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Artificial Intelligence and Chatbots in Patient Management

Artificial intelligence (AI) and chatbots are expected to play an increasingly important role in patient management systems worldwide. These technologies have the potential to support preliminary triage, reduce waiting times, and alleviate the administrative burden placed on healthcare professionals. At the same time, their application raises substantial challenges related to data protection, ethical accountability, clinical responsibility, and professional practice. The purpose of this study is to present the opportunities and limitations of chatbot applications in healthcare and to illustrate their regional relevance in Hungary through the example of Northern Hungary. Based on a structured literature review and secondary data analysis, the findings indicate that chatbot integration may contribute to enhanced system efficiency and reduced inequalities in access to outpatient care, provided that implementation is accompanied by appropriate regulatory, ethical, and institutional safeguards.
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Introduction

Healthcare systems across Europe and globally are facing persistent structural challenges related to workforce shortages, limited capacities, rising costs, and increasing patient demand. These pressures are particularly pronounced in outpatient care, where long waiting lists, administrative overload, and regional inequalities in access remain key policy concerns. In Hungary, outpatient specialist care has been characterised by significant territorial disparities, shortages of medical professionals, and prolonged waiting times, especially in socio-economically disadvantaged regions (Boncz et al., 2021; Fernandes et al., 2021). In response to these challenges, the digitalisation of healthcare processes has become a strategic priority at both national and European levels. In Hungary, recent policy initiatives have focused on the development of digital patient management tools, including the Outpatient Routing System (ORS) and the continuous expansion of the National eHealth Infrastructure (EESZT). These systems aim to improve transparency, coordination, and efficiency in patient pathways while supporting more equitable access to care (Döbrössy et al., 2024). Within this context, artificial intelligence (AI)-based chatbots have emerged as a potentially valuable component of digital patient management. Chatbots are computer programs designed to simulate human interaction through text- or voice-based communication, typically relying on natural language processing (NLP) and machine learning techniques (Adamopoulou & Moussiades, 2020). In healthcare settings, chatbots may support preliminary symptom assessment, appointment scheduling, patient information provision, and administrative tasks, thereby reducing the workload of healthcare staff and improving patient flow. Despite these potential benefits, the implementation of AI-based chatbots also raises important concerns. Issues related to data protection, ethical accountability, algorithmic bias, cybersecurity, and patient safety remain highly relevant, particularly in healthcare systems that rely on sensitive personal and medical data. Furthermore, the effectiveness of chatbot applications

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depends on their integration into existing healthcare infrastructures and regulatory frameworks, as well as on user acceptance and digital literacy.

The research problem addressed in this study concerns the extent to which Hungary's efforts to digitalise outpatient management—particularly through the ORS and the EESZT—can be complemented by AI-based chatbot solutions, and what benefits and risks their introduction may entail. The study has a dual objective: first, to review international and domestic experiences with chatbot applications in healthcare, highlighting opportunities and limitations; and second, to evaluate the regional relevance of chatbot-supported patient management in Hungary through an empirical analysis focusing on Northern Hungary.

The main research questions are as follows:

- How can chatbots contribute to the efficiency and patient safety of outpatient management?
- What lessons can be drawn from international practice, and to what extent are these transferable to the Hungarian context?
- What ethical, data protection, and cybersecurity challenges arise in the application of chatbots in healthcare?
- How may digital patient management tools contribute to reducing regional health inequalities in Northern Hungary?

The central hypothesis of the study is that AI-based chatbots in outpatient care – particularly through supporting pre-screening, appointment management, and the reduction of no-show rates – can measurably improve system efficiency, provided that they are properly integrated into the EESZT ecosystem and aligned with the Hungarian regulatory and institutional environment

Literature Review

The application of artificial intelligence (AI) and chatbot technologies in healthcare has become one of the most dynamically expanding fields of digital health research in recent years. The literature highlights a wide range of potential benefits, including improved access to care, enhanced efficiency of patient pathways, and reduced administrative burdens. At the same time, empirical findings remain heterogeneous, and concerns related to diagnostic accuracy, ethical accountability, and user acceptance persist. Based on the reviewed literature, three interrelated thematic areas are particularly relevant for the present study: international experiences and performance outcomes, domestic developments and implementation challenges in Hungary, and the regional relevance of chatbot-supported healthcare solutions.

