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Pathways to democratized healthcare: Envisioning human-centered AI-as-a-service for customized diagnosis and rehabilitation

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ABSTRACT

The ongoing digital revolution in the healthcare sector, emphasized by bodies like the US Food and Drug Administration (FDA), is paving the way for a shift towards person-centric healthcare models. These models consider individual needs, turning patients from passive recipients to active participants. A key factor in this shift is Artificial Intelligence (AI), which has the capacity to revolutionize healthcare delivery due to its ability to personalize it. With the rise of software in healthcare and the proliferation of the Internet of Things (IoT), a surge of digital data is being produced. This data, alongside improvements in AI's explainability, is facilitating the spread of person-centric healthcare models, aiming at improving health management and patient experience.

This paper outlines a human-centered methodology for the development of an AI-as-a-service platform with the goal of broadening access to personalized healthcare. This approach places humans at its core, aiming to augment, not replace, human capabilities and integrate in current processes. The primary research question guiding this study is: "How can Human-Centered AI principles be considered when designing an AI-as-a-service platform that democratizes access to personalized healthcare?" This informed both our research direction and investigation.

Our approach involves a design fiction methodology, engaging clinicians from different domains to gather their perspectives on how AI can meet their needs by envisioning potential future scenarios and addressing possible ethical and social challenges. Additionally, we incorporate Meta-Design principles, investigating opportunities for users to modify the AI system based on their experiences. This promotes a platform that evolves with the user and considers many different perspectives.

1. Introduction

The integration of Artificial Intelligence (AI) into the healthcare sector is no longer a speculative future but an unfolding reality that is reshaping medical practices and research. Regulatory bodies, such as the US Food and Drug Administration (FDA), have advocated the importance of harnessing digital advancements in healthcare, providing a clear trajectory towards more individualized, person-centric models. Such models transition patients from being mere recipients to empowered stakeholders in their health journeys, with AI playing a pivotal role in this transformation. However, while the burgeoning of tools in healthcare and the ubiquity of the Internet of Things (IoT) have provided an unprecedented amount of digital data, they also bring forth critical challenges.

Central to our concerns is the alignment between AI solutions and the needs of medical professionals, particularly in this initial phase of our research. While the ultimate aim is to create solutions that serve both patients and professionals, at present, we are focusing on how these tools can be attuned to therapeutic goals and flexible enough to meet diverse patient needs. As we gravitate towards person-centric models, the emphasis on personalization becomes more pronounced. In this context, it is crucial to consider how AI solutions, informed by the deep insights of medical professionals, can be adjusted to cater to individual patient requirements. This approach sets a foundation for

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future stages where direct patient input will play a more prominent role in shaping these solutions.

Further complicating this landscape is the challenge of algorithmic bias. Such biases can skew outcomes, often at the disadvantage of specific groups. This necessitates an ethical framework ensuring fairness, transparency, and accountability in AI solutions.

To navigate these complexities, we employed the MiniCoDe methodology — a workshop-centric approach designed for the ethical deployment of emerging technologies [1,2]. Through this lens, we examined the implications and potential of AI within two distinct medical domains: endocrinology and child neuropsychiatry.

Central to our exploration is the research question: *"How can HCAI principles be considered when designing an AI-as-a-service platform that democratizes access to personalized healthcare?"*

This paper positions itself as a foundational step towards creating an AI-as-a-service (AIaaS) platform tailored for Customized Diagnostic and Rehabilitative Processes embedding Human-Centered Artificial Intelligence (HCAI) principles. In engaging initially with the medical community, our goal is to tap into their deep understanding of patient needs and treatment complexities. This engagement is a critical first step in a longer journey towards developing AI solutions that are truly reflective of both patient and medical professional perspectives. This also facilitated a clearer envisioning of potential AI service touchpoints within professional settings.

Our objective, through this exploration, is to offer a foundational framework, assisting the development of AI systems in healthcare that resonate with both practicality and ethical considerations.

The paper will:

- Detail our human-centered approach to AI in healthcare, emphasizing the current focus on medical professionals while acknowledging the ultimate goal of inclusive patient involvement;
- Dive into the central research question, highlighting its broader implications;
- Share insights derived from the MiniCoDe methodology, using our two case studies as a backdrop;
- Conclude with a discussion, emphasizing meta-design as a crucial bridge aligning stakeholder needs and ensuring ethical integration.

2. Related works

The healthcare domain, a critical sector with profound implications for human well-being, is undergoing a transformative phase with the integration of AI. This integration, while promising, brings forth many challenges and opportunities [3], especially when viewed through the lens of Human-Computer Interaction (HCI).

As we navigate the intricacies of integrating AI-driven solutions into clinical settings, it becomes imperative to understand both the opportunities and challenges that arise. The integration of AI into healthcare, as highlighted in [4], underscores the profound social, political, and economic implications of such advancements [5]. While AI promises enhanced diagnostics, treatment planning, and patient care [6], its successful deployment in real-world clinical settings remains a complex endeavor [7].

As reported in [8], AI systems are poised to redefine various aspects of healthcare, from automating routine tasks to aiding in complex diagnostic processes. The transformative potential of AI in medical imaging, for instance, is profound, offering the possibility of more accurate and timely diagnoses [9]. Such advancements, while technologically impressive, necessitate a user-centric approach to ensure that healthcare professionals can effectively leverage these tools without being overwhelmed [10].

Jacobs et al. [11] also underscore the importance of designing AI systems that foster trust and collaboration in time-constrained medical decisions, emphasizing a sociotechnical approach that balances technical prowess with the intricate social dynamics of clinical settings. This perspective is further elaborated by Zając et al. [12], who delve into the sociotechnical challenges and opportunities presented by clinician-facing AI in real-world settings. Their emphasis on a participatory design approach highlights the significance of involving end-users in the design and development process to ensure AI systems are contextually relevant and fit for purpose [13].

This is where the principles of HCI and meta-design come into play. Meta-design, as conceptualized by Fischer and Scharff [14], refers to the activities, processes, and objectives aimed at creating new media and environments that empower users to act as designers and foster creativity. This approach allows for the redistribution of design activities across time and levels of interaction with the environment, enabling open systems to evolve during use [15]. In the context of healthcare, this means creating Clinical Decision Support Systems (CDSS) that are adaptable, allowing medical professionals to tailor them according to specific patient needs or emerging medical knowledge. Such systems exemplify the confluence of HCI, meta-design, and healthcare, with a significant emphasis on user interface design. The design of these interfaces is paramount, as it directly influences the efficacy and adoption of AI systems in clinical settings. Intuitive and flexible interfaces are crucial in assisting medical professionals in making informed decisions and improving patient outcomes, as discussed by Holzinger and Mueller [16]. This aligns with the multidisciplinary approach adopted in [17] to analyze the relevance of explainability for medical AI from technological, legal, medical, and patient perspectives, particularly focusing on AI-based CDSS.

However, the journey of integrating AI into healthcare has other challenges too. As underscored by [18], there is a pressing need to understand the limitations and potential biases of AI models. The overarching importance of transparency, interpretability, and ethical considerations cannot be overstated [19]. These concerns resonate deeply with HCI principles, emphasizing the need for designs that prioritize user trust, understanding, and effective communication [20].

