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Integrated Quality and Environmental Management in Healthcare: Impacts, Implementation, and Future Directions Toward Sustainability

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Abstract: Healthcare institutions are under increasing pressure to deliver high-quality, patient-centered care while reducing their environmental footprint. Integrating quality and environmental management systems (ISO 9001 and ISO 14001) into a unified integrated management system (IMS) offers a potential pathway to meet these dual imperatives. This study investigates the effects of IMS implementation in three European hospitals through a comparative qualitative analysis of institutional reports, audit documentation, and performance indicators. The methodology combines a literature-informed conceptual framework with a multi-case analysis guided by four domains: environmental impact, care quality, process efficiency, and stakeholder engagement. The data were collected from institutional documentation over a six-year period (three years before and after IMS implementation), covering key indicators such as energy and water consumption, medical waste recycling, audit compliance, and patient satisfaction. The findings show that IMS adoption was associated with a 20–28% improvement in resource efficiency, increased recycling rates, and consistent gains in compliance and satisfaction metrics. These results were supported by strategic leadership, cross-functional training, and digital monitoring tools. The study concludes that IMS enhances institutional performance and sustainability while aligning healthcare operations with broader governance and policy goals. Further research is recommended to explore the long-term impacts and generalize the findings across healthcare systems.

Keywords: environmental sustainability; healthcare quality; hospital management; Integrated Management Systems; ISO 9001; ISO 14001; patient satisfaction



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1. Introduction

Healthcare systems around the world are increasingly challenged to deliver high-quality, patient-centered care while simultaneously addressing the environmental consequences of their operations. Hospitals and other medical facilities are major consumers of energy and water, producers of hazardous and non-hazardous waste, and contributors to greenhouse gas emissions. The World Health Organization (WHO) has emphasized

the significant environmental footprint of the healthcare sector, with estimates suggesting that it contributes approximately 4.4% of global carbon emissions [1–3]. However, recent estimates indicate that the global healthcare sector is responsible for approximately 4.6% to 5.2% of total greenhouse gas emissions, underscoring its significant role in contributing to climate change. These environmental concerns must be addressed alongside the growing demand for safe, efficient, and equitable healthcare services [1–5].

Traditionally, quality management systems (QMSs), such as ISO 9001 (<https://www.iso.org/standards/popular/iso-9000-family>, accessed on 21 May 2025), have focused on optimizing clinical processes and ensuring patient safety through structured procedures, risk-based thinking, and continuous improvement. In parallel, environmental management systems (EMSs), exemplified by ISO 14001 (<https://www.iso.org/standards/popular/iso-14000-family>, accessed on 21 May 2025), have targeted pollution prevention, regulatory compliance, and resource efficiency. While both frameworks contribute to institutional performance, their isolated application often results in fragmented workflows, redundancies, and missed opportunities for synergy. In response, healthcare organizations are increasingly adopting integrated management systems (IMSs) that consolidate QMSs and EMSs under a unified strategy. This integrated approach fosters operational coherence, enhances regulatory alignment, and enables institutions to pursue sustainability and quality improvement as complementary rather than competing goals [6–9].

Figure 1 illustrates the rationale behind the adoption of integrated management systems (IMSs) in healthcare institutions. Faced with the dual responsibilities of ensuring high-quality care and minimizing environmental impacts, healthcare organizations are increasingly turning to IMSs as a strategic solution. By integrating quality and environmental management practices, institutions can align with ISO standards, enhance operational efficiency, and reduce the institutional risk, thereby supporting sustainable and patient-centered care delivery.