Performance – International Experiences

International experience demonstrates that chatbots have primarily been implemented in healthcare as supportive tools rather than autonomous decision-makers. In the United Kingdom, the National Health Service (NHS) introduced chatbot-based applications in primary care pilot programmes to support patient pre-screening and reduce administrative workload. These systems were primarily designed to guide patients toward appropriate services rather than to provide diagnoses, thereby reinforcing patient safety through professional oversight (Hindelang et al., 2024). In the United States, large healthcare organisations such as Kaiser Permanente and the Mayo Clinic have implemented chatbot solutions to assist with appointment scheduling, symptom checking, and patient information provision. During the COVID-19 pandemic, similar tools were widely adopted in Canada to manage surges in patient inquiries and reduce pressure on call centres (Bhatt et al., 2024). Empirical studies evaluating diagnostic or triage performance present mixed results. For example, the health chatbot "August" achieved an accuracy rate of 81.8% for first-hit diagnoses under controlled conditions; however, performance declined substantially when patient input was incomplete or imprecise (Bhatt et al., 2024). These findings underline that chatbot effectiveness is highly dependent on data quality and system design. The most favourable

outcomes have been observed in hybrid models, where chatbot-generated recommendations are reviewed or supplemented by healthcare professionals (Pawellek et al., 2022). Research on user attitudes further indicates that patient acceptance is strongly influenced by ease of use, transparency regarding data processing, and trust in the underlying information sources. Conversely, limited digital literacy—particularly among older populations—may constrain adoption and exacerbate inequalities if not adequately addressed (Simon et al., 2024; Mihalicza & Boncz, 2021).

Implementation – Domestic Developments and Challenges

In Hungary, digital health development has been strongly shaped by institutional initiatives and national infrastructure projects. Key academic and professional actors include the Health Services Management Training Centre (EMK) and the Institute of Digital Health Sciences (DEI) at Semmelweis University, whose research focuses on the lifecycle management of AI-based healthcare applications, clinical validation, and system-level integration (Balogh et al., 2022). The cornerstone of Hungarian healthcare digitalisation is the National eHealth Infrastructure (EESZT), which serves as a central platform for the storage and exchange of health-related data. The system contains several hundred million medical documents and is accessible to citizens through the EgészségAblak mobile application (Joó, 2024; EESZT, 2024). In addition, the e-Jelentés system of the National Health Insurance Fund (NEAK) provides an important basis for monitoring healthcare performance and supporting financing mechanisms (NEAK, 2022; Horváthné Csolák, 2025). Hungarian literature emphasises several implementation challenges relevant to chatbot applications. These include linguistic and cultural adaptation to the Hungarian language, compliance with strict data protection and cybersecurity requirements, and the need for adequate user training among both patients and healthcare professionals (Palicz et al., 2020; Olar et al., 2021). Ethical concerns are also prominent, particularly with respect to algorithmic bias, unclear clinical responsibility, and potential psychological risks associated with excessive reliance on automated systems. For instance, emerging evidence suggests that overuse of conversational agents may, in rare cases, contribute to distorted perceptions of reality among vulnerable users (AP News, 2023; Rao, 2025).

