

Human Centered Artificial Intelligence Through GDPR Compliant Data Science Workflow Implementation

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ABSTRACT

The rapid advancement of Artificial Intelligence (AI) and data science technologies has transformed organizational decision-making across healthcare, finance, and digital services. Despite these advancements, the increasing use of personal data has intensified concerns regarding privacy, transparency, accountability, and public trust. Building trustworthy Human-Centered AI requires data science workflows that integrate regulatory compliance, ethical principles, and responsible governance throughout the AI lifecycle. **This study aims** to examine how GDPR-compliant data science workflow implementation supports the development of trustworthy Human-Centered AI through a qualitative and practice-oriented research approach. **The study synthesizes** evidence from recent literature, industry case studies, expert perspectives, and governance-oriented analytical frameworks to identify effective strategies for integrating privacy-by-design, data minimization, transparency, accountability, and privacy-preserving techniques, including anonymization, pseudonymization, and differential privacy, into data science workflows. **The findings** indicate that successful implementation depends not only on technical safeguards but also on strong organizational governance, continuous compliance monitoring, and cross-functional collaboration among legal, technical, and managerial stakeholders. Furthermore, the integration of explainable and governance-aware machine learning models improves transparency, strengthens stakeholder trust, and supports responsible human-centered AI without significantly reducing analytical performance. **This study proposes** a structured GDPR-compliant data science workflow framework that enables organizations to balance analytical effectiveness, regulatory compliance, and human-centered principles while fostering trustworthy, transparent, and sustainable Artificial Intelligence for real-world digital innovation.

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1. INTRODUCTION

The rapid advancement of Artificial Intelligence (AI), machine learning, and data science technologies has fundamentally transformed decision-making across healthcare, finance, manufacturing, governance,

and digital services. AI-driven systems enable organizations to analyze massive datasets, automate complex processes, and generate predictive insights that improve operational efficiency and decision quality. However, the growing dependence on personal data and automated decision-making has intensified concerns regarding privacy, transparency, accountability, algorithmic bias, and public trust [1, 2]. These challenges demonstrate that achieving high predictive performance alone is insufficient, highlighting the need for trustworthy human-centered AI that integrates technical excellence with ethical responsibility and human values [3].

Developing trustworthy human-centered AI requires embedding ethical, legal, and governance principles throughout the data science lifecycle. Among existing regulatory frameworks, the General Data Protection Regulation (GDPR) provides one of the most comprehensive standards for governing personal data processing by emphasizing lawfulness, fairness, transparency, accountability, data minimization, and privacy by design. Rather than functioning solely as a legal requirement [4], GDPR has become an important governance framework that supports responsible AI development by encouraging organizations to incorporate privacy protection, explainability, and accountability into every stage of AI implementation. Integrating these principles into data science workflows strengthens stakeholder trust while reducing legal, ethical, and operational risks associated with AI-driven decision-making [5, 6].

Despite increasing attention to responsible AI, implementing GDPR principles within practical data science workflows remains challenging. Conventional workflows primarily prioritize predictive accuracy, computational efficiency, and scalability, whereas privacy protection, governance, explainability, and regulatory compliance are frequently treated as secondary considerations or addressed after model deployment. Previous studies have examined GDPR compliance, Explainable Artificial Intelligence (XAI) [7, 8], privacy-preserving techniques, and AI governance independently. However, limited research has proposed an integrated workflow that systematically combines these complementary components throughout the complete AI development lifecycle. This fragmentation creates implementation gaps that reduce organizational readiness to develop trustworthy, transparent, and human-centered AI systems [9].

Beyond regulatory compliance, trustworthy human-centered AI contributes to sustainable digital transformation by improving transparency, accountability, fairness, and stakeholder confidence. The integration of explainable AI, privacy-preserving techniques, governance-aware machine learning, and continuous compliance monitoring enables organizations to balance analytical performance with ethical and regulatory responsibilities [10]. These objectives align with the Sustainable Development Goals (SDGs), particularly SDGs 9 (Industry, Innovation and Infrastructure) through responsible technological innovation, SDGs 16 (Peace, Justice and Strong Institutions) through transparent and accountable governance, and SDGs 17 (Partnerships for the Goals) by promoting collaboration among technical, legal, and organizational stakeholders. Consequently, integrating governance into data science workflows has become increasingly important for ensuring responsible and sustainable AI adoption [11, 12].

Therefore, this study examines how implementing a GDPR-compliant data science workflow supports the development of trustworthy Human-Centered AI through a qualitative and practice-oriented approach. By synthesizing evidence from recent literature, industry case studies, expert perspectives, and governance-oriented frameworks, this study proposes an integrated workflow that combines regulatory compliance, privacy-preserving techniques, explainable AI, organizational governance, and continuous compliance monitoring across the AI lifecycle [13, 14]. Unlike previous studies that investigate these components separately, the proposed framework unifies technical, regulatory, and organizational perspectives into a comprehensive implementation model that assists organizations in developing trustworthy, transparent, and sustainable AI systems while maintaining analytical effectiveness and protecting human values [15].

