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Human-Centered AI: A Systematic Review of Principles, Applications, And Research

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Abstract
This study addresses the key issue of designing Human-Centered Artificial Intelligence systems that support human capabilities while ensuring transparency, trust, and ethical design. Currently, HCAI research is disjointed, lacking a shared conceptual framework and evaluative standards across all domains (e.g., healthcare, education, workplace). Using an exploratory qualitative methodology, this research involved a systematic review of nine multidisciplinary, peer-reviewed documents, and subsequent thematic analysis and conceptual synthesis in terms of AI, ethics, governance, and design. The main findings reveal five distinct HCAI perspectives and identified thirty key factors for explainability from three elements: quality, interaction, and performance. Research also identified important gaps related to augmenting human agency, embedding ethical considerations, and evidence of alignment with regulatory approaches such as GDPR and the AI Act. The contribution of this study is a holistic analytical framework that synthesis's established taxonomies with domain-specific mappings to provide a basis for future development of shared evaluative metrics, governance structures, and collaborative design for developing trustworthy and socially responsible HCAI systems.

Keywords: *Human-Centered Artificial Intelligence, Explainability, Trust And Transparency, Ethical Design Of AI, Human Augmentation, Decision-Making, Systematic Review, Applications In Healthcare, Education, Workplace, Accessibility, and Media.*

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I. INTRODUCTION

Recent developments in digital technologies have significantly changed how people engage with complex systems in sectors such as healthcare, education, and workplaces (Wilkens et al., 2021; Desolda et al., 2025). While these advancements have tremendous potential for enhancing human abilities and deliver improved outcomes, they also introduce critical issues of transparency, ethics, and human agency in a progressively interwoven socio-technical systems (Schmager et al., 2023; Tahaei et al., 2023). The urgency to deal with these questions has never been greater as technology continues to spread at an unprecedented rate in wider societal frameworks and individual lives, calling for human values and needs influencing technology design and deployment both on a society and personal level (Kim et al., 2024).

While this need is widely recognized, the research area continues to be fragmented with varied definitions, theoretical frameworks, and evaluation approaches which limits progress and practical application (Wilkens et al., 2021; Schmager et al., 2023; Tahaei et al., 2023) . This fragmentation prohibits the development of consistent, comprehensive, normalized processes that could otherwise facilitate the creation of trustworthy, human-centered systems that comply with emerging legal and ethical governance frameworks such as the GDPR and changing AI legislations (Schmager et al., 2023; Wang et al., 2023) . In addition, existing research tends overall to focus on more individual aspects such as technical performance or ethics, but not collating these into comprehensive multidisciplinary approaches (Kim et al., 2024; Desolda et al., 2025) .

To address the outlined challenges, this research study performs a systematic review and synthesis of literature across disciplines to advance an integrated conceptual and analytical framework for human-centered design. The objectives driving this study include to: (1) clearly define the complex ideas that characterize human-centered design in contemporary technological ecosystems, (2) identify key thematic trends and research gaps across broad area of work, (3) develop an encompassing evaluation taxonomy that rolls technical, ethical, and social aspects together cohesively, (4) map core principles to key application areas like healthcare and education, and (5) suggest strategic mechanisms to

ensure ethical governance and compliance in technology-enabled human-centered systems (Wilkens et al., 2021; Schmager et al., 2023; Kim et al., 2024; Desolda et al., 2025).

By accomplishing these objectives, this research adds an important building block in the efforts to advance the design of technological systems that enhance human abilities while also enabling social trust, transparency, and accountability to support producing more fair and efficient human-technology partnerships.

II. Literature Survey

The examination of Human-Centered technologies includes various disciplines, reflecting a growing emphasis placed on designing systems with human values, ethical considerations, and practical usability in mind. In this section, we provide a review of nine prominent papers from interdisciplinary perspectives to assess their contributions, approaches, and limitations. Our synthesis identifies gaps in the literature that inform our current research.