Data Sources and Methodology

The empirical analysis focuses on outpatient specialist care utilisation in Northern Hungary, specifically in the counties of Borsod-Abaúj-Zemplén, Heves, and Nógrád. The analysis is based on secondary data obtained from the Hungarian Central Statistical Office (KSH), complemented by county-level statistics collected by the authors for the period 2021–2023. Historical reference data were also drawn from the KSH STADAT database (Table 4.1.2.4.) to ensure methodological consistency. The selected indicators include the total number of outpatient specialist care cases, population figures, case rates per 1,000 inhabitants, and each county's share of the national total. Using population-adjusted indicators allows for meaningful regional comparisons and helps to control for demographic differences across counties. Aggregated regional values are compared with national totals to assess relative utilisation patterns and potential territorial inequalities. It is important to note that access to detailed waiting list data at institutional and regional levels remains limited in Hungary. Consequently, the empirical analysis primarily reflects utilisation volumes and intensity rather than direct waiting time measures. As a result, findings must be interpreted with scientific caution, particularly when drawing conclusions about system efficiency and access constraints.

Table 1 Northern Hungary counties: cases, population, cases per 1000 inhabitants and national share (2021–2023)

Year	County	Cases	Population	Cases per 1000 inhabitants	National share (%)
2021	Borsod-Abaúj-Zemplén	3,036,894	635,644	4,775	5.5
2021	Heves	1,518,207	290,396	5,227	2.7
2021	Nógrád	828,032	185,153	4,474	1.5
2022	Borsod-Abaúj-Zemplén	3,394,366	629,621	5,392	5.9
2022	Heves	1,544,054	288,430	5,356	2.7
2022	Nógrád	828,032	183,318	4,517	1.4
2023	Borsod-Abaúj-Zemplén	3,629,928	624,219	5,814	6.0
2023	Heves	1,617,659	287,533	5,627	2.6
2023	Nógrád	868,348	182,038	4,770	1.4

Source: own editing

Outpatient Care Utilisation in Northern Hungary (2021–2023)

The total number of outpatient specialist care cases in the region increased by approximately 13.6% over the observed period, rising from around 5.38 million cases in 2021 to more than 6.12 million cases in 2023. During the same period, the population of all three counties declined slightly, reflecting broader demographic trends in Hungary. The most substantial absolute increase was observed in Borsod-Abaúj-Zemplén County, where the number of cases grew by nearly 593,000 (+19.5%). Heves County recorded a more moderate increase of approximately 99,000 cases (+6.6%), while Nógrád County experienced a smaller rise of around 40,000 cases (+4.9%). When adjusted for population size, utilisation rates increased in all three counties, with the strongest growth observed in Borsod-Abaúj-Zemplén, where cases per 1,000 inhabitants rose from 4,775 to 5,814 (+21.8%). By 2023, Borsod-Abaúj-Zemplén surpassed Heves County in terms of specific utilisation intensity, indicating a structural shift in service use within the region. Nógrád County consistently exhibited the lowest utilisation rates, suggesting persistent access and capacity constraints.

Regional Trends and National Comparisons

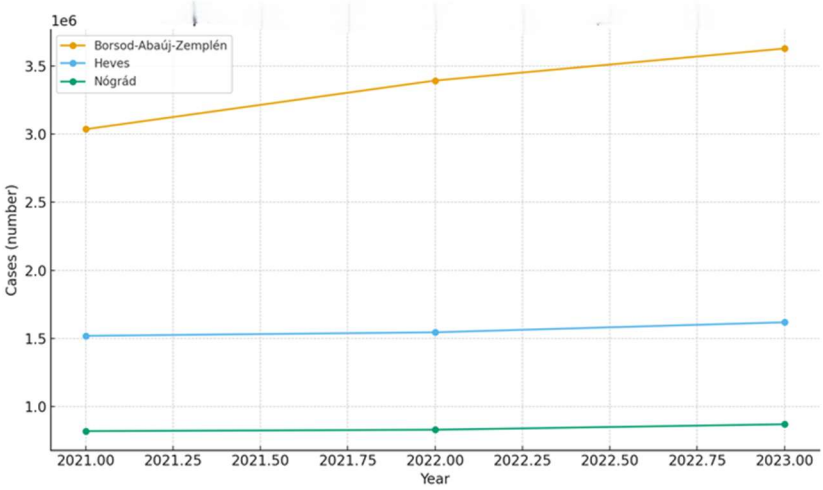

Figure 1 Outpatient visits in Northern Hungary counties (2021–2023)
Source: based on KSH.hu, own editing

