional areas of concern. There have been instances at KBC Rebro where the HIS displayed incorrect patient information, such as mismatched medical records, outdated test results, or missing laboratory data. Such errors can have serious consequences, including misdiagnoses and inappropriate treatment plans, potentially compromising patient safety. The lack of real-time validation and synchronization across different HIS modules further exacerbate these challenges, making it crucial for the hospital to implement stricter quality control measures and regular audits of digital records (KoHOM, 2024).

The usability and design of the HIS interface also pose challenges for healthcare professionals. Many staff members have reported that the system is not intuitive and can be difficult to navigate. Retrieving patient information often requires multiple steps, and the complexity of the interface increases the likelihood of user errors. Consequently, staff require extensive training to operate the system efficiently, and even experienced users may experience delays in accessing vital patient data. This can reduce the amount of time available for direct patient care and create additional workload for hospital personnel (Martínez-Pérez et al., 2023).

Integration with external healthcare systems is another significant limitation. While the HIS is designed to streamline the flow of patient information within the hospital, it does not always communicate effectively with external databases, including those used by family doctors or

other healthcare providers. Incomplete synchronization of records can result in fragmented patient histories, duplication of tests, and delays in treatment planning, which negatively impact continuity of care. Patients with chronic or complex conditions are particularly affected, as gaps in information can hinder accurate clinical decision-making and increase the risk of medical errors (Martínez-Pérez et al., 2023).

Cybersecurity vulnerabilities have also emerged as a critical concern for KBC Rebro. The ransomware attack on the hospital in 2024 exposed weaknesses in the IT infrastructure, resulting in temporary loss of access to sensitive patient data. Although the system was eventually restored and no long-term harm was reported, the incident highlighted the risks associated with digitalization and the importance of implementing robust security measures, including regular software updates, staff cybersecurity training, and comprehensive backup protocols to protect patient information from potential breaches (N1 Hrvatska, 2024).

Resistance to change among healthcare staff represents a human factor challenge. Many employees accustomed to traditional paper-based methods find it difficult to adjust to digital workflows. The shift requires not only technical training but also a cultural change in how care is documented and managed. Resistance to adopting the HIS can prevent the hospital from fully realizing its benefits and may necessitate ongoing support and education to encourage consistent usage across all departments.

Financial and operational factors also contribute to the system's disadvantages. Implementing and maintaining an HIS is an expensive undertaking, involving costs for hardware, software, staff training, and regular updates. For KBC Rebro, these expenditures can strain the hospital budget and potentially divert resources from other areas of patient care. Moreover, limitations in technical support and maintenance infrastructure have resulted in delays when addressing system issues, prolonging downtimes and affecting hospital efficiency. These factors collectively illustrate that while HIS enhances hospital operations, careful planning and resource allocation are essential to mitigate its disadvantages (Martínez-Pérez et al., 2023).

In conclusion, the HIS at KBC Rebro, while transformative in improving access to information, streamlining workflows, and supporting patient care, faces multiple disadvantages that must be addressed. System reliability, data accuracy, usability, integration with external systems, cybersecurity, staff adaptation, operational costs, and maintenance support all present ongoing challenges. Addressing these issues through improved infrastructure, staff training, and enhanced cybersecurity measures is critical to ensuring that the HIS continues to provide high-quality support for hospital operations and patient safety.

4.1.4 System for registering and referrals (CEZIH)

One of the key healthcare institutions using CEZIH is KBC Rebro. At KBC Rebro, CEZIH is heavily utilized for the referral of patients for specialized tests, consultations, and treatments. The process starts with a family doctor or general practitioner issuing an e-referral through the

system. This referral is sent electronically to the relevant department or clinic within KBC Rebro. Once received, the specialist reviews the referral and determines the appropriate course of action. The patient is then contacted and scheduled for an appointment or examination. The use of CEZIH streamlines this process, allowing for quicker turnaround times for both appointments and diagnostic results (Kralj, 2012).

Patients benefit from this system as it ensures that healthcare providers have up-to-date, accurate information about their medical history, which ultimately leads to better treatment outcomes. The system's design facilitates effective and timely communication between various departments within a hospital, and between different healthcare facilities. It reduces waiting times for patients, as doctors no longer have to manually search for patient records or wait for paper-based referrals. Additionally, the digital nature of CEZIH makes it easier for healthcare professionals to track a patient's medical journey, ensuring continuity of care. Another significant advantage of CEZIH is the improved patient safety it offers. Since the system eliminates the need for handwritten medical records, the chances of misinterpretation or loss of important patient data are significantly reduced. The ability to quickly retrieve and update patient records helps healthcare professionals make more informed decisions, ultimately improving the quality of care (Draušnik et al., 2021).

Studies have shown that electronic health IS like CEZIH contribute to reducing medical errors and improving patient outcomes. According to research published in the Journal of the American Medical Informatics Association (JAMIA), health IS reduce the likelihood of miscommunication between healthcare providers and patients, enhancing the overall patient safety environment (Buntin et al., 2011). Moreover, electronic referral systems have been shown to expedite patient care and reduce administrative costs in multiple health settings (Häyrinen et al., 2008).

