

A Comprehensive Survey on Requirements and Design of AI-Powered Clinical Intelligence Systems in Healthcare

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Abstract: *With the increasing complexity of healthcare services, artificial intelligence (AI) is emerging as a vital tool to support medical practitioners by providing real-time clinical insights, automating routine documentation, and enhancing patient engagement. This survey investigates the design requirements, technical challenges, and ethical considerations for AI-powered clinical intelligence systems intended for healthcare environments. Our study is based on a survey conducted with healthcare professionals, patients, and AI researchers, capturing diverse perspectives on functionality, usability, data privacy, and ethical concerns. This paper synthesizes these insights into a detailed requirement analysis that can guide the development of clinically effective, ethically sound, and user-centric AI systems. Through this analysis, we aim to lay the groundwork for creating AI-driven tools that improve clinical workflows, foster better patient outcomes, and support healthcare professionals in delivering quality care.*

Keywords: AI in healthcare, clinical intelligence, large language models, survey, requirement analysis, healthcare assistance.

I. INTRODUCTION

Health care has transformed drastically toward digitalization, wherein AI replaced the entire methodology used to handle patient care, diagnostics, and administrative work [1]. This overall shift is driven by more substantial use of advanced machine learning and NLP models, expected to better health care providers by providing clinically relevant data-driven insights at the point of care during doctor-patient consultations. In this research, the objective is to discuss the specific needs and issues involved in developing an entire clinical intelligence system that integrates AI for improving real-time decision-making capabilities among health care providers. The current clinical tools are largely fragmented in nature mainly because they are designed to be used to perform a limited set of activities, which might include EHR management, disease prognosis, or simple note-taking [2]. It continues, however unsatisfied, in demand for an integrated solution, which has potential for dynamic support of many facets of clinical services, including diagnosis, documentation, and patient engagement.

The paper outlines a questionnaire among healthcare professionals, patients, and AI researchers to get a rich view of the functional and ethical requirements for such a system. Preference areas include disease prediction, security of data, and ease of operation—all areas that current systems lack and therefore need correction.

II. BACKGROUND AND RELATED WORK

Research in AI-based healthcare systems has developed dramatically in the last years, particularly within diagnostics, NLP, and predictive analytics. Initially, medical support systems relied on rule-based algorithms wherein capabilities were not adaptive and depended on deep domain experience, which is now replaced by the new versions where models can be learned from huge sets of data; hence, insights are produced dynamically in real time, and the dependency on manually encoded rules is reduced. [3].

A. Natural Language Processing in Healthcare

NLP is necessary for understanding and exploring the complex language involved in medical records, doctor-patient interaction, and other medical environments. The recent NLP models, with great emphasis on large language models (LLMs) such as GPT-3 and LLaMA, have demonstrated a remarkable capacity for language understanding and generation; therefore, they are suitable for clinical application [4]. However, the challenge remains on interpretability, which is needed in healthcare because transparency is created in decision-making. IAI methods are increasingly thought to be important because their outputs can actually serve to explain the reasoning behind a model's conclusions, which leads to the fostering of medical professional trust [5].

B. Challenges with Data Privacy and Security

One of the issues that arise in healthcare applications involving artificial intelligence is patient privacy. Traditional machine learning often calls for large datasets, which could be a problem to institutions and organizations bound by US HIPAA and European GDPR rules. Recent advances in federated learning, wherein models training is carried out locally without sending data to central servers offer several promising solutions to such problems [6]. With federated learning, clinical intelligent systems may be able to harness the benefit of getting multiple datasets from institutions without losing their data privacy.

C. Ethical and Regulatory Considerations

The rules governing the use of artificial intelligence in health care are very strict in terms of confidentiality of data regarding patient safety and equal application. Such rules help emphasize the lack of bias and prevention of algorithmic discrimination as well as ensure that AI recommendations are best for the patient. Many studies emphasize the concept of "explainability" in clinical AI when healthcare providers understand and trust the insights provided by AI systems. Compliance with ethical and regulatory frameworks is an important stride toward cultivating trust and facilitating the safe incorporation of artificial intelligence in clinical settings.

III. SURVEY METHODOLOGY

We conducted a well-designed and planned three-layered level of stakeholders, which included health professionals, patients, and AI researchers on whom there was a survey. This survey was such that it covered the diverse needs and demands for clinical intelligence systems. The method of survey by this approach captures the diversity of thoughts in the minds of all the stakeholders pertaining to functionality usability, and safety and security of data.

A. Survey Design

The survey was well-crafted not only to focus on the means of gathering quantitative data but also to provide some insight into the qualitative perceptions. In this respect, questions were crafted in multiple-choice format for the participants so that they could rank their priorities regarding functionalities that they considered important. Open-ended questions were also included to allow respondents to comment on particular issues, preferences, and ideas for new applications more deeply. The mixed-method approach so carefully considered would lead toward a holistic and balanced view on the requirements and concerns brought out by the participants.

B. Demographic Information

The survey comprised 80 respondents, divided into:

- **Healthcare Professionals (30):** Including physicians, specialists (e.g., cardiologists, dermatologists), and nurses.
- **Patients (30):** With diverse age ranges, health conditions, and familiarity with digital health tools.
- **AI Researchers (20):** Experts in machine learning, NLP, and healthcare informatics.

This distribution then gave us insights from people with a range of experience and expertise in both domains, clinical as well as artificial intelligence related.