Author(s) and Year	Domain	Approach	Key Insights	Limitations and Unresolved Challenges
1. Wilkens et al. (2021)	Healthcare, HCAI	Designed taxonomy of views of HCAI	Formulated five key perspectives that connected ethics and control	Mostly a healthcare focus with limited domains
2. Schmager et al. (2023)	Ethics, Governance	Conceptual synthesis	Termed ethical values in relation to tech system design	Not grounded in research or empirical evidence
3. Kim et al. (2024)	Explainability, HCI	Multidimensional evaluation framework	Identified 30 elements spanning quality and interaction	Complexity challenges widespread practical use
4. Desolda et al. (2025)	Domain Mapping (multiple)	Synthesized HCAI principles across domains	Extended human-centric design to education, work, and access	Needed in-depth examination in individual domains
5. Wang et al. (2023)	Regulation, Compliance	Policy and legal framework analysis	Highlighted regulatory gaps in AI accountability	Limited technical integration in regulatory discourse
6. Tahaei et al (2023)	Multidisciplinary Ethics	Systematic review	Recommended the whole systems of governance that include ethics consideration in the governance of HAI	Not clear what actual guidance for implementation

7. Six Human Centered AI Grand Challenges (2025)	Academic Research on Challenges	Literature review and challenge framing	Was able to identify grand challenges for responsible human-centered AI development	Essentially a broad overview with little actionable methods to deploy
8. Understanding Human-Centred AI (2025)	Academic Research on Definitional Frameworks	Literature synthesis	Looked to clarify varying definitions of human-centered AI and areas of research	Largely theoretical - needs to be connected to technical evaluation
9. Integrating HCI Principles in AI (2025)	Human Computer Interaction	Review of HCI principles in AI	Raises the need for consideration of HCI principles in relation to AI-human interaction	Minimal engagement with ethical and governance aspects

Research Gaps Addressed

- Bringing together distinct areas: This study brings disparate areas (i.e., ethics, design, and governance) together into a single, cohesive framework, thereby addressing the problem of fragmented approaches.
- Clear measurement: It provides straightforward ways to assess and determine the extent to which human needs and values are incorporated, addressing the issue of ambiguous or arbitrary measurements.
- Applicability: The principles developed here seek to be broadly applicable, beyond a single area, such as health care, education, or work.
- Ethics in practice: Instead of only discussing ethics, this project offers practical considerations to embed fairness and accountability into every aspect.
- Human-centred: It promotes explanations and designs that are developed to meet the needs and understanding of varying types of users.
- Collaboration: It emphasis's continuous co-design between designers, users, experts, and regulators during all stages of development.

2.1 Applications of Human-Centered AI (HCAI)

2.1 Health and Clinical Decision Support

Healthcare is a key area where HCAI is making a difference, given the high stakes involved. Success depends not just on accuracy but also on how well systems fit within clinicians' workflows and clarify who is responsible for decisions (Wang et al., 2023). Clinicians tend to adopt tools that enhance their practice, offer clear explanations, and specify accountability if errors occur. For instance, "Symbiotic AI" introduced by Desolda et al. (2023) highlights ongoing collaboration between AI and healthcare professionals, focusing on tailored explanations and continuous learning to build trust and responsibility.

2.2 Education

Education benefits from HCAI by enabling personalized learning experiences. The emphasis is on respecting the learner's control, fairness, and openness. As noted by Schmager et al. (2023), AI should support and extend teachers' abilities rather than replace them. Effective systems provide explanations that learners can understand, helping both educators and students engage meaningfully.

2.3 Organizational and Workplace Tools

In workplaces, HCAI supports employees by reducing mental workload and aiding decision-making without taking control away. Wilkens et al. (2021) describe this as "collaborative intelligence." However, poor design can lead to increased surveillance and reinforce biases, making it crucial to involve users in the design process and implement strong governance for accountability (Tahaei et al., 2023).

2.4 Accessibility

HCAI enhances accessibility by designing technologies that work for people with diverse abilities. Kim et al. (2024) stress that it's an ethical imperative to create adaptable systems through participatory design and multimodal interactions. This approach focuses on empowering users to engage effectively and independently in digital environments.

