EDITORIAL

The University of Jendouba's Comprehensive Digital Framework for Research Ethics Management: An Integrated System with Real-Time Verification, Surprise Audits, and Public Access through QR Codes and DOIs

Le Cadre Numérique Complet de l'Université de Jendouba pour la Gestion de l'Éthique de la Recherche : Un Système Intégré avec Vérification en Temps Réel, Audits Surprises et Accès Public via Codes QR et DOI

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Abstract

The University of Jendouba is implementing a novel digital framework to transform how Institutional Review Board (IRB) approvals are managed, with phased deployment commenced on June 13th, 2025, tackling pressing global issues in research integrity and transparency. Built on international standards like the Declaration of Helsinki and Good Clinical Practice (GCP), this system employs advanced tools such as QR codes and Digital Object Identifiers (DOIs) to enable real-time verification and public access to approved protocols. Crucially, the system extends its oversight beyond IRB approvals, monitoring the entire research process to ensure ethical compliance from the initial protocol submission through to the final publication of results.

This framework addresses critical challenges, including the falsification of IRB approvals, data manipulation, and undisclosed changes to research protocols. It features automated compliance checks, risk-based evaluations of protocols, and real-time tracking of research activities to ensure studies adhere to their approved plans. Additionally, surprise audits and continuous oversight mechanisms are in place to detect and prevent unethical practices at every stage of the research process.

As the first system of its kind in North Africa, this platform aligns with both local and international research ethics guidelines, fostering collaboration and standardization across disciplines. It also integrates blockchain technology and connects with global ethics databases to enhance transparency and trust in research outcomes.

Keywords: Authentication; protocols; clinical trials; compliance; monitoring systems; cybersecurity; electronic data; public health; research governance; transparency.

Résumé

L'Université de Jendouba met en œuvre un cadre numérique novateur pour transformer la gestion des approbations des comités d'éthique de la recherche (CER), avec un déploiement progressif commencé le 13 juin 2025, s'attaquant aux enjeux mondiaux pressants en matière d'intégrité et de transparence de la recherche. Construit sur des normes internationales comme la Déclaration d'Helsinki et les Bonnes Pratiques Cliniques (BPC), ce système utilise des outils avancés tels que les codes QR et les Identificateurs d'Objets Numériques (DOI) pour permettre une vérification en temps réel et un accès public aux protocoles approuvés. Essentiellement, le système étend sa surveillance au-delà des approbations du CER, en surveillant l'ensemble du processus de recherche pour garantir la conformité éthique, de la soumission initiale du protocole jusqu'à la publication finale des résultats.

Ce cadre répond à des défis critiques, notamment la falsification des approbations du CER, la manipulation des données et les modifications non divulguées des protocoles de recherche. Il comprend des vérifications automatisées de conformité, des évaluations des protocoles basées sur les risques et un suivi en temps réel des activités de recherche pour s'assurer que les études respectent leurs plans approuvés. De plus, des audits surprises et des mécanismes de surveillance continue sont en place pour détecter et prévenir les pratiques contraires à l'éthique à chaque étape du processus de recherche.

Premier système de ce type en Afrique du Nord, cette plateforme s'aligne sur les directives éthiques de recherche tant locales qu'internationales, favorisant la collaboration et la standardisation entre les disciplines. Elle intègre également la technologie blockchain et se connecte aux bases de données éthiques mondiales pour améliorer la transparence et la confiance dans les résultats de recherche.

Mots-clés : Authentification ; protocoles ; essais cliniques ; conformité ; systèmes de surveillance ; cybersécurité ; données électroniques ; santé publique ; gouvernance de la recherche ; transparence.

