Ethical Requirements in the Age of Artificial Intelligence: A Systematic Literature Review

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Abstract

Context: Software developers and users are growing concerned about the ethical use of software, especially with Artificial Intelligence (AI). In this context, we investigated how ethical requirements can be elicited and incorporated into software development. **Problem**: The challenge is identifying and defining effective methods for eliciting and managing ethical requirements in software development. **Solution**: We conducted a Systematic Literature Review (SLR) to identify techniques, methods, processes, frameworks, and tools for eliciting, analyzing, and specifying ethical requirements. **IS Theory**: We explore the application of theories related to requirements engineering, ethics in technology, and data governance. It focuses, in particular, on ensuring that information systems comply with ethical and legal principles from the beginning of the development cycle. **Method**: Following the Kitchenham and Charters protocol, we conducted an SLR with stages of planning, conducting, and reporting the results. **Summarization of Results**: We have identified 47 primary studies. These studies address different approaches to eliciting ethical requirements, including techniques based on user stories, analysis of ethical guidelines, specific frameworks such as ECCOLA, and methods such as interviews and modeling. **Contributions and Impact on the IS area**: The report contributes to the field by consolidating existing practices in the literature regarding ethical requirements. It provides a comprehensive overview of the techniques and tools available for integrating ethical considerations into software systems and identifies gaps and opportunities for future research. The study significantly impacts the IS field by providing practical and theoretical guidelines for eliciting ethical requirements in information systems.

CCS Concepts

• **Software and its engineering → Requirements analysis**.

Keywords

Ethical Requirements, Requirements Elicitation, Systematic Literature Review

1 Introduction

The proliferation of systems in the context of Artificial Intelligence (AI) has significantly impacted Requirements Engineering (RE) due to its complexities [5]. Existing techniques and methods designed to support RE activities face numerous challenges when dealing with AI-based systems, primarily because of their probabilistic nature and the need for constant adaptation. To address these challenges, RE must adopt techniques that align with the inherent concerns of AI systems [3]. The roles and responsibilities related to RE are evolving, with data scientists now tasked with specifying high-level requirements for machine learning systems. This shift can lead to systems prioritizing data quality over stakeholder requirements, particularly concerning ethical considerations [22]. Despite its long history, RE has not been widely applied in the context of AI systems, especially in areas dealing with sensitive data, as the requirements for AI systems are complex to elicit, document, validate, and manage [4].

Ethical requirements are essential in software development, especially for AI systems [8, 9]. Ethical requirements for AI systems are standards derived from ethical principles or codes of conduct (norms). They are similar to legal requirements based on laws and regulations [17]. Regulations such as the Brazilian General Data Protection Law (Lei Geral de Proteção de Dados, LGPD) or Brazilian General Data Protection Law (acronym in Portuguese, LGPD) [7]; and the General Data Protection Regulation (GDPR) [19] enforce data protection and user rights. With AI proliferating, ethical guidelines ensure systems respect these regulations and universal ethical principles [3, 4, 8].

Ethical requirements should be established at the outset of the development process, utilizing various techniques, methods, processes, frameworks, and tools. Globally published ethical guidelines provide high-level principles for the development of ethical AI, emphasizing transparency, security, and accountability [9]. Ethical requirements encompass functional and non-functional aspects, addressing the needs of users and other stakeholders affected by these systems. The definition of “user" is broadened to include family members, practitioners, and community members impacted by AI systems. By integrating these principles from the project’s outset, we can build trust, ensure legal compliance, and mitigate the ethical risks associated with technology [13].

Ethical requirements refer to the principles and standards that guide the development and implementation of systems, particularly in contexts such as AI. These requirements aim to ensure that systems are designed and operated in a manner that respects

human rights, promotes fairness, and avoids harm. Key aspects of ethical requirements include: transparency, privacy, accountability, fairness, autonomy, explainability, justice, non-maleficence, human dignity, beneficence, responsibility, safety, data security, sustainability, freedom, solidarity, prosperity, prosperity, effectiveness, accuracy, predictability, and interpretability [13].

Recently, there has been a substantial increase in studies addressing ethical requirements in the context of AI. Given this proliferation, practitioners need to understand how these requirements are managed by practitioners and the techniques, methods, processes, frameworks, and tools employed during the requirements engineering phases. Thus, this study conducts a systematic literature review (SLR) to investigate which techniques, methods, processes, frameworks, and tools are utilized in the literature to handle ethical requirements. Practitioners must identify which strategies can be applied in their daily work and at which stages they can support their activities. Therefore, we conduct a systematic review of the literature to explore the application of these techniques within requirements engineering.

The main observations of this SLR are summarized as follows: i) The most commonly used techniques and methods in the literature to address ethical requirements include ethical guideline/ethical principle analysis, interviews, modeling, and surveys; ii) The requirements elicitation and specification phases are the most frequently addressed by primary studies. Additionally, most studies conducted qualitative data analysis; and iii) Among the positive impacts, transparency, accountability, and trust stand out, while the negative impacts include increased complexity in developing software features and a higher workload for team members.

2 Related Work

The integration of AI ethics as requirements within software engineering is progressing, primarily as society increasingly relies on AI and AI-enabled systems [8]. Ethical issues in requirements engineering pertain to the complex moral concerns that arise during software artifacts' design, development, and deployment [16]. Ethical requirements for AI represent the standards for these systems derived from AI guidelines, principles, or ethical codes (norms), much like legal requirements are based on laws and regulations. These ethical requirements seek to foster the dissemination of AI ethics practices [11].

Research indicates that ethical requirements are rarely prioritized at management levels, primarily due to their perceived low impact on human lives and lack of financial value. Decision-makers are seldom involved in pro-ethical projects, leaving most responsibilities to designers and development team members. Additionally, development teams rarely discuss ethical requirements with stakeholders except when the software scope includes legal requirements, such as privacy laws. In such cases, implementing ethical requirements risks being superficial—limited to communications, corporate social responsibility projects, and occasional emergency interventions [1]. IEEE Std 7000-2021 [12] proposed an approach to implementing ethical requirements to develop trustworthy or responsible AI systems for society. This standard emphasizes the practical engagement of all stakeholders, from top management to AI system users, to implement ethical requirements in these systems. The goal is to identify, address, and sustain ethical requirements for AI systems, helping to determine their meaningful value—referred to as their ethical requirement value—for stakeholders. The standard underscores the importance of ethical requirements beyond financial considerations, highlighting the need to engage with human rights and other social values to achieve practical implementation beyond mere legal compliance.