IV. SURVEY FINDINGS AND ANALYSIS

Surveys were used to elicit responses to deliver rich information about the functionalities, design considerations of clinical intelligence systems, and ethical issues.

A. Desired Functionalities

- **Real-Time Disease Prediction:** The much interest of the healthcare providers was held for the predictive AI models that predict diseases based on patient history and presenting symptoms. Real-time diagnostic support was conceived as being crucial to raising both levels of accuracy in care provision and efficiency, particularly for time-sensitive cases.
- **NLP-Based Summarization and Documentation:** An overwhelming majority of clinicians underscored the need for NLP applications capable of automatically transcribing and summarizing patient consultations. The automation of documentation promises to free more time for physicians to spend on their patients, which is fundamentally important: patients appreciated the possibility that a summation of visit notes could help them better understand what was going on with them.
- **Patient Engagement and Simplified Communication:** Patients wanted a resource to be developed that would enhance the patient's comprehension of health information: in other words, more user-friendly summary forms and relevant guidelines for their health care. Physicians and patients alike reported the need for factors that make health care more interactive and patient-oriented.

B. User Interface and Usability

- **Ease of Use and Workflow Compatibility:** All interviewees considered usability to be the most important requirement. Clinicians said an interface has to be user-friendly and must be intuitive without forcing itself into current workflows. They further suggested voice-activated command and realtime feedback mechanisms in minimizing interference while consulting patients.
- **Customization for Different Specialties:** Physicians from other specialties in medicine also opined that uniformity would not be satisfactory and impossible. They instead proposed the use of modular templates that will allow customization for each specialty in particular, to tailor the system according to its specific needs for workflow. A cardiologist, who deals more directly with the heart and associated diseases or conditions, may have different needs for diagnostic cues or prompts than a dermatologist, who deals with skin-related problems and treatments.

C. Data Privacy and Security Concerns

- **Encryption and Secure Data Storage:** The problem was essentially a call to action on a critical issue of privacy, one that patients who were anxious and afraid of the mishandling or mis-handling of their confidential health information viewed. Health professionals campaigned more vociferously towards the introduction of strong encryption schemes tailored for securing the protection of patient information from unauthorized access. Experts in AI were now touting federated learning as the only practical realistic method that could safeguard privacy and yet not compromise data quality in any way.
- **Compliance with Regulatory Standards:** According to participants, any AI system in healthcare should be subject to standards like HIPAA in the USA and GDPR in Europe. Ensuring that the systems would carry the standards of ethics was crucial because it would build trust and promote the widespread adoption of systems like this.

D. Ethical and Interpretability Concerns

- **Interpretability of AI Models:** Concerns raised were regarding the "black-box" character of most AI models, and that the models must be explainable so that the justification behind the recommendation can be provided. It was deemed critical for clinical applications, where transparency would greatly impact patient safety and trust.

- **Bias and Fairness in AI Recommendations:** This is a wake-up call to both patients and researchers in AI because it brought out the essential questions around the issue of algorithmic bias. The call was summed up by the speakers emphasizing how critical it was that the system be trained from diverse, representative datasets; otherwise, it would make biased predictions such as medical diagnoses across populations that might have differing health characteristics and needs-when that happens.

V. REQUIREMENT ANALYSIS

Based on our survey, we distilled a few key requirements that must come together in an AI-powered clinical intelligence system to make it viable and effective in the healthcare industry.

A. Functional Requirements

- **Predictive Analytics:** The system is to provide realtime predictive analytics that will be very instrumental in assisting healthcare professionals in the diagnosis of various diseases. It should also arm clinicians with trustworthy and dependable diagnostic cues to effectively aid their decision-making processes.
- **NLP-Driven Summarization:** It should apply NLP to transcribe, summarize, and classify the patient interaction, thus reducing the administrative burden on healthcare providers.
- **Personalized Patient Summaries:** In the patient engagement, the system should be able to generate readable summaries and recommendations based on the findings derived from a clinical encounter, corresponding in detail to the capabilities of a patient's understanding.

B. Non-Functional Requirements

- **Security and Privacy:** The system has to satisfy relevant regulatory requirements, such as HIPAA and GDPR, with strong encryption, and where possible, federated learning to safeguard the data for patients.
- **Interoperability and Scalability:** Such a system should be integrable with different kinds of hospital IT systems to accommodate diverse healthcare contexts and should scale flexibly across institutions.
- **Transparency and Interpretability:** The model outputs should be interpretable, helping health professionals understand why predictions have been made so that their confidence in any AI-based recommendation will increase.

VI. CONCLUSION

Our thorough survey brings forward the major needs and general concerns that should not be ignored while developing effective and ethical AI-based clinical intelligence systems. While health care service providers are extremely supportive of AI tools that could reduce the burden of admin work, make diagnostic assistant tools important, and, above all, improve patient engagement considerably, there are significant concerns in the area, especially along critical lines such as data privacy, model interpretability, and the smooth integration of such state-of-the-art technologies into clinical workflows.

This comprehensive survey attempts to provide a base requirements analysis that distinctly focuses on certain areas, which require more research and development that especially focus on clinical AI systems. There are lots of room for adaptive learning models in the future work, making AI applications in health care more responsive and personalized. The work can also be concerned with better patient education tools made on the lines of privacy issues related to AI usage. There will come forth innovative ways of managing algorithmic bias that may create inequalities and unfairness in AI usages. The output of these capabilities will certainly be quite necessary to ensure the enormous potential of AI transforms the healthcare industry while simultaneously protecting patient trust and maintaining the highest ethical standards.

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