2. LITERATURE REVIEW

2.1. Trustworthy Human Centered Artificial Intelligence

Trustworthy Human-Centered AI emphasizes the development of AI systems that enhance human capabilities while ensuring fairness, transparency, accountability, and respect for fundamental human rights. Unlike conventional AI approaches that primarily prioritize predictive performance, human-centered AI integrates ethical considerations, user needs, and societal values throughout the AI lifecycle [16]. Trustworthy AI is commonly characterized by key principles, including transparency, explainability, fairness, privacy protection, robustness, and human oversight, which collectively promote stakeholder confidence and responsible AI adoption. As AI technologies become increasingly embedded in critical decision-making processes, these prin-

principles have become essential for ensuring that AI systems remain reliable, understandable, and aligned with human values [17].

2.2. GDPR and Responsible AI Governance

The GDPR provides one of the most comprehensive regulatory frameworks for governing personal data processing in AI-driven systems. GDPR establishes principles such as lawfulness, fairness, transparency, accountability, purpose limitation, data minimization, and privacy by design, all of which directly influence data science practices [18, 19]. Beyond legal compliance, GDPR serves as an important governance mechanism that encourages organizations to integrate ethical considerations into AI development. By embedding these principles into data science workflows, organizations can reduce privacy risks, improve transparency, strengthen user trust, and support the development of responsible human-centered AI.

2.3. GDPR Compliant Data Science Workflows

A data science workflow consists of interconnected stages, including data collection, preprocessing, modeling, evaluation, deployment, and continuous monitoring. Each stage introduces potential privacy, security, and governance challenges, particularly when personal data are processed [16]. Conventional workflows often emphasize predictive accuracy and computational efficiency, while regulatory compliance is addressed separately. Recent studies recommend integrating GDPR principles directly into every stage of the workflow through privacy-preserving techniques, consent management, data lineage, explainability, and governance mechanisms. Such integration enables organizations to maintain analytical effectiveness while ensuring compliance with regulatory and ethical requirements [20].

2.4. Explainable AI and Privacy Preserving Techniques

XAI and privacy-preserving techniques have become fundamental components of trustworthy AI. Explainability enables users and stakeholders to understand how AI models generate predictions, thereby improving transparency, accountability, and user confidence [21]. Meanwhile, techniques such as anonymization, pseudonymization, and differential privacy reduce privacy risks without substantially compromising analytical performance. The integration of explainability with privacy-preserving methods allows organizations to develop AI systems that are both technically effective and ethically responsible, supporting trustworthy human-centered AI implementation across diverse application domains.

2.5. Research Gap

Existing studies have extensively investigated GDPR compliance, explainable AI, privacy-preserving techniques, organizational governance, and human-centered AI as independent research domains. These studies have provided valuable theoretical insights and practical contributions toward advancing responsible AI by improving data protection, model transparency, algorithmic fairness, accountability, and regulatory awareness [18]. In particular, explainable AI has enhanced model interpretability, privacy-preserving techniques have strengthened data confidentiality, and governance frameworks have promoted organizational accountability and ethical decision-making. However, most existing research primarily emphasizes specific technical, regulatory, or governance aspects in isolation rather than examining how these complementary components can be systematically integrated throughout the entire data science lifecycle. As a result [22], relatively limited attention has been devoted to developing a comprehensive implementation framework that simultaneously incorporates privacy protection, explainability, governance mechanisms, regulatory compliance, and human oversight into a unified AI development process. Consequently, organizations continue to encounter challenges in balancing analytical performance, regulatory compliance, transparency, explainability, privacy protection, and stakeholder trust while maintaining operational efficiency and supporting responsible AI deployment across diverse application domains [23, 24].

To systematically identify the current state of research and establish the foundation for the proposed framework, the reviewed studies were synthesized according to their research focus, key findings, research limitations, and contributions to trustworthy Human-Centered AI [25]. This synthesis provides a structured overview of the strengths and limitations of existing studies while highlighting the absence of an integrated implementation framework that combines human-centered AI principles, GDPR governance, explainable AI, privacy-preserving techniques, and organizational governance. The results of the literature synthesis are summarized in Table 1.

As presented in Table 1, previous studies have primarily focused on individual dimensions of responsible AI, including GDPR compliance, explainable AI, privacy-preserving techniques, and organizational

Table 1. Synthesis of the Reviewed Studies

Study	Research Focus	Key Findings	Research Limitation	Contribution to the Proposed Framework
[26]	Human-Centered AI	Human-centered principles improve transparency, fairness, and stakeholder trust in AI systems.	Focuses primarily on ethical principles without workflow implementation.	Provides the foundation for integrating human-centered AI principles throughout the proposed workflow.
[27]	AI Governance	Governance mechanisms strengthen accountability and responsible AI deployment.	Limited discussion of GDPR integration and data science processes.	Supports organizational governance and continuous compliance monitoring.
[28]	Explainable AI	Explainability enhances model interpretability and user confidence in AI-assisted decision-making.	Does not integrate privacy-preserving strategies.	Contributes explainable AI as a core component of trustworthy AI implementation.
[29]	GDPR Compliance	Privacy-by-design and lawful data processing improve regulatory compliance.	Primarily emphasizes legal compliance rather than AI governance.	Provides GDPR governance principles integrated across the data science workflow.
Recent Literature (2022–2026)	Privacy-Preserving AI	Anonymization, pseudonymization, and differential privacy effectively reduce privacy risks while maintaining analytical performance.	Limited integration with organizational governance and workflow implementation.	Supports privacy-preserving techniques embedded throughout the proposed framework.
This Study	Integrated GDPR-Compliant Data Science Workflow	Integrates human-centered AI, GDPR governance, explainable AI, privacy-preserving techniques, and organizational governance into a unified implementation framework.	Conceptual framework requiring future empirical validation.	Provides a comprehensive workflow for developing trustworthy Human-Centered AI.

