Recommendations for User-Centered Design of Intelligent Systems in Healthcare

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Abstract
Medical artificial intelligence (AI) systems that incorrectly represent patients' experiences can put a patient's health at risk. These misrepresentations occur when the system's developers unintentionally incorporate their own worldviews into the algorithm's decision-making processes. A user-centered approach to development enables the development team to remain focused on their users' needs and limit the influence of their own biases. This paper provides a set of recommendations for engineers of medical AI systems to engage in user-centered design while developing the system's logic. As a proposed methodology, the paper builds off of previous studies that either propose ways to incorporate user-centered methods into general AI development, or have investigated applications of user-centered design in specific healthcare settings. The recommendations should be evaluated in practical situations before they are fully incorporated into engineering practice.

1 Introduction

Artificial intelligence (AI) was first conceptualized in 1950, but did not become popularized in medicine until recent decades. Now, AI is integral to medicine: it can recognize symptoms of disease, assist with online scheduling or check-ins, and support patients emotionally [1]. However, the medical field does not have a standard for designing the logic of intelligent systems. Logic refers to algorithms' decision-making processes: the criterion by which a model analyzes its input in order to reach some conclusion [2]. According to Forsythe [3], improperly designed logic can represent assumptions of its designers that are not reflective of the users' perspectives. Because these beliefs become hidden within the system's architecture, end-users, such as physicians or patients, are unaware of these traits. As Forsythe [3] demonstrates, physicians may then incorrectly diagnose a disease or prescribe treatment without consulting their patients, both of which may risk patient health. Although these systems are intended to empower patients, uninformed design choices can decrease the quality of patient care or limit patients' control over their medical care.

Social scientists employ user-centered design to understand user needs while reducing the effect of their own worldview. This approach promotes working with participants throughout a project's lifecycle, resulting in systems that are less biased and more reflective of users' perspectives [4]. The goal of this approach is to develop a robust understanding of users' experiences.

However, engineers who construct AI systems often do not engage in user research. Instead, this responsibility is delegated to social scientists or ethnographers on the team [3]. Because engineers do not work with their participants, they may unintentionally incorporate their own worldviews into the product. For instance, Straw [5(p.2)] notes that some mental health apps have not been trained on culturally diverse datasets and so only recognize Western "expressions of suffering," which prevents patients of marginalized communities from accessing proper care. Other mobile apps that identify melanoma skin cancer via imaging software are prone to false negatives or false positives, which increases patient worry and dermatologist workload and delays much-needed diagnoses [6].

Continued development of such systems will cause increasing harm to patients, which risks the perceived trustworthiness of medical AI and healthcare itself [7]. Therefore, developers should consider taking a

user-centered design approach to developing the logic of intelligent systems in order to better represent the needs and perspectives of their users, making models more reliable and improving patients' quality of care.

2 Related Works

This project builds on previous studies that either propose ways to incorporate user-centered methods into general AI development, or have investigated applications of user-centered design in specific healthcare settings.

When designing city infrastructure, urban planners typically engage in a participatory planning process, in which the community decides how the resources are to be used. Falco [8] suggests using a similar approach when designing smart city AI. Particularly, Falco [8] emphasizes the need for transparency when designing the algorithms' logic, which can be achieved using a blockchain-based ledger. All parties involved in the development of the AI, from city officials to AI developers to community members, contribute to and review the ledger. This approach encourages transparency and accountability throughout the development process.

Forsythe [3] highlights a failed attempt to incorporate ethnography into the development of an informatics system for migraine sufferers. Members of the research team, which included physicians, social scientists, and system developers, disagreed on the sequence in which development should occur. As a result, the developers began constructing the system's logic before ethnographic research was complete. The resulting system thus did not reflect the results of the user-based research and was dangerously misleading to its patient users. This instance demonstrates the need for developers to engage in and use the results of user research.

Tsiourti et al. [9] used a user-centered design approach to create a virtual daily life companion for older adults living alone. The group used focus groups, individual interviews, questionnaires, log files, and diary entries to design and evaluate the system. This project demonstrates the way in which user research can be used to inform the design of a medical AI system.

3 Proposed Design

This section presents the project's recommendations for developing user-centered medical AI logic.

3.1 Review of User-Centered Design

In order to understand the recommendations, an understanding of user-centered design should be established.