Biable et al. [6] presents a proposal for an ethical framework for requirements engineering. The aim is to address common ethical problems in the requirements elicitation phase of software development. The main issues include knowledge gaps, difficulties identifying requirements, and inappropriate or prohibited practices. The framework is made up of some categories. The results highlight that the framework not only helps to minimize ethical problems but also offers structured support for software engineers to conduct the process more ethically and efficiently.

Another study investigates the ethical issues faced during the Requirements Elicitation (RE) process in software engineering as discussed by Siakas et al. [20]. The authors assert that this phase is essential and requires the development team to convert customer needs into precise, actionable requirements. This stage is particularly susceptible to ethical dilemmas, which, if not addressed, can result in unforeseen consequences. The research suggests that developers tackle these issues in line with the goals of the Software Process Improvement (SPI) Manifesto, aimed at enhancing software through better processes, improved engineers' attitudes, and refined organizational practices. Consequently, the paper outlines ethical obligations for the SR process, positing that it should be rooted in ethical principles. Implementing these practices can help alleviate persistent problems and align software development with ethical and social values, improving client and end-user outcomes.

Vainio-Pekka et al. [21] presents a systematic mapping of the role of XAI (Explainable AI) within AI ethics, analyzing existing literature to identify trends, gaps, and future opportunities. Unlike this paper, Vainio-Pekka et al. [21] focuses exclusively on XAI (AI systems that are interpretable or understandable to humans). The results highlight the growing relevance of XAI in addressing real problems but indicate the need for further validation, as does our work. Additionally, the authors emphasize a greater understanding of human perspectives and research aimed at practical implementation to ensure that solutions are technically robust and aligned with stakeholder values.

3 Research Method

We conducted a Systematic Literature Review (SLR) following the guidelines of Kitchenham and Charters [15]. Next, we outline our research question (RQ) and its rationale, describe the study selection process, and explain our systematic analysis approach. This research aims to uncover and share the state of the art in addressing ethical requirements. We aim to understand the landscape outlined in specialized literature. With this objective, the research question guiding this study is defined as follows: **RQ.1. What techniques, methods, processes, frameworks, and tools are described in the literature for the elicitation, analysis, specification, validation, and management of ethical requirements?**

To address RQ.1, we conducted an SLR to investigate the techniques, methods, processes, frameworks, and tools related to ethical software requirements as discussed in the literature. To run the SLR, a search string was initially defined based on the set of PICO criteria [18]. **Population**: the requirements engineering process and its phases (identification, specification, validation, verification, and management); **Intervention**: the tools used to achieve the result; **Comparison**: this does not apply since the aim of this research is not to compare methods; **Result**: ethical requirements.

The requirements engineering process (population) undergoes the intervention of methods/tools/processes (intervention) to generate ethical requirements (result). This process defined and adjusted an original search string for each database consulted, as shown in [2]. We looked for studies in ACM, IEEE Xplore, Scopus, and Web of Science digital databases. We searched databases for keywords in the title, abstract, and keywords.

We carried out an SLR, which identifies, evaluates, and interprets relevant studies in an area or research question of interest [14]. We followed the protocol of Kitchenham and Charters [15] to identify relevant studies in the area. According to Kitchenham and Charters [15], an SLR consists of the following phases: planning, conducting, and reporting the results. Initially, 2344 papers were returned through the search string After our searches in the databases, all the bibtexts of the studies were downloaded and stored locally. The data was then imported into the StArt tool to support the systematic reviews. On importing the data into the StArt tool, duplicate papers were automatically identified and removed from the analysis, resulting in 1477 unique papers for analysis.

We used inclusion (I) and exclusion (E) criteria for the SLR to ensure consistency among the studies regarding the purpose of the research, as well as their quality and content. These criteria are: [**I1.**] The study presents techniques, methods, processes, frameworks, or tools related to ethical software requirements; [**I2.**] The study is a peer-reviewed research article (i.e., a journal article or conference paper); [**E1.**] The study is outside the research context (e.g., it does not present techniques, methods, processes, frameworks, or tools related to ethical software requirements); [**E2.**] The study is not a peer-reviewed research article (i.e., it is not a journal article or conference paper); [**E3.**] The study is not a primary or secondary work on ethical requirements (e.g., event proceedings, book prefaces, or duplicated/extended work); [**E4.**] The study is not a full article (e.g., less than six pages); [**E5.**] The study is from before 2009 (i.e., it is more than 15 years old); and [**E6.**] The study is not written in English or Portuguese.

In the next step, we applied the selection criteria to the 1477 remaining papers. Two evaluators reviewed half of the paper, and if there was any uncertainty, the other reviewer was consulted. Of these 1477 unique papers, 132 studies were ultimately chosen based on the inclusion and exclusion criteria. At this stage, all 132 papers had to be read in full to capture the relevant data for the research. It is important to note that, during data extraction, some studies were reclassified as rejected if it was perceived that they fit any exclusion criteria. A total of 47 studies were accepted, 83 (62.9%) studies were rejected, and 3 (2.3%) studies were marked as duplicates. The complete list of the 47 (34.8%) accepted papers can be found in [2].

We performed a quality assessment on the accepted papers to evaluate the relative strength of the empirical evidence or findings reported. The evaluation criteria were: QA.1. Is the research goal clearly articulated and strongly justified? QA.2. Is the context (industry, project setting, product used, participants or observational units, etc.) in which the research was carried out clearly stated? QA.3. Is the approach to and formulation of the analysis presented? QA.4. Do the findings and conclusions hold credibility? QA.5. Are limitations and credibility of the study adequately discussed?

We employed a three-point scale for evaluating the assessment questions: no (0), partially (0.5), and yes (1). Two reviewers assessed the papers. Each study could earn a maximum of 5 points, with nearly 2.5 points required for acceptance onto the final list. During the full-text review, we conducted the data extraction. At this time, each protocol question was extracted with the assistance of the StArt tool. The extracted data defined in the protocol are available in [2]. Two independent reviewers cross-checked the extracted data for each protocol question to ensure consistency and reduce potential bias. Any disagreements were discussed until a consensus was reached. This step was essential to validate the information gathered and to align it with the research objectives. The findings based on each protocol question are also summarized in [2].