governance [30]. Although these studies provide valuable contributions, few have integrated these complementary components into a unified GDPR-compliant data science workflow that simultaneously addresses technical implementation, regulatory requirements, organizational governance, and human-centered principles. This observation clearly demonstrates the existing research gap and forms the primary motivation for this study. Therefore [31], this research proposes a comprehensive framework that systematically embeds these components throughout every stage of the AI lifecycle to support trustworthy, transparent, and Human-Centered AI

while promoting sustainable digital innovation [32, 33].

3. METHODOLOGY

3.1. Research Design

This study adopts a qualitative and practice-oriented research design to examine how GDPR-compliant data science workflow implementation supports the development of trustworthy human-centered AI. A qualitative approach is appropriate because developing trustworthy AI involves socio-technical dimensions that integrate regulatory compliance, organizational governance [34], ethical considerations, and technical implementation throughout the data science lifecycle [35]. The study synthesizes evidence from recent literature, industry case studies, expert perspectives, and governance-oriented frameworks to develop a comprehensive understanding of responsible AI implementation.

3.2. Data Collection

Data were collected through a comprehensive review of recent literature, industry case studies, expert perspectives, and governance-oriented reports related to trustworthy Human-Centered AI [36], GDPR compliance, explainable AI, privacy-preserving techniques, and data science workflows. The literature primarily covers publications from reputable journals, conference proceedings, and international regulatory documents that address the integration of ethical principles, governance mechanisms, and regulatory compliance into AI development [37, 38]. In addition, case studies from healthcare, finance, and digital service sectors were examined because these domains extensively process personal data and face significant privacy, security, and regulatory challenges.

To systematically organize the collected evidence, this study mapped the relationships among human-centered AI principles, GDPR governance, explainable AI, privacy-preserving techniques, organizational governance, and the data science workflow [12]. This mapping process enabled the identification of critical components required to support trustworthy AI implementation while maintaining transparency [39], accountability, and regulatory compliance throughout the AI lifecycle.

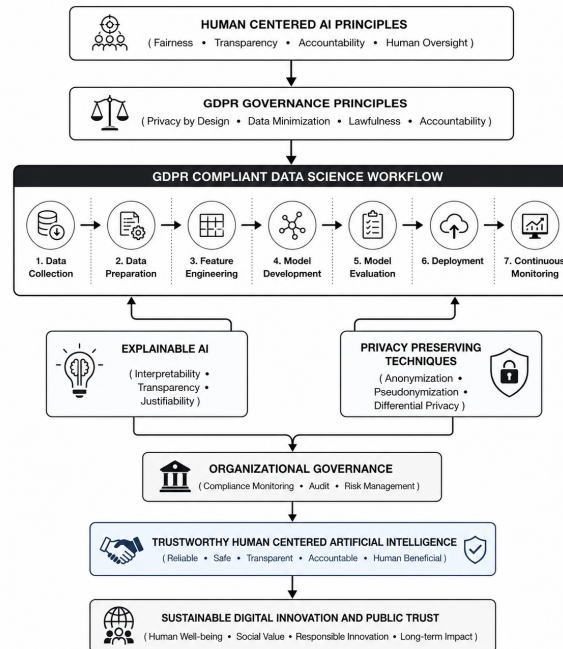


Figure 1. Proposed Framework for Trustworthy Human Centered AI

Figure 1 presents the proposed framework for implementing trustworthy Human-Centered AI through a GDPR-compliant data science workflow. The framework illustrates how human-centered AI principles provide the conceptual foundation, while GDPR governance guides the implementation of each stage of the data

science workflow [40]. Explainable AI and privacy-preserving techniques function as complementary mechanisms that strengthen transparency, privacy protection, and stakeholder trust, whereas organizational governance ensures continuous compliance monitoring, risk management, and accountability. Collectively, these components contribute to the development of trustworthy Human-Centered AI that supports sustainable digital innovation [41, 42].

Table 2. Mapping of Trustworthy Human-Centered AI Components Across the GDPR-Compliant Data Science Workflow

Data Science Workflow	GDPR Principles	Human-Centered AI Principles	Supporting Technologies	Expected Outcome
Data Collection	Lawfulness, Consent	Transparency	Consent Management	Trusted Data Acquisition
Data Preparation	Data Minimization	Fairness	Data Cleaning, Anonymization	Privacy Protection
Feature Engineering	Privacy by Design	Accountability	Pseudo-anonymization	Secure Feature Construction
Model Development	Integrity and Confidentiality	Explainability	Explainable AI (XAI)	Transparent AI Models
Model Evaluation	Accountability	Trustworthiness	Model Validation, Bias Assessment	Reliable Decision Making
Deployment	Governance	Human Oversight	Monitoring System	Responsible AI Deployment
Continuous Monitoring	Compliance Monitoring	Sustainability	AI Auditing, Risk Assessment	Continuous Trust and Compliance