In summary, the intersection of AI, healthcare, and meta-design presents a rich tapestry of opportunities and challenges. As the healthcare domain continues to embrace AI, the principles of HCI and meta-design will play a pivotal role in ensuring that technological advancements align seamlessly with user needs, ethical considerations, and the dynamic nature of medical knowledge. The studies referenced herein collectively underscore the importance of a holistic, user-centric approach as we navigate the future of AI in healthcare.

In the following, we contribute to the existing body of research by presenting our methodology and findings to gain deeper perspectives on AI in healthcare, specifically for personalized medicine.

3. Methodology

To explore the integration and implications of AI within the medical domain, we combined a participatory design approach with empirical data collection. Our research methodology is composed by two key components: a variation of the previously introduced MiniCoDe workshop [1,2] and a structured questionnaire. This dual approach was aimed at obtaining both qualitative insights from the participatory design activities and quantitative data from the questionnaire responses.

3.1. MiniCoDe workshops for AI in healthcare

In this study, we employed and adapted the MiniCoDe workshop structure [1,2], a method previously introduced in our earlier work. Our research sought to explore the potential of AI within the medical domain through the lens of MiniCoDe. Herein, we outline the modified methodology and the nuances we introduced for our specific research context.

3.1.1. Prepare: Setting the scene for AI in healthcare

Objective. Craft a foundational narrative for stimulating creativity and framing the subsequent stages.

In this initial phase, we utilized design fiction [21] to paint a picture of a healthcare environment where AI plays a significant role. The narrative (Appendix A), set in a plausible future, was designed to serve as an anchor, enabling participants to consider transformative possibilities of AI-human collaboration in healthcare settings.

3.1.2. Ideate: Constructing a day in AI-Augmented healthcare

Objective. Understand the potential touchpoints and collaborations between medical professionals, patients, and AI.

Instead of the usual brainstorming approach detailed in the original MiniCoDe framework, we redirected our focus towards user journey mapping. Participants were encouraged to sketch out interactions over a typical day, incorporating AI as a pivotal actor. By doing so, we hoped to glean insights into how AI might be seamlessly integrated into the many interactions within a healthcare setting. We presented them with three personas to be considered for the user journey map: a domain-specific AI assistant equipped with specific knowledge and with patient monitoring capabilities; a tech-savvy clinician; and a patient. The inclusion of a persona for the AI agent was a deliberate choice, intended to humanize the AI's role within the healthcare ecosystem. This approach not only facilitated a user-centric exploration of AI's potential functionalities and impacts but also aligned with HCAI principles. By personifying the AI, we aimed at simplifying complex technological concepts, making them more accessible and relatable to our participants [22]. Our goal was to encourage participants to critically consider not just the capabilities, but also the limitations and ethical constraints of AI within healthcare settings, thereby fostering a more nuanced and holistic discourse.

3.1.3. Refine: Delving into meta-design opportunities

Objective. Identify areas within AI-enhanced healthcare interactions that could benefit from the principles of meta-design.

Post ideation, the spotlight turned to meta-design. First we introduced the concept to participants, using straightforward, real-world examples from healthcare to explain this idea. Meta-design is about users – both healthcare professionals and patients – being active in shaping and improving the technology they use. We gave examples like customizable Electronic Health Records (EHRs), health apps that patients can adjust to their needs, and CDSS that learn and adapt from user feedback. These examples were chosen to show how meta-design makes technology more responsive and user-centered. This introduction helped participants understand and engage with the idea of meta-design as it applies to AI in healthcare. Recognizing its potential to introduce adaptability and customization into the AI interfaces, participants then re-examined their user journeys. The goal was clear: pinpoint nodes within the journey where the AI's dynamics could be tailored to align with specific user needs or contexts. This phase helped elucidate the opportunities and challenges that lie in making AI systems flexible and adaptable within the healthcare environment.

3.1.4. Reflect: Considering ethics in AI interactions

Objective. Ground the proposed AI-medical collaborations in ethical considerations, ensuring sensitivity to potential pitfalls.

Drawing from the original MiniCoDe's reflection phase, participants were provided with the MiniCoDe Ethics deck to guide their contemplations. Each card, inspired by Floridi's framework [23], served as a compass, prompting participants to critically assess their proposed AI interactions in light of ethical principles with multiple levels of detail [24]. This phase ensured that ethical considerations remained at the forefront, fostering a collective awareness of AI's ethical dimensions in healthcare.

Concluding the workshop, groups presented their crafted user journeys, facilitating a rich exchange of perspectives, and fostering collective insights into the envisioned role of AI in healthcare.

3.2. Evaluation

In the following, we report the evaluation carried out, detailing the insights gathered through both user journey maps and a post-workshop questionnaire, each offering unique perspectives on the integration of AI in healthcare in both case studies.

3.2.1. User journeys

The user journey maps created during the workshop were analyzed through a three-phase approach. Initially, we examined each map to understand the envisioned user experience, focusing on the stages and touchpoints outlined by participants. The second phase involved identifying and analyzing pain points and ethical risks, crucial for anticipating and addressing potential ethical concerns in the system's design. Lastly, we focused on opportunities for meta-design, particularly system adaptability, as identified by participants. This comprehensive analysis helped us gain insights into user interaction, ethical considerations, and adaptability of the system, integral for informing our design recommendations for AI systems in healthcare.

3.2.2. Questionnaire

Post-workshop, we administered a questionnaire to the participants aiming to gather their insights and reflections on the presented speculative scenario, the role of AI in the medical field, its adaptability, and the significance of meta-design. The rationale behind these questions was three-fold:

AI Expectations The initial set of questions aimed at gauging participants' prior experiences with AI in healthcare and their perspectives on its feasibility and relevance. This would provide an understanding of their expectations from AI solutions and the degree to which they perceived these solutions as practical and actionable within their realm of work.

Meta-Design Recognizing the significance of adaptability in the context of AI applications in healthcare, this segment of the questionnaire delved into participants' views on meta-design as a mechanism to ensure this adaptability. This would offer insights into whether they perceived adaptable AI systems as integral to the success and utility of such tools in their daily practice.

Ethical Considerations Given the sensitivities around patient data and the ethical responsibilities of medical practitioners, it was vital to understand the participants' level of concern regarding ethical issues linked to AI use in healthcare. Moreover, this part of the questionnaire explored if they saw meta-design as a possible solution to these ethical challenges.

For a comprehensive list of the questions presented to the participants, please refer to Appendix C.

This questionnaire hoped to achieve a holistic understanding of where clinicians stand on the potential of AI, the need of adaptability, and the ethical issues intrinsic to its wider adoption, highlighting the potential of meta-design as a mitigation strategy.

4. Case studies

In the pursuit of person-centric healthcare and the vision of personalized medicine, our emphasis naturally gravitated towards the domains of endocrinology and child neuropsychiatry. Both disciplines exemplify the principles of Customized Diagnostic and Rehabilitative Processes, manifesting not only in the clinician-led diagnostic procedures but also in the subsequent at-home patient self-monitoring regimens. By integrating AI within these intricate, dual-phased medical pathways, our case studies delve into contexts where technology and human-centered care merge, presenting rich scenarios to evaluate and refine our MiniCoDe approach.

Fig. 1. The Endocrinology case study setting.

4.1. Endocrinology

Endocrinology, the study of the endocrine system and its disorders, is deeply intertwined with individualized treatment regimes. The intricacies of hormonal imbalances necessitate continuous monitoring and individualized feedback, making this domain ripe for the implementation of person-centric AI solutions.