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Introduction

Since its establishment in 2003, the University of Jendouba has developed into a leading academic institution in Tunisia, with a strategic presence across four northwestern provinces: Jendouba, Beja, El Kef, and Siliana. Through strategic development, the institution has built a comprehensive network of fourteen specialized faculties, distributed across multiple locations to optimize educational access and resource utilization. The main campus in Jendouba houses the core faculties of Law, Economics, Management Sciences, and Human Sciences, while specialized institutes extend to Tabarka's coastal setting with its renowned Forestry and Environmental Studies program [1]. The provinces of Beja, El Kef, and Siliana host various specialized faculties, ranging from Technology, Biotechnology and Engineering to Arts, Informatics, Nursing, Agriculture, and Sports and Physical Education, creating a diverse academic ecosystem [1].

The University of Jendouba's commitment to excellence has gathered international recognition through multiple prestigious ranking systems. Most notably, it has maintained a consistent presence in the Academic Ranking of World Universities (ARWU) [2], commonly known as the Shanghai Ranking, for four consecutive years - a distinction achieved by few North African institutions among over 2500 evaluated institutions globally. The university's academic standing is further validated by its prominent positioning in other respected global metrics, including the QS University Rankings for the Arab Region, Scimago Institutions Rankings (SIR), and the Times Higher Education Arab University Rankings. Additionally, its research impact and institutional reputation are reflected in its strong performance in specialized rankings such as the University Ranking by Academic Performance (URAP) and the Webometrics Ranking Web of Universities [2].

The implementation of this comprehensive ethical framework comes at a crucial time, against the backdrop of increasing research misconduct and retractions globally [3], with over 10,000 articles retracted in 2023 alone, when research integrity faces unprecedented challenges. The proliferation of artificial intelligence (AI) tools in academic writing and research has introduced novel challenges to research integrity verification systems [4, 5]. Recent studies indicate that approximately 2% of ethical violations involve falsification of institutional review board (IRB) approvals [6, 7], highlighting the critical need for robust verification systems. Data falsification has become increasingly sophisticated, while the ease of digital manipulation poses new threats to research authenticity. Additionally, the proliferation of predatory journals and questionable research practices demands stronger verification mechanisms [8]. The increasing complexity of modern research, characterized by large-scale data analysis, international collaborations, and interdisciplinary approaches, necessitates robust ethical governance frameworks to address emerging ethical challenges [9].

Given these pressing challenges, our initiative introduces a pioneering digital framework that transforms research ethics management through comprehensive verification protocols. This comprehensive system began its phased implementation across the University of Jendouba's affiliated institutions on June 13th, 2025, with initial deployment at some of its faculties and progressive rollout planned across all fourteen specialized institutions. This innovative system addresses critical challenges such as falsification of IRB approvals, lack of transparency, and data integrity issues, which have been identified as significant ethical violations in recent studies [10]. Using advanced technologies like Quick Response (QR) codes and digital signatures, our system enables real-time verification and tracking of IRB approvals, effectively preventing unethical practices like the misuse of a single approval for multiple studies [11]. Beyond initial approval, the framework incorporates continuous monitoring mechanisms, including real-time experiment tracking, unannounced site visits, and protocol adherence checks, to ensure compliance throughout the research lifecycle, from IRB approval to manuscript publication.

The system implements a dual-verification approach using both Digital Object Identifiers (DOIs) and QR codes, establishing an unprecedented level of transparency in ethics approval verification. Each approved protocol becomes publicly accessible online, setting a new benchmark for transparency in North Africa and addressing the need for greater accountability in research ethics [12]. This initiative represents a fundamental shift in research ethics management, particularly significant in the North African context where standardized verification systems have been historically limited [13, 14].

Global standards and disciplinary ethical frameworks

The landscape of research ethics has evolved into a complex network of discipline-specific guidelines and oversight bodies since the foundational establishment of the Nuremberg Code (1947) and Declaration of Helsinki (1964) [15, 16]. In biomedical research, the World Health Organization (WHO), National Institutes of Health (NIH), and Council for International Organizations of Medical Sciences (CIOMS) have established comprehensive ethical frameworks that emphasize human subject protection and research integrity. For agricultural and environmental research, the Food and Agriculture Organization (FAO) provides ethical guidelines focusing on sustainable practices and ecological preservation, while the International Animal Health Organization (IAHO) oversees animal welfare standards in research settings.