Table 2 presents the mapping of GDPR principles, human-centered AI principles, supporting technologies, and expected outcomes across each stage of the proposed GDPR-compliant data science workflow. The mapping demonstrates that every phase of the workflow contributes to the development of trustworthy Human-Centered AI by integrating regulatory compliance, ethical principles, and technical implementation [43, 44]. During the early stages, lawful data collection and data minimization ensure privacy protection and transparency, while feature engineering and model development incorporate privacy-by-design and explainable AI to improve accountability and model interpretability. In the later stages, model evaluation, deployment, and continuous monitoring emphasize governance, human oversight, compliance auditing, and risk management to maintain trustworthy AI performance throughout the system lifecycle [43, 45, 46]. Together with the proposed framework illustrated in Figure 1, the mapping presented in Table 2 provides a systematic foundation for implementing trustworthy, transparent, and Human-Centered AI while ensuring GDPR compliance and supporting sustainable digital innovation [47].

3.3. Data Analysis

The collected qualitative data were analyzed using a thematic analysis approach to identify recurring patterns, relationships, and implementation strategies associated with trustworthy Human-Centered AI. The analysis focused on synthesizing evidence related to GDPR compliance, explainable AI, privacy-preserving techniques [48], and organizational governance across the data science workflow. Relevant information extracted from the selected literature and case studies was systematically categorized according to the workflow stages presented in Figure 1 and the mapping criteria summarized in Table 2 [49]. This analytical process enabled the identification of common implementation practices, governance mechanisms, and technical approaches that collectively contribute to trustworthy, transparent, and human-centered AI systems [50, 51].

3.4. Framework Development Process

The framework development process was conducted through an iterative synthesis of findings obtained from the literature review, case study analysis, and governance-oriented evidence [52]. Initially, key concepts related to trustworthy Human-Centered AI, GDPR principles, explainable AI, privacy-preserving techniques, and organizational governance were identified and categorized [53, 54]. These concepts were subsequently mapped to the corresponding stages of the data science workflow to determine their relationships and implementation roles.

The mapped components were then integrated into a unified framework by aligning regulatory requirements with technical and organizational practices. The resulting framework emphasizes the incorporation of transparency, accountability, privacy protection, explainability, and human oversight throughout the AI lifecycle. This systematic development process ensures that the proposed framework is grounded in both theoretical evidence and practical implementation strategies, providing a structured foundation for trustworthy Human-Centered AI [55, 56].

4. RESULTS AND DISCUSSION

4.1. Key Findings from the Literature Analysis

The literature analysis revealed that trustworthy human-centered AI requires the integration of technical, regulatory, and ethical dimensions throughout the data science lifecycle. Across the reviewed studies, transparency, accountability, fairness, explainability, privacy protection, and governance consistently emerged as essential factors influencing AI trustworthiness. Rather than functioning independently [57], these components collectively support responsible AI implementation by improving stakeholder confidence and ensuring compliance with evolving regulatory requirements.

Another significant finding is that existing research predominantly investigates GDPR compliance, explainable AI, privacy-preserving techniques, and AI governance as separate research domains. Although these studies provide valuable contributions, relatively few propose an integrated implementation strategy capable of embedding these components throughout the complete data science workflow. Consequently, organizations often implement regulatory compliance after model development, resulting in fragmented governance and reduced transparency.

4.2. Proposed Framework for Trustworthy Human Centered AI

Based on the findings obtained from the literature analysis, this study proposes the framework illustrated in Figure 1. The framework integrates human-centered AI principles, GDPR governance, explainable AI, privacy-preserving techniques, and organizational governance into a unified GDPR-compliant data science workflow. The proposed workflow spans data collection, data preparation, feature engineering, model development, model evaluation, deployment, and continuous monitoring.

The framework demonstrates that trustworthy AI should be considered a continuous process rather than a single technical objective. By embedding regulatory compliance and ethical principles throughout each development stage, the framework establishes a systematic approach for balancing analytical performance with transparency, accountability, privacy protection, and human oversight.

4.3. Integration of Trustworthy Human Centered AI Across the Data Science Workflow

The implementation mapping presented in Table 1 illustrates how GDPR principles, human-centered AI principles, supporting technologies, and expected outcomes are integrated throughout every stage of the proposed data science workflow. Early workflow stages emphasize lawful data acquisition, consent management, and data minimization to establish a trusted foundation for AI development while protecting personal information.

The subsequent stages incorporate privacy-by-design, explainable AI, fairness assessment, organizational governance, compliance auditing, and continuous monitoring to ensure that trustworthy AI characteristics are maintained throughout the operational lifecycle. Overall, the findings indicate that integrating governance, privacy protection, and explainability across the workflow provides a more comprehensive implementation strategy than treating these components as isolated technical or regulatory requirements.

4.4. Discussion

4.4.1. Key Findings

The findings demonstrate that trustworthy Human-Centered AI extends beyond algorithmic performance and requires continuous integration of governance, regulatory compliance, and ethical principles throughout the AI lifecycle. This observation is consistent with recent studies emphasizing that transparency, accountability, explainability, and privacy protection are fundamental requirements for responsible AI implementation. However, unlike previous studies that primarily focus on individual components, this study integrates these complementary perspectives into a unified implementation framework. This integration represents the primary contribution of the study by providing a comprehensive strategy that simultaneously addresses technical development, regulatory compliance, and organizational governance.