4.1.1. Workshop setting and participants

Our workshop aimed to explore the intersection of endocrinology and AI-driven person-centric healthcare. It took place in a lecture room of an hospital, as depicted in Fig. 1. We involved a total of 14 participants randomly assigned to 3 groups, with diverse professional backgrounds: 1 Assistant Professor in endocrinology, 2 Medical Directors, and 11 Resident Doctors. This composition ensured a blend of theoretical knowledge and practical clinical experience. The range of expertise, from experienced academic insight to hands-on clinical exposure, was intentional. Furthermore, the participants exhibited varied exposure to AI in healthcare, which was instrumental in capturing both the intricacies of existing digital interactions and the cautious or curious perspectives of those less acquainted with AI (more details in Section 5.2). This mixed cohort provided a multi-dimensional view, encapsulating both academic and clinical standpoints, and fostering a rich dialogue about the challenges and potentials of AI integration in endocrinology.

The discussion was framed around three guiding personas:

AI Model for Endocrinology Tailored specifically for endocrinological applications, this AI assists in real-time monitoring, diagnosis, and offers treatment suggestions. It is particularly skilled at diabetes management, emphasizing data protection and the enhancement rather than replacement of clinical decisions.

Endocrinologist This persona embodies an experienced practitioner who values real-time patient data, cherishes the human touch in patient interactions, and is cautious about the ethical dimensions of AI in medical treatments.

Patient with Type 2 Diabetes Representing a tech-savvy individual, this persona has recently been diagnosed with Type 2 diabetes. They are juggling their professional commitments with health management, actively seeking digital tools that integrate seamlessly into their lifestyle while ensuring a balance of technology and human contact in healthcare consultations.

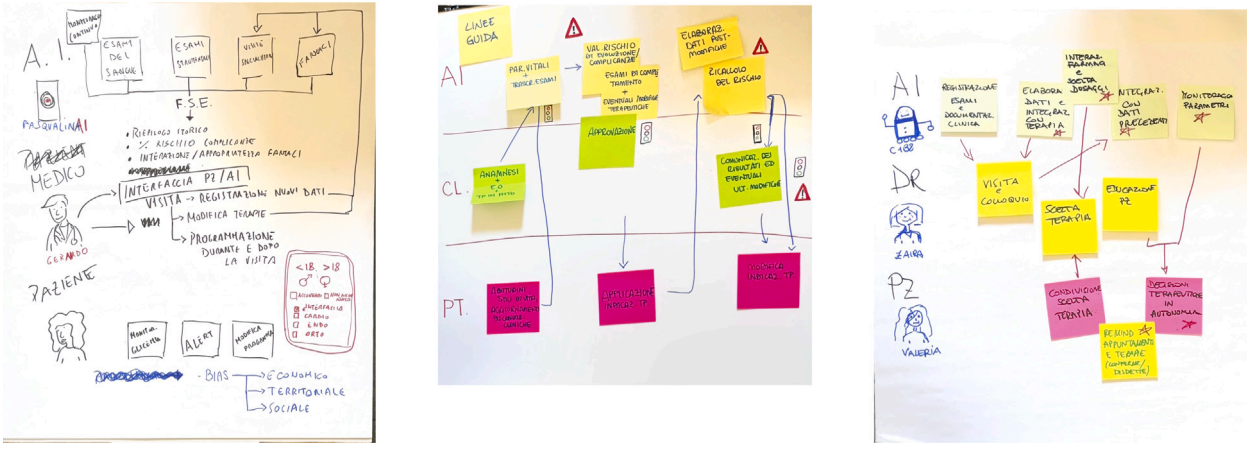
These personas helped frame and focus discussions, ensuring a consistent perspective on the nuances of integrating AI within endocrinological settings. For more detailed descriptions of these personas, please refer to Appendix B.1.

4.1.2. Findings

In the analysis of the first case study, user journey maps emerged as a significant tool to elucidate the roles and interplay between AI, medical practitioners, and patients within the healthcare system. These journey maps, as sketched by participants in Fig. 2, shed light on the envisioned processes and sequences of healthcare operations, while simultaneously highlighting the potential for AI augmentation.

In the journey depicted in Fig. 2(a), the process initiates with data collection for summary, risk evaluation, and therapy recommendation. Here, the physician plays an active role, endorsing and inputting data. Patients, in this scenario, receive alerts; however, any changes to their treatment plan are made collaboratively, ensuring that patient comfort and agreement are prioritized.

The second journey in Fig. 2(b) portrays a more AI-centric approach. AI uses the patient data and guidelines to evaluate risk and determine therapeutic interventions. This recommendation then awaits the doctor's approval. As the journey unfolds, patients engage with the platform, updating it on lifestyle shifts, habits, and overall health conditions. Responding dynamically, the AI recalculates risk based on these new patient inputs. Notably, it autonomously amends therapeutic directives, informing both the doctor and patient of any alterations. This depiction hints at a future where AI is more than just a passive tool; it is an active participant, collaboratively working alongside human actors.



(a) (b) (c)

Fig. 2. User journey maps resulting from the Endocrinology case study.

The final journey in Fig. 2(c) still emphasizes the integration of AI, but with a unique twist. While the AI's usage for data handling, therapy suggestions, past records, and medications remains consistent, there is a progressive delegation of responsibilities. Post the initial consultation, some therapeutic decisions are entrusted to the AI, emphasizing the educational role of the physician. This suggests a vision where the doctor's primary responsibility evolves from just decision-making to also educating the patient about the AI's role and the broader treatment process.

This vision also emerged from the collected feedback, where one participant remarked that "The first goal of the AI should be to integrate clinical data and simplify their consultation, in order to increase the time dedicated to patient-doctor interaction".

The user journey maps also surfaced insights regarding potential biases and the openings for meta-design in the healthcare ecosystem. These biases, primarily economic, territorial, and social, were conspicuously spotlighted by participants, indicating a shared awareness of their implications in real-world medical settings.

One such bias was evident in the risk assessment and its subsequent recalculations. Here, not only there is a concern of AI's potential bias in this evaluation, but the physician's review and approval of therapy also hold the potential for being influenced — or "nudged". Such nuances raise pertinent questions about the validity and transparency of decision-making processes in a setting as critical as healthcare.

However, alongside these concerns, participants also highlighted several opportunities where meta-design could play a pivotal role in alleviating these biases and enhancing the patient experience. For instance, as patients adapt the platform to reflect changes in their lifestyle, meta-design can ensure that these personal modifications are accommodated seamlessly. Furthermore, when therapeutic decisions are made – taking into account these lifestyle changes and habits – both by the doctor and the AI, there exists a profound opportunity for meta-design principles to be adopted. This could ensure that therapy is not only effective but also tailored to the unique nuances of each patient, reflecting a holistic understanding of their life.

Another intriguing meta-design opportunity emerges when integrating past data with real-time health parameter monitoring. This seamless link provides patients the agency to manage and even schedule new appointments with their physician, fostering a sense of control and participation in their own healthcare journey.

Through these journey maps, it is evident that while AI's role in healthcare is perceived as expanding, the human touch – whether it is the doctor's expertise or the patient's inputs – remains invaluable.