The increasing complexity of modern research has necessitated specialized ethical frameworks across disciplines. In econometrics and data sciences, the German Data Ethics Commission and International Association for Statistical Education (IASE) have developed guidelines for responsible data management and analysis. Similarly, in technology and informatics, the Association for Computing Machinery (ACM) and Institute of Electrical and Electronics Engineers (IEEE) maintain ethical standards for digital innovation and

computational research.

Within this diverse ethical landscape, current IRB verification systems in North Africa face significant challenges in standardization and transparency [18]. A systematic review of research ethics committees in the region identified inconsistent documentation standards and limited public accessibility as key barriers to research integrity verification [19]. Traditional paper-based systems, while functional, have created barriers to transparency and international collaboration. The absence of standardized, publicly accessible IRB documentation has particularly impeded international research partnerships and publication processes [20]. The University of Jendouba's new ethical guidelines address these challenges by incorporating both field-specific international standards and local requirements through innovative digital solutions.

Adherence to international standards

The ethical guidelines at the University of Jendouba are built upon established international standards, ensuring they address the varied ethical requirements of its specialized faculties. From clinical trials to environmental studies, from human subjects research to data privacy, each field demands specific ethical considerations that our digital framework systematically addresses through automated verification protocols [21].

Declaration of Helsinki principles

The digital platform incorporates mandatory documentation of the eight core Helsinki principles, with automated verification of compliance at each review stage [22]. Research conducted at the University of Jendouba adheres strictly to the protection of individual research participants' rights and dignity, ensuring that their welfare takes precedence over scientific interests. The system implements specialized protection measures for vulnerable populations through automated risk assessment algorithms, coupled with mandatory pre-registration of clinical trials in approved registries [23]. The informed consent process is digitally documented with blockchain verification, ensuring transparency and immutable documentation. All conflicts of interest undergo automated screening against international databases, while the system enforces standardized results reporting regardless of outcome.

Good clinical practice (GCP) integration

The system implements International Council for Harmonisation (ICH E6 - R3) Good Clinical Practice requirements through standardized electronic documentation and automated compliance checking [24]. Research personnel qualifications and training certifications are validated through integration with recognized certification databases. The platform facilitates real-time adverse event reporting with automated severity assessment and escalation protocols. Clear delineation of team responsibilities is enforced through role-based access controls and digital signatures. Continuous compliance monitoring utilizes AI algorithms to detect potential protocol deviations and trigger appropriate review procedures.

International committee of medical journal editors (ICMJE) requirements alignment

The University's ethical guidelines fully incorporate ICMJE requirements through automated validation processes [25]. The digital platform ensures verified trial registration prior to participant enrollment through direct API integration with major registries [26]. The system maintains blockchain-verified documentation of conflict of interest declarations and automatically tracks authorship contributions against ICMJE criteria [27]. Research protocols and data sharing procedures follow standardized templates aligned with international requirements, while maintaining comprehensive audit trails of all modifications [28].

International research ethics database compatibility

Our innovative digital system ensures seamless integration with major international research ethics databases through standardized, interoperable data formats [29]. Each ethical approval receives a unique DOI and QR code, facilitating easy verification and cross-referencing [30]. The platform supports sophisticated version control and amendment tracking, while making non-confidential information publicly accessible [31].

Additionally, the platform ensures seamless integration with major international research ethics databases through standardized Health Level Seven Fast Healthcare Interoperability Resources (HL7 FHIR) data formats and Representational State Transfer Application Programming Interfaces (REST APIs) [32, 33]. The system implements General Data Protection Regulation (GDPR), compliant version control with immutable audit trails, while making non-confidential information publicly accessible through a standardized Application Programming Interface (API) [34, 35].