4 Results

Regarding the year of the studies' publication, we accepted studies from 2013 to 2024. Figure 1 summarizes the distribution of studies by year of publication.

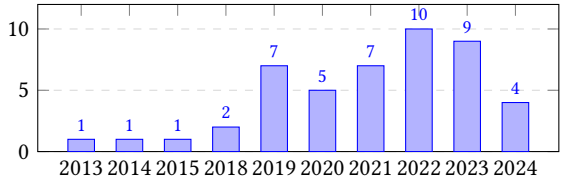

Figure 1: Distribution of Studies by Year of Publication

Table 1 shows the participants' distribution in the studies analyzed. Probably because of the search string, requirements engineers were the most common participants, with 34 occurrences. 26 participants represented stakeholders. Customers and students were less frequent, with 7 and 11 participants, respectively.

4.1 Techniques, Methods, Processes, Frameworks, and Tools

The analyzed studies explored various techniques for incorporating ethical aspects into software development. "Ethical Requirements Analysis and Modeling" was a prominent approach emphasizing all guidelines and principles. It analyzes ethics used in seven studies. Techniques centered on user stories were standard, appearing in four studies, including the "Ethical User Story" in two. Techniques such as "ECCOLA" represented ethical software engineering, which appeared in five studies. All techniques are presented in Table 2.

Among the techniques reported in the studies reviewed, a series of ethical requirements were identified as essential to guide the development of systems. These include support for informed choice,

Table 1: Distribution of participants in the studies analyzed

Participants	Quantity	Studies
Requirements Engineers	34	S1, S2, S4, S5, S6, S8, S9, S10, S11, S12, S13, S14, S16, S17, S18, S19, S20, S22, S23, S25, S28, S29, S31, S32, S33, S34, S35, S37, S39, S40, S43, S44, S45, S46
Stakeholders	26	S1, S2, S3, S4, S5, S7, S9, S10, S11, S15, S16, S18, S20, S22, S23, S24, S25, S30, S32, S33, S36, S37, S38, S41, S46, S47
Customers	7	S9, S15, S16, S17, S26, S36, S43
Students	11	S2, S4, S11, S17, S19, S20, S21, S27, S30, S35, S36

which ensures that users can make informed decisions when interacting with technology. Other important requirements include transparency and explainability, which are fundamental to making the systems' decisions and processes understandable and auditable. Privacy and security/protection were also widely mentioned, reinforcing the need to protect user data from misuse and violation. The complete list of ethical requirements referenced in the papers are:

(1) Supporting informed choice: Ensuring users have all the information they need to make informed decisions.
(2) User data monitoring: Implement mechanisms to track and manage the use of user data.
(3) Introduction of measures to combat problematic behavior: Adopt strategies to prevent and mitigate unwanted or harmful behavior.
(4) Responsibility: Establish clear responsibilities for the results produced by the systems.
(5) Reliability: Ensure that systems work consistently and predictably.
(6) Transparency: Making system processes and decisions accessible and understandable to users.
(7) Explainability: Provide clear and understandable justifications for automated decisions.
(8) Contestability: Allow users to question and challenge the decisions made by the systems.
(9) Privacy: Protect users' data from unauthorized access and breaches.
(10) Fairness/Equality/Impartiality: Ensuring that systems treat all users fairly and without discrimination.
(11) Interpretability: Make it easy for users and developers to understand the internal operations of the systems.
(12) Reliability: Ensuring systems are robust and can operate correctly under different conditions.
(13) Security/Protection: Protecting systems against attacks and failures that could compromise their integrity.
(14) Robustness: Ensuring that systems are resilient to failures and variations in the operating environment.
(15) Human-centered values: Develop systems that prioritize human values and needs.
(16) Autonomy: Promote users' ability to make independent decisions when using systems.
(17) Beneficence: Maximizing the benefits of systems for users and society.
(18) Non-maleficence: Minimizing the harm that systems can cause to users and society.

As shown in Table 3, the methods used in the studies analyzed cover a variety of approaches to investigating and improving ethical and transparency aspects in systems. Among the methods identified, each contributes a specific way to the research. "Action research" was applied in two studies, indicating an interest in methods that involve active collaboration with participants. Other approaches, such as "Case analysis and theoretical discussion" and "Document analysis of ethical guidelines", were used in one study each, showing the diversity of methods applied to address ethical issues. Techniques based on "Value Sensitive Design" and the use of "NLP for expert support" were also mentioned, as were "Interviews" and the creation of specific guidelines for transparency and explainability requirements in AI systems.

The processes identified in the analyzed studies reflect various approaches to managing and developing ethical requirements, as shown in Table 4. The "Agile management" process was the most frequent (five studies), indicating a preference for agile methodologies for adapting and managing requirements. "Requirements elicitation, analysis, and prioritization" was also a relevant process, with three occurrences highlighting the importance of defining and ordering requirements systematically. Other processes, such as "IEEE CertifAIEd", debates on ethical regulations, line-by-line coding techniques, and the design and manufacture of surgical tools were only mentioned once, highlighting more specialized or less familiar approaches.

The frameworks used in the studies analyzed reflect a variety of approaches to integrating ethical principles and values into systems projects. As shown in Table 5, "Generic frameworks" was predominant, with four occurrences, suggesting a broad application of frameworks adaptable to different contexts. Specific frameworks, such as the "FormaTive framework" and the "Ethical framework dedicated to IoT" (expanding the PAPA model), were also identified, each with a unique application for specific contexts, such as the Internet of Things. Other frameworks, such as the "ESSENCE Framework", "Design for Values Framework", and "Ontology-based Requirements Engineering (ObRE) Framework", were applied in one study, demonstrating the diversity in approaches to integrating ethical values into systems development. The "PAPA Framework" and the "Process-based Governance (PBG) Framework" were mentioned once, indicating specialized or less familiar approaches.