Figure 1 illustrates the absolute number of outpatient specialist care cases in the three counties between 2021 and 2023. While all counties experienced growth, underlying differences in scale remained pronounced. Borsod-Abaúj-Zemplén consistently accounted for the largest share of cases, followed by Heves and Nógrád. The strongest growth dynamic was observed in Borsod-Abaúj-Zemplén, which acted as the primary driver of the regional increase.

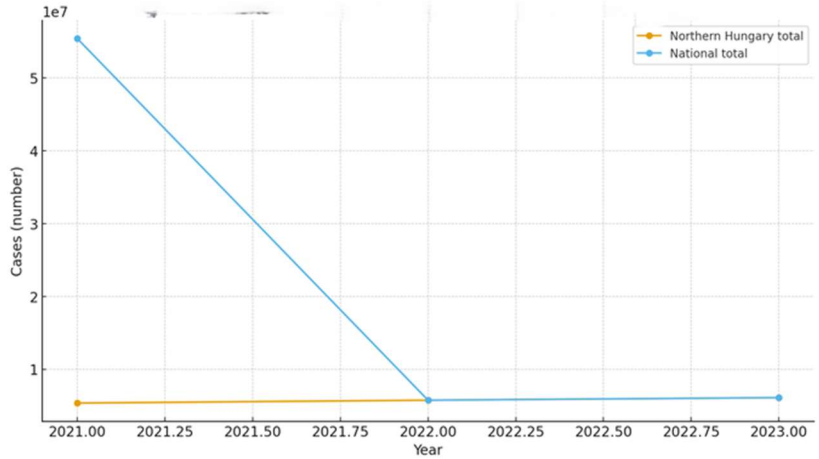

Figure 2 Outpatient visits – Northern Hungary vs National total (2021–2023)
Source: based on KSH.hu, own editing

Figure 2 compares the aggregated outpatient case volume of Northern Hungary with the national total. The region's share of national utilisation increased slightly from approximately 9.7% in 2021 to around 10.0% in 2023. This suggests that utilisation in Northern Hungary did not lag behind national growth trends during the study period, although absolute and relative disparities between regions persisted.

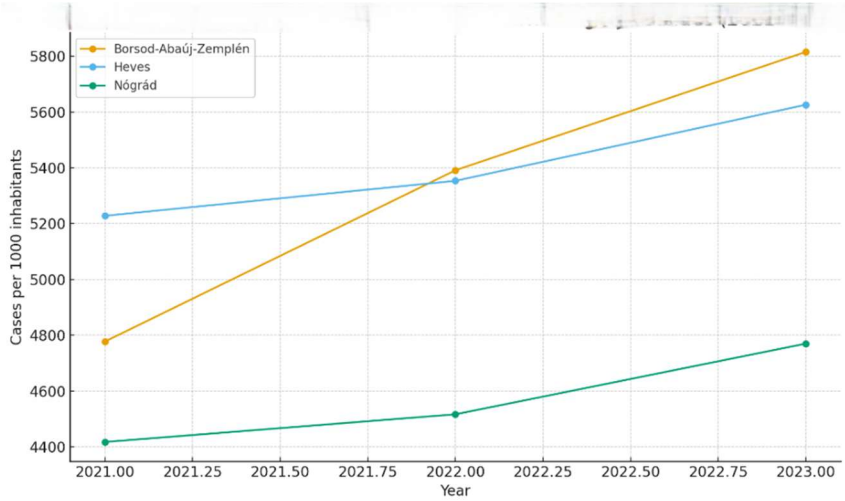

Figure 3 Outpatient visits per 1000 inhabitants – Northern Hungary counties (2021–2023)
Source: based on KSH.hu, own editing