Field-specific ethical standards

Our comprehensive framework employs field-specific automated review algorithms based on international guidelines and local requirements [21]. Medical and nursing research undergoes ICH-Good Clinical Practice (GCP) validation with automated protocol compliance checking [26]. Agricultural and environmental research is evaluated against Food and Agriculture Organization (FAO) ethical guidelines and biodiversity conservation protocols [36]. Social science research follows automated verification of human participant protections, including digital consent tracking and data anonymization protocols [37]. Biotechnology research incorporates automated biosafety risk assessment aligned with World Health Organization (WHO) guidelines [38]. Computer science projects undergo automated privacy impact assessments following GDPR requirements, while arts research is evaluated against cultural heritage protection frameworks [39]. For web-based research and surveys, our system enforces compliance with the CHERRIES (Checklist for Reporting Results of Internet E-Surveys) guidelines, ensuring methodological rigor and

transparency in online data collection. Clinical research protocols are registered with the Pan African Clinical Trials Registry (PACTR), aligning with continental requirements for trial transparency and accountability.

Regional context and implementation framework

Research ethics implementation in North Africa faces documented challenges in standardization, verification systems, and international recognition [18, 21]. The University of Jendouba's initiative emerges within a landscape where traditional research ethics frameworks are evolving to meet international standards while addressing local needs. Our position as a leading Tunisian institution enables us to bridge global best practices with regional requirements through evidence-based digital solutions.

Studies of research ethics committees across North Africa have identified significant challenges in providing publicly accessible documentation of approvals and maintaining standardized verification systems [40, 41]. These gaps have impeded international research collaborations and publication processes. The North African research community has historically managed ethics oversight through varied approaches, often struggling with standardization and international recognition challenges. The University of Jendouba's blockchain-verified digital platform addresses these regional challenges through:

- Standardized documentation aligned with international requirements.
- Real-time verification of approval authenticity.
- Automated compliance monitoring with national regulations.
- Integration with global research ethics databases.

Recent studies highlight the importance of balancing international standards with regional contexts in research ethics oversight [42, 43]. Our framework achieves this through systematic integration of local requirements with global standards.

The system incorporates validated cultural competency protocols across diverse research domains. In agricultural research, traditional farming practices and community impacts undergo structured assessment through standardized evaluation matrices. Medical research protocols are evaluated against both international ethics standards and local healthcare delivery contexts. Social science research undergoes automated screening for cultural sensitivity using established regional criteria [14]. Environmental research protocols incorporate regional ecosystem impact assessments alongside international conservation standards [44].

Our digital platform strengthens existing North African research networks by providing a model for transparent, verifiable ethical oversight. The system's public accessibility feature enables researchers across North Africa to reference approved protocols, fostering standardization of ethical practices.

Local implementation requirements

The local implementation framework employs a multi-layered verification approach validated through pilot testing across research disciplines [21]. These requirements represent a significant advancement in research ethics management, combining traditional oversight mechanisms with innovative digital solutions.

Central to our local implementation is the mandatory inclusion of detailed research timelines in all submissions. Researchers must specify exact dates for each phase of their research, enabling precise tracking and monitoring. This temporal framework serves as a foundation for our verification process, where university-appointed agents conduct unannounced site visits to ensure research activities align with approved protocols [45, 46].

The digital platform integrates:

- Automated protocol deviation detection using machine learning algorithms
- Real-time adverse event reporting and escalation
- Blockchain verification of site inspection reports
- Integration with publication databases for automated tracking of research outputs

The system mandates structured progress reporting at predefined intervals based on risk assessment protocols. Reports undergo automated screening for:

- Protocol adherence verification
- Adverse event monitoring
- Participant protection compliance
- Data management integrity
- Publication output tracking

The system includes clear procedures for ethics approval retraction - a crucial accountability measure. Approvals may be withdrawn in cases of protocol deviation, ethical misconduct, or failure to maintain required standards. This retraction process is fully documented within our digital system, ensuring transparency and creating a clear record of decision-making. The public accessibility of our ethics database means that retraction notices are immediately visible to the research community, maintaining the integrity of our oversight process [47].