3.1.1 Principles and Mindsets

User-centered design is not a methodology but a framework for action that encourages optimism and empathy through direct user engagement. IDEO [4], a design firm, states that a user-centered designer sees all problems as inherently solvable, and the communities facing these problems as the path to the solution. The firm presents seven mindsets that can help a designer achieve these principles:

1. Creative confidence: everyone is creative, and creativity is necessary to understanding our surroundings
2. Make it: frequently develop and test tangible prototypes
3. Learn from failure
4. Empathy: understand the problem from the user's perspective
5. Embrace ambiguity: begin work without knowing the solution to the problem
6. Optimism: believe that the solution exists and is discoverable
7. Iterate: use frequent user feedback to improve the prototyped solution

3.1.2 Potential Methods

As a framework, user-centered design does not require that a specific set of methods be used when conducting user research. Rather, various quantitative and qualitative methods are available, each providing different insights about the user. Designers should choose the methods that best fit their needs. Examples of quantitative methods include app analytics, which track how users engage with a live product, and surveys or questionnaires, which gather user responses via predetermined questions and/or answers [10]. Examples of qualitative methods include interviews, which involve direct communication with the target communities, and card sorting, during which users rank cards containing single words or images in order of preference [4].

3.2 Recommendations

The development of a medical AI system can be broken down into five steps. First, team members and stakeholders should be identified. At least some members of the team should have experience conducting user research. In addition, care should be taken to identify all stakeholders or groups with insight into the target community's experience. In the case example discussed by Forsythe [3], nurses were not included on the research team, despite the fact that they closely work with the target community, patients who suffer migraines. As a result, the team was not fully aware of the patients' experiences.

Next, the team should conduct initial user research with the identified stakeholders in order to gain a robust understanding of the context of the problem and their users' needs. Methods that may be useful at this stage include observations, interviews, content analysis, and focus groups. Using the gathered data, the team should develop an initial problem statement and seek user feedback to ensure its accuracy. Different user groups may have conflicting feedback that should be appropriately resolved in order to satisfy all groups to the degree possible.

After defining the problem, the team should develop a generalized proposal for the logic and data that the system will use. The proposal should be evaluated by both the stakeholders and another group of developers not otherwise involved in the project. The stakeholders can assess the proposal's ability to satisfy the defined problem. The second team of developers can identify other areas of concern, such as instances in which the team may have inadvertently made inaccurate assumptions about the problem and/or solution.

Next, the team should implement the proposed design. While developing, the team should iteratively conduct usability testing to ensure the product appropriately reflects users' own backgrounds. For instance, patients and physicians may use different verbiage to discuss the same concept.

Finally, the developed prototype should be subjected to a comprehensive review. Just as in the initial stage of research, the team should conduct thorough user engagement, such as with observations and interviews. The team should also seek feedback from another team of developers. After this stage, the product should not be expected to undergo further major changes. Rather, the emphasis should turn to maintaining and improving the system.

Throughout each of the above stages, the team should maintain thorough documentation. As Forsythe [3] notes, the logic behind medical systems is often invisible to users and thus less intensely evaluated. Proper documentation can overcome this barrier and increase the logic's trustworthiness. For instance, blockchain offers version control and is more secure against hacking, and so should be considered as an option [8]. However, future work should be done to evaluate all available alternatives.

4 Anticipated Results

The recommendations presented above are designed to help developers build empathy with users and limit the influence of their own cultural values and professional assumptions. They also promote greater transparency about the system's design, creating an environment of accountability. Both purposes serve to increase the trustworthiness and reliability of medical AI systems. User-centered systems can empower patients and increase the quality of their care, thus improving patients' view of the general medical system.

However, these recommendations do not come without their own challenges. First, such continued direct engagement with users can greatly increase the time to design and develop these systems. Developers may be accustomed to an agile development process, which emphasizes iteratively developing and receiving feedback in short bursts in order to release a live product faster. However, the responsibility and impact of medical AI systems should encourage greater care around their development and documentation. Second, there may be power differentials between team members or stakeholders, which may discourage certain parties from sharing their perspectives. All viewpoints should be seen as equally valued, so care should be taken to empower each member.

5 Conclusion

AI currently has a significant role in the medical field, ranging in applications that manage and support patients' health. However, some intelligent systems

unintentionally misrepresent their users' experiences and worldviews, which can seriously risk patients' health and quality of care. Therefore, it is essential to ensure that the logic of these systems accurately represents their users, which can be achieved through the principles and practices of user-centered design. This project recommends using different user design practices throughout development, including interviews, feedback sessions, and audit logging. By following these guidelines, engineers can establish a practice of seeking user feedback throughout development. This constant engagement will help developers remain grounded in their users' experiences, leading to unbiased and reliable systems.

6 Future Work

The recommendations presented in this paper are preliminary. They form a general guide of conduct but have not yet been implemented and tested in practical situations. Thus, the next step is to evaluate these recommendations in different development scenarios across the field of medicine. Testing will reveal areas of improvement, and the recommendations can be adjusted before they are fully incorporated into engineering practice. As the principles of user-centered design suggest, it is also important to seek feedback from any system's end-users. Therefore, feedback on these recommendations should be sought from developers of medical AI, as well as social scientists, who are experienced with conducting user research, in order to ensure that the recommendations are relevant and actionable.

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