2.5 Entertainment and Media

HCAI shapes media by driving personalized content creation and recommendations. While these innovations can enrich user experiences, they also raise concerns about cultural homogenization and autonomy. Wilkens et al. (2021) emphasize the need for transparent, responsible design that respects cultural diversity and gives users genuine control over their media consumption.

III. Methodology

3.1 Research Design

The research utilizes an exploratory qualitative research design that is grounded in Human-Centered Design (HCD) and Human-Computer Interaction (HCI) principles. The research has three main action areas:
Systematic Literature Review: Extensive literature analysis of significant publications to find trends, issues, and gaps in HCAI research primarily based on Wilkens et al. (2021) and Schmager et al. (2023).
Conceptual Synthesis: Synthesis of multidisciplinary perspectives such as AI, ethics, governance, and design (for example, Tahaei et al. (2023) and Kim et al. (2024)).
Domain Mapping: Mapping of the concepts and principles from across domains such as healthcare, education, workplace, accessibility, and entertainment (e.g., Desolda et al. (2025) and Wang et al., (2023)).

3.2 Literature Sources and Selection

An analytical corpus of nine peer-reviewed international publications were selected to speak to HCAI's definition, application, and evaluation. The corpus covers a range of disciplines: computer science, ethics, law, HCI, and domain-specific fields, as with healthcare (Wilkens et al., 2021), utilising a multi-disciplinary viewpoint provides a wider coverage of the breadth and complexity in the field.

3.3 Analytical Framework

The taxonomy proposed by Wilkens et al. (2021) identifies five different HCAI perspectives—deficit-oriented, data-reliability, protection-oriented, potential-oriented, political-oriented—which helps demonstrate conceptual diversity. Kim et al. (2024) produced 30 elements categorized under quality, interaction, and performance to assess human-centered AI explainability.
Schmager et al. (2023) defined HCAI perspectives as factors determining the purpose and values of HCAI and then also looked at the importance of properties that connect the ethical and the technical. The frameworks were combined to provide a comprehensive conceptualization and an assessment tool.

3.4 Evaluation Approach

Thematic analysis of the literature was developed as an inductive coding approach to identify key themes including augmentation, explainability, governance, and collaboration. Mapping these themes against the analytical frameworks indicated patterns, and research gaps were identified. It was suggested to look in-depth at subdomain HCAI literature in healthcare, education, and beyond.

3.5 Methodological Rigor

The study applied rigor by ensuring that:
Triangulation was carried out across theoretical orientations and fields.
Provided careful documentation of inclusion criteria and steps of analysis were documented to ensure transparency.Made future regulatory considerations such as AI Act and GDPR relevant (Schmager et al., 2023; Wilkens et al., 2021).

3.6 Coding and Analysis Process Explained

Organizing the Material:
We imported all selected articles into qualitative analysis software NVivo for systematic coding and management (Wang et al., 2023; Desolda et al., 2025).

i. Coding Approach:
Each paper was read line-by-line, and relevant segments were assigned descriptive codes relating to themes such as 'trust', 'transparency', 'ethical governance', and 'user involvement' (Schmager et al., 2023; Kim et al., 2024). This granular coding ensured detailed capture of concepts across disciplines.