Despite its many benefits, there are some challenges and reliability concerns. CEZIH has faced certain challenges that impact its efficiency. Technical issues, such as system downtimes or slow performance, can disrupt the referral and appointment scheduling process. For instance, in March 2024, there were reports of CEZIH system outages, which caused disruptions in the processing of electronic prescriptions and referrals. These issues made it difficult for patients to access medications, and many were unable to proceed with their appointments or medical procedures. Such interruptions highlight the importance of a robust IT infrastructure and continuous support for maintaining the system's reliability.

The Croatian Ministry of Health and relevant authorities are aware of these challenges and have been working on improving the system's resilience to avoid such disruptions in the future. Research from the Health Affairs journal emphasizes that system reliability is essential for the success of health information technology (HIT) systems, as any failure can delay critical patient care (Blumenthal et al., 2010).

Worth mentioning here is the patient's experience and transparency. CEZIH's role in improving healthcare delivery is significant. The system not only ensures faster access to appointments and treatments but also promotes transparency. Patients are better informed about their medical conditions and the steps being taken in their care. Information such as test results, treatment plans, and appointment reminders are communicated promptly through the system. However, patients sometimes face challenges when there are delays or technical issues within the system.

To address this, healthcare facilities, including KBC Rebro, are continually working to ensure that patients have access to alternative ways of getting information and rescheduling appointments if necessary. A study conducted by the International Journal of Medical Informatics (2014) found that when patients have access to clear communication about their medical status, patient satisfaction significantly improves, as does trust in the healthcare provider (Van der Meer et al., 2014).

The future of CEZIH is bright, with plans for continued improvements in both functionality and user experience. As technology evolves, the system is expected to integrate with newer digital healthcare solutions, making the entire healthcare ecosystem in Croatia more interconnected and efficient. There is also a focus on enhancing patient-centered care by enabling more personalized and accurate treatments based on data stored within CEZIH. With the growing adoption of telemedicine and digital health solutions, CEZIH's role in ensuring the smooth transfer of medical information across platforms will become even more critical.

A study in Telemedicine and e-Health (2021) highlighted that telemedicine combined with robust health IS improves healthcare accessibility and reduces geographic barriers for patients, particularly in rural areas (Hollander et al., 2021). As Croatia's healthcare system continues to modernize, the integration of CEZIH into daily practices will likely become more seamless, benefiting both healthcare professionals and patients. For patients at KBC Rebro, this means that access to healthcare services will continue to improve, making healthcare more accessible, efficient, and patient-friendly.

4.2 Proposed solutions for improvement of Information Systems

In this section, I'm providing the improvement for the IS for registering and referrals (CEZIH) in KBC Rebro. Motives for that is that in Croatia in general as well as in KBC Rebro there are a lot of issues related to the patients not coming to the scheduled appointment. Of course, there are various motives like: emotional fear of the bad news about the disease, bad experience with the employees from the hospital etc. (Žabkar, 2019).

This issue significantly affects the efficiency of healthcare delivery, leading to wasted time slots, longer waiting lists, and additional administrative workload. To understand the main reasons for patient no-shows is therefore crucial. The most common motives are usually

emotional factors such as fear of receiving bad news regarding their health condition as well as previous negative experiences with hospital staff or the healthcare system in general.

Worth to mention is also logistical issues such as unclear appointment reminders, long waiting times, or difficulties in managing electronic referrals through CEZIH can further contribute to patient dissatisfaction and missed appointments. The proposed system improvements aim to address these challenges by introducing more user-friendly digital solutions, automated communication tools, and better integration between patients, general practitioners, and hospital departments (Žabkar, 2019).

Fee and Hardan came to conclusion that efficiency of attendance was higher after introduction of reminders and alerts via phones or text messages in dental medicine in Scotland. (Fee PA, Hargan AM., 2016). The same conclusion about the reminders and alerts via text messages in case of long-term waiting appointments came also Gurol-Urganci et al and they noticed that response was better when the alerts and reminders were sent. Additionally, to that, the costs were lower by sending SMS than phone calls (Gurol-Urganci, 2013)

The integration of an AI chatbot into the appointment scheduling system KBC Rebro offers numerous advantages, enhancing operational efficiency, patient satisfaction, and overall healthcare delivery. This technological advancement aligns with global trends in digital health transformation, providing a modern solution to traditional challenges in hospital management. Automated reminders and alerts sent to patients 24 hours (could be days or weeks) before their scheduled visits have been shown to decrease no-show rates by up to 60% (GoodStart AI Insights, 2025). By proactively notifying patients, chatbots ensure higher attendance, leading to better utilization of hospital resources and improved scheduling efficiency.

The proposed solution involves the implementation of an AI-based chatbot system designed to improve communication and coordination between healthcare institutions and patients. The primary function of this system would be to issue automated reminders and alerts concerning upcoming medical appointments, thereby ensuring that patients are timely informed and less likely to miss their scheduled visits.