The analyzed studies employed various tools to address different aspects of developing ethical and technical systems. Unspecified, generic tools were the most frequent, appearing in five studies, indicating a wide range of tools used without explicit details about their characteristics. Other tools included "AutoCheck" and "ECCOLA topic cards", each used in one study, showing specific approaches to evaluation and analysis. Tools for "computational design and 3D printing" and "modeling and analysis", such as "ChatGPT prompt engineering", were also mentioned, highlighting the diversity in the applied techniques. Tools for "interviews, participant observation, and co-design methods" and specialized systems for "traffic monitoring and psychophysiological fatigue measurement" complete the

Table 2: Techniques and Methods Identified in the Studies

Category	Technique	Quantity	Studies
Ethical Requirements Analysis and Modeling	Analysis of ethical guidelines/Ethical principles	7	S14, S28, S40, S41, S42, S44, S47
	Use of models (e.g., goal modeling, AML models)	1	S35
	Use of ontologies	2	S7, S12
	Negotiation techniques	1	S4
	Acceptance tests	2	S4, S33
User Stories and Design	Techniques centered on user stories	4	S19, S30, S33, S46
	Design for Values, Values-Sensitive Design, Participatory Design	1	S10
	Computational design and digital fabrication	1	S18
Ethical Software Engineering	Ethics-Aware Software Engineering	1	S24
	ECCOLA	5	S11, S20, S25, S36, S45
	Use of letters (AI)	1	S11
	Ethical Heuristics	1	S32

Table 3: Methods Used in the Studies Analyzed

Method	Quantity	Studies
Case analysis and theoretical discussion	1	S18
Documentary analysis of ethical guidelines	1	S44
NLP for expert support	1	S4
Interviews	1	S28
Techniques based on Value Sensitive Design	1	S10
Action research	2	S11, S33
Guideline to help elicit, negotiate, and validate transparency and explainability requirements for AI systems	1	S43

Table 4: Processes Used in the Studies Analyzed

Process	Quantity	Studies
Requirements elicitation, analysis and prioritization	3	S4, S10, S33
Agile management	3	S11, S17, S28
IEEE CertifAIEd	1	S13
Debates on social and cultural choices related to ethical regulations	1	S35
Line-by-line coding techniques	1	S44
Design and manufacture of surgical tools	1	S18

Table 5: Frameworks Used in the Analyzed Studies

Framework	Quantity	Studies
CCVSD approach	1	S1
Generic structures	4	S4, S31, S34, S35
Formative work structure	1	S39
Ethical framework dedicated to IoT (expanding the PAPA model)	1	S15
ESSENCE framework	1	S33
"Design for Values" framework	1	S10
Ontology-based Requirements Engineering (ObRE) Framework	1	S7
PAPA framework	1	S29
Process-based governance (PBG) framework	1	S22

Table 6: Tools Used in the Studies Analyzed

Tools	Quantity	Studies
Generic tool not specified in the paper	1	S4
ECCOLA thematic charts	1	S11
AutoCheck tool	1	S39
Tools such as interviews, participant observation, and co-design methods	1	S10
Computer design tools and 3D printing	1	S18
Modeling and analysis tools, such as ChatGPT prompt engineering	1	S17
Traffic monitoring systems and devices used to measure psychophysiological fatigue in drivers	1	S35
SLEEC-TK	1	S38

tools covered in the studies. Table 6 presents studies and respective cited tools.

Some studies analyzed cover topics that do not fall directly into the categories of techniques, methods, processes, frameworks, or tools. Among the topics identified and shown in Table 7, the "European Commission Guidelines for AI, IBM, Google, and IEEE" are the most frequent, appearing in five studies. These guidelines cover important principles of ethics and regulation in AI, reflecting a concern for compliance and good practice. The guidelines include Microsoft AI principles, Google DeepMind Ethicsnciples,

IEEE Global Initiative on Ethics of Autonomous and Intelligent Systems principles, Partnership on AI tenets, and EU statement on AI, Robotics, and Autonomous systems.

Other approaches include the "RESOLVEDD Strategy", mentioned in two studies and suggested focusing on specific strategies for dealing with ethical issues. Several additional themes were addressed in one study, such as "Blockchain", "Ethics education for software engineering professionals", and the "ISE (Identification, Specification and Exploitation) Model". These themes highlight the importance of integrating moral and social values, resolving ethical conflicts, and creating awareness about ethical issues.

Table 7: Other Approaches Used in the Studies Analyzed

Theme	Quantity	Studies
European Commission Guidelines for AI, IBM, Google, and IEEE	5	S3, S6, S8, S28, S47
Blockchain	1	S9
RESOLVEDD Strategy	2	S21, S27
Create awareness of ethical issues and ethics education for SE professionals	1	S4
ISE (Identification, Specification, and Exploration) model defined	1	S5
Aspects such as ethical ideals, social choices, personal interpretations, world models, and real-world observations	1	S35
Ethical conflicts and their resolution	1	S7

4.2 Requirements phases

The studies analyzed address different phases of Requirements Engineering (RE), reflecting a varied focus on the stages of the process. The most frequently considered phases were the "Specification" and "Elicitation" phases, with 38 studies each. This highlights their central importance in the Requirements Engineering process. The "Validation" phase is the second most common, with 11 studies indicating a significant focus on ensuring that requirements meet needs and expectations. The "Analysis" and "Management" phases appear with 10 and 8 studies, respectively, suggesting moderate attention to these essential stages. Table 8 summarizes the phases of RE considered in the analyzed studies.

Some of the studies analyzed indicate which phases of Requirements Engineering (RE) are most impacted by ethical requirements. The "Elicitation" phase is the most affected, with 20 studies mentioning the influence of ethical requirements at this stage. The "Specification" phase follows in importance, with 17 studies highlighting how ethical requirements impact the definition and detailing of requirements. The "Validation" and "Analysis" phases have a more moderate impact, with four studies each indicating reasonable but less attention to incorporating ethical requirements in these phases. The "Management" phase is the least affected, with only one study addressing the impact of ethical requirements at this stage. Table 9 summarizes the influence of ethical requirements on Requirements Engineering phases.