4.4.2. Organizational and Practical Implications

The proposed framework provides practical guidance for organizations seeking to implement trustworthy AI within GDPR-regulated environments. Embedding governance mechanisms from the earliest stages of AI development enables organizations to improve regulatory readiness, reduce implementation risks, strengthen explainability, and enhance stakeholder confidence. The framework is applicable to various sectors, including healthcare, finance, public administration, education, and digital services, where responsible management of personal data is essential.

Furthermore, integrating explainable AI, privacy-preserving techniques, and continuous compliance monitoring supports more sustainable AI governance by enabling organizations to maintain transparency and accountability throughout the operational lifecycle. Consequently, organizations can balance innovation with regulatory obligations while improving long-term trust in AI-supported decision-making.

4.4.3. Humanistic Impact

Beyond technical and organizational contributions, the proposed framework promotes the broader objective of human-centered digital innovation by embedding transparency, fairness, accountability, and privacy protection throughout AI development. These principles strengthen public trust while ensuring that AI systems respect individual rights and support ethical decision-making. Such characteristics are particularly important for AI applications that directly affect people's lives, including healthcare, financial services, education, and public governance.

The integration of GDPR governance with human-centered AI principles demonstrates that regulatory compliance can function not only as a legal requirement but also as a mechanism for improving societal trust and responsible technology adoption. By aligning technological innovation with ethical values and human well-being, the proposed framework contributes to the development of trustworthy AI that supports sustainable digital ecosystems and responsible innovation.

5. MANAGERIAL IMPLICATIONS

The findings of this study provide several managerial implications for organizations seeking to implement trustworthy Human-Centered AI within GDPR-regulated environments. First, managers should consider GDPR compliance as an integral component of the AI development lifecycle rather than as a post-deployment legal obligation. Embedding privacy-by-design, transparency, and accountability into data science workflows enables organizations to reduce compliance risks while improving stakeholder trust and organizational resilience.

Second, organizations should establish cross-functional governance involving data scientists, AI engineers, legal experts, compliance officers, and business managers throughout the AI lifecycle. Such collaboration facilitates the integration of explainable AI, privacy-preserving techniques, and continuous compliance monitoring into technical development processes, thereby improving decision quality, reducing operational risks, and strengthening organizational accountability.

Finally, the proposed framework supports strategic decision-making by providing a structured implementation approach that aligns AI innovation with regulatory requirements and human-centered values. Managers can utilize this framework as a practical reference for developing transparent, explainable, and trustworthy AI systems that promote responsible digital transformation while maintaining public trust and long-term organizational sustainability.

6. CONCLUSION

This study addressed the research gap in the existing literature, where GDPR compliance, explainable AI, privacy-preserving techniques, and AI governance have predominantly been investigated as independent research domains. Although these studies have significantly advanced responsible AI development, limited research has systematically integrated these complementary components into a unified implementation framework. Consequently, organizations often face challenges in embedding regulatory compliance, transparency, and ethical governance consistently throughout the entire data science lifecycle.

The findings demonstrate that trustworthy Human-Centered AI requires more than technical excellence or predictive performance. Instead, trustworthy AI depends on the continuous integration of human-centered AI principles, GDPR governance, explainability, privacy protection, organizational governance, and human oversight across every stage of the data science workflow. By incorporating these elements from data collection to continuous monitoring, organizations can strengthen transparency, accountability, stakeholder trust, and regulatory compliance while supporting responsible AI development.

The primary novelty of this study lies in the development of a GDPR-compliant data science workflow that unifies technical, regulatory, and organizational perspectives within a single implementation framework. Unlike previous studies that address GDPR compliance, explainable AI, or AI governance separately, the proposed framework provides a comprehensive implementation strategy that integrates these complementary dimensions into a coherent workflow for developing trustworthy Human-Centered AI. This integrated perspective contributes to both the theoretical understanding and practical implementation of responsible AI across diverse application domains.

The proposed framework also offers practical guidance for organizations implementing AI in data-intensive sectors such as healthcare, finance, public administration, education, and digital services. By embedding governance mechanisms, explainable AI, and privacy-preserving techniques throughout the AI lifecycle, the framework supports transparent, accountable, and human-centered decision-making while promoting sustainable digital innovation and strengthening public trust.

This study is limited by its reliance on qualitative literature synthesis and conceptual framework development without empirical validation. Future research should evaluate the proposed framework through real-world organizational case studies, quantitative assessments, or cross-sector comparative analyses to examine its effectiveness in improving AI trustworthiness, regulatory compliance, organizational performance, and human-centered outcomes. Such empirical validation will further strengthen the generalizability and practical applicability of the proposed framework across different AI implementation contexts.

7. DECLARATIONS

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7.2. Author Contributions

Conceptualization: AJ; Methodology: DK; Software: NP; Validation: SU and AR; Formal Analysis: NP and AJ; Investigation: AR; Resources: SU; Data Curation: DK; Writing Original Draft Preparation: AR and DK; Writing Review and Editing: SU and NP; Visualization: AJ; All authors, NP, DK, SU, AR, and AJ, have read and agreed to the published version of the manuscript.

7.3. Data Availability Statement

The data presented in this study are available on request from the corresponding author.