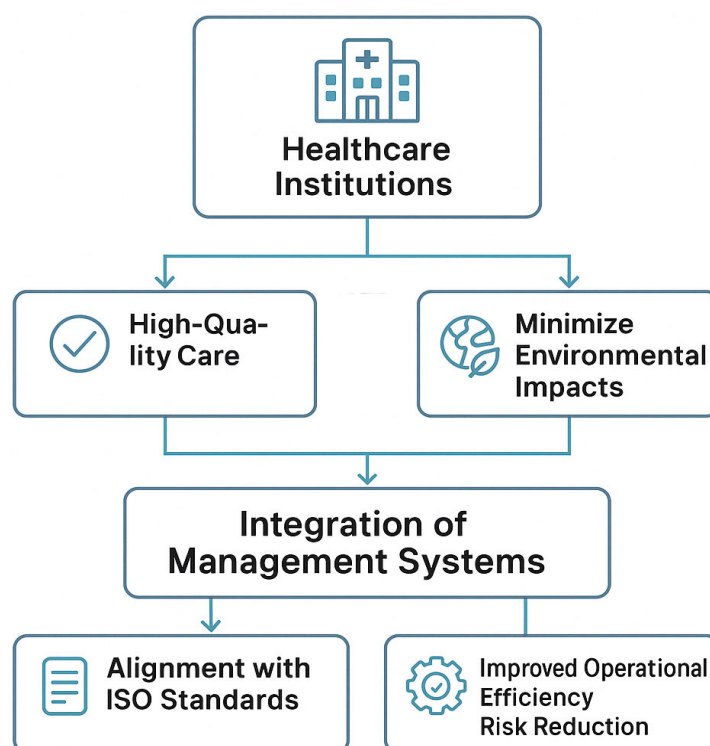


Figure 1. Conceptual overview of the introduction of integrated management systems (IMSs) in healthcare institutions.

Integrated management systems (IMSs), built on ISO 9001 and ISO 14001 standards, offer healthcare institutions a structured pathway to align operational quality with environmental responsibility. Numerous studies have highlighted IMS benefits such as enhanced compliance, resource efficiency, stakeholder engagement, and process standardization [6,7]. However, empirical applications in healthcare remain limited, particularly multi-institutional evaluations that track both quality and environmental indicators. This study addresses that gap through a comparative analysis of IMS implementation outcomes in three European hospitals using performance indicators such as satisfaction, compliance, energy and water use, and waste recycling [10–14].

The introduction of IMSs in healthcare is not only a response to regulatory and stakeholder pressures but also a strategic tool for enhancing institutional resilience, reputation, and long-term performance. By embedding environmental consciousness within the culture of continuous quality improvement, institutions can create value for patients, staff, and the broader community.

The conceptual framework applied in this study integrates the ISO 9001 and ISO 14001 standards through the Plan–Do–Check–Act (PDCA) cycle [15,16], supported by aligned governance policies, internal audits, and risk management procedures. Four core domains, quality of care, environmental responsibility, process efficiency, and stakeholder engagement, were assessed using key performance indicators (KPIs) to evaluate change before and after IMS implementation. This model reflects a systems-based approach to continuous improvement, consistent with broader sustainability and accountability goals in healthcare [17–20].

2. Integrated Quality and Environmental Management in Healthcare: Current Research and Knowledge Gaps

The integration of ISO 9001 (quality management) and ISO 14001 (environmental management) into a unified management system has become increasingly relevant for healthcare institutions seeking to align quality care with environmental sustainability. Although the structural compatibility of these standards is well documented, the literature on their combined implementation in healthcare remains fragmented and underdeveloped. The existing research highlights multiple advantages of integrated management systems (IMSs), such as improved efficiency, better regulatory compliance, enhanced stakeholder satisfaction, and stronger institutional alignment [8,9,14]. IMS adoption is also associated with a shift from siloed departmental operations toward more holistic, systems-based approaches. Mezinska et al. [13] emphasize that IMSs enable institutions to internalize sustainability and social responsibility principles into their organizational culture, while Sroufe [10] underlines the potential of integrated systems to support strategic decision-making and performance improvement.