Table 8: Requirements Engineering Phases in the Studies

RE phase	Quantity	Studies
Elicitation	38	SE1, S2, S3, S4, S6, S7, S8, S10, S11, S12, S15, S16, S17, S19, S20, S21, S23, S24, S25, S26, S28, S29, S31, S32, S33, S34, S35, S36, S37, S38, S39, S40, S41, S43, S44, S45, S46, S47
Specification	38	S1, S3, S4, S5, S6, S7, S8, S10, S11, S12, S15, S16, S17, S18, S19, S20, S21, S23, S24, S25, S26, S28, S29, S30, S32, S33, S35, S36, S37, S38, S40, S41, S42, S43, S44, S45, S46, S47
Validation	11	S4, S7, S11, S17, S18, S24, S28, S33, S35, S36, S38
Analysis	10	S4, S7, S11, S14, S17, S24, S28, S33, S35, S36
Management	8	S7, S11, S17, S24, S28, S33, S35, S36

Table 9: RE Phases Most Affected by Ethical Requirements

ER phase	Quantity	Studies
Elicitation	20	S1, S4, S6, S7, S10, S11, S16, S17, S19, S24, S25, S26, S31, S32, S33, S34, S35, S38, S39, S44
Specification	17	S1, S4, S6, S10, S11, S16, S18, S19, S24, S25, S26, S29, S32, S33, S35, S38, S44
Validation	4	S4, S18, S24, S38
Analysis	4	S4, S14, S24, S35
Management	1	S24

4.3 Domains Applied to Ethical Requirements

The studies analyzed applied ethical requirements to various domains, reflecting various areas of interest. The "AI" domain is the most addressed, with six studies highlighting the application of ethical requirements to artificial intelligence systems. "Autonomous agents" and "Health and wellness applications" are equally relevant, each with four studies mentioning the application of ethical requirements in these contexts. The area of "6G networks" and the development of "domain models to understand the field of ethics as a whole" were addressed in ONE study each, indicating more specialized or emerging attention. In addition, domains such as "IoT", "Conversational agents" and "SMART port terminals" were considered, with varying frequency levels. Table 10 summarizes the domains in which ethical requirements were applied in the studies analyzed. In addition to these domains, paper S16 addressed several domains: software consulting companies, retail companies in the automotive, food, and construction sectors, and financial service providers.

4.4 Methods used in the studies

The methods used in the analyzed studies show diverse data collection and analysis approaches. "Document analysis" is the most

Table 10: Domains Applied for Ethical Requirements

Domain	Quantity	Studies
IA	6	S9, S23, S27, S28, S42, S47
Autonomous agents	4	S5, S12, S13, S38
Health and wellness applications	4	S1, S2, S3, S26, S40
IoT	2	S15, S26
Others	4	S14, S16, S20, S22

frequent method used in 11 studies, indicating a solid reliance on reviewing and interpreting documents to gain insights. "Interviews" and "Other" methods are equally relevant, with nine studies each reflecting a varied application of qualitative techniques. "Modeling" and "Survey" appear in 7 studies each, suggesting a significant use of structured data analysis and collection methods. "Framework" is mentioned in 4 studies, indicating a specific application of theoretical or methodological structures. Table 11 summarizes the methods used in the studies analyzed.

Table 11: Methods Used in the Studies Analyzed

Method	Quantity	Studies
Document analysis	11	S3, S6, S8, S11, S17, S20, S30, S37, S43, S44, S47
Interview	9	S10, S14, S16, S20, S28, S29, S33, S34, S44
Modeling	7	S5, S7, S10, S12, S32, S38, S40
Survey	7	S2, S4, S26, S34, S36, S41, S44
Other	7	S7, S9, S11, S23, S25, S35, S42
Framework	4	S13, S14, S15, S24

The studies analyzed were conducted in various contexts, reflecting different environments and approaches. "Academia" is the most common location, with 31 studies conducted in academic institutions (SS2, S3, S4, S5, S7, S9, S10, S11, S15, S17, S18, S19, S21, S22, S23, S24, S25, S27, S29, S30, S31, S32, S33, S35, S37, S39, S40, S42, S45, S46, S47), which indicates a significant focus on research and theoretical development. "Industry" continues to be the second most frequent location, with 14 studies conducted in the industrial sector (S1, S6, S8, S13, S14, S16, S20, S26, S28, S34, S36, S41, S43, S44), suggesting a practical, market-oriented application. "Author's illustration" is mentioned in 2 studies (S12, S38), which may indicate a more informal or exploratory representation of the results.

The analyzed studies present a wide range of participants, with most not specifying this information. The range of participants varies considerably among the studies that provide specific numbers. The highest number of participants recorded is 1107, while the lowest is 3. Most studies with specific numbers have between 3 and 40 participants. Table 12 summarizes the number of participants.

The data analysis types in the studies show a clear preference for qualitative approaches. Qualitative analysis is predominant and used in 44 studies, indicating a significant focus on methods that explore and interpret data in a detailed and subjective way. On the other hand, quantitative analysis is mentioned in only two studies, reflecting a more structured, numbers-based approach. Only 1 study combines qualitative and quantitative methods, suggesting a less common application of mixed approaches. Table 13 summarizes the types of data analysis used.

Table 12: Number of Participants

Number of Participants	Quantity of Studies	Studies
Not specified	32	SE1, S3, S4, S5, S6, S7, S8, S9, S10, S11, S12, S13, S15, S17, S19, S22, S23, S24, S25, S29, S31, S32, S33, S35, S37, S38, S39, S40, S41, S42, S44, S45
1 - 10	4	S16, S20, S28, S47
11 - 20	4	S14, S27, S43, S46
21 - 40	3	S21, S18, S34
41 - 80	1	S2
81 - 100	2	S30
Over 100	2	S26

Table 13: Types of Data Analysis Used in the Studies Analyzed

Type of Data Analysis	Quantity of Studies	Studies
Qualitative	43	S1, S2, S3, S4, S5, S6, S7, S8, S9, S10, S12, S13, S14, S15, S16, S17, S18, S19, S20, S21, S22, S23, S24, S25, S27, S29, S30, S31, S32, S33, S34, S35, S36, S37, S38, S39, S40, S41, S42, S43, S44, S45, S46
Quantitative	2	S26, S28
Mixture of both	1	S11

The studies were evaluated using various methods, reflecting different approaches to analyzing and validating the practices and theories discussed. Table 14 summarizes the evaluation methods used in the studies.

5 Analysis

The studies highlight the need to integrate ethical considerations from the earliest stages of system design and development, particularly in artificial intelligence (AI) and software engineering. Methods such as ECCOLA, ObRE, and FormaTive are suggested for structuring and managing ethical requirements, allowing human values to be incorporated directly into the process. These approaches help translate abstract principles into tangible requirements, ensuring that ethics is integral to the development lifecycle.