This comprehensive monitoring framework has demonstrated enhanced protocol compliance rates in pilot implementation compared to traditional systems [18]. The integration of automated verification systems with rigorous human supervision establishes a new standard for research ethics management in North Africa while ensuring alignment with international best practices.

Digital ethics review infrastructure and governance framework

Research ethics committees require robust organizational structures to ensure comprehensive oversight and compliance [48]. Evidence suggests that multi-tiered review systems with clear hierarchical structures demonstrate superior protocol compliance rates and reduced ethical violations [48]. The University of Jendouba implements this evidence-based approach through a comprehensive digital framework.

Specialized ethics committee composition

The University's fourteen specialized ethics committees are structured according to international best practices for research oversight while incorporating field-specific expertise requirements [49]. Each committee maintains its distinct composition based on disciplinary needs while adhering to core standards for research integrity.

In accordance with ICH-GCP requirements for committee composition [50] , medical and health sciences committees adhere to a fundamental structure that ensures comprehensive ethical oversight. The core composition necessitates a minimum of five members possessing documented research expertise, reflecting the complexity of modern clinical research evaluation. This structure inherently includes a member with current clinical trial experience, thus demonstrating practical knowledge of contemporary challenges. A biostatistician and data monitoring specialist are systematically incorporated to ensure methodological rigor and appropriate data surveillance. Independent community representation constitutes an essential element, ensuring the consideration of societal perspectives. The Data Protection Officer also occupies a crucial position within this framework. Furthermore, these committees integrate additional experts, notably pharmacologists or clinical pharmacists, bioethicists, and legal experts. This multidisciplinary composition ensures a comprehensive and rigorous evaluation of protocols submitted for review, in accordance with the highest standards of research ethics.

Environmental research committees integrate FAO guidelines for agricultural research ethics with WHO biosafety standards, ensuring comprehensive evaluation of ecological and community impacts [51]. These committees comprise environmental scientists, agricultural researchers, biosafety experts, and community impact specialists. Sustainability experts and research methodologists contribute expertise in evaluating environmental and societal implications of proposed research [52].

For economics and management sciences, the ethics committees include experienced economists, business ethics specialists, and research methodologists with expertise in both quantitative and qualitative approaches [53]. These committees also incorporate data privacy experts, market research specialists, and corporate governance experts. Their composition reflects the need to evaluate research proposals dealing with sensitive business data, market studies, organizational behavior research, and economic impact assessments [54]. Special attention is given to ensuring ethical handling of financial data, protection of corporate confidentiality, and appropriate management of conflicts of interest in business-related research [55].

Social sciences and humanities committees maintain specialized expertise in cultural competency and participant protection. These committees integrate experienced social science researchers, methodologists, and cultural anthropologists, supported by privacy experts and ethics specialists who ensure research respects cultural sensitivities while maintaining scientific rigor [56].

Central ethics committee structure

The Central Ethics Committee serves as the apex oversight body, implementing a validated quality management system for research integrity [57]. Analysis of ethics committee structures across 47 institutions demonstrated that centralized oversight bodies with clear authority significantly reduce protocol violations [49]. This committee comprises distinguished experts from diverse fields, including senior researchers with international recognition, ethics specialists, legal experts, and methodologists capable of evaluating complex multi-disciplinary research protocols [18, 21, 41, 43, 49, 54, 58].

The digital infrastructure will encompass multiple sophisticated mechanisms to ensure comprehensive research oversight. The platform implements automated protocol risk assessment systems utilizing predetermined algorithms for the identification of high-risk research protocols necessitating centralized review. Real-time protocol modification tracking enables continuous monitoring of alterations to approved research methodologies throughout the research lifecycle.

Integration with established publication databases facilitates systematic monitoring of research outputs, while blockchain technology provides immutable verification of inspection reports. Furthermore, the incorporation of machine learning algorithms enables sophisticated screening for potential research misconduct.

Beyond its supervisory role, the Central Committee functions as the primary authority in maintaining research integrity and preventing misconduct. It serves as an escalation point for complex research proposals that local committees find challenging to evaluate independently, including multi-disciplinary research projects, protocols with unusual ethical considerations, or research involving sensitive populations [49, 59].