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7.5. Declaration of Conflicting Interest

The authors declare that they have no conflicts of interest, known competing financial interests, or personal relationships that could have influenced the work reported in this paper.

REFERENCES

- [1] R. Abi, "Ethical and explainable ai in data science for transparent decision-making across critical business operations," *International Journal of Advance Research Publication and Reviews*, vol. 2, no. 6, pp. 50–72, 2025.
- [2] H. Handoko, S. B. Waluya, W. Wardono, S. Sugiman, and L. W. Ming, "Geometry learning pathways for creative thinking via edupreneurial approaches," *Aptisi Transactions on Technopreneurship (ATT)*, vol. 8, no. 2, pp. 669–681, 2026.
- [3] D. A. Adepoju and A. G. Adepoju, "Establishing ethical frameworks for scalable data engineering and governance in ai-driven healthcare systems," *Int. J. Res. Publ. Rev.*, vol. 6, no. 4, pp. 8710–8726, 2025.
- [4] A. Kokala, "The intersection of explainable ai and ethical decision-making: advancing trustworthy cloud-based data science models," *International Journal of All Research Education & Scientific Methods*, vol. 10, no. 12, pp. 2166–2183, 2022.
- [5] A. Goncalves and A. Correia, "Engineering explainable ai systems for gdpr-aligned decision transparency: A modular framework for continuous compliance," *Journal of Cybersecurity and Privacy*, vol. 6, no. 1, p. 7, 2025.
- [6] P. Paroli and R. Evans, "Charismatic leadership and participation strengthening innovation culture in hrm planning," *Aptisi Transactions on Technopreneurship (ATT)*, vol. 8, no. 2, pp. 537–550, 2026.
- [7] S. Jenko, E. Papadopoulou, V. Kumar, S. S. Overman, K. Krepelkova, J. Wilson, E. L. Dunbar, C. Spice, and T. Exarchos, "Artificial intelligence in healthcare: How to develop and implement safe, ethical and trustworthy ai systems," *Ai*, vol. 6, no. 6, p. 116, 2025.
- [8] A. Potdar, "Ai-based big data governance frameworks for secure and compliant data processing," *International Journal of Artificial Intelligence, Data Science, and Machine Learning*, vol. 5, no. 4, pp. 72–80, 2024.
- [9] H. Nufus, S. Subyantoro, H. B. Mardikantoro, and R. Pristiwati, "Developing 21st century creative writing competencies through edupreneurship and creativepreneurship in journalism education," *Aptisi Transactions on Technopreneurship (ATT)*, vol. 8, no. 2, pp. 455–468, 2026.
- [10] M. Böckle, U. Mohme, and M. Bick, "Design thinking and ai: Facilitating hcai solutions," in *Handbook of Human-Centered Artificial Intelligence*. Springer, 2026, pp. 635–695.
- [11] D. S. Schiff, "Strategies for harmonizing fragmented ai ethics frameworks, standards, and regulations," in *Handbook of human-centered artificial intelligence*. Springer, 2026, pp. 1897–1940.
- [12] O. Kaya, A. S. Shah, M. A. Karabulut, S. N. Karahan, M. S. Osmanca, and N. Acir, "Explainable artificial intelligence (xai): Concepts, applications, challenges, and future perspectives," *IEEE Access*, 2026.
- [13] A. Rizky, U. Rahardja, M. Muhtarom, D. N. Ramadhan, S. Triandari, and R. F. Terizla, "Responsible ai governance in decentralized web systems," *Legal Autonomous Web-based Governance (LAW)*, vol. 1, no. 1, pp. 123–133, 2026.
- [14] E. E. Kim, "Ethical ai standards and governance: A perspective of human-centered ai," in *Handbook of Human-Centered Artificial Intelligence*. Springer, 2026, pp. 1–34.
- [15] B. Winslow, O. Ozmen Garibay, T. Goyal, S. Koon, G. Margetis, G. Salvendy, B. Shneiderman, A. Tayebi, and L. Vardoulakis, "Revisiting the six human-centered artificial intelligence grand challenges in the age of generative ai," *International Journal of Human–Computer Interaction*, vol. 42, no. 7, pp. 4697–4738, 2026.
- [16] M. Zalfani, E. Süle, and M. Bakar, "Human-centered ai for decision support systems: Enhancing usability and trustworthiness," *Systems*, vol. 14, no. 6, p. 651, 2026.
- [17] M. S. Gunawan, U. Rahardja, A. Ardien, J. Edwards, and D. I. Desrianti, "Enhancing audience engagement through interactive aidriven narrative structures," *Bridging of Emerging AI and Media Broadcasting (BEAM)*, vol. 1, no. 2, pp. 87–98, 2026.
- [18] M. Nazar, S. Unar, A. Ahmed, M. M. Su'Ud, M. M. Alam, and A. Rahmat, "Requirements driven explainable artificial intelligence framework for secure and transparent clinical decision support systems," *IEEE Access*, 2026.