Ethical education for students and professionals is a key focus in several studies. To enrich software engineering practices, it must be accompanied by interdisciplinary collaboration involving different areas of knowledge, such as social sciences, law, and computer science. In addition, engaging a wide range of stakeholders, such as

Table 14: Study Evaluation Methods

Evaluation Method	Quantity of Studies	Studies
Interviews and Qualitative Analysis	3	S4, S28, S34
Practical Application and Validation of Tools	4	S12, S17, S20, S35
Empirical Studies and Workshops	6	S10, S11, S13, S30, S33, S44
Case Studies	9	S1, S7, S18, S19, S21, S22, S31, S39, S46
No Assessment or Limited Assessment	24	S2, S3, S5, S6, S8, S9, S14, S15, S16, S23, S24, S25, S26, S27, S29, S32, S36, S37, S38, S40, S41, S42, S43, S45

politicians, end-users, and technical experts, is essential to ensure ethical guidelines are applied inclusively and transparently.

The studies also recommend using specific technologies and tools to address ethical and legal issues. For example, blockchain can protect sensitive data, ensuring compliance with laws like the LGPD. Practical methods, such as the RESOLVEDD strategy and continuous validation tools, are crucial to monitoring and adjusting systems during and after implementation, focusing on explainability, transparency, and fairness. Finally, the studies emphasize the need to continuously validate human-centered AI systems, with a focus on transparency, interpretability, and sustainability. This includes exploring new areas, such as IoT in small and medium-sized businesses, addressing emerging challenges in the evolution of AI, and ensuring that systems are reliable, secure, and socially responsible. These recommendations reflect a comprehensive approach to mitigating risks and promoting trust in modern technologies.

5.1 Gaps and research opportunities

The gaps and research opportunities identified reveal areas with potential for further development and exploration. "Evaluation and Improvement of Ethical Design Processes and Methods" is highlighted as the area with the most opportunities, with 31 studies pointing to the need to improve and evaluate existing processes. "Integrating Ethics into Development Processes" and "Case Studies and Practical Implementation" are equally relevant, with 26 and 13 studies suggesting a significant interest in integrating ethics practically and concretely. The "Development of New Tools and Methods to Support Ethics" also appears essential, with six studies focusing on creating new solutions to support ethical practices. Table 15 summarizes the gaps and research opportunities identified. The review of studies identified the main recommendations for improving the integration of ethical requirements into projects and practices.

- Adoption of Frameworks, Methods, or Models is the most frequent recommendation, with 13 studies suggesting that frameworks and structured methods can improve the integration of ethical requirements.
- The integration of ethical considerations into development is referenced in 11 studies, emphasizing the importance of incorporating them from the earliest stages of development.
- The development of guidelines and certification is recommended in eight studies, highlighting the necessity for clear guidelines and certifications to ensure adherence to ethical requirements.
- Ethics Education and Interdisciplinary Collaboration is suggested in 6 studies, indicating that continuing education in ethics and collaboration between disciplines is essential for effectively addressing ethical requirements.
- Social Impacts and Expanded Considerations is the least frequent recommendation, with three studies suggesting that a broader analysis of social impacts should be considered.

5.2 Impacts of working with ethical requirements

The impacts of working with ethical requirements can be classified into positive and negative, reflecting the various effects of this practice on different aspects.

Positive Impacts:

(1) Promoting Transparency, Accountability, and Trust is the most frequently mentioned impact, with 17 studies highlighting how incorporating ethical requirements can improve clarity and accountability, generating greater stakeholder trust.
(2) Improving Quality of Life and Inclusion and Improving Software Design and Engineering Processes are mentioned in 10 studies each, indicating benefits for users' quality of life and improvements in development processes.
(3) Identifying and Mitigating Ethical Risks and Biases is the third most impacted area, with eight studies highlighting the importance of identifying and reducing ethical risks and biases.
(4) Improving Ethical Decision-Making and Governance significantly impacts five studies, suggesting that ethical requirements can improve decision-making and governance.
(5) Improving Software Design and Engineering Processes is relevant for four studies, suggesting that ethical requirements can improve software development processes.

Negative Impacts:

(1) Increased Complexity and Workload is the most common negative impact, mentioned in 8 studies, indicating that implementing ethical requirements can complicate processes and increase workload.
(2) Negative Impact on Quality and Implementation is mentioned in 2 studies, suggesting that quality and implementation may suffer when integrating ethical requirements.
(3) Social Influence and Negative Perceptions is the least frequent negative impact, with two studies indicating possible adverse reactions from society and negative perceptions.

The studies have suggested several strategies to minimize the negative impacts associated with working with ethical requirements: 1) Integrating Ethical Considerations from the Start is the

Table 15: Gaps and Research Opportunities Identified

Gaps and Opportunities	Quantity of Studies	Studies
Evaluation and Improvement of Ethical Design Processes and Methods	31	S1, S3, S4, S6, S7, S8, S14, S15, S16, S18, S20, S21, S22, S23, S24, S25, S27, S28, S29, S30, S31, S32, S33, S35, S36, S37, S38, S40, S42, S44, S46
Integrating Ethics into Development Processes	26	S2, S3, S7, S8, S9, S10, S11, S12, S13, S14, S15, S17, S19, S20, S21, S26, S27, S29, S30, S32, S34, S36, S39, S43, S44, S45
Case Studies and Practical Implementation	13	S1, S5, S19, S20, S28, S30, S32, S34, S41, S43, S42, S45, S47
Development of New Tools and Methods to Support Ethics	6	S2, S10, S12, S19, S30, S46

most mentioned indication, with four studies suggesting that integrating ethical requirements from the early stages of development can reduce complexity and improve implementation; 2) Developer Education and Resources, Use of Flexible Frameworks and Iterative Methods, and Conflict Management Models and Techniques are recommended equally in 3 studies each. These strategies emphasize the importance of providing adequate training, using adaptable frameworks, and applying effective conflict-resolution techniques; 3) Psychomotor and Interdisciplinary Considerations are suggested in 2 studies, indicating the relevance of approaches that consider psychomotor and interdisciplinary aspects to mitigate negative impacts; and 4) Use of Ethical User Stories (EUS) is mentioned in 1 study, highlighting a less common but still relevant approach to improving the consideration of ethical aspects.