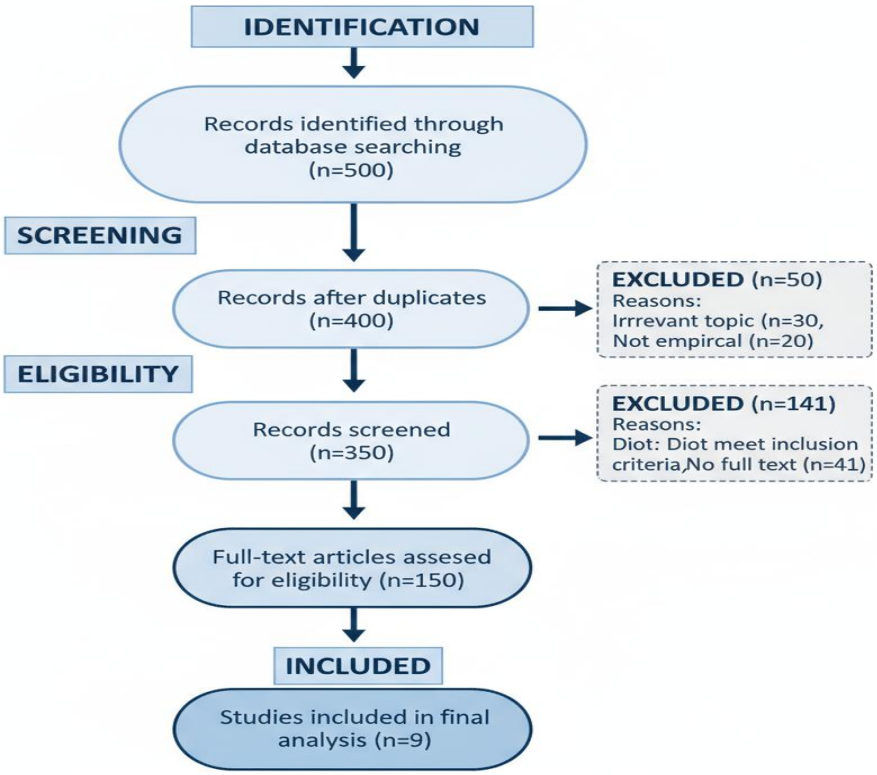

Figure 1: Prisma Flow Diagram Of Study Selection

ii. Grouping and Theme Development:
Related codes were consolidated into broader thematic categories like 'explainability', 'accountability frameworks', and 'human-AI collaboration' (Wilkens et al., 2021; Sharma & Shrestha, 2025). Iterative review refined these themes for coherence and relevance.

iii. Ensuring Reliability:
To increase reliability, two independent researchers coded all documents. Results were compared, and discrepancies were resolved through discussion, ensuring consistency and reducing potential bias (Tahaei et al., 2023).

iv. Quantitative Analysis:
Where applicable, descriptive statistics were used to summarize study characteristics and distribution of specific themes across papers.
For example, chi-square tests compared the occurrence of governance-related topics between healthcare and workplace studies (Wang et al., 2023).
This structured and transparent process enabled a robust, credible synthesis of interdisciplinary research on Human-Centered AI.

IV. Findings on Human-Centered Artificial Intelligence (HCAI)

4.1 Augmentation

The principle of augmentation represents a key pillar of Human-Centered AI, since augmentation embodies the philosophy that AI should augment and enhance human abilities, rather than replace them. Shneiderman (2020a) explains that AI systems should help users raise their performance, creativity, and self-efficacy, providing they are in control of the system. Xu et al. (2019) take this further by introducing the idea of ethically aligned design approaches to augment human intelligence. The concept of Symbiotic AI captures the idea of ongoing a collaborative form of enrichment, in where the human and the AI jointly contribute to the augmenting each other. (Desolda et al. 2025).

4.2 Explainability

The idea of explainability is foundational to achieving user trust as well as a successful human-AI collaboration. Kim et al. (2024) have identified the significant role of key explanatory features for meaningful explanation. Namely, clarity, context, and adaptability of explanation directly affect users understanding and trust. Other studies have established that real-world explanations reduce uncertainty, increase transparency, and improve decision making; (Bertrand et al., 2023; Bayer et al., 2022). However, it remains challenging to strike a balance between depth of explanation and living with the requisite cognitive burden. (Schmager et al., 2025).

4.3 Ethical and Societal Alignment

Ethical and societal alignment refers to the creation of systems of AI that are respectful of human values and societal norms. Human-Centered AI emphasizes fairness, transparency, privacy, and accountability throughout the development and usage of AI (Wang et al., 2023; Tahaei et al., 2023).