Despite these documented benefits, the available literature tends to focus on conceptual models, sector-wide guidelines, or isolated applications of either ISO 9001 or ISO 14001. Empirical studies that systematically evaluate the joint impacts of these standards on healthcare institutions remain scarce. As noted by Tarí et al. [6] and Talib et al. [7], while many institutions adopt one standard, integrated implementation is less common and often lacks a performance-based evaluation. There is a paucity of comparative analyses that track changes across key indicators such as patient satisfaction, clinical error rates, environmental compliance, and resource consumption before and after IMS implementation. In addition to limited empirical data, several barriers to IMS adoption in healthcare are frequently cited. These include fragmented management structures, resistance to procedural change, insufficient staff training, and the absence of cross-functional collaboration mechanisms [11,12,15]. Hospitals often operate under complex regulatory environments, with constrained bud-

gets and workforce pressures that further complicate the integration of new management systems. Moreover, IMS success depends heavily on leadership commitment, institutional learning, and the ability to customize system frameworks to local contexts [9].

The increasing digitalization of healthcare offers new opportunities for strengthening IMS frameworks. Technologies such as IoT-based sensors, electronic audit tools, and real-time dashboards allow for better monitoring, data integration, and predictive analytics. Abdulmalek et al. [16] suggest that digital systems can enhance transparency and responsiveness in quality and environmental monitoring, while Santamato et al. [17] argue that artificial intelligence can facilitate the coordination of complex processes in large healthcare institutions. However, Wang and Liu [18] point out that these benefits are contingent on the organization's digital maturity and strategic approach to integration. Furthermore, the role of IMSs in supporting broader policy goals, such as the Sustainable Development Goals (SDGs), has also been discussed in recent studies. For instance, Ramos et al. [14] and Shams et al. [8] demonstrate how an IMS contributes to responsible resource consumption, institutional accountability, and decent work environments, aligning healthcare management practices with SDG targets such as good health and well-being (SDG 3), clean water and sanitation (SDG 6), and responsible consumption and production (SDG 12). Despite these promising developments, a critical gap persists in the availability of robust, multi-institutional evidence on IMS outcomes in healthcare. Most studies rely on qualitative assessments or focus on single institutions, limiting generalizability and comparative learning. As noted by Mezinska et al. [13], there is an urgent need for more detailed investigations into the mechanisms by which IMS influence organizational performance in different contexts.

This study addresses that gap by presenting a multi-institutional comparative analysis of IMS implementation in three European hospitals. Using performance indicators including energy and water consumption, medical waste recycling, patient and staff satisfaction, and compliance incidents, this research provides empirical evidence on how IMSs can enhance sustainability, operational quality, and stakeholder satisfaction. Drawing from case studies, institutional reports, and best practices, this work offers actionable insights into how integrated systems can support the transition toward greener, more efficient, and more accountable healthcare delivery.

3. Framework and Standards

3.1. Theoretical Foundations of IMSs in Healthcare Institutions

The implementation of integrated management systems (IMSs) in healthcare is grounded in several interrelated theoretical frameworks. At its core, IMSs reflect systems theory, which views organizations as complex, interdependent systems composed of interacting subsystems. This approach is particularly relevant to healthcare institutions, where clinical, administrative, and environmental operations are deeply intertwined. By integrating quality and environmental management under a unified system, IMS promotes coordination, feedback loops, and optimization across departments, aligning with the systems-thinking approach required for effective institutional governance.

The theoretical foundation of IMS draws on Total Quality Management (TQM) principles, which emphasize continuous improvement, patient-centeredness, and evidence-based decision-making [19–22]. When combined with the environmental emphasis of ISO 14001, these principles extend beyond clinical care to include risk management and sustainable operations. Organizational learning theory also supports IMSs, highlighting the roles of audits, corrective actions, and staff engagement in fostering adaptability and institutional responsiveness [21–27].

Finally, stakeholder and sustainability theories provide a normative justification for IMSs in healthcare. These frameworks stress the need to address the expectations of diverse stakeholders—patients, staff, regulators, and the community—while ensuring the long-term viability of institutional operations. IMSs support these goals by embedding accountability, transparency, and sustainability into routine processes and decision-making. Together, these theoretical perspectives demonstrate that an IMS is not merely a technical or procedural tool but a strategic management model well-suited for the multidimensional demands of contemporary healthcare institutions.