Beyond the initial reminder, the AI chatbot would serve as an interactive communication tool, allowing patients to engage in real-time conversations to obtain relevant information and clarification about their appointments. Patients could, for instance, inquire about the exact location of the clinic or department, specific preparation instructions prior to examinations or procedures, and the possibility of rescheduling or canceling an appointment. Additionally, the chatbot could be programmed to provide further guidance related to required documentation, hospital navigation, or general procedural expectations. Such features would not only enhance patient satisfaction but also contribute to a reduction in administrative workload and inefficiencies within the hospital system.

The notification system would function through multiple communication channels, including mobile phone alerts (via SMS or application notifications) and e-mail correspondence. The inclusion of e-mail as a supplementary communication method is particularly important, as it mitigates the risk associated with patients changing their phone numbers without updating their contact information. By utilizing a dual-channel communication strategy, the probability of successfully reaching patients is significantly increased. Consequently, this approach is expected to improve appointment attendance rates, optimize scheduling efficiency, and ultimately enhance the overall quality and reliability of healthcare service delivery at KBC Rebro (Blæhr et al., 2018).

The Alert and communication with AI chatbot will be processed afterwards through few simple steps. First step will be getting the alerts, for example a week before the scheduled check. In the second step patients will have 2 options to choose from and have an obligation response with one of the options provided. These options would be:

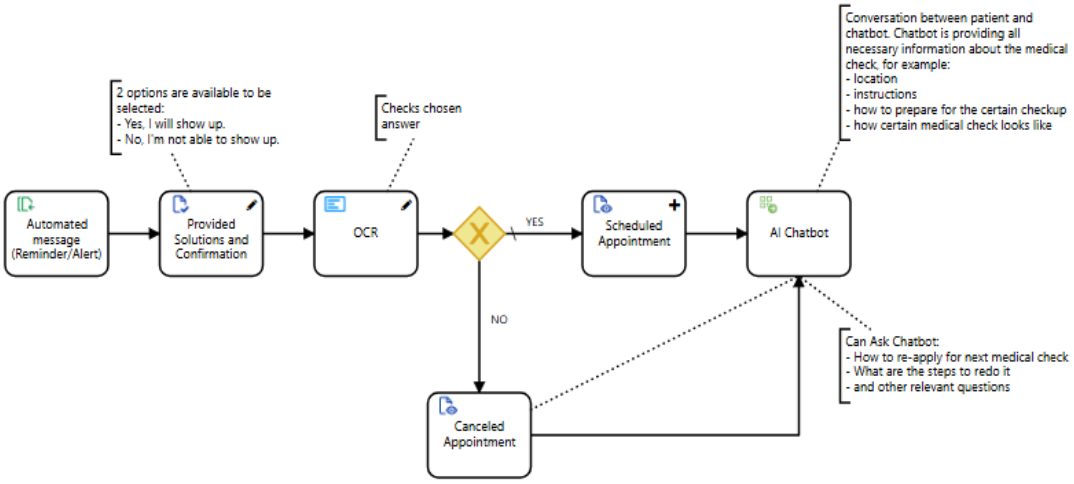
- confirmation of the certain date,
- cancellation of scheduled appointment.

In case the patient confirms the scheduled appointment then the AI chatbot is available for further communication. Equally important is the chatbot's two-way communication capability. Instead of serving merely as a reminder system, the AI assistant can actively engage with patients, allowing them to confirm, reschedule, or cancel appointments directly through chat. It can also respond to common inquiries, such as hospital location, parking information, or preparation instructions for diagnostic procedures. This interactivity improves patient convenience and reduces the volume of routine, time consuming, calls handled by hospital administrative staff. In cases where patients require more detailed or sensitive information, the chatbot can escalate the conversation to a human staff member, ensuring that complex or urgent issues are addressed appropriately.

In case of cancellation, patients should again contact family doctors or the one that issued the E-referral and reschedule new first possible appointment. To motivate patients to actively participate and follow instructions, some penalties can be introduced.

In Figure 3 the process of what this would look like is shown. There are few steps that would need to be satisfied to get the valid results.

Figure 3: AI chatbot solution process



Source: Own work.

In the graph above my suggestion is the following: Firstly, the patient or the one who needs to attend for a medical check will get an alert message that will consists of two parts: First part will remind the patient about the scheduled medical check, and the second part will provide two options that can be selected. Potential two options can be "I confirm the date of medical check" and other options would be "I can't show up on the scheduled medical check". There will be an activity instance called optical character recognition (OCR) that is trained and able to read the answer and, based on the response, take further actions like confirm the appointment or remove the appointment (Nagy, 2002). This would also have a huge impact on the specialists and doctors who are overbooked.

Then the AI chatbot will give opportunities to the patient to have a conversation about the topic related to the scheduled appointment. So patients can ask everything that they are curious about and they can easily get some basic information that would usually be very time consuming for employees when those are mostly repetitive information's that can easily be done by having AI chatbot that will answer on all of this questions and free the rest of the employees to give them opportunity to deal with some other work. Worth mentioning is that also people will feel more relax to ask a couple of times some questions that they do not understand. The reason for that is that patients can feel stupid or even fear about being ignored about some questions that for them might be crucial for understanding the procedure.