Figure 3 presents outpatient specialist care utilisation rates per 1,000 inhabitants by county. The results indicate partial convergence among counties over time. While Heves County exhibited the highest utilisation rate in 2021, Borsod-Abaúj-Zemplén overtook it by 2023. Despite these shifts, all three counties remained below the national average in each year, highlighting a continued regional disadvantage in effective access to outpatient specialist care. Taken together, the empirical findings point to enduring territorial asymmetries in capacity and access within Northern Hungary. Although utilisation volumes increased substantially between 2021 and 2023, differences between counties persisted, and regional averages continued to lag behind national indicators. These patterns are consistent with post-pandemic readjustments as well as long-standing structural constraints in healthcare supply.

Opportunities in Hungarian Outpatient Management

Hungarian outpatient care is confronted with several interrelated challenges, including prolonged waiting times, shortages of healthcare professionals, high administrative burdens, and persistent territorial inequalities in access. Within this context, the integration of artificial intelligence (AI)-based chatbots into digital patient management systems—particularly the Outpatient Routing System (ORS) and the National eHealth Infrastructure (EESZT)—may offer relevant opportunities to improve both efficiency and equity.

Integration, Resource Optimisation and Financing

Effective patient management requires real-time information flow and coordinated decision-making across institutional boundaries. Close integration between the ORS and the EESZT is therefore essential for the successful application of chatbot-based solutions. In practical terms, chatbots may function as front-end interfaces that guide patients through preliminary symptom assessment, eligibility checks, and appointment requests, while relying on EESZT-backed data for verification and continuity. By accessing structured information on previous visits, referrals, and bookings—subject to strict access control and consent requirements—chatbots may help prevent parallel scheduling and reduce duplication of services. This can contribute to a more transparent allocation of outpatient capacities and support the prioritisation of patients based on clinical need rather than informal access mechanisms. Importantly, chatbot-generated outputs should be limited to administrative and pre-screening functions, with clinical decision-making remaining the responsibility of healthcare professionals.

Regional Inequalities and Empirical Opportunities

One of the most significant potential benefits of chatbot integration lies in the reduction of administrative workload. Chatbots can manage appointment confirmations and modifications, send reminders, provide standardised patient information, and answer frequently asked questions. These functions may substantially reduce the burden placed on call centres and administrative staff, allowing healthcare professionals to devote more time to direct patient care. From a system perspective, improved appointment management may also reduce no-show rates, which represent a major source of inefficiency in outpatient care. International evidence suggests that automated reminders and digital recall systems – including those implemented through chatbot platforms – can contribute to measurable reductions in missed appointments and more efficient use of available capacities (Laymouna et al., 2024).

Financing and Sustainability Considerations

The implementation of AI-based chatbots requires initial investment in software development, system integration, cybersecurity, and user training. However, these upfront costs must be evaluated against potential long-term savings resulting from reduced administrative expenditures, fewer unnecessary visits, and more efficient utilisation of specialist capacities. International experience indicates that the cost-effectiveness of AI-supported patient management tools is most pronounced when such systems are fully integrated into existing care pathways and supported by clear performance indicators (Laymouna et al., 2024). In the Hungarian context, alignment with financing mechanisms administered by the National Health Insurance Fund (NEAK) is essential. Transparent monitoring of performance indicators – such as waiting times, no-show rates, and utilisation intensity – may support evidence-based decisions regarding reimbursement and scaling. Without such alignment, the sustainability of chatbot-based interventions remains uncertain.