3.2. Standards-Based Framework for IMS Implementation in Healthcare

The theoretical foundation of integrated management in healthcare institutions rests on the principles established by internationally recognized standards: ISO 9001 for quality management and ISO 14001 for environmental management. These standards provide structured, process-oriented approaches to improving organizational performance, though they target different, but increasingly overlapping domains [23].

ISO 9001, developed by the International Organization for Standardization, is the most widely adopted quality management standard worldwide. It is based on seven core principles: customer focus, leadership, engagement of people, process approach, improvement, evidence-based decision making, and relationship management. In the context of healthcare, these principles translate into delivering safe, effective, and patient-centered services. ISO 9001 requires the establishment of quality objectives, documentation of procedures, and monitoring of outcomes to ensure continuous improvement. It is particularly relevant in healthcare environments where patient safety, treatment effectiveness, and stakeholder trust are paramount [24,25].

ISO 14001, also issued by the ISO, provides a framework for establishing an environmental management system (EMS). It emphasizes the identification and control of environmental aspects, compliance with legal requirements, prevention of pollution, and continuous improvement in environmental performance. In healthcare, these include reducing hazardous waste, managing resource consumption (energy, water, and materials), and mitigating risks associated with environmental incidents. ISO 14001 encourages a lifecycle perspective and systematic review of environmental impacts across operations, procurement, and service delivery [26,27]. While ISO 9001 and ISO 14001 were developed independently, they share several common structural elements, particularly after the adoption of the Annex SL high-level structure introduced by the ISO in 2012. This structural alignment facilitates the integration of management systems (IMS), enabling organizations to implement both standards simultaneously through harmonized policies, objectives, and processes. The integrated approach reduces redundancy in documentation and auditing, improves efficiency, and promotes a unified organizational culture of accountability and sustainability [10,13].

A comparative overview of the ISO 9001 and ISO 14001 standards, along with their potential for integration in healthcare institutions, is presented in Table 1 [19–27]. This table highlights the core principles, operational domains, and synergistic benefits of combining these frameworks within an integrated management system (IMS).

In healthcare institutions, where both quality and environmental concerns intersect across multiple departments, from clinical operations to logistics and facility management, an IMS promotes cross-functional collaboration. For example, improving sterilization processes can enhance patient safety while also reducing energy and water consumption. Likewise, waste segregation initiatives can reduce the environmental impact while supporting infection control and operational efficiency [28,29].

Table 1. Overview of the ISO 9001 and ISO 14001 standards and their integration in healthcare institutions.

Aspect	ISO 9001 (Quality Management)	ISO 14001 (Environmental Management)	Integration in an IMS
Purpose	Ensures consistent quality and continuous improvement in healthcare	Controls environmental impacts and improves sustainability	Aligns quality and environmental objectives for holistic performance
Core principles	Customer focus, leadership, process approach, improvement	Compliance, pollution prevention, resource optimization	Shared commitment to continuous improvement and stakeholder satisfaction
Main activities	Clinical process control, audits, corrective actions, risk management	Identification of environmental aspects, monitoring, legal compliance	Unified auditing, documentation, and corrective actions
Key outcomes	Improved patient safety and satisfaction	Reduced waste, emissions, and resource use	Enhanced efficiency, accountability, and stakeholder trust
Structural framework	High-level structure (Annex SL)	High-level structure (Annex SL)	Facilitates harmonization through common clauses and terminology
Application in healthcare	Clinical governance, infection control, and service quality	Waste management, energy and water efficiency, and environmental hygiene	Encourages cross-departmental collaboration and strategic alignment

The structural compatibility of ISO 9001 and ISO 14001, especially following the adoption of the Annex SL framework, facilitates their joint implementation. This harmonization allows healthcare institutions to develop integrated documentation, audit protocols, and reporting mechanisms, thereby reducing duplication and streamlining compliance processes [30,31].