6 Discussion

The only research question used in this study was RQ.1: *What techniques, methods, processes, frameworks, and tools are described in the literature for the elicitation, analysis, specification, validation, and management of ethical requirements?* By revisiting this research question, we can answer it from the data obtained in the SLR. The results obtained can be highlighted as follows:

Techniques: Regarding techniques, it is worth noting that several techniques have been used in the literature to support ethical requirements. Among them, the techniques "Ethical Guidelines Analysis/Ethical Principles" and "ECCOLA" are worth highlighting. These were the techniques most commonly found in the papers accepted in this study. It should also be mentioned that some studies reported "techniques centered on user stories", which suggests the more common use of agile methods.

Methods: Concerning methods, none stood out from the rest. Various methods were cited, from document analysis and interviews to natural language processing and the creation of guidelines. It is worth mentioning that the action research method was found in more than one study. This suggests an attempt to integrate academic research with the software development industry.

Processes: Some processes related to ethical requirements were found. However, two categories stood out: "Requirements bidding, analysis, and prioritization" and "Agile management". The former represents routine requirements management activities, while the latter is linked to agile methods. Reinforcing what was identified in the topic of techniques.

Frameworks: About frameworks, there was great diversity among the studies. As can be seen from Table 5, each framework appears only once. The only item that occurs more than once is "Generic frameworks", which represent unidentified frameworks not directly addressed in the studies.

Tools: As with frameworks, there was great diversity in the tools category. Several tools were presented, but none were directly addressed in more than one study. This indicates that there is no consolidated tool for dealing with ethical requirements.

7 Threats to Validity

The possible threats associated with this RSL are based on the prominent threats defined by Zhou et al. [23]. ***Inadequate research question*** and ***Incomprehensible sites or database***: In this study, the research questions may not address all aspects of the treatment of ethical aspects during the requirements phase in software development. To minimize this threat, we have developed research questions that explore different perspectives on treating ethical requirements. Search engines and associated databases are well-known sources that return studies from scientific events and relevant journals on the subject under investigation.

Duplication of primary studies: We use the Start [10] tool to make it easier and less likely to make mistakes when dealing with duplicate papers. The tool automatically removes duplicate studies from the list of articles. ***Incorrect search method*** and ***Inadequate or incomplete search terms in the automatic search***: Concerning the search string, we tried to be very assertive with the terms used. After several tests with other strings, we arrived at the current string with a lower volume of disposable papers. We checked whether it could return all the previously known studies to validate the search string used.

Bias in the selection of studies e ***Misidentification of primary studies in the search process***: We must consider the subjective decisions that may have occurred while selecting primary studies. Consequently, relevant studies may not have been selected. A rigorous plan was followed to minimize this threat, guided by well-defined inclusion and exclusion criteria that were carefully applied to the selected studies. In addition, to reduce fatigue and human error, each review session lasted a maximum of four hours. ***Bias in data extraction, misclassification of primary studies*** and ***Subjective interpretation of extracted data***: We need to recognize the subjective choices that may have influenced data extraction. This study involved a second author during the extraction

process to address any uncertainties. It's important to note that the conclusions in this RSL were based solely on the reports from each study, which means only the characteristics explicitly mentioned were analyzed. Additionally, many studies are still in development (i.e., early-stage research), which may result in unclear research aspects. This could impact the conclusions presented in this RSL.

8 Final Remarks

This study reviews the literature on ethical requirements in software development. By analyzing the selected papers, some trends and gaps in this area of research were identified. One of the central diversity of techniques, methods, processes, frameworks, and tools used to address findings was the ethical requirements. No consolidated approach was identified or widely adopted by the community. Another relevant point is the application of ethical requirements in different domains, such as artificial intelligence, health systems, and government systems. This demonstrates the growing importance of this topic and the need for solutions that can be adapted to different contexts. As for the software development process phases, the results indicate that ethical requirements have been addressed more in the initial stages, such as requirements gathering and analysis. However, this concern must extend throughout the software lifecycle, ensuring that ethical principles are considered at all stages.

Finally, the impacts of working with ethical requirements were also explored, pointing to challenges such as the lack of awareness, the complexity of defining and prioritizing these requirements, and the need to involve multiple stakeholders. Given this scenario, this study contributes to a better understanding of the state of the art on ethical requirements in software development. It is hoped that the gaps and opportunities presented here can inspire and direct future research in this area to develop more robust and practical solutions to deal with the ethical challenges present in the construction of computer systems. In future research, we plan to explore how we can help in requirements activities using tools. We intend to research how AI can help in these activities.

Data Availability

The material produced during the research is available on Zenodo at https://doi.org/10.5281/zenodo.14170192.

Acknowledgments

This study was financed in part by the Project No. 514/2023 – Call Nº 10/2023 – FAPDF Learning Program, a strategic development initiative in the macro areas of Agro Learning, Bio Learning, Gov Learning, and Tech Learning.

References

[1] Mamia Agbese, Rahul Mohanani, Arif Ali Khan, and Pekka Abrahamsson. 2023. Implementing AI Ethics: Making Sense of the Ethical Requirements. In *Proceedings of the 27th International Conference on Evaluation and Assessment in Software Engineering, EASE 2023*. ACM, https://doi.org/10.1145/3593434.3593453, 62–71.

[2] Anonymous Anonymous. 2024. *Ethical Requirements in the Age of Artificial Intelligence*. doi:10.5281/zenodo.14183399

[3] Nagadivya Balasubramaniam, Marjo Kauppinen, Kari Hiekkanen, and Sari Kujala. 2022. Transparency and Explainability of AI Systems: Ethical Guidelines in Practice. In *Requirements Engineering: Foundation for Software Quality - 28th International Working Conference, REFSQ 2022*, Vol. 13216. Springer, https://doi.org/10.1007/978-3-030-98464-9_1, 3–18.

[4] Nagadivya Balasubramaniam, Marjo Kauppinen, Antti Rannisto, Kari Hiekkanen, and Sari Kujala. 2023. Transparency and explainability of AI systems: From ethical guidelines to requirements. *Inf. Softw. Technol.* 159 (2023), 107197.