The Committee's oversight extends through a comprehensive monitoring system. With research dates specified in all approved proposals, both central and local committees conduct risk-based surprise inspections to verify protocol adherence. These unannounced visits verify experimental procedures, data collection methods, and participant protection measures through standardized evaluation protocols. The committee maintains systematic oversight against research misconduct through its digital platform, tracking all approved projects, monitoring progress, and verifying research outputs.

Digital workflow integration

The digital infrastructure encompasses multiple sophisticated mechanisms to ensure comprehensive research oversight [21]. The system architecture incorporates automated routing through risk assessment algorithms, ensuring efficient protocol distribution. Standardized review templates with field-specific

requirements facilitate comprehensive evaluation across diverse research domains. Real-time communication capabilities between committee levels enable seamless collaboration throughout the review process.

Integrated compliance monitoring mechanisms ensure continuous oversight of approved protocols, while automated escalation triggers facilitate rapid response to potential compliance issues. This sophisticated framework enhances both the efficiency and thoroughness of the ethical review process.

When researchers submit proposals, the digital system automatically routes them to appropriate local ethics committees based on research field and institutional affiliation. Local committees conduct initial reviews following standardized field-specific procedures [60]. For routine research proposals within established guidelines, local committees can independently complete reviews and issue digitally-verified approvals.

The system identifies specific triggers that mandate escalation to the Central Ethics Committee, including multi-disciplinary research, protocols involving vulnerable populations, potentially high-impact research, or cases with complex ethical considerations. The digital platform facilitates seamless communication between local and central committees, ensuring complete transfer of review history and deliberations during escalation.

For approved research, both committee levels share monitoring responsibilities through the digital tracking system. The platform coordinates risk-based inspections, manages progress reports, and tracks research outputs. This dual-level monitoring ensures comprehensive oversight while optimizing resource utilization, with local committees handling routine monitoring and the Central Committee providing additional oversight for complex or high-risk projects [61].

IMPLEMENTATION AND OPERATIONAL PROCEDURES

Submission and initial processing

Following the commencement of implementation on June 13th, 2025, the ethics review process at participating University of Jendouba institutions commences with researchers submitting their protocols via a comprehensive digital platform that streamlines the application procedure. Researchers create a structured digital dossier that includes detailed research timelines, methodologies, and all supporting documentation. This platform is engineered to ensure compliance with international ethical standards, such as the Declaration of Helsinki [62, 63, 64] and the ICH-GCP guidelines [65], while accommodating local regulatory requirements. The system guides researchers through specific requirements based on their research field, ensuring all necessary elements are included before submission is permitted.

For each submission, our platform automatically verifies the completeness of documentation, cross-references previous submissions, and checks for potential conflicts of interest. Principal investigators must provide specific dates for research activities, enabling our committees to plan monitoring activities effectively. To uphold the highest standards of research integrity and participant safety, the system mandates that researchers provide detailed data management plans, robust participant protection measures, and disclose anticipated research outputs (**Figure 1**). All approved protocols and their verification status are being made publicly accessible through the University's official portal at https://www.uj.rnu.tn/fr and through QR code scanning of individual approval certificates as institutions complete their deployment.