3.3. Barriers and Challenges in IMS Implementation

While the integration of ISO 9001 and ISO 14001 offers considerable advantages, implementing an IMS in healthcare settings presents a series of institutional, operational, and cultural challenges. One of the primary obstacles is the complex organizational structure of hospitals, which often includes decentralized management, diverse professional cultures, and fragmented processes [11,15]. These factors can hinder the standardization and coordination required for integrated systems. Moreover, resource constraints, including limited budgets, staff shortages, and time pressures are frequently cited as impediments to effective implementation. Healthcare workers may perceive IMS procedures as adding an administrative burden rather than supporting care delivery [12]. Ensuring staff engagement and training across clinical and non-clinical departments is therefore a critical challenge [32].

Resistance to change is another notable barrier, particularly in environments where traditional practices are deeply embedded. The successful adoption of an IMS often requires cultural transformation, leadership commitment, and sustained communication to build shared understanding and accountability [9,13]. In addition, technical and infrastructural limitations, such as outdated information systems or the lack of digital tools for monitoring

and reporting, can compromise data accuracy and hinder the effectiveness of process integration [18,33]. These challenges underscore the importance of tailored implementation strategies, leadership-driven change management, and investment in capacity-building to ensure the effective and sustainable adoption of IMSs in healthcare institutions.

3.4. Operationalizing Integrated Quality and Environmental Management

The implementation of integrated management systems (IMSs) in healthcare institutions involves the alignment of ISO 9001 (quality management), and ISO 14001 (environmental management,) principles within a unified operational framework. These standards share a common structure through Annex SL, which enables organizations to integrate core management processes, including leadership, planning, support, operation, performance evaluation, and continual improvement. Key quality management principles operationalized in the studied hospitals include a process-based approach, risk-based thinking, continuous improvement, and stakeholder engagement. These were implemented through standardized clinical protocols, feedback-driven performance reviews, corrective action tracking, and documented internal audit cycles [34,35]. On the environmental side, principles such as pollution prevention, life cycle thinking, compliance assurance, and responsible resource use were embedded through the adoption of waste tracking systems, energy and water monitoring, eco-friendly procurement policies, and structured environmental reporting aligned with ISO 14001 [36].

The IMS framework provided a cohesive mechanism for harmonizing policies, aligning documentation formats, streamlining training modules, and synchronizing audit schedules across departments. This reduced redundancy, improved traceability, and promoted a culture of cross-functional accountability. Importantly, operationalization was context-specific: for instance, digital dashboards were used in German and Italian institutions to track key indicators in real time, while in an Eastern European hospital, the IMS served primarily to formalize fragmented documentation and build procedural consistency.

4. Environmental and Quality Challenges in Healthcare

Healthcare institutions operate in a complex environment where high standards of clinical performance must be achieved within increasingly constrained operational, financial, and ecological parameters. As essential service providers, hospitals and clinics are expected to offer safe, timely, and patient-centered care. Simultaneously, they are major contributors to environmental degradation through their high resource consumption, generation of hazardous waste, and carbon emissions. The intersection of these demands creates a multifaceted challenge for healthcare management [37]. One of the most pressing environmental issues in healthcare is the management of medical and infectious waste. Hospitals generate a wide range of waste streams, including pharmaceuticals, sharps, laboratory chemicals, and pathological waste [38,39]. According to the World Health Organization, up to 15% of healthcare waste is hazardous, posing risks to human health and the environment if not properly treated and disposed of. The segregation, treatment, and disposal of this waste require stringent protocols and significant resource input, often conflicting with efforts to streamline operations and reduce costs [40,41].

This study conceptualizes integrated management systems (IMSs) in healthcare as formal frameworks that align quality and environmental objectives within a unified institutional model, primarily guided by the ISO 9001 and ISO 14001 standards. The theoretical foundation of IMSs is rooted in systems thinking, which views healthcare institutions as interconnected, adaptive systems where operational, clinical, and environmental components influence one another. Integration is seen not merely as administrative alignment but

as a strategic transformation, requiring shared governance, coordinated procedures, and harmonized goals.