Regional Inequalities and Access

Digital patient management tools may be particularly relevant in regions characterised by limited healthcare capacity and workforce shortages. In Northern Hungary, patients frequently face longer waiting times and greater travel distances compared with national averages. Chatbots may serve as a primary digital entry point to the healthcare system, especially when combined with telemedicine solutions, thereby reducing access barriers for rural populations. The empirical findings presented in this study indicate that, despite increasing utilisation volumes, Northern Hungary continues to lag behind national averages in outpatient care access. In this context, chatbot-supported pre-screening and appointment management may contribute to more equitable distribution of available capacities and improved transparency in patient pathways. While digital tools alone cannot eliminate structural inequalities, they may form part of a broader strategy aimed at mitigating regional disadvantages.

Ethical, Data Protection, Accountability and Security Issues

The application of artificial intelligence (AI)-based chatbots in healthcare raises complex ethical, legal, and security challenges that extend beyond purely technical considerations. Given the sensitivity of health-related data and the potential consequences of erroneous or biased outputs, the implementation of chatbot solutions in patient management requires clearly defined ethical frameworks, regulatory safeguards, and institutional accountability mechanisms.

Data Protection and GDPR Compliance

Healthcare data belong to the most sensitive categories of personal information under European Union law. The General Data Protection Regulation (GDPR) establishes strict requirements for the collection, storage, processing, and transmission of personal and health-related data. In the context of chatbot applications, compliance with GDPR is not optional but a foundational prerequisite for lawful operation. From a practical perspective, chatbot systems must adhere to the principles of data minimisation, purpose limitation, and transparency. Only data that are strictly necessary for the intended administrative or pre-screening function should be processed, and patients must be clearly informed about how their data are used. Explicit and informed consent is essential, particularly when chatbots interact directly with patients and collect symptom-related information. Technical safeguards such as encryption, anonymisation or pseudonymisation, and secure authentication mechanisms are indispensable. In Hungary, integration with the EESZT further amplifies data protection requirements, as access to central health records must be logged, role-based, and auditable. Any chatbot accessing EESZT-linked data must therefore operate within clearly defined access boundaries and under continuous supervision.

Ethical Frameworks and Algorithmic Accountability

Beyond legal compliance, ethical considerations play a central role in the responsible deployment of AI in healthcare. One of the most critical ethical issues concerns accountability. Chatbots, regardless of their level of sophistication, cannot assume clinical responsibility. Medical decision-making must remain the exclusive responsibility of qualified healthcare professionals. To address this, ethical frameworks for chatbot implementation should explicitly adopt a “human-in-the-loop” approach. This means that chatbot-generated recommendations or classifications are used solely as supportive inputs, while final decisions are made by clinicians. Clear disclaimers and transparent communication are necessary to ensure that patients understand the limits of chatbot functionality and do not interpret automated outputs as medical advice. Algorithmic bias represents another major ethical challenge. AI systems are trained on historical datasets that may reflect existing inequalities or underrepresent certain population groups. In the Hungarian context, linguistic complexity and cultural specificities further increase the risk of biased outputs if training data are insufficiently representative. Regular auditing, validation, and recalibration of algorithms are therefore required to mitigate discriminatory effects and ensure fairness.

Patient Safety and Clinical Responsibility

Patient safety must remain a central consideration in any digital health intervention. While chatbots may enhance efficiency by supporting pre-screening and administrative processes, errors in symptom interpretation or inappropriate guidance may pose risks if not adequately controlled. For this reason, chatbot outputs should be restricted to low-risk functions and should never replace professional medical evaluation. Clear escalation protocols are essential. When chatbot interactions indicate potentially serious symptoms or uncertainty, the system should automatically redirect patients to appropriate professional channels. This approach not only safeguards patient safety but also reinforces trust in digital solutions.

Cybersecurity Risks

Healthcare systems are increasingly targeted by cyberattacks, including ransomware and data breaches, which can disrupt services and compromise sensitive information. The introduction of chatbot applications creates additional entry points into digital infrastructures, thereby increasing the attack surface. To mitigate these risks, robust cybersecurity measures must be implemented, including regular system updates, penetration testing, intrusion detection mechanisms, and staff training. In addition, contingency plans should be established to ensure continuity of care in the

event of system failures or security incidents. Without adequate cybersecurity governance, the potential benefits of chatbot solutions may be outweighed by operational and reputational risks.