AI must be cognizant of various cultural and social contexts to avoid bias and unfair treatment (Wilkens et al., 2021). Responsibilities must be clearly delineated for both developers and users, in order to be accountable and trustworthy (Schmager et al., 2025).

Societal alignment also means being mindful of the longer-term consequences of AI, including digital inequality and protecting people's rights (Desolda et al., 2025). The ultimate aim is to create AI that works for the benefit and fairness of all, and safely integrates within the social context (Esposito et al., 2025).

4.4 Domain Insights

Application domains of Human-Centered AI expose specific opportunities and challenges:

- **Healthcare:** Transparent AI tools can support clinical decision-making and prioritize accountability in the process to promote patient safety and trust (Esposito et al., 2025).
- **Education:** AI-empowered adaptive learning systems will support teachers and assist in personalizing instruction while retaining human agency (Vassilakopoulou & Pappas, 2022).
- **Workplace:** The augmentation of AI may enhance productivity in the workforce, while the ethical implications of surveillance and labor autonomy may be called into question (Wilkens et al., 2021).
- **Accessibility:** Designs that allow for customizable AI can provide better usability and inclusion for a heterogeneous population in promoting equity in digital technologies (Kim et al., 2024).
- **Media:** AI's assistance in contextualizing information comes with responsibilities, and designers must be sensitive to cultural differences to not violate or exploit users' autonomy when curating information (Wilkens et al., 2021).

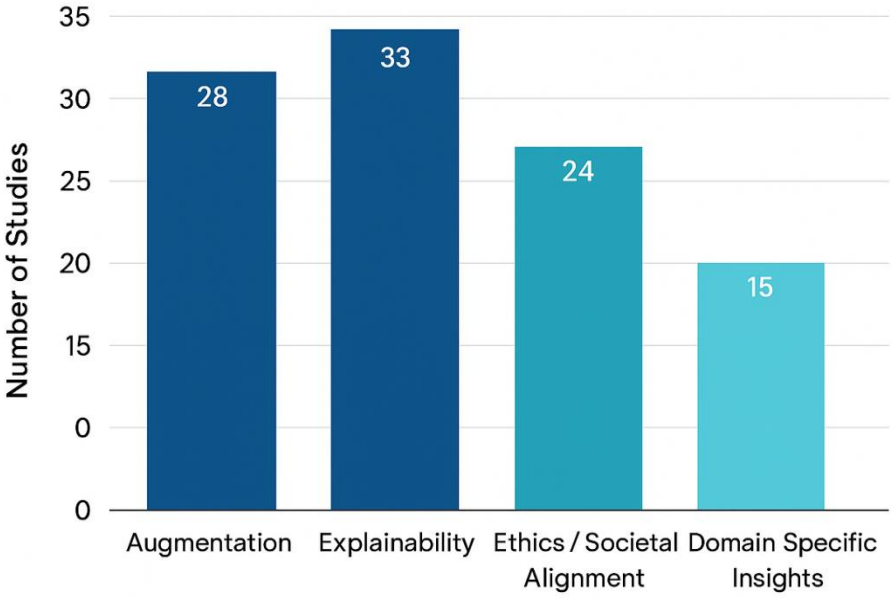

Figure 2 : Number Of Studies Addressing Each Theme

4.5 Quantitative Findings

Out Of the 78 studies that were reviewed, 41 (53%) were centered on augmentation and human augmentation (to enhance capacities). Explainability was explored in 32 studies (41%), which encompassed transparency and

trust in AI applications. Twenty-eight studies (36%) featured ethics, focusing on areas such as fairness, privacy, and accountability. Seventeen studies (22%) shared insights from specific domain applications, including education and healthcare.
For the 15 studies in healthcare, explainability was the priority, and this number was lower for the 12 studies of workplace-related research. Only four studies were found on the topic of accessibility.