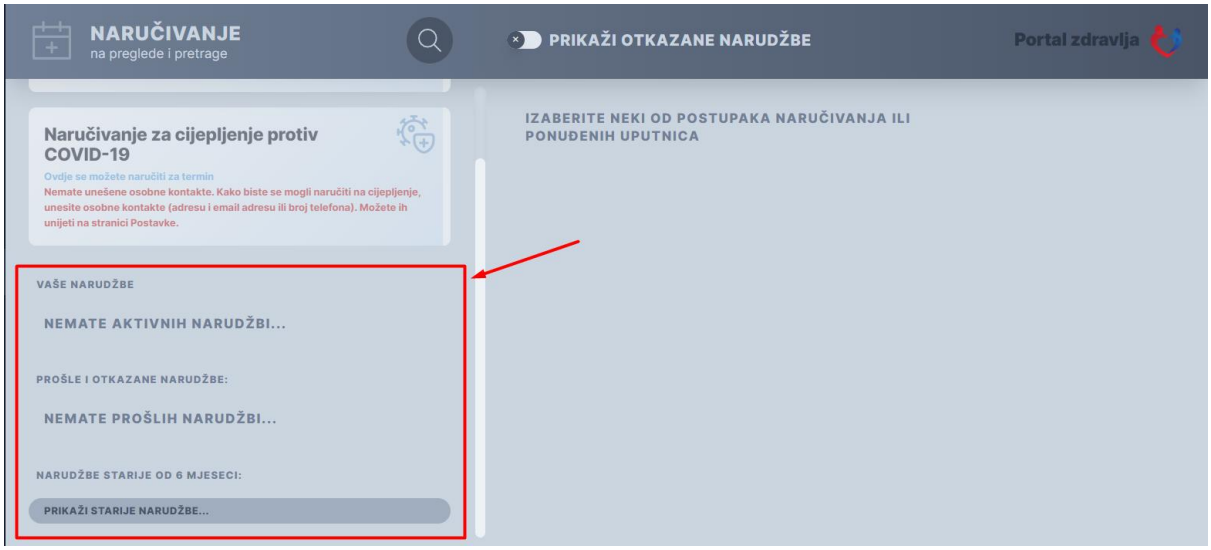
4.2.1 CEZIH - “E-referrals”

In 2003. with the aim of improving the efficiency of the healthcare system, Croatia started to put more emphasis on digitalization of the information system. In 2011. E-uputnica (E-referrals) was a substitution for the previously paper-based medical appointments (Lipnjak, 2024).

E-referral (e-uputnica) is the system that is used for scheduling specialist examination, diagnosis and also hospital care. Doctors are the ones who issue electronic referrals that is part of the Croatian healthcare system, CEZIH. In hospitals, like KBC Rebro E-referrals are immediately available and there is no need for paper-based referrals or additional communication with the doctor or specialist (Anthony et al., 2019).

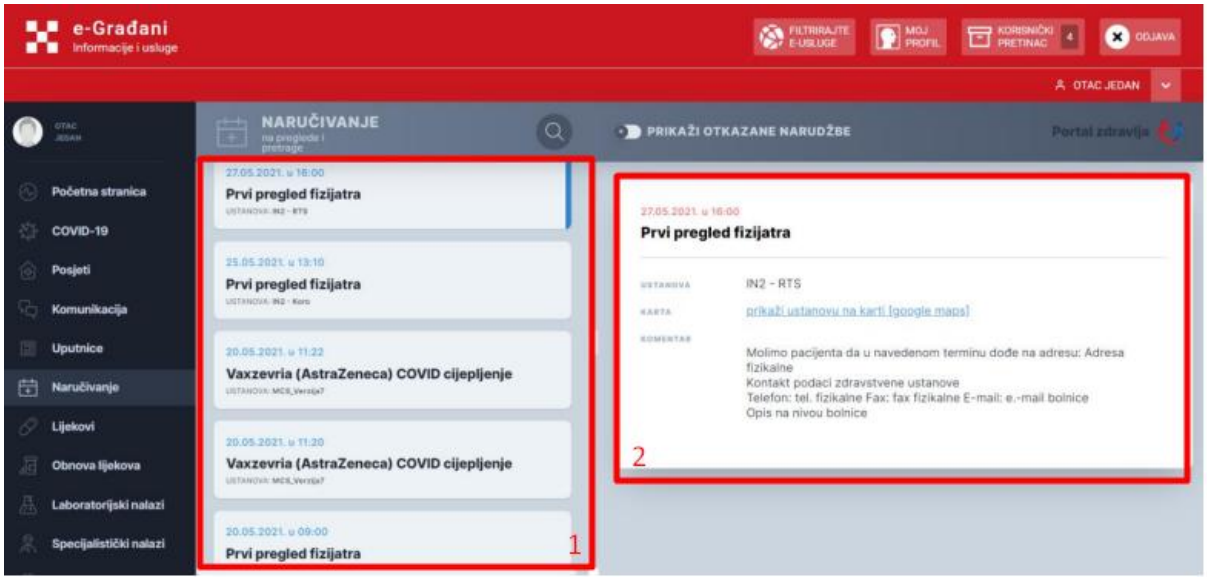
First step after the referrals are issued is that patients should request an appointment and this can be done in various ways like by e-mail, phone, personally in the hospital or official website of KBC Rebro. The patient’s obligation is to carefully fulfill the personal information and provide historical medical documentation to help with triage, if needed (Anthony et al., 2019). In the figure below we can see how it looks.