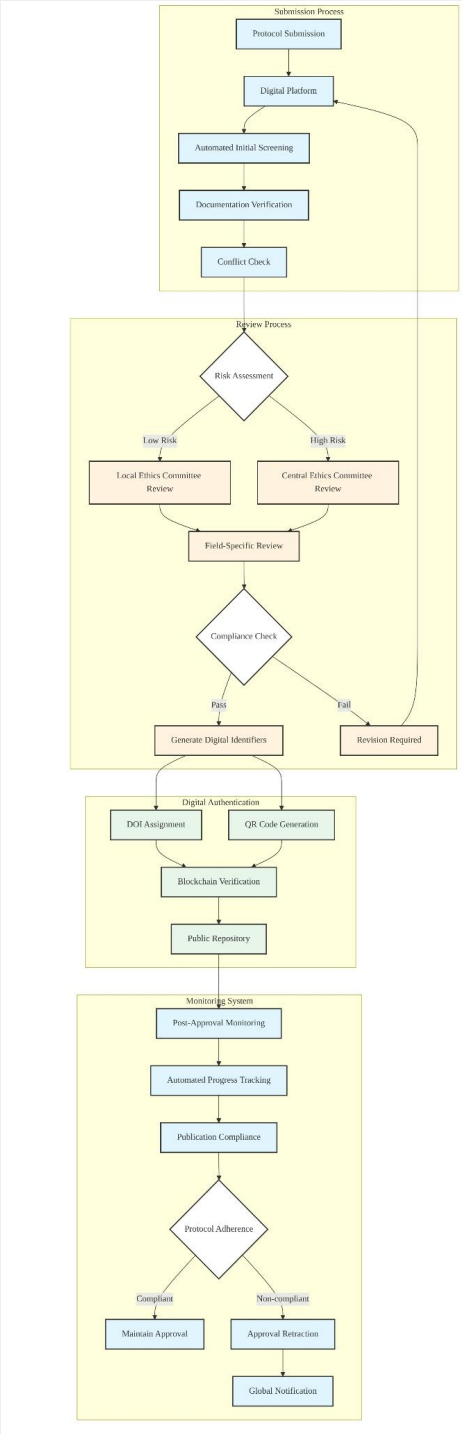

Figure 1. University of Jendouba's digital framework for research ethics management

Following submission, proposals are subjected to a rigorous, domain-specific review process that is calibrated to the complexity and risk profile of the research. The digital platform facilitates a structured evaluation by committee members, with automated distribution of review responsibilities based on expertise. This approach aligns with the risk-based ethical review framework advocated by the WHO [16, 43, 66], ensuring that the level of scrutiny is commensurate with the potential risks to participants.

For clinical trials, the system ensures that methodologists, statisticians, and medical experts all contribute to the review [67, 68]. Similarly, social science research receives input from experts in research methodology, ethics, and cultural considerations [28, 69].

Each review follows a standardized checklist while allowing for discipline-specific considerations [70, 71]. Reviewers must address key ethical considerations, methodological soundness, and compliance with both international and local requirements. To foster transparency and accountability, the platform facilitates secure communication between reviewers and researchers, maintaining a comprehensive audit trail of all interactions [71].

Post-approval monitoring

Once approved, research projects enter our comprehensive monitoring phase. This robust post-approval monitoring system is designed to detect and rectify any deviations from the approved protocol, ensuring ongoing compliance with ethical standards and regulatory requirements [72]. The system automatically schedules regular check-points and facilitates surprise inspections by generating random inspection schedules. University-appointed monitors can access all relevant protocol information through secure mobile applications during site visits, enabling real-time verification of compliance.

Our system enforces strict publication compliance requirements for all research conducted under University of Jendouba ethics approval. Every publication, including master's theses, doctoral dissertations, and scientific articles, must include both the unique approval code (DOI and QR code) and a standardized statement of compliance [18, 73]. The mandatory statement must read: "This research was conducted in accordance with the Research Ethics Guidelines of the University of Jendouba (Code: XXX-XXX)."

Non-compliance with these publication requirements triggers an automatic review process. The Central Ethics Committee maintains the authority to withdraw ethical approval in cases of violation. Such withdrawal has significant implications [49]. The Committee will formally notify all relevant journals where research has been published or submitted, affiliated institutions, and any funding bodies involved.