The underlying assumptions include (1) that integration reduces redundancies and improves resource efficiency; (2) that aligning quality and environmental priorities enhances institutional resilience and stakeholder accountability; and (3) that continuous monitoring and improvement foster sustainable performance. These assumptions draw from well-established theories of organizational learning [42], evidence-based management [43], and total quality management, all of which reinforce the role of IMSs in creating structured yet adaptive institutions. This framework guides both the case selection and the comparative evaluation presented in this study.

4.1. Energy Management and Efficiency in Healthcare Facilities

Energy consumption in healthcare facilities is another critical concern. The operation of diagnostic equipment, heating, ventilation, air conditioning (HVAC) systems, lighting, and sterilization units contributes to a high energy demand. Many hospitals operate 24/7, resulting in continuous consumption and high utility costs. Efforts to introduce energy-saving technologies and practices can be hindered by the need to maintain uninterrupted, high-reliability services essential for patient care [44,45].

Although detailed sub-metered data were not available in this study, the existing literature provides insights into the typical energy consumption profiles of healthcare facilities. According to recent energy audits in European and international hospital systems, HVAC systems (heating, ventilation, and air conditioning) account for the largest share of energy use, often exceeding 40–50% of total consumption, due to the strict indoor air quality and temperature control requirements [46,47]. Medical imaging and diagnostic equipment, such as MRI and CT scanners, contribute significantly to electricity use, particularly in specialized and high-throughput facilities. These systems can represent up to 15–20% of energy demand in diagnostic units.

Lighting systems typically account for 10–15%, especially in 24/7 operating departments, while sterilization units, laboratory operations, and IT infrastructure also add to the load. Energy consumption profiles differ substantially across institutions depending on their function (e.g., acute care vs. outpatient), size, technological infrastructure, and climate zone. While the uninterrupted operation of clinical services imposes constraints on energy interventions, multiple studies have demonstrated the feasibility of implementing energy-efficient technologies in healthcare settings without compromising reliability or safety. For instance, LED lighting retrofits have been widely adopted in hospitals, offering energy savings of 30–60% over conventional lighting systems while improving visual comfort and reducing maintenance frequency [48]. Similarly, high-efficiency HVAC systems using variable air volume control, thermal zoning, and demand-based ventilation strategies have shown significant reductions in energy use, up to 40% in optimized hospital retrofits, while maintaining the strict air quality and temperature standards required for patient care [47]. Moreover, the integration of renewable energy sources, such as solar photovoltaic (PV) systems, is gaining traction, particularly in non-critical infrastructure zones. Case studies from European hospitals have reported solar installations covering 10–25% of the total electricity demand, often supplemented by energy storage to ensure resilience [46]. These examples indicate that energy-saving solutions can be adapted to the operational realities of healthcare facilities, especially when integrated through structured frameworks like IMSs. Careful planning, load analysis, and staged implementation enable the coexistence of energy efficiency and uninterrupted service delivery.

The implementation of an IMS provides a structured framework for tracking and managing energy performance through regular audits, KPI monitoring, and the integration

of energy-saving practices into daily operations. In institutions where real-time monitoring systems are integrated within the IMS, energy consumption data can be used to identify high-load zones and inform targeted efficiency interventions.

4.2. Managing Water Use in Healthcare: Patterns, Challenges, and Infection Control Considerations

Water usage also presents a challenge. Healthcare institutions rely heavily on water for hygiene, sanitation, disinfection, and cooling processes. Excessive water use not only increases operational costs but also places stress on local water systems, especially in regions facing water scarcity. Balancing infection control protocols, which often require intensive water use, with sustainability goals can be particularly difficult [49,50].

Water consumption in healthcare facilities is highly variable, depending on the size of the institution, its clinical focus, infrastructure age, and operational model (e.g., inpatient vs. outpatient care). Among the most water-intensive departments are surgical units, which use large volumes of water for preoperative hand scrubbing, sterilization of surgical instruments, and cleaning of operating rooms. Central sterile services departments (CSSDs) also consume significant water for instrument reprocessing cycles [28,51].