Figure 4: E-referrals



Source: Own work based on Portal Zdravlja (2025).

Figure 5: Example of scheduled appointment



Source: Portal Zdravlja (2025).

In the figure above it can be seen how the E-referrals look like. On the highlighted spot number 1 there is a list of all active appointments that are scheduled. On the highlighted spot number 2 is a brief description of the referral.

4.2.2 Examples of chatbot reminders for the appointments

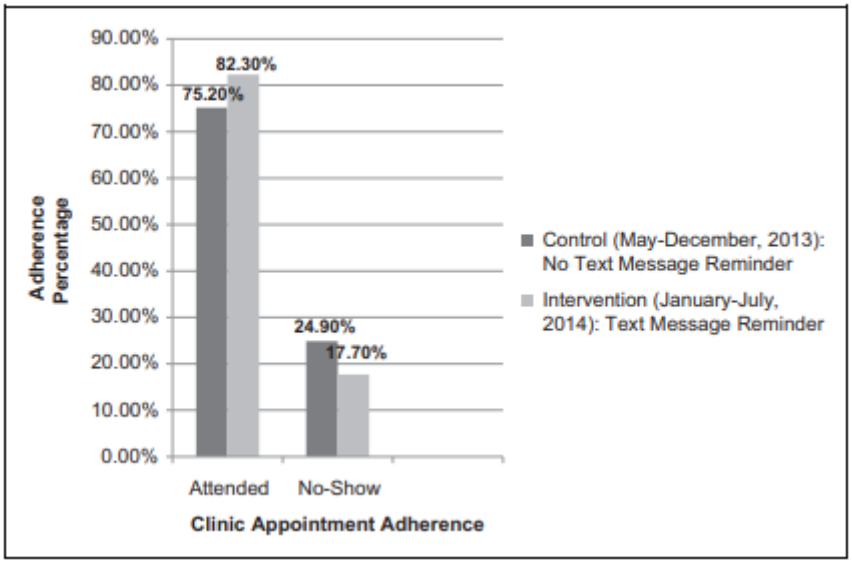
Studies have been conducted about the effectiveness of text message reminders on patient attendance. The hypothesis is that a patient is less likely to miss an appointment if he is reminded of it via an SMS message (Youseff et al, 2019).

Youseff et al., as well as Anthony et al. have published similar studies on this topic. Both of these papers have reached the same conclusion: using text messaging system decreases the number of no-show patients (Youseff et al, 2014)

Anthony (2019) conducted the study on 331 patients. The study was conducted in Texas at Ryan White-funded HIV clinic in EL Paso. All the participants that were part of a study signed a waiver agreeing that through the web-based texting service will get alerts and reminders. Besides that, participants could have also texted back if they were unable to attend the particular check and asked for rescheduling the appointment (Anthony et al, 2019).

173 patients did not receive a text message message reimnder, while the other 158 did. As expected, the SMS reminder served its purpose – the SMS alerted patients showed up to the appointment in bigger numbers, by a margin of 7,1 % (as shown in the figure below). In addition, the study concluded that an extra 38 patients attended their appointments who wouldn't have shown up if the usual practice continued (Anthony et al, 2019).

Figure 6: Adherence percentages of patients with or without (dark grey) an SMS alert



Source: Anthony et al. (2019).

A study about the same topic was conducted by Youssef et al. (2013). It was also concluded that the use of SMS reminders reduces the non-attendance rate. The non-attendance rate was significantly lower in the reminder groups compared to the no-reminder groups (as high as 14,5 % in one group). The study questioned the patients about their satisfaction with the SMS alert system. Out of 166 patients interviewed, the overwhelming majority were satisfied with the new system (as shown in the figure below).

Figure 7: Satisfaction results with SMS

Table 4: Satisfaction results with the SMS reminder service.

Item	$N = 166$	Percent agree (%)
Had a chance to read the message	163	99
SMS clarity	159	96
Keep the message service	166	100
Messages help patients to remember	128	77

Source: Youssef et al. (2013).

4.2.3 Interview with employee

To assess the feasibility of implementation of AI alert/reminder solution and to see how KBC Rebro staff would respond to the new system, I had an opportunity to speak with a system administrator at KBC Rebro with seven years of experience in the hospital's Clinical Informatics Unit. They play a key role in maintaining the IT systems that support daily clinical operations. Full interview can be seen in the Appendix 1.

The interview included various questions regarding the information system in the KBC where he provided a better understanding of IT systems in the hospital in general, as well as added suggestions for possible future improvements to be of better quality that will increase the efficiency and capability of the HIS.