4.2. Child Neuropsychiatry

Child Neuropsychiatry, the study regarding psychomotor development during childhood, is crucial for early detection, monitoring and intervention, if necessary, of childhood neurodevelopmental disorders. Given the emphasis on personalized intervention for children facing neuropsychomotor challenges, this field offers an excellent platform for AI-driven, patient-centric approaches, also considering the crucial role played by the families in this quite delicate and sensitive scenario.

4.2.1. Workshop setting and participants

To delve deeper into the confluence of childhood neuropsychiatry and AI, we organized a workshop that invited a total of 7 participants randomly clustered in 2 groups in a meeting room of a hospital, as depicted in Fig. 3. The participant demographics were diverse, ensuring a well-rounded input for our workshop. We had 3 therapists specialized in neurodevelopmental disorders with 1 year of experience, 3 Psychologists with 5 years of experience, and a Ph.D. student engaged in the field for 4 years. This composition enabled us to harness insights from both young professionals and those with substantial experience, facilitating comprehensive feedback on AI integration within child neurology and psychiatry.

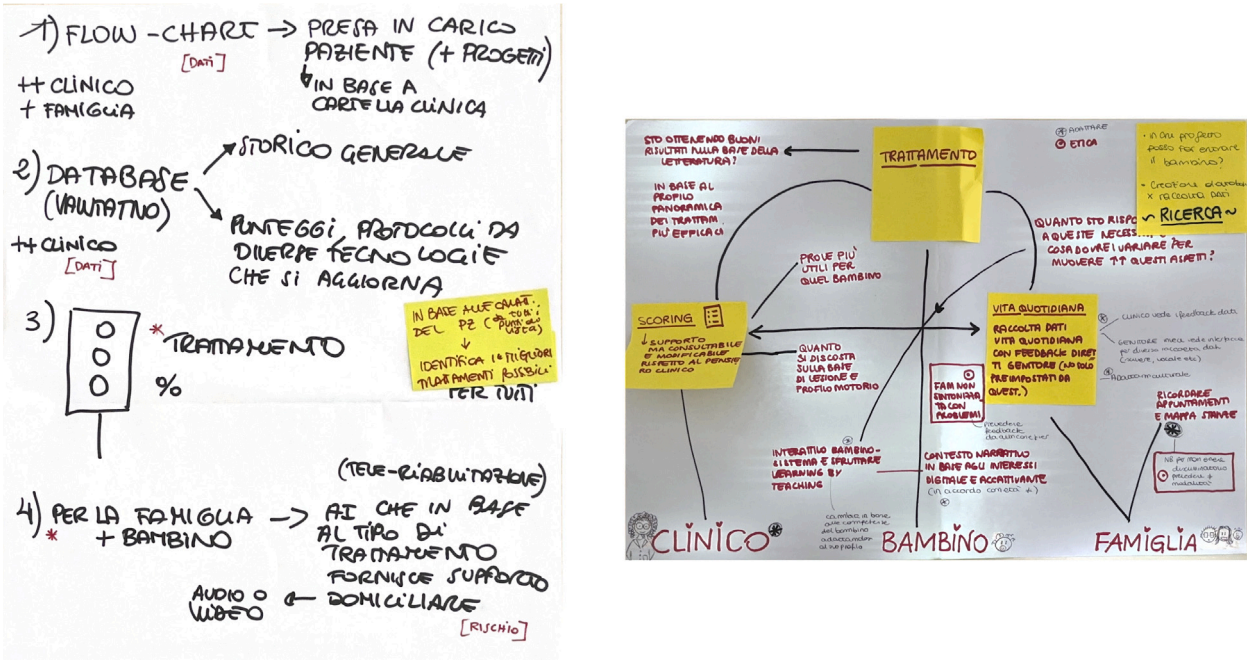
For our discussion, five guiding personas were established:

AI Model for Cognitive Insights and Analysis Developed specifically for childhood neuropsychiatric care, this AI is proficient in processing vast patient data, suggesting possible therapeutic approaches, monitoring patient progress, and alerting clinicians to changes in a patient's cognitive or behavioral status. The modes of interaction include voice, text, and visual feedback.

Specialist A medical doctor specialized in child neuropsychiatry with 12 years of experience, this persona embodies a staunch believer in technology's potential to enhance therapy quality and monitoring for their young patients. They have integrated several digital tools into their therapeutic approach and are continually exploring innovative methods to uplift their patients' lives.

Patient and Care Givers At 7 years old, this child was diagnosed with cerebral palsy. An energetic child with a penchant for digital games and animations, they often use tablet applications for educational and therapeutic activities under their parents' guidance. The care givers, deeply involved in their child's care, are always on the lookout for the best interventions and support tools to enhance their child's life quality and development.

Fig. 3. The child Neuropsychiatry case study setting.



(a) **(b)**

Fig. 4. User journey maps resulting from the child Neuropsychiatry case study.

These personas served as the backbone of our workshop discussions, keeping them grounded and relevant to the challenges and potential of integrating AI in child neuropsychiatry scenarios. For more detailed descriptions of these personas, please refer to Appendix B.2.

4.2.2. Findings

In the second case study, the role of AI in child neuropsychiatric care, as captured through the user journey maps in Fig. 4, presented a complex weave of technology, patient care, and potential challenges. The applications of AI in this realm ranged from preliminary patient onboarding to the ongoing treatment process.

The user journey maps revealed an innovative application of AI in the patient intake process. Upon assessing the patient's clinical record, AI was employed to assign the patient to the most fitting existing programs. This not only ensures the patient receives the most relevant care but also minimizes human errors and biases. Parallelly, a database was shown to maintain a general historical record, leveraging scores from various technologies, which is continually updated, serving as a dynamic repository of patient progress.

Furthermore, the incorporation of tele-rehabilitation for both the patient and their families is notable. Here, AI's role is to provide support tailored to the specific treatment type, extending beyond mere information dispensation to include audio-visual interactions. This elevates the patient experience, but the potential for AI bias in tele-rehabilitation underscores the need for careful system design and oversight.

One of the most significant pieces of feedback we received from participants during the workshop centered on the need of incorporating diverse perspectives into these systems. One participants remarked that "the design should include at different levels other points of view, such as the families' one", whilst another pointed out that "collaboration should happen with all stakeholders involved".

Finally, several meta-design opportunities were discerned by participants:

- Tailoring treatments based on individual patient characteristics, ensuring each patient receives the most effective care tailored to their unique circumstances.
- Enabling clinicians to modify AI-generated treatment scores which compare with established literature. This grants the clinician agency over AI's recommendations, ensuring a balance of human expertise and algorithmic precision.
- Adapting treatment methods based on the lifestyles of parents, especially when there is a difference between parental perception and the child's actual needs. Here, the provision for clinician feedback is crucial, as it touches upon ethical concerns and potential biases.
- An interactive 'learning by teaching' support mechanism for children, which evolves based on their engagement, allowing for a continually adapting educational experience by enabling children to influence the content and approach.
- For families, the AI system provides alerts about appointments and aids in navigating the hospital premises based on their previous interactions and preferences, thus evolving to meet their specific needs and enhancing the overall healthcare experience.

In essence, while AI offers transformative potential in child neuropsychiatry care, the highlighted meta-design opportunities underscore the imperative of a patient-centric approach. Ensuring that technology is adaptable, sensitive to individual needs, and ethically sound becomes paramount in the quest to integrate AI seamlessly into healthcare.