- [19] J. R. Schoenherr and K. Michael, "Multi-level sociotechnical systems approach to human-centered ai," in *Handbook of Human-Centered Artificial Intelligence*. Springer, 2026, pp. 119–192.
- [20] A. S. Bist, U. Rahardja, N. Lutfiani, R. N. Muti, and S. Ramirez, "Heart attacks and brain strokes in early, mid and late age: Study from data science perspective," *Health, Empathy, and AI Learning (HEAL)*, vol. 1, no. 2, pp. 94–101, 2026.
- [21] B. K. Gudepu and R. Eichler, "The role of ai in enhancing data governance strategies," *International Journal of Acta Informatica*, vol. 3, no. 1, pp. 169–186, 2024.
- [22] S. Sunanto, K. Kasmad, and J. Andriani, "Predicting professional entrepreneurial intention through core determinants of entrepreneurial attitude," *International Journal of Cyber and IT Service Management (IJCITSM)*, vol. 6, no. 1, pp. 25–36, 2026.
- [23] S. J. Soundappan, "Building trustworthy ai: Explainability and security in modern cloud-native data-driven ecosystem platforms," *International Journal of Engineering & Extended Technologies Research (IJEETR)*, vol. 8, no. 2, pp. 570–579, 2026.
- [24] S. Winby and W. Xu, "Human-centered ai maturity model (hcai-mm): An organizational design perspective," in *Handbook of human-centered artificial intelligence*. Springer, 2026, pp. 2493–2525.
- [25] B. M. Mangalampalli, "Ai-enhanced data governance: Automating compliance in healthcare analytics platforms," *The Review Of DIABETIC STUDIES OPEN ACCESS*, 2024.
- [26] N. I. Susanthi, M. Ali, and A. H. Hernawan, "Digital learning platforms as facilitator for university-business collaboration in logistics management curriculum design," *International Journal of Cyber and IT Service Management (IJCITSM)*, vol. 6, no. 1, pp. 37–50, 2026.
- [27] R. Ejjami, "The holistic intelligent healthcare theory (hiht): Integrating ai for ethical, transparent, and human-centered healthcare innovation," *Int. J. Multidiscip. Res*, vol. 6, no. 5, pp. 1–6, 2024.
- [28] M. A. Rahman and B. T. Haque, "Secure distributed data processing using privacy-preserving artificial intelligence and zero trust architecture for enterprise risk identification and performance evaluation," *American Journal of Data Science and Analytics*, vol. 5, no. 12, pp. 86–124, 2024.
- [29] M. Choiri, E. S. Pramudito, F. Sutisna, and R. S. Sean, "Business artificial intelligence for enhancing sustainable decision intelligence," *IAIC Transactions on Sustainable Digital Innovation (ITSIDI)*, vol. 7, no. 1, pp. 106–116, 2025.
- [30] K. K. R. Chinthala, M. S. Thakur, M. Shuaib, and S. Alam, "Prospects of computational intelligence in society: Human-centric solutions, challenges, and research areas," *Journal of Computational and Cognitive Engineering*, 2024.
- [31] H. Maathuis, M. Stalenhoef, S. Van Otterloo, R. Zwaal, K. Van Montfort, and D. Sent, "Designing effective explainable ai: a human-centered evaluation of explanation formats in financial decision-making," *Frontiers in Artificial Intelligence*, vol. 9, p. 1668029, 2026.
- [32] A. Mallempati, "Mastering data: The strategic role of mdm & data governance in the digital era," *International Journal of AI, BigData, Computational and Management Studies*, vol. 5, no. 2, pp. 235–245, 2024.
- [33] K. Lekadir, A. F. Frangi, A. R. Porras, B. Glocker, C. Cintas, C. P. Langlotz, E. Weicken, F. W. Asselbergs, F. Prior, G. S. Collins *et al.*, "Future-ai: international consensus guideline for trustworthy and deployable artificial intelligence in healthcare," *bmj*, vol. 388, 2025.
- [34] L. Sitoay, M. V. A. Sin, S. Riyadi, M. Daeli, and J. Parker, "Smart urban mental health mapping through iot sensor networks and ai analysis," *Journal of Orange Technology*, vol. 1, no. 1, pp. 19–28, 2024.
- [35] R. T. J. Loo, F. Nasta, M. Macchi, A. Baudot, F. Burstein, R. Bove, M. Greve, H. Fröhlich, S. Khalid, A. Kuderle *et al.*, "Recommendations for successful development and implementation of digital health technology tools," *Journal of Medical Internet Research*, vol. 27, no. 1, p. e56747, 2025.
- [36] K. D. Tzimourta, "Human-centered design and development in digital health: Approaches, challenges, and emerging trends," *Cureus*, vol. 17, no. 6, 2025.
- [37] J. Woodring, K. Perez, and A. Ali-Gombe, "Enhancing privacy policy comprehension through privacy: A user-centric approach using advanced language models," *Computers & Security*, vol. 145, p. 103997, 2024.
- [38] O. Jayanagara, I. Y. Purnama, M. M. Sari, S. A. Anjani, and C. Perez, "Enhancing academic wellbeing through empathic digital attendance systems using utaut approach," *Journal of Orange Technology*, vol. 1, no. 2, pp. 63–74, 2025.
- [39] H. Boussi Rahmouni, N. B. E. H. Hassine, M. Chouchen, H. İ. Ceylan, R. I. Muntean, N. L. Bragazzi, and