[5] Hrvoje Belani, Marin Vukovic, and Zeljka Car. 2019. Requirements Engineering Challenges in Building AI-Based Complex Systems. In *27th IEEE International Requirements Engineering Conference Workshops, RE 2019 Workshops, Jeju Island, Korea (South), 2019*. IEEE, https://doi.org/10.1109/REW.2019.00051, 252–255.

[6] Seblewongel E. Biable, Nuno M. Garcia, and Dida Midekso. 2023. Proposed Ethical Framework for Software Requirements Engineering. *IET Software* 17, 4 (2023), 526–537. doi:10.1049/sfw2.12136

[7] Edna Dias Canedo, Angélica Toffano Seidel Calazans, Ian Nery Bandeira, Pedro Henrique Teixeira Costa, and Eloisa Toffano Seidel Masson. 2022. Guidelines adopted by agile teams in privacy requirements elicitation after the Brazilian general data protection law (LGPD) implementation. *RE* 27, 4 (2022), 545–567.

[8] José Antonio Siqueira de Cerqueira, Anayran Pinheiro De Azevedo, Heloise Acco Tives Leão, and Edna Dias Canedo. 2022. Guide for Artificial Intelligence Ethical Requirements Elicitation - RE4AI Ethical Guide. In *55th Hawaii International Conference on System Sciences, HICSS 2022, Virtual Event / Maui, Hawaii, USA, January 4-7, 2022*. ScholarSpace, http://hdl.handle.net/10125/80015, 1–10.

[9] José Antonio Siqueira de Cerqueira, Heloise Acco Tives Leão, and Edna Dias Canedo. 2021. Ethical Guidelines and Principles in the Context of Artificial Intelligence. In *SBSI 2021: XVII Brazilian Symposium on Information Systems, Uberlândia, Brazil, June 7 - 10, 2021*. ACM, https://doi.org/10.1145/3466933.3466969, 36:1–36:8.

[10] Sandra Fabbri, Cleiton Silva, Elis Hernandes, Fábio Octaviano, André Di Thommazo, and Anderson Belgamo. 2016. Improvements in the StArt tool to better support the systematic review process. In *Proceedings of the 20th International Conference on Evaluation and Assessment in Software Engineering* (Limerick, Ireland) *(EASE '16)*. Association for Computing Machinery, New York, NY, USA, Article 21, 5 pages.

[11] Renata S. S. Guizzardi, Glenda Carla Moura Amaral, Giancarlo Guizzardi, and John Mylopoulos. 2020. Ethical Requirements for AI Systems. In *Advances in Artificial Intelligence - 33rd Canadian Conference on Artificial Intelligence, Canadian AI 2020, Ottawa, ON, Canada (Lecture Notes in Computer Science, Vol. 12109)*. Springer, https://doi.org/10.1007/978-3-030-47358-7_24, 251–256.

[12] IEEE Std 7000-2021. 2021. IEEE Standard Model Process for Addressing Ethical Concerns during System Design. *IEEE Std 7000-2021* (2021), 1–82. doi:10.1109/IEEESTD.2021.9536679

[13] Arif Ali Khan, Muhammad Azeem Akbar, Mahdi Fahmideh, Peng Liang, Muhammad Waseem, Aakash Ahmad, Mahmood Niazi, and Pekka Abrahamsson. 2023. AI Ethics: An Empirical Study on the Views of Practitioners and Lawmakers. *IEEE Trans. Comput. Soc. Syst.* 10, 6 (2023), 2971–2984.

[14] Barbara Kitchenham. 2004. Procedures for performing systematic reviews. *Keele, UK, Keele University* 33, 2004 (2004), 1–26.

[15] B. Kitchenham and S. Charters. 2007. *Guidelines for performing systematic literature reviews in software engineering*. Technical Report Technical Report EBSE 2007-001. School of Computer Science and Mathematics, Keele University / School of Computer Science and Mathematics, Keele University.

[16] Olga Levina. 2024. Incorporating Ethical Aspects in Information Systems Requirements Engineering. In *Perspectives in Business Informatics Research - 23rd International Conference on Business Informatics Research, BIR 2024, Prague, Czech Republic (Lecture Notes in Business Information Processing, Vol. 529)*. Springer, https://doi.org/10.1007/978-3-031-71333-0_10, 153–161.

[17] Paul N. Otto and Annie I. Antón. 2007. Addressing Legal Requirements in Requirements Engineering. In *15th IEEE International Requirements Engineering Conference, RE 2007, October 15-19th, 2007, New Delhi, India*. IEEE Computer Society, https://doi.org/10.1109/RE.2007.65, 5–14.

[18] Kai Petersen, Sairam Vakkalanka, and Ludwik Kuzniarz. 2015. Guidelines for conducting systematic mapping studies in software engineering: An update. *Information and software technology* 64 (2015), 1–18.

[19] General Data Protection Regulation. 2018. General data protection regulation (GDPR). *Intersoft Consulting, Accessed in October* 24, 1 (2018).

[20] Errikos Siakas, Harjinder Rahanu, Joanna Loveday, Elli Georgiadou, Kerstin Siakas, and Margaret Ross. 2023. Managing Ethical Requirements Elicitation. In *Systems, Software and Services Process Improvement*. Vol. 1890. Springer Nature Switzerland, Cham, 258–272.

[21] Heidi Vainio-Pekka, Mamia Ori-Otse Agbese, Marianna Jantunen, Ville Vakkuri, Tommi Mikkonen, Rebekah Rousi, and Pekka Abrahamsson. 2023. The Role of Explainable AI in the Research Field of AI Ethics. *ACM Trans. Interact. Intell. Syst.* 13, 4, Article 26 (Dec. 2023), 39 pages. doi:10.1145/3599974

[22] Andreas Vogelsang and Markus Borg. 2019. Requirements Engineering for Machine Learning: Perspectives from Data Scientists. In *27th IEEE International Requirements Engineering Conference Workshops, RE 2019 Workshops, Jeju Island, Korea (South)*. IEEE, https://doi.org/10.1109/REW.2019.00050, 245–251.

[23] Xin Zhou, Yuqin Jin, He Zhang, Shanshan Li, and Xin Huang. 2016. A Map of Threats to Validity of Systematic Literature Reviews in Software Engineering. In *2016 23rd Asia-Pacific Software Engineering Conference (APSEC)*. 153–160. doi:10.1109/APSEC.2016.031