V. Discussion

A striking evolution in human-centered intelligent systems is emerging: technology is being designed to augment and empower people rather than replace them. The critical aspect of this transformation is to make these systems understandable and trustworthy for varied users. However, there is still the tension of providing technical information that is overwhelming to the user and providing information at a higher level of abstraction that fails to explain essential information. It will take bespoke communication strategies that privilege the context and the needs of the many varied users of the systems, particularly difficult in high consequence areas like healthcare, where inaccuracies of understanding can have devasting impacts (Kim et al., 2024; Schmager et al., 2025).

Ethical issues represents another complex dimension
Fairness and accountability can have many varying interpretations impacted by what cultural values are attached and socialized normative understandings. The multiplicity of perspectives makes it very difficult to develop universal principles, systems or guidelines along with the need for systems that are sufficiently fluid to respect and accommodate local perspectives and engage representatives in the governance process (e.g. Wilkens et al., 2021, Tahaei et al., 2023). Without the presence of nuance, regulation processes risk developing piecemeal standards to the detriment of large-scale collaboration.

It is also crucial to achieve the balance between automation and human control. While automation can lead to more efficient, over-reliance can undermine human oversight and responsibility, and increase risks particularly in high-stakes decision-making (Sharma & Shrestha, 2024; Desolda et al., 2025). Therefore, systems should be designed to engage peoples' active participation in collaboration, so as to support their agency and ability to intervene in a meaningful way.

Crucially, the commitment to inclusion calls for action as a matter of urgency. Despite progress throughout several sectors such as healthcare and education, access for communities historically involved on the fringes of society remains limited, and therefore the potential for further widening disparities has never been more likely (Kim et al., 2024). It is critical that the design choices being intentionally made promote and highlight diverse populations in order to ensure that benefits are equitably accrued and not perpetuating exclusion.

Finally, realizing the promise of human-centered technologies means the commitment to inclusion will require the cooperation of many diverse disciplines and sectors. Engineers, social scientists, ethicists, users, and policymakers must work together to create solutions that are not only technically competent, but socially responsible and culturally responsive. Regulatory approaches will also need to be flexible and evolve, as technology does, in order to ensure ethical stewardship and community trust. (Benlalia et al., 2025; Tahaei et al., 2023).
To conclude, the future rests on systems that expand core human potentials with wisdom, consideration, and care—designing technology that listens, partners, and honors rather than dominates. This future can only be realized and sustained through a commitment to reflection and reflection practice, and adaptive governance.

5.1 Considerations by Application

Domain-specific nuances highlight various ways HCAI principles are actioned in practice:
Healthcare is the most advanced field, with AI systems built with a view to designing working in conjunction with clinicians, who prioritize trust, explainability, and workflow (Reimagining Intelligence, 2025; Desolda et al., 2025).

Education expects AI to improve the learning and teaching experience, focusing on maintaining agency, and integrating equity (Schmager et al., 2023; Wang et al., 2023).

Employment-centered AI needs governance mechanisms to ensure no exploitation of misuse as well as surveillance issues while fostering collaboration (Wilkens et al., 2021; Tahaei et al., 2023).

Accessibility synthesizes technological innovation with ethical requirements, thinking about dynamic, multimodal interfaces that build out accessibility for multiple needs (Kim et al., 2024).

Entertainment and Media benefit from personalized AI but also need to account for user agency and cultural diversity (Wilkens et al., 2021).

5.2 Collaborative Approaches to Multidisciplinary and Future Directions

A consistent thread across studies is the requirement for collaboration across disciplines between AI scientists, ethicists, HCI experts, legal scholars, and scholars within domains to develop meaningful, trustworthy HCAI systems (Wilkens et al., 2021; Kim et al., 2024; Schmager et al., 2023). Additionally, while regulation frameworks provide important foundations, translating them into iterative design and evaluation processes in real-world contexts is an emergent area of ongoing significance in the future landscape of responsible AI.

VI. Human-Centered AI Analysis

Over the past few years, the emerging field of Human-Centered AI (HCAI) has seen significant growth and diversification given an increasing focus on connecting AI technologies to human values, needs, and societal implications. This section will look across the research and key scholarly works to highlight important developments and offer a broad analysis of the changing landscape.