Inpatient wards, particularly those dealing with infectious diseases or intensive care, require frequent linen changes and surface disinfection, further increasing water use. Diagnostic laboratories use water for specimen preparation, washing of glassware, and equipment cooling. HVAC systems that rely on chilled water or evaporative cooling can also contribute substantially to non-clinical water use, especially in older buildings with less efficient systems. Conversely, departments such as administrative offices, pharmacies, or outpatient clinics generally have lower water demands, though aggregate use can still be high in large facilities [52,53].

Understanding the distribution of water use across hospital departments is essential not only for improving sustainability but also for ensuring that essential clinical processes are not compromised. In particular, water-intensive procedures, such as sterilization and hygiene practices are integral to infection control protocols. Healthcare institutions can achieve water conservation without compromising patient safety by adopting strategies that align efficiency with strict hygiene standards. Recognizing these department-level differences is essential for developing effective conservation strategies. IMS implementation supports this effort by enabling healthcare organizations to monitor usage trends, audit departmental performance, and implement targeted measures, such as retrofitting high-use areas with water-saving technologies or scheduling cleaning operations during off-peak periods. Tailored interventions, guided by facility-specific usage data, are essential for balancing sustainability goals with operational and clinical requirements. Therefore, any water conservation strategy must be carefully evaluated for its impact on infection prevention protocols. While activities such as hand hygiene, sterilization, and surface cleaning are inherently water-intensive, studies have shown that targeted efficiency measures can reduce consumption without increasing the risk of hospital-acquired infections (HAIs) [54,55].

For example, sensor-activated faucets and low-flow fixtures have been successfully implemented in hospitals to reduce unnecessary water flow while maintaining handwashing compliance. Likewise, automated sterilization units with water recovery systems offer more efficient disinfection cycles compared to older models. These technologies, when properly maintained and integrated into infection control policies, have not shown an increase in HAI incidence [51,56]. Additionally, routine water quality monitoring, reinforced through IMS procedures, ensures that conservation measures do not affect microbiological safety. The IMS framework enables institutions to establish standard operating procedures that reconcile water-saving targets with clinical risk management. This includes zoning water

use (e.g., prioritizing clinical over non-clinical areas), scheduling high-demand activities during off-peak times, and incorporating real-time feedback from infection control teams into resource planning. In this way, water conservation and infection control need not be in conflict; rather, with coordinated planning and the support of integrated systems, they can be pursued simultaneously to ensure both sustainability and patient safety.

4.3. Systemic Challenges to Quality and Sustainability in Healthcare

In terms of quality challenges, healthcare institutions must adhere to a broad array of national and international regulations while striving to improve clinical outcomes and patient experiences. Factors such as overcrowding, staff shortages, and underfunded infrastructure compromise the delivery of high-quality services [57]. The pressure to comply with national and international standards in under-resourced healthcare systems, often characterized by staff shortages, infrastructure deficits, and patient overcrowding, has measurable consequences for clinical quality. Studies consistently show that infection control indicators, such as hospital-acquired infection (HAI) rates, are among the first to deteriorate under staffing and capacity strains. Overcrowded wards and overburdened hygiene facilities increase cross-contamination risks, especially when environmental and cleaning standards are compromised [58,59].

Patient wait times and delays in treatment are also common in resource-limited contexts, particularly in emergency departments and surgical units [60]. These delays may lead to clinical deterioration, lower patient satisfaction, and reduced adherence to care pathways. In parallel, readmission rates and avoidable complications may increase when discharge planning or follow-up care is inconsistent due to staff turnover or a lack of coordination [61]. Furthermore, staff-related indicators, including the frequency of clinical errors and occupational burnout, are closely tied to the workload and resource availability. High turnover and absenteeism can disrupt care continuity and reduce institutional learning [62,63]. In this context, the use of structured frameworks such as IMSs can support healthcare institutions in prioritizing resource allocation based on performance data. By regularly tracking indicators across departments, institutions can identify vulnerable areas, direct staffing or investment accordingly, and strengthen resilience [64]. For example, if patient satisfaction and hygiene audits indicate a decline in certain units, targeted training, schedule rebalancing, or maintenance interventions can be implemented to prevent clinical quality deterioration. Thus, even in constrained environments, strategic management systems can help align limited resources with high-impact areas.