- I. Dergaa, "Healthcare 5.0-driven clinical intelligence: the learn-predict-monitor-detect-correct framework for systematic artificial intelligence integration in critical care," in *Healthcare*, vol. 13, no. 20. MDPI, 2025, p. 2553.
- [40] B. Amangeldy, T. Imankulov, N. Tasmurzayev, G. Dikhanbayeva, and Y. Nurakhov, "A review of artificial intelligence and deep learning approaches for resource management in smart buildings," *Buildings*, vol. 15, no. 15, p. 2631, 2025.
- [41] E. Vyhmeister and G. G. Castane, "When industry meets trustworthy ai: a systematic review of ai for industry 5.0," *AI and Ethics*, vol. 6, no. 2, p. 200, 2026.
- [42] G. Di Fede, L. Alrabie, and S. Andolina, "Human-centered llm," in *Handbook of Human-Centered Artificial Intelligence*. Springer, 2025, pp. 1–35.
- [43] M. Ghobakhloo, M. Fathi, S. Okwir, M. Al-Emran, and D. Ivanov, "Adaptive social manufacturing: a human-centric, resilient, and sustainable framework for advancing industry 5.0," *International Journal of Production Research*, vol. 64, no. 3, pp. 1127–1160, 2026.
- [44] K. Lekadir, A. Feragen, A. J. Fofanah, A. F. Frangi, A. Buyx, A. Emelie, A. Lara, A. R. Porras, A.-W. Chan, A. Navarro *et al.*, "Future-ai: international consensus guideline for trustworthy and deployable artificial intelligence in healthcare," *arXiv preprint arXiv:2309.12325*, 2023.
- [45] M. F. Hilmi, H. Hamdan, A. Faturahman, B. N. Henry, and J. Wilson, "Ai in industry forecasting: The use of ai in predicting industry trends and demands," *Health, Empathy, and AI Learning (HEAL)*, vol. 1, no. 1, pp. 78–83, 2025.
- [46] U. F. Ikwuanusi, P. A. Adepoju, and C. S. Odionu, "Advancing ethical ai practices to solve data privacy issues in library systems," *International journal of multidisciplinary research updates*, vol. 6, no. 1, pp. 033–044, 2023.
- [47] M. Nwanna, E. Offiong, T. Ogidan, O. Fagbohun, A. Ifaturoti, and O. Fasogbon, "Ai-driven personalisation: Transforming user experience across mobile applications," *Journal of Artificial Intelligence, Machine Learning and Data Science*, vol. 3, no. 1, pp. 1930–1937, 2025.
- [48] T. L. Anita, R. G. Freedy, N. Silawati, and M. Sunengsih, "Mathematical logic as a foundation for ai-driven decision-making systems," *Smart Human-centered Emerging Research in Machine Intelligence*, vol. 2, no. 1, pp. 14–25, 2026.
- [49] G. Desolda, A. Esposito, R. Lanzilotti, A. Piccinno, and M. F. Costabile, "From human-centered to symbiotic artificial intelligence: a focus on medical applications," *Multimedia Tools and Applications*, vol. 84, no. 27, pp. 32 109–32 150, 2025.
- [50] R. J. Geukes Foppen, V. Gioia, S. Gupta, C. L. Johnson, J. Giantsidis, and M. Papademetris, "Methodology for safe and secure ai in diabetes management," 2025.
- [51] E. B. Weiner, I. Dankwa-Mullan, W. A. Nelson, and S. Hassanpour, "Ethical challenges and evolving strategies in the integration of artificial intelligence into clinical practice," *PLOS digital health*, vol. 4, no. 4, p. e0000810, 2025.
- [52] G. Pisoni and N. Díaz-Rodríguez, "Responsible and human centric ai-based insurance advisors," *Information Processing & Management*, vol. 60, no. 3, p. 103273, 2023.
- [53] Y. Shahsavari, Y. Baseri, A. Hafid, O. A. Dambri, and D. Makrakis, "Integration of federated learning and blockchain in health care: Tutorial on medical data, architectures, privacy, security, and regulatory compliance," *Journal of Medical Internet Research*, vol. 28, p. e80178, 2026. [Online]. Available: <https://pmc.ncbi.nlm.nih.gov/articles/PMC13268642/>
- [54] Z. Benlalia, G. Al-Kateb, M. Mzili, and K. Diamanti, "Reimagining intelligence: A comprehensive review of human-centric ai systems and their societal and healthcare integration," *Mesopotamian Journal of Artificial Intelligence in Healthcare*, vol. 2025, pp. 173–186, 2025.
- [55] T. Adenuga, A. T. Ayobami, U. Mike-Olisa, and F. C. Okolo, "Enabling ai-driven decision-making through scalable and secure data infrastructure for enterprise transformation," *International Journal of Scientific Research in Science, Engineering and Technology*, vol. 11, no. 3, pp. 482–510, 2024.
- [56] P. R. Konda, "Ai-driven cloud data analytics framework for intelligent enterprise decision systems," *Indonesian Journal of Advanced Research & Technology*, vol. 6, no. 6, 2024.
- [57] A. Kiourtis, A. Mavrogiorgou, G. Makridis, D. Kyriazis, J. Soldatos, G. Fatouros, D. Ntalaperas, X. Papa-georgiou, B. Almeida, J. Guedes *et al.*, "Xr5. 0: Human-centric ai-enabled extended reality applications for industry 5.0," in *2024 36th Conference of Open Innovations Association (FRUCT)*. IEEE, 2024, pp. 314–323.