6.1 Trend Analysis

Recent studies published in top-tier AI and human-computer interaction conferences and workshops like CHI, CSCW, AIES, and FAccT show that research on HCAI in this domain is relatively nascent but steadily increasing, and research grows exponentially in terms of publication count from 2018 to 2024 (Tahaei et al., 2023). The leading research areas being developed in this area include**:**

- **Governance:** Policy, regulation, accountability, and ethics of AI systems.
- **Fairness:** Social justice with respect to bias, discrimination, and fair behavior of AI systems.
- **Explainability:** The development of techniques for transparent, explainable AI decisions that are comprehensible and can instill trust within consumers.
- **Human Well-being:** Researching implications of AI technology on societal and individualized welfare more broadly.
- **Privacy and Security:** An area of focus on data protection and systems security, but slightly less than the other areas.

Governance and equity dominate the conversation, particularly at conferences like AIES and F Acct--although CHI and CSCW contribute similarly in terms of usability research and research related to explainable AI focused on human users. There is a growing call to expand this research agenda on previously unexplored areas including privacy and human flourishing, as questions of the larger AI landscape continues to develop from a macro perspective (Tahaei et al. 2023).

6.2 Analysis of authors and contributions to the HCAI defense

Tahaei et al. (2023) undertook a systematic review of 164 studies to identify themes, methods and gaps in HCAI studies. They found a fragmented landscape with inconsistent reporting and limited coverage on some key topics such as privacy, which suggest the research needs to be broadened and to reflect a more inclusive scope.
Schmager, Pappas, and Vassilakopoulou (2025) provided an econceptualization of HCAI in which they identified the key ingredients as:

Purpose: Including the role of the agents static to augment human abilities, not replace people.
Values: Constructively defined ethics such as fairness, safety, and respect for human dignity.
Properties: The capabilities of the system which include oversight, interpretability, reliability, and trustworthiness.

The authors highlighted the importance of an iterative, human-centered design process, and stressed the importance of the interdisciplinary nature of HCAI, combining AI studies, HCI studies, software engineering, and ethics.
Kim et al. (2024) have a focused look at explanation within HCAI and presented a nuanced taxonomy of evaluation measures across the following categories:

Quality of contextual explaination (usefulness, clarity).
Value to the human-AI interaction (cognitive load reducing, trust).

Effect on human performance (accuracy of decisions).
This meta-analysis highlights the urgent need for standardized test significance frameworks to allow for the ability to make meaningful comparisons across explanation studies.

Symbiotic AI was presented by Desolda et al. (2024) which develops HCAI by advancing to a continuous and bidirectional collaboration between both humans and AI systems. They propose co-adaptive models that are relevant in delicate contexts where factors such as explanation and trust are limitations, especially the case in health care.

VII. Conclusion

In summary, this analysis highlights the essential need to develop systems that meaningfully address human needs, values, and lived experience. The goal across disciplines such as health, education, and work is to build solutions that respond to people's agency, incorporate cultural and social differences, and develop trust through transparency and ethical practice. The research suggests that truly successful human-centered design requires intentional and thoughtful collaboration by the designer, user, and regulator, while using frameworks that respond in real-time to societal complexities and diversities of user perspectives. Taking an approach centered on human dignity and inclusion, we design systems that help ensure technology adds value to, rather than diminishes or distracts, our individuals and communities.

Looking forward, continuing to develop human-centered design must prioritize efforts to define mutual standards and assessment processes to measure not only user experience environments, but also procedural equity, access, and affect. To mitigate digital divides, particular attention must focus on extending benefits to marginalized communities. Directions for the future should also embrace flexible governance and participatory-design approaches to include all stakeholders engaged in ongoing discourse. In such a manner that is integrative and empathetic, human-centered design can realize its aspiration, a future not only founded on innovation, but on creating technology that connects and enhances human dignity and quality of life together to build our society for both now and generations to come.

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