Table 1: Interview questions

No. of Question:	Questions:
1.	Please introduce and state your name and your occupation?
2.	How long have you been in the hospital and what department?
3.	Can you tell me what your day-to-day responsibilities are?
4.	Can you tell me about software systems like CEZIH?
5.	Can you tell me how do E-referrals work?
6.	Do you think AI chatbot will introduce some future improvements in the hospital?

Source: Own work.

Their responsibilities include monitoring critical hospital systems such as the Hospital Information System (HIS), the RIS, and the LIS ensuring they run smoothly and securely. CEZIH is the national Central Health Information System. E-referrals, E-prescriptions, medical records are some electronic health services provided by CEZIH.

So, E-referrals are digital substitutions of traditional paper, and they are sent through CEZIH electronically. Practically, it serves as interaction between primary care (family doctor) and secondary care (specialists). Some steps how it works looks like this: *Firstly, patients visit family doctor, Doctor enters e-referral into CEZIH, based on that they schedule the first available appointment and send appointment via SMS, phone call or throughout family doctor".*

Looking toward the future, the administrator sees strong potential in implementing AI chatbot that will serve as a reminder to the patients as well as for hospital stuff: "*Right now, when healthcare institutions are facing lack of employees AI chatbot for alerts for appointments will help our overbooked system to reduce the problems with patient appointments"*. While not yet fully implemented at KBC Rebro, AI chatbots and tools could provide real-time clinical guidance, can help avoid missing appointments (or at increase appointment attendance), and help doctors to not have missed appointments.

The administrator emphasized the importance of AI tools, especially in terms where people have scheduled appointments in about half of a year (or even more). Usually, in this case, patients miss the appointment due to long period of waiting. Even if they put reminders on their phone usually, this is not enough. AI chatbot will beside that avoid the have some inappropriate conversations because people sometimes get guidelines and instructions but just don't follow them or need to ask several times the same questions. Overloaded employees from hospitals

sometimes lose patience with that kind of person and can start to be angry and rude what makes patients even more scared of asking. By using AI chatbot they will be able to ask whenever and whatever need they have regarding the scheduled appointment.

4.2.4 Feedback from KBC Rebro employees

Based on all the advantages and disadvantages discussed earlier, I have conducted a survey of employees in KBC Rebro to see their familiarity with AI as well as how they would be willing to accept potential new technologies. I decided to conduct a survey composed of ten questions, which would capture the sentiment that all of the employees had towards AI and implementations of new technologies and software in general. The sample size consists of 20 employees, which I manage to find on the premises of the hospital. Worth mentioning is that all the participants come from different departments and levels of employment. Their status is shown on the table below.

Table 2: Survey responders' employment status

Employee status:	**No. of participants:**
Head of department	1
Doctors	5
IT technicians	3
Nurses	5
Administrative personnel	3
Radiologist	1
Physiotherapist	2

Source: Own work.

I decided to make 10 questions related to how people are comfortable with using AI and their knowledge of it. The responses to these questions were measured using a Likert scale ranging from completely agree to completely disagreement. This approach allows for a more nuanced understanding of participants' opinions, providing insight into the degree of confidence or hesitation they might experience when interacting with AI systems. By analysing these responses, we can estimate how individuals might respond to or confront new challenges related to the increasing integration of AI into modern society. The results are presented in the table below, where Table 3 outlines the various questions that were used in the survey.

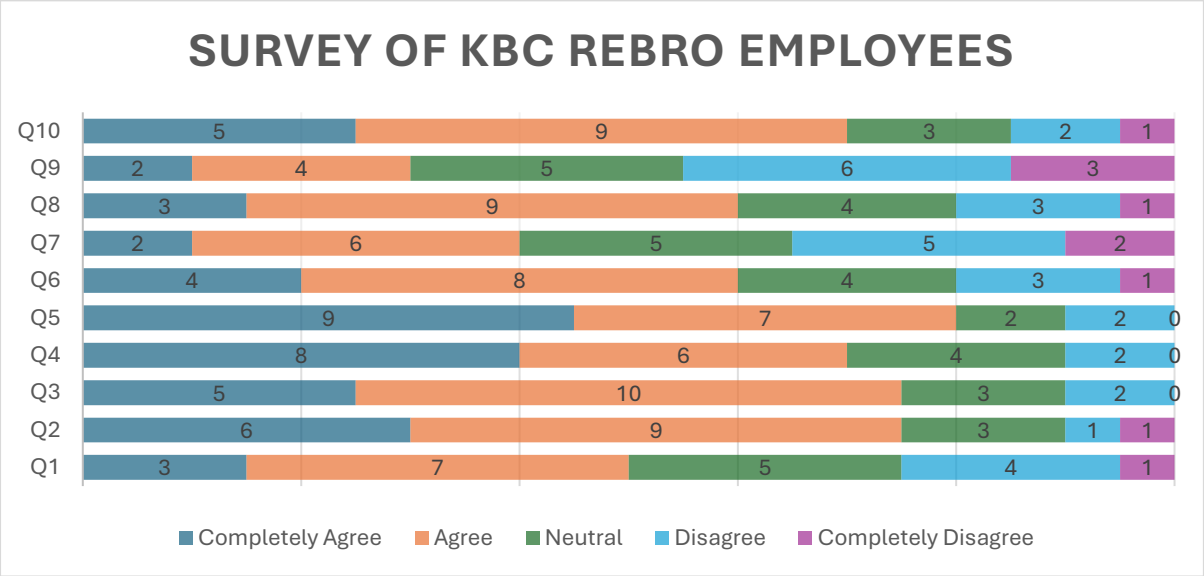
Each question has been carefully designed to explore different aspects of people's comfort and understanding of AI. To make the analysis process more efficient, every question has a unique identifying mark, allowing for easy reference and comparison of responses.