5. Results and discussion

In this section, we present a comprehensive analysis of the data gathered from our case studies. Beginning with an overview of the aggregated findings, we subsequently detail the responses from the questionnaire, shedding light on participants' experiences and perceptions. Concluding the section, we elucidate the key takeaways, underscoring the primary implications and considerations for future research.

5.1. Aggregated findings

In analyzing the findings from the two distinct case studies – one pertaining to endocrinology and the other to child neuropsychiatry care – a number of convergent patterns emerge. These commonalities underscore the broader challenges and opportunities that AI introduces in healthcare, offering crucial insights that transcend the specifics of each case.

When examining the integration of AI across both case studies, there is a discernible pattern in the adaptation and use of AI in the healthcare context. These overlaps not only highlight the foundational principles but also the more nuanced challenges and opportunities that arise. The primary overlaps include:

Patient-Centric AI Deployment In both domains, the primary thrust of AI application is to enhance the patient's healthcare journey. From the AI's role in risk assessment and therapeutic adjustments in endocrinology to tailoring treatments based on individual patient characteristics in neuropsychiatry, the emphasis remains on delivering personalized care.

Dynamic Data Utilization The importance of continually updating and integrating data sources becomes evident in both studies. While endocrinology highlighted the AI's capability to recalibrate risk based on patient inputs, neuropsychiatry emphasized a database that adapts with scores from varied technologies.

AI and Clinical Collaboration Another shared facet is the symbiotic relationship between AI recommendations and clinical oversight. Whether it is endocrinology's emphasis on physician approval or neuropsychiatry's focus on clinician-modifiable AI scoring, the necessity for human checks and balances on AI outputs is a clear consensus.

Similarly, as we pivot our focus towards the design and ethical dimensions, it is evident that both case studies highlight the importance of addressing biases and leveraging meta-design for a collaborative and inclusive healthcare AI experience. Key shared insights in this domain are:

Patient Lifestyle Integration Both case studies spotlight the significance of accommodating patient lifestyle and habits into AI-driven healthcare protocols. Whether it is adapting treatment methods based on a child's parents' lifestyle or crafting therapies considering a patient's daily habits in endocrinology, AI systems must be inherently flexible.

Bias Recognition and Mitigation Recognizing potential biases is another shared concern. While the endocrinology study showcased territorial, economic, and social biases, neuropsychiatry drew attention to biases in tele-rehabilitation and parental feedback. Both instances stress the importance of constructing AI systems that are aware of, and can counteract, these biases.

Empowering Users through Meta-Design Opportunities for meta-design, where end-users can influence the AI system's behavior, emerge as a salient theme in both studies. From allowing patients to inform AI recommendations based on lifestyle changes in endocrinology to enabling clinicians to modify AI-generated scores in neuropsychiatry, there is a shared understanding of the user's role in co-designing their AI-augmented healthcare experience.

In conclusion, while the two case studies delve into different medical specialties, their aggregated findings portray a holistic view of the challenges and possibilities in integrating AI into healthcare. The parallels drawn, especially in the realms of meta-design and ethics, offer a blueprint for constructing AI systems that are not only technologically advanced but also ethically sound and patient-centric.

5.2. Questionnaire results

The collected responses provide insights into participants' perceptions regarding AI tools, speculative scenarios, and the role of meta-design in healthcare fields such as endocrinology and neuropsychiatry. The Cronbach's Alpha was determined to be 0.75 for the questionnaire, suggesting a reasonable level of internal consistency among the questions [25]. The results are presented through two primary visualizations, which offer a comparative and holistic view of the participants' feelings.

Drawing initial insights from the distribution of AI familiarity amongst participants, as shown in Fig. 5, a noticeable trend emerges when assessing the prior experience with AI tools based on the case studies of Child Neuropsychiatry and Endocrinology. A significant proportion of participants from the Child Neuropsychiatry group have had previous engagements with AI-based solutions, whereas the Endocrinology group paints a slightly contrasting picture, with a more balanced split between those with and without AI experience.

The plot in Fig. 6 illustrates the overall average Likert scale responses across all participants for each of the ten questions. Predominantly, the average responses remained around or exceeded the neutral response line (red dotted line). This inclination suggests that participants held a general agreement or positive sentiment towards the statements presented in the questionnaire. Notably, questions 9

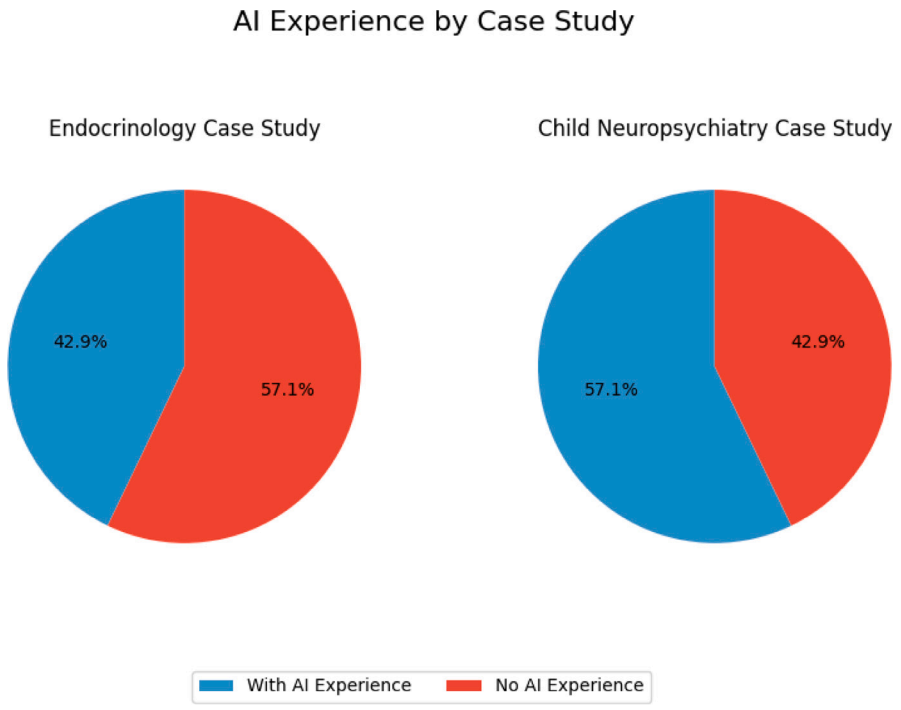


Fig. 5. Distribution of participants' prior experience with AI tools differentiated by case study.