Societal Implications and Trust

At the societal level, the widespread adoption of chatbot-based healthcare solutions raises concerns related to trust, acceptance, and inclusion. Excessive reliance on automated systems may, in rare cases, contribute to psychological risks, such as excessive attachment to virtual agents or distorted perceptions of reality among vulnerable users (Rao, 2025). Furthermore, digital health innovations risk widening the digital divide if they primarily benefit individuals with high digital literacy. Elderly patients and socially disadvantaged groups may face barriers to access, potentially exacerbating existing inequalities. To counteract these risks, chatbot implementation should be accompanied by user education, alternative access channels, and continuous evaluation of user experience. Building trust requires transparency regarding system capabilities, limitations, and performance. Public documentation, ongoing professional validation, and participatory design involving healthcare professionals and patients can support acceptance and sustainable use of chatbot technologies in healthcare.

Conclusions, Limitations and Future Research

Based on the reviewed international literature and the empirical analysis presented in this study, artificial intelligence (AI)-based chatbots have the potential to become a relevant component of modern outpatient patient management systems. Evidence from systematic reviews, pilot projects, and institutional case studies indicates that chatbot-supported solutions may contribute to improved efficiency in preliminary triage, appointment scheduling, patient information provision, and administrative processes. When appropriately implemented, these tools can reduce waiting times, alleviate workforce pressures, and enhance transparency in patient pathways. International experiences demonstrate that AI-based systems can deliver measurable improvements in patient flow and waiting time reduction when integrated into existing care structures. For example, studies report substantial reductions in average waiting times and improved utilisation of healthcare resources in settings where chatbot-supported patient management was combined with professional oversight and robust digital infrastructure (Li et al., 2021; Wah, 2025; Khare et al., 2025). These findings underline that the effectiveness of chatbots depends not on automation alone, but on their embedding within coordinated organisational and regulatory frameworks. In the Hungarian context, the integration of chatbots into the Outpatient Routing System (ORS) and the National eHealth Infrastructure (EESZT) presents particularly promising opportunities. The empirical analysis focusing on Northern Hungary confirms that, despite increasing utilisation volumes between 2021 and 2023, the region continues to face persistent capacity constraints and access inequalities. County-level outpatient care indicators consistently lag behind national averages, suggesting that digital patient management tools may be especially valuable in disadvantaged regions. Chatbot-supported pre-screening, appointment coordination, and patient information services could contribute to more equitable distribution of available capacities and improved transparency in access. At the same time, the study highlights several important limitations. First, the empirical analysis relies on secondary data sources and does not include primary patient satisfaction surveys or qualitative user experience assessments. Second, access to detailed institutional-level waiting list data remains limited, restricting the precision of regional comparisons. Third, the study does not empirically analyse the impact of Hungarian linguistic and cultural specificities on chatbot performance, although these factors are likely to influence accuracy and user acceptance. These limitations point to clear directions for future research. Further studies should focus on longitudinal monitoring of outpatient care indicators following the introduction of chatbot-based interventions, allowing for causal assessment of their effects on waiting times, no-show rates, and patient satisfaction. Pilot projects implemented in diverse

regional settings would provide valuable evidence on practical feasibility, acceptance, and cost-effectiveness. In addition, future research should examine the interaction between AI-based chatbots and healthcare professionals, with particular attention to accountability, trust, and the long-term implications for clinical workflows. In conclusion, AI-based chatbots may become an integral part of the Hungarian healthcare system if their introduction is accompanied by coordinated regulatory, ethical, and organisational development. Gradual implementation, continuous evaluation, and sensitivity to regional and societal differences are essential to ensure that digital innovations move beyond technological novelty and contribute meaningfully to improved quality, efficiency, and equity in patient care.

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