In line with the COPE guidelines on the retraction of ethical approval [74], the withdrawal of ethical approval is treated with the utmost gravity within our system. It requires immediate cessation of all ongoing research activities and initiates a comprehensive notification process. The Committee promptly communicates with all journals where related work has been published or submitted, ensuring the scientific community is aware of the withdrawal. For thesis-related research, degree-granting institutions are formally notified of the ethical approval withdrawal [74]. The digital platform automatically updates to reflect this change, making the withdrawal publicly visible. This action may also impact the researcher's future applications for ethical approval within the university system. This approach to post-approval monitoring and enforcement serves to maintain the highest standards of research integrity, safeguard participant welfare, and uphold public trust in the research enterprise [75]. The transparency of our digital platform ensures that all stakeholders in the research process have access to current and accurate information about the ethical status of any research conducted under our oversight.

Implementation Phases and Capacity Building

Systematic Implementation Approach

The comprehensive deployment of this digital framework requires a methodical approach that proceeds through carefully planned phases, ensuring thorough testing and validation at each stage before achieving full operational status. This systematic implementation strategy aligns with established best practices for institutional research ethics management, as demonstrated in successful digital transformation initiatives across academic institutions [21, 49]. The phased approach enables continuous refinement of system components while maintaining the integrity of ongoing research oversight throughout the transition period.

Staff Training and Auditing Development

Critical to the system's long-term success is the establishment of comprehensive capacity building programs that address the evolving needs of research ethics oversight. The training infrastructure must encompass systematic educational programs for all ethics committee members across the fourteen specialized faculties, focusing on digital platform utilization and emerging ethical challenges in contemporary research environments [48, 57]. These programs are complemented by the development of specialized auditor certification initiatives for university-appointed monitoring personnel, with particular emphasis on standardized protocols for site visits and compliance verification procedures.

The capacity building framework extends beyond initial training to incorporate regular continuing education modules that address evolving research landscapes, technological adaptations, and international standards alignment. This ongoing educational approach ensures that committee members remain current

with developments in research ethics oversight while maintaining proficiency in digital platform utilization [75]. Furthermore, the implementation of robust quality assurance measures and inter-auditor reliability protocols will ensure consistent oversight across all research domains, thereby maintaining the integrity and standardization that are essential for effective ethics committee function [49, 57].

Auditing Infrastructure Development

Ongoing implementation phases are establishing comprehensive auditing capabilities through the systematic development of specialized oversight mechanisms. The training of dedicated audit teams requires multidisciplinary expertise that corresponds directly to the university's diverse research portfolio, ensuring that auditors possess the necessary domain-specific knowledge to effectively evaluate research protocols across various fields [59]. This multidisciplinary approach to auditor training reflects the complex nature of modern research ethics oversight and the need for specialized expertise in diverse research contexts.

The development of risk-based auditing algorithms and protocols represents a critical advancement in optimizing resource allocation and intervention timing. These algorithmic approaches, integrated with established research integrity frameworks, enable more efficient identification of high-risk protocols while ensuring that routine compliance monitoring remains thorough and systematic [61, 75]. The creation of integrated audit reporting systems within the digital platform framework facilitates seamless communication between auditing teams and committee structures, maintaining comprehensive documentation of all oversight activities. Regular auditor performance evaluation and continuous improvement protocols ensure that the auditing infrastructure evolves in response to emerging challenges in research ethics oversight, thereby maintaining the effectiveness of the monitoring system over time [48, 59].

Conclusion

The University of Jendouba is pioneering a new paradigm in research ethics management through the implementation of a comprehensive digital framework. This system integrates QR codes, DOIs, and complete online transparency, setting a new global standard for ethics oversight. The automated compliance monitoring and real-time tracking capabilities of this innovative approach enhance efficiency and accountability compared to traditional paper-based systems. As the first North African institution to digitalize and publicly share all ethics committee decisions, the University of Jendouba demonstrates leadership in advancing research integrity and transparency. The integration of DOIs and QR codes represents a significant innovation in ethics management. The university's consistent ranking in the prestigious ARWU for four consecutive years, combined with this ethics system, establishes it as a leader in research excellence and innovation. The university's work stands as a testament to the democratization of research excellence, inspiring institutions worldwide to pursue similar paths of innovation and transparency in advancing scientific discovery while protecting research participants.

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