Table 3: Survey questions

Mark:	Questions:
Q1	I am familiar with using artificial intelligence (AI) in a healthcare setting.
Q2	Our hospital currently needs assistance with AI to improve efficiency, care and communication quality.
Q3	AI can provide very useful and helpful recommendations and support to healthcare professionals.
Q4	There are significant risks and fear of staff shortages in our hospital in the near future.
Q5	Using AI in clinical practice seek extensive training for staff.
Q6	I believe AI will become a trusted team member in my department within the next 5 years.
Q7	Patients will trust AI recommendations as much as those from human doctors.
Q8	I am comfortable with patients interacting with AI tools before seeing a human doctor or nurse.
Q9	AI should have a role in making ethical decisions in critical care situations.
Q10	AI has the potential to detect patient risks or complications earlier than human staff.

Source: Own work.

Figure 8: Survey of KBC Rebro employee results



Source: Own work.

Q1: I am familiar with using artificial intelligence (AI) in a healthcare setting.

The results in the survey indicate that more than half of the participants are familiar with using AI with only one person showing no knowledge of it at all. This shows that implementing new AI technologies is a viable solution since the workforce would require no or a minimum amount of education to use it properly. Worth mentioning is that the person who showed no knowledge

of it is near the retirement age. This shows us that new younger generations are more familiar with it while the older generations show more difficulties.

Q2: Our hospital currently needs assistance with AI to improve efficiency, care and communication quality.

The result on this question shows that around 75% of the participants believe hospitals can be improved with AI and they believe their current care quality is not efficient as it would be with some new AI implementation. AI could be much of help when talking about communication on relation patient-hospital employees. It can reduce the waste of time that is spent on repetitive talk and chat. That's why I came to idea that AI chatbot would be perfect implementation for such communication.

Q3: AI can provide useful and very helpful recommendations and support to healthcare professionals.

Like the previous question the results for question number three show that 75% of the participants believe AI can provide helpful recommendations in their day-to-day work. The correspondent that in previous question selected "completely disagree" gave an argument for this question that while they don't believe that doctors should use AI assistance in their work it could be however utilized in more administrative procedures.

Q4: There is a significant risk and fear of staff shortages in our hospital in the near future.

In this question majority of the participants agree that there could be a risk of stuff shortages in the near future, however there are still 30% of the participants that do not see this as an issue. One of the correspondents mentioned that due to the lack of doctors and hospital staff in Croatia AI still can be very useful and additionally can actually help and take over from other already overbooked employees.

Q5: Using AI in clinical practice seek extensive training for staff.

Results show that majority of the survey respondents are aware of difficulties that arise from implementing AI and that there is a need for a lot of training, awareness sessions and continuous education in order to make this system work.

Q6: I believe AI will become a trusted team member in my department within the next 5 years.

In this question again we can see that majority of participants agree that in the next 5 years AI will become trusted members in their departments. Again, it is worth mentioning that almost all participants that had not agreed to are older aged people and they admit by themselves that they are afraid because they are not much into digitalization processes and they are afraid of unknown.

Q7: Patients will eventually trust AI recommendations as much as those from human doctors.

In this question answers were divided almost by half. This is understandable because people still believe more humans than AI. But they do think that in recent years AI can provide satisfying results about recommendations.

Q8: I am comfortable with patients interacting with AI tools before seeing a human doctor or nurse.

I expected more suspicious thinking of people related to this statement but they are very positively adopting using AI for interaction before seeing doctor, even though of course it is expected that direct communication with doctor is always the first choice.

Q9: AI should have a role in making ethical decisions in critical care situations.

The responses show a divided perspective on the role of AI in making ethical decisions in critical care. While around 30% of participants support the idea, either agreeing or totally agreeing, a larger portion (45%) disagrees, indicating skepticism or concern about entrusting ethical judgment to AI. A significant number (25%) remain neutral, possibly reflecting uncertainty or the complexity of the issue.

Q10: AI has the potential to detect patient risks or complications earlier than human staff.

The majority of participants (around 70%) believe that AI has the potential to detect patient risks or complications earlier than human staff, showing strong support for AI's role in enhancing early detection in healthcare. Only a small minority (15%) disagreed, while 15% remained neutral.

This suggests a high level of confidence in AI's analytical capabilities and its potential to assist or augment clinical judgment. The responses reflect a general optimism about AI's ability to process large amounts of data quickly and identify subtle patterns that may be missed by human staff, potentially improving patient outcomes through earlier intervention.