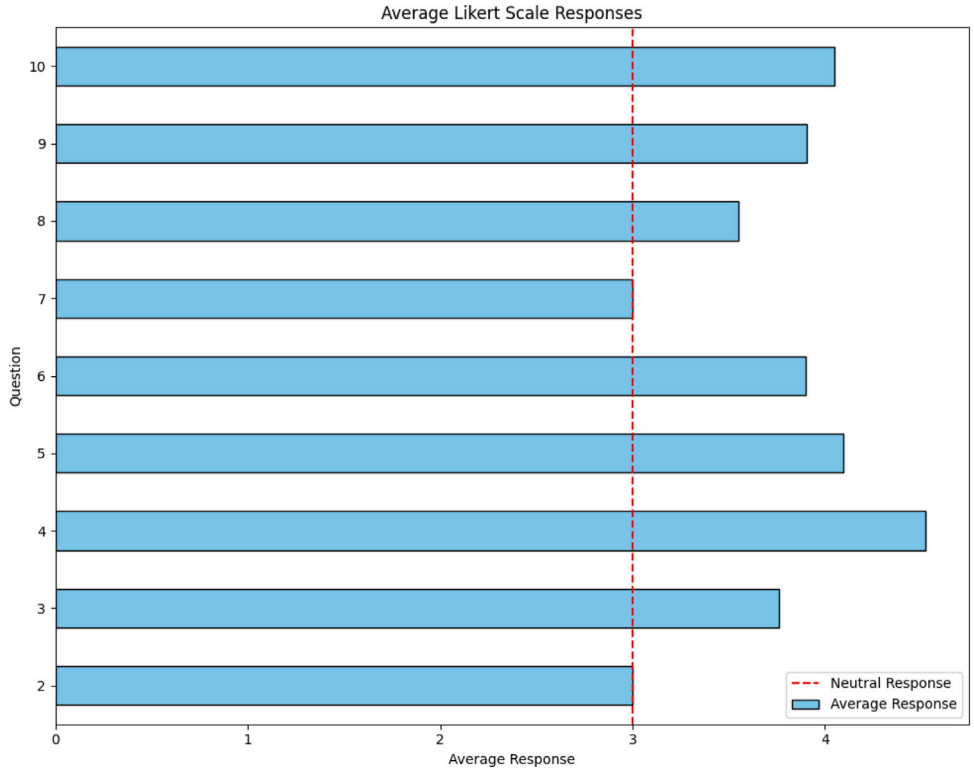


Fig. 6. Overall average Likert scale responses across all participants for the nine questions, indicating general sentiment towards AI tools, speculative scenarios, and the role of meta-design in healthcare. The red dotted line represents the neutral response threshold. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

and 10, which delve into the importance and efficiency of a meta-design-based approach in AI tools, garnered particularly high scores. This signals that participants might perceive meta-design as especially pivotal for AI integration and efficiency in their respective fields. Several observations can be derived from these results:

- The responses to question 2, gauging the plausibility of the speculative scenario, and question 3, assessing the perceived persuasiveness of AI's role, indicate participants' optimistic outlook towards the near-future applications of AI in healthcare.
- Questions 4 and 6, examining the value of AI system adaptability and its potential for real-world implementation, garnered positive feedback, reinforcing the idea that adaptable AI systems are not only desirable but also deemed implementable.
- Ethical concerns, highlighted in question 7, emerged as a significant consideration, suggesting that practitioners remain wary of potential ethical pitfalls in AI applications in healthcare.
- Responses to question 8 underscore a hope or belief that meta-design might offer solutions to such ethical concerns.

In synthesizing the results, we observe a collective optimism towards the integration of AI tools in healthcare, especially when facilitated by meta-design. However, alongside this enthusiasm, there remains a palpable caution concerning the ethical dimensions of such integrations.

5.3. Key takeaways

As we venture to address the pivotal research question – "How can HCAI principles be considered when designing an AI-as-a-service platform that democratizes access to personalized healthcare?" – our aggregated findings from both the questionnaires and the case studies provide rich insights. Our vision highlights the importance of empowering patients in the personalization of the system. This aspect is crucial for ensuring that the platform not only serves the needs of clinicians but also actively involves patients in their healthcare journey. While our findings indicates that meta-design opportunities are currently more clinician-focused, we recognize the emerging need to balance this with stronger patient-centered features, which will be involved at a later stage. The following primary takeaways and recommendations are gathered to reflect this dual focus:

1. **Democratized Access & Inclusivity**: A recurring theme, both from the questionnaires and the user journey maps, emphasizes the importance of ensuring the AI platform is accessible to all, irrespective of economic, territorial, or social backgrounds. It is essential to develop features that cater to diverse patient demographics and ensure that no group is inadvertently excluded from the platform's benefits.
   Recommendation: AI platforms should integrate adaptive mechanisms that can adjust based on user profiles, thereby catering to a wider patient demographic.
2. **Meta-design Opportunities**: Both case studies and questionnaire insights pointed towards the importance of adaptability. AI tools should not be static; instead, they need the capability to be co-designed, with clinicians and patients having a say in the customization. This adaptability ensures the system remains relevant and fits the ever-evolving healthcare landscape.
   Recommendation: Integrate features that allow users (both clinicians and patients) to provide feedback, adapt the system's behavior, and co-create the AI experience.
3. **Ethical Considerations & Bias Mitigation**: The user journey maps from both case studies underscored potential biases in AI, and the questionnaires reiterated concerns regarding AI's ethical challenges. The confluence of these insights points towards the critical need for designing AI systems with transparency and fairness at the forefront.
   Recommendation: Develop and incorporate bias-detection mechanisms and ensure the platform's decisions are explainable to end-users. Regularly audit and refine the AI models to reduce potential biases.
4. **Collaborative Decision-making**: A mutual finding between the aggregated results and the questionnaire outcomes was the necessity of a collaborative role between AI and human professionals. AI should serve as an augmentative tool, and critical decisions should always involve a human touch.
   Recommendation: Design the AI platform to serve suggestions or recommendations rather than decisive conclusions, ensuring that medical professionals have the final say in critical matters.
5. **Holistic Data Integration**: The case studies highlighted the importance of using a myriad of data sources, including past data, lifestyle changes, and other pertinent patient information. The AI platform's efficacy hinges on its capability to integrate and analyze diverse data types to render meaningful insights.
   Recommendation: Ensure the platform supports integration with various health data sources and can adapt its recommendations based on the comprehensive data profile of a patient.
6. **Employing Design Fiction as a Probe**: The use of design fiction in our methodology underscores its potency as an effective tool in exploring AI integration scenarios within healthcare. This approach not only allows HCI researchers and clinicians to visualize and anticipate technological challenges but also fosters discussions around potential opportunities and pitfalls in AI-enabled systems. By facilitating a narrative-driven exploration, design fiction serves as a bridge between technology and its real-world implications, offering stakeholders a comprehensive view of the AI healthcare landscape.
   Recommendation: Encourage HCI researchers and healthcare professionals to employ design fiction methodologies during the early stages of AI system development. Such an approach can lead to more robust, ethical, and user-centric AI solutions, informed by a wider range of perspectives.

In conclusion, the design of an AI-as-a-service platform in healthcare demands a delicate balance between technological innovation and human-centric considerations. By heeding these key takeaways and recommendations, we can inch closer to democratizing access to personalized healthcare without compromising on ethical standards or quality of care.

5.4. Limitations and future work

In our investigation into the development of an AI-as-a-Service platform for personalized healthcare using Human-Centered Artificial Intelligence (HCAI) principles, several limitations have emerged that are crucial to address in future research. Firstly, the practical implementation challenges within clinical settings were not deeply explored. The intense workloads and time constraints faced by physicians may hinder the proposed solutions in their daily routines. This leads to concerns regarding the feasibility of the proposed approaches under existing clinical workflow pressures and within given resource limitations. Additionally, the current study has not sufficiently addressed the potential gap between the envisioned AI solutions and their realistic implementation within set cost frameworks. Such a gap may result in a divergence between the desired functionalities by the clinicians and what is practically achievable.