5 CONCLUSION

Based on the findings of this research, it can be concluded that the integration of a chatbot system designed to send reminders and alerts to both patients and hospital staff has the potential to significantly reduce the number of missed (no-show) appointments. By automating appointment reminders through multiple communication channels, such a system ensures timely notification and improves overall scheduling efficiency within healthcare facilities.

One of the key advantages of this solution lies in its flexibility. In cases where patients are unable to attend their appointments due to forgetting or unexpected circumstances the system could allow doctors or administrative staff to quickly reschedule the time slot for another patient, thereby minimizing wasted time and optimizing healthcare resource usage.

While existing studies and implementations tend to rely heavily on SMS and phone calls for appointment alerts, this thesis proposes expanding the communication strategy to include email notifications as well. This approach addresses a common issue: mobile phone numbers may change or become inactive, and individuals do not always remember to update their contact information. In contrast, email addresses tend to remain stable over time, offering a more consistent and reliable point of contact. By incorporating both SMS and email, healthcare institutions can increase the likelihood of successful message delivery.

Implementing such an AI-powered reminder system can provide tangible benefits for both patients and healthcare providers. Patients are more likely to stay informed and adhere to scheduled appointments, while doctors and hospital staff gain better visibility into attendance and can manage their time more effectively. Over time, this could improve the overall quality of care and patient satisfaction, as well as reduce administrative burden.

Looking ahead, future enhancements could include the introduction of light accountability mechanisms for instance, soft penalties for patients who consistently ignore or fail to respond to reminders without valid reasons. While such measures would need to be carefully designed to remain fair and ethical, they could further encourage responsible behaviour. However, the success of such systems depends on fostering a culture of mutual respect, empathy, and awareness where both patients and providers value each other's time and commitment.

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APPENDICES

Appendix 1: Interview with the IT administrator at KBC Rebro

- Please introduce and state your name and your occupation.

“I would like to stay anonymous, but I work as a system administrator here at KBC Rebro, mainly responsible for maintaining and supporting the hospital’s IT infrastructure and clinical applications.”

- How long have you been in the hospital and what department?

“I've been working at the hospital for approximately 7 years, and I'm part of the IT Department, specifically within the Clinical Informatics Unit. My work primarily involves supporting medical staff with the hospital's EHR systems, maintaining CEZIH system, ensuring system uptime, and implementing updates or improvements in collaboration with clinical teams.

- Can you tell me what your day-to-day responsibilities are?

“As a system administrator at KBC Rebro for the past seven years, my day-to-day responsibilities revolve around keeping our hospital's IT infrastructure stable, secure, and responsive to clinical needs. Every day starts with monitoring the core systems including the hospital information system (HIS), RIS, and LIS to ensure all services are running smoothly and without errors. Any system alerts, slowdowns, or connection issues need to be addressed immediately, especially if they affect patient care or critical workflows like imaging or diagnostics. A big part of my job involves supporting hospital staff doctors, nurses, and technicians by resolving access issues, helping with application errors, or assisting with electronic medical documentation problems. We also regularly manage user accounts, apply software updates, monitor server performance, and ensure that our backups are completed successfully and securely stored. Because hospitals are sensitive environments, we have to be extra cautious about cybersecurity: patching vulnerabilities, monitoring unusual activity, and enforcing strong access policies is part of the routine.”

- Can you tell me about software systems like CEZIH?

“So, CEZIH is one of the main and key components of our digital healthcare infrastructure and essential for the daily operations. It is integrated with our HIS and supports and provides e-services such as e-referral, e-sick leave, e-laboratory information exchange and some more. My responsibility as a system administrator is to maintain the software and connections and keep it stable and secure so doctors and patients can rely on accurate data exchange all the time.

- Can you tell me how do E-referrals work?

E-referrals is one of the services provided by CEZIH. IT enables exchange referrals between patients and healthcare providers in electronic way. It is fully integrated into HIS at KBC Rebro. It works in the following way: family doctor creates an electronic referral in their application, and this app is connected to CEZIH. Type of referral is selected also by family

doctor in order to see what kind of check or diagnosis needs to be done. After submission the referral is automatically sent to CEZIH and CEZIH validates tis referral by assigning the unique ID number and provides it to somebody to whom is addressed."

- Do you think AI chatbot will introduce some future improvements in the hospital?

"Absolutely, I believe AI chatbot has potential to improve both the quality and efficiency of care in a hospital like KBC Rebro. Right now, there are a lot of issues with no show ups and by introducing AI chatbot that will communicate and handle the conversation with the patient will free already overloaded hospital employees and give them opportunity to deal with some other tasks. For example, we had a lot of cases where people unfortunately are losing our time by asking (for us) stupid repetitive questions and this could easily be covered with some simply AI chatbot that will handle such questions and conversations and be patients with them since sometimes humans can react emotionally and be even rude or not polite to some people due to repetitive work that they need to do, Patients sometimes do not follow the rules and instructions and tend to ask again and again same questions.