Furthermore, our exploration lacks a detailed discussion on the data quality and availability issues, which are pivotal for the effective functioning of AI systems in healthcare. Issues related to interoperability, integration with existing hospital systems, and the continuous learning and adaptation of AI systems to new medical knowledge and practices also remain underexplored. Ethical and legal considerations, particularly surrounding patient privacy, consent, biases in decision-making,

and the liability in case of AI-driven errors as highlighted by Stoeger et al. [26], are crucial areas that our study only partially addressed. Lastly, the necessity for robust clinical validation and reliability of AI models, as well as the importance of building user trust and acceptance among clinicians, have been identified as significant areas needing further attention.

Considering these limitations, future research directions include a more in-depth exploration of the practical integration of AI in healthcare, especially focusing on the constraints and challenges within clinical settings. Future studies should aim to bridge the gap between theoretical AI applications and their practical implementation, considering the cost and resource limitations of healthcare institutions. This involves conducting a thorough analysis of data quality and availability, interoperability issues, and the challenges of integrating AI tools with existing healthcare systems. Our future endeavors will include the development and integration of visual and interactive tools [27,28], enabling clinicians to engage directly with datasets, providing hands-on experience in identifying potential data-related issues.

A focused examination of the ethical and legal aspects of AI in healthcare, including patient privacy, consent, decision-making biases, and liability concerns, is paramount. Future work should also emphasize the importance of robust clinical validation of AI models and explore strategies to enhance clinician trust and acceptance of AI tools. Addressing these areas will ensure that the AI-as-a-Service platform for healthcare is not only technologically advanced and ethically responsible but also practical, legally compliant, and effectively integrated into the healthcare ecosystem.

Finally, as stated in the Introduction and remarked also by some of the participants, it is clear that involving patients and all relevant stakeholders is a vital next step in our research. Future iterations will focus on engaging patients, healthcare professionals, and technologists to gather collaborative insights. This approach is aimed at comprehensively understanding the challenges and opportunities in integrating AI into healthcare from multiple viewpoints. By incorporating the perspectives of all involved parties, we aim to develop AI solutions that are not only technically sound but also align closely with the practical needs and experiences of everyone in the healthcare community.

5.5. Threats to validity

Several potential threats to validity arise in the design of this study.

Internal Validity The limited scope of our case studies makes it challenging to draw conclusive insights about the diverse outcomes observed during the research. For a thorough validation, there is a need for a broader investigation encompassing a larger participant pool and more varied scenarios. Potential biases, such as the experimenter effect, related to the researcher's influence and the subject effect, tied to participants' behavioral alterations when being studied, were carefully considered. The researchers, while acting as facilitators of the workshops, aimed to minimize undue influence, though their involvement might have introduced certain dynamics to the discussions and outcomes.

External Validity Our research was concentrated on a particular demographic group. Therefore, a wider study involving a more diverse and international cohort is required to explore the full spectrum of implications. Furthermore, the lack of reliable collaborative modalities might have shaped the results, emphasizing the importance of introducing more comprehensive tools in future research.

Construct Validity All participants completed the post-test questionnaire. However, due to the constraints associated with the workshop format, the questionnaire had a limited number of questions focused on different facets of the experience. While this might impact the overall feedback, it is worth noting that the findings were not solely based on these responses but were supplemented with direct feedback throughout the workshops.

6. Conclusion

The intersection of AI with healthcare implies a potential paradigm shift in patient care methodologies. Using the MiniCoDe methodology as a framework, this paper sought to explore the intricacies associated with such an integration, specifically within the realms of endocrinology and child neuropsychiatry.

One central observation from our research is the importance of aligning AI technologies with the specific needs of patients and the expertise of medical professionals. While technological advancements provide notable opportunities for enhanced care, their effective deployment requires a nuanced understanding of both therapeutic goals and patient-specific considerations. Our two case studies offered insights into the challenges and advantages of AI deployment, highlighting the imperative of adaptability and continual engagement with relevant stakeholders.

Furthermore, our exploration identified concerns related to algorithmic bias and the associated ethical challenges. As AI systems gain prominence in healthcare, it becomes crucial to ensure that these systems are developed and refined with considerations of equity, transparency, and accountability. Our findings stress the need for ongoing scrutiny of AI models to ensure alignment with established ethical principles.

The emphasis on meta-design throughout our research signals its potential as an approach that fosters adaptability and inclusivity in AI system development. By advocating for iterative design processes and continuous stakeholder engagement, meta-design suggests that AI deployments in healthcare can be seen as evolving frameworks rather than fixed solutions.

Looking ahead, future works include broadening the scope of our research by incorporating diverse stakeholders such as patients, caregivers, and experts from other health disciplines into our workshops. Such a holistic approach is expected to provide a more comprehensive understanding of AI's role in healthcare.

In summary, this research contributes foundational perspectives on the interplay between AI and healthcare, highlighting both potential advantages and challenges. While the current findings provide a basis for further exploration, it is evident that the journey towards integrating AI in healthcare, especially within an AIaaS platform guided by HCAI principles, requires ongoing research, collaboration, and vigilant monitoring of ethical considerations.

CRediT authorship contribution statement

Tommaso Turchi: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Giuseppe Prencipe:** Writing – review & editing, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Data curation. **Alessio Malizia:** Writing – review & editing, Writing – original draft, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Formal analysis, Conceptualization. **Silvia Filogna:** Writing – review & editing, Validation, Supervision, Resources, Methodology. **Francesco Latrofa:** Writing – review & editing, Supervision, Resources, Project administration, Methodology, Funding acquisition. **Giuseppina Sgandurra:** Writing – review & editing, Validation, Supervision, Resources, Project administration, Investigation, Funding acquisition.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Declaration of Generative AI and AI-assisted technologies in the writing process

Statement: During the preparation of this work the author(s) used OpenAI's ChatGPT in order to improve readability and language. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

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Appendix A. Design fiction narrative

[*Ambient hospital sounds: distant conversations, a soft beep of machinery, footsteps.*]

NARRATOR: The year is 2035. Welcome to St. Aria Hospital. As dawn breaks, the hospital corridors start buzzing with life. Let us take a closer look at Dr. Laura's day.
[*Sound of an office door opening, gentle chime of a computer booting up.*]

DR. LAURA: [*speaking to the AI, named AIDEN*] Morning, AIDEN. Show me today's schedule.

AIDEN: [*AI voice*] Good morning, Dr. Laura. You have 12 patient appointments today. I've analyzed their medical histories overnight. Would you like an overview?

DR. LAURA: Yes, start with the first one.

AIDEN: Your 9 AM is with Mr. Thompson. Given his recent blood work and his genomic data, there's a 72% probability he might be pre-diabetic. I'd recommend a more in-depth glucose tolerance test.
[*Sound of footsteps, a door knocking, and a patient greeting.*]

DR. LAURA: Hello, Mr. Thompson. How have you been feeling? I want to discuss your recent blood work.
[*Fast-forwarding sound effect.*]

NARRATOR: The day goes on, with AIDEN assisting Dr. Laura seamlessly.

AIDEN: Dr. Laura, for your 2 PM with Mrs. Ruiz, her wearable devices have noted irregular sleep patterns. Coupled with her self-reported symptoms, it might indicate early signs of a sleep disorder. Perhaps consider a sleep study?
[*Gentle evening sounds: distant chirping of crickets, a faint lullaby playing in the pediatrics wing.*]

DR. LAURA: [*reflecting*] AIDEN, show me the treatment plans for all patients today.

AIDEN: Displaying now. By the way, I've also drafted some personalized health advice and exercise regimes for each patient, based on today's consultations. Would you like to review and approve?

DR. LAURA: Perfect, AIDEN. Let us go through them.

NARRATOR: With AIDEN's predictive analytics and deep learning, Dr. Laura not only diagnoses but also anticipates her patients' needs, offering them tailored, proactive care.
[*Fade-out*]

NARRATOR: [*concluding*] This is a day in the life of Dr. Laura, where advanced AI meets compassionate care. Where technology doesn't replace human touch but amplifies its reach.

Appendix B. Personas

B.1. Endocrinology case study

B.1.1. AI model: ENDOAI (Endocrinology Adaptive Intelligence)

Background. ENDOAI is a cutting-edge AI model developed specifically for endocrinology. Its design is centric to assisting in the diagnosis, monitoring, and treatment suggestions for endocrine and metabolic disorders, with a significant focus on diabetes.

Features.

- Continuous Glucose Monitoring: Seamlessly integrates with wearable devices for real-time glucose level tracking.
- Diagnosis Aid: Proposes potential diagnoses based on a synthesis of patient symptoms and past medical history.
- Treatment Planner: Tailors treatment approaches grounded on individual patient responses.
- Interaction Modes: Capable of voice, text, and visual engagements.

Ethical constraints.

- Prioritizes data protection and maintains patient confidentiality.
- Enhances, rather than replaces, clinical decisions in endocrinology.

B.1.2. Clinician: Dr. Francesca Romano

Background. A seasoned endocrinologist, Dr. Romano holds expertise in diabetes management and is receptive to technological interventions that can refine patient care.

Day-to-day. Manages a consistent patient flow, with a significant portion requiring long-term diabetes care, and regularly collaborates with fellow healthcare professionals.

Needs & preferences. She places premium value on precise, up-to-the-minute patient data and tools that intuitively map patient progress.

Concerns. Remains vigilant about the ethical ramifications of AI, especially pertaining to treatment suggestions, and is apprehensive about potential data breaches.

B.1.3. Patient: Sofia Ricci

Background. Sofia, 28, thrives in the marketing domain. Recently diagnosed with Type 2 diabetes, she's tech-savvy and is inclined towards digital tools that can optimize her health management.

Day-to-day. Balances a demanding job with frequent travels, attempts to maintain a holistic balance between work, exercise, and dietary habits, and routinely checks her glucose levels at home.

Needs & preferences. Seeks efficient mechanisms to relay her health metrics and values digital consultations that align with her dynamic lifestyle.

Concerns. While open to AI interactions, she remains wary about data security and desires a human-centric touch in her consultations.

B.2. Child neuropsychiatry case study

B.2.1. AI model: LUCIA (Learning Unit for Cognitive Insights and Analysis)

Background. LUCIA is an advanced AI system tailored for neuropsychiatric care. It processes extensive patient data, suggesting potential therapeutic approaches, monitoring patient progress, and alerting clinicians to changes in a patient's cognitive or behavioral state.

Features.

- Data Processing: Capable of handling large volumes of patient data for insightful analysis.
- Therapeutic Suggestions: Recommends possible therapeutic approaches based on patient data.
- Patient Monitoring: Tracks patient progress and alerts clinicians about significant changes in condition.
- Cognitive and Behavioral Alerts: Notifies about shifts in cognitive or behavioral patterns of patients.

Ethical constraints.

- Ensures stringent data privacy and security measures.
- Aims to complement, not replace, clinician judgment in neuropsychiatric care.

B.2.2. Clinician: Dr. Laura Ricci

Background. Dr. Laura Ricci, a 38-year-old child neuropsychiatrist with 12 years of experience, specializes in the treatment and research of pediatric cerebral palsy. She is an avid proponent of technological integration in therapy and monitoring.

Day-to-day. Focuses on cerebral palsy treatment in children, incorporating digital tools in her therapeutic approach, and actively seeks innovative methods to enhance patient care.

Needs & preferences. Values technology's potential in improving therapy quality and patient monitoring.

Concerns. Emphasizes the importance of balancing technology with traditional treatment methods and is cautious about over-reliance on digital tools.

B.2.3. Patient: Matteo Ferrari

Background. Matteo, aged 7, has been diagnosed with cerebral palsy since infancy. An energetic child, he loves digital games and animations, with his parents deeply involved in his care and therapy.

Day-to-day. Actively engages in educational and therapeutic activities using tablet applications, guided by his parents.

Needs & preferences. Enjoys interactive and digital means for education and therapy, appreciating tools that make learning and treatment engaging.

Concerns. His family is focused on ensuring the balance between digital tools and personal care in his treatment.

B.2.4. Parent: Sara Ferrari

Background. Sara, aged 35, mother of Matteo, is an elementary school teacher. She is keen on integrating innovative educational methods to aid Matteo's development, believing strongly in the power of technology as a support tool.

Day-to-day. Balances her professional life with actively seeking and incorporating technological solutions in Matteo's daily life and therapy.

Concerns. Cautious about choosing the right technological tools that are beneficial and not overwhelming for Matteo.

B.2.5. Parent: Giovanni Ferrari

Background. Giovanni, aged 37, father of Matteo and a software engineer, is tech-savvy and explores technological solutions that could benefit Matteo. He introduced various digital applications and tools to his family, aiming to enhance Matteo's life.

Day-to-day. Continuously searches for and evaluates new technological advancements that can be integrated into Matteo's care and development.

Concerns. Focuses on finding the right balance between technology and medicine, ensuring the tools are effective and positively contribute to Matteo's growth.

Appendix C. Questionnaire

1. Have you had previous experiences with AI-based tools or solutions in the healthcare field?

   Yes No

2. How plausible do you find the speculative scenario presented at the beginning of the workshop for the next 5 years?

   Not at all 1 2 3 4 5 Very Much

3. From the narrative you heard, how convincing do you find the AI's role in the speculative scenario?

   Not at all 1 2 3 4 5 Very Much

4. How valuable is the adaptability of an AI system in your daily practice?

   Not at all 1 2 3 4 5 Very Much

5. Do you see meta-design facilitating the customization and adaptability of AI tools in endocrinology/child neuropsychiatry?

   Not at all 1 2 3 4 5 Very Much

6. How much do you believe that the AI adaptation opportunities discussed during the workshop have a high potential for real-world implementation?

   Not at all 1 2 3 4 5 Very Much

7. Are you concerned about the potential ethical dilemmas related to AI in endocrinology/child neuropsychiatry?

   Not at all 1 2 3 4 5 Very Much

8. Can meta-design effectively address or alleviate these ethical concerns?

   Not at all 1 2 3 4 5 Very Much

9. Based on the workshop, how important do you think meta-design is for the integration of AI in endocrinology/child neuropsychiatry?

   Not at all 1 2 3 4 5 Very Much

10. Do you think that a meta-design based approach can lead to more efficient AI tools in your field?

    Not at all 1 2 3 4 5 Very Much

11. Do you have any further comment or suggestion on how AI could be better integrated in your field?

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