Fragmented workflows and disjointed oversight structures in many healthcare institutions lead to inefficiencies that hinder performance and sustainability. Addressing these inefficiencies requires more than procedural adjustments; it calls for integrated strategies that align environmental and quality goals through shared leadership, robust training, and continuous engagement with staff at all organizational levels. An IMS offers a platform for embedding these integrative practices in a coherent and coordinated manner, provided that institutional readiness and cultural adaptability are in place [65–68]. Moreover, there is often a lack of integration between environmental and clinical objectives. For instance, single-use plastics, while vital for infection control, contribute heavily to the environmental burden [69]. Similarly, advanced diagnostic and life-support technologies, though essential for critical care, consume large amounts of energy and generate heat and noise pollution. Navigating such trade-offs requires a nuanced understanding of both clinical and environmental priorities [33,70].

4.4. Operational Challenges at the Intersection of Quality and Environmental Sustainability

Many healthcare institutions still rely on limited or outdated data systems, making it difficult to assess performance, identify inefficiencies, or benchmark improvements over time. The absence of standardized indicators and performance metrics limits accountability and constrains the ability to pursue data-driven quality and sustainability initiatives [71,72]. The practical effectiveness of an IMS in healthcare depends not only on its conceptual design but also on the presence of reliable and unified data systems. Many institutions, particularly in resource-constrained settings, continue to face significant barriers due to fragmented platforms, making it difficult to support consistent performance assessment and strategic improvements [18].

An effective IMS-supportive infrastructure combines digital data acquisition tools (e.g., EHRs, environmental sensors, and incident reporting systems) with interoperable platforms that connect clinical and environmental data across departments. These systems allow cross-functional teams to access shared performance indicators, enabling real-time visualization and decision-making. Standardized metrics and consistent reporting formats are essential for benchmarking, compliance, and external accountability. When embedded into institutional protocols, such frameworks help build a culture of transparency and continuous improvement [17,73–76].

As shown in Figure 2, healthcare institutions face interconnected challenges such as complex waste handling, high energy and water demands, fragmented systems, and staff resistance to change, all of which impact quality and sustainability. Waste management presents significant difficulties, with healthcare facilities generating both hazardous and non-hazardous waste that require complex segregation and strict disposal protocols. These processes place a considerable burden on operations and carry inherent risks to health and the environment while also demanding strict compliance with regulatory standards. Energy consumption is another pressing issue, driven by the continuous operation of energy-intensive systems such as HVAC units and sterilization equipment. These demands contribute to high utility costs and make it difficult to implement energy-saving measures without compromising the reliability of critical services. Similarly, water usage remains high due to the essential role water plays in hygiene, sanitation, disinfection, and cooling processes. In regions experiencing water scarcity, this creates added stress on local resources and challenges healthcare institutions to reduce consumption while still upholding stringent hygiene standards. In the area of clinical quality, institutions are often under pressure to meet national and international standards despite limited resources. This situation can lead to compromised care quality and an increased risk of staff burnout. Moreover, fragmented systems within healthcare organizations, such as siloed departments and disconnected quality and environmental management efforts, result in operational redundancies, inefficiencies, and conflicting priorities that hinder cohesive action. Cultural resistance is another barrier, as some staff may be reluctant to adopt new practices, preferring to maintain established routines. This resistance can delay or obstruct the implementation of sustainability initiatives and continuous improvement programs. Finally, data limitations, including the absence of standardized indicators and inadequate monitoring systems, impair institutions' ability to assess performance accurately and make data-driven decisions, ultimately affecting the effectiveness of both quality and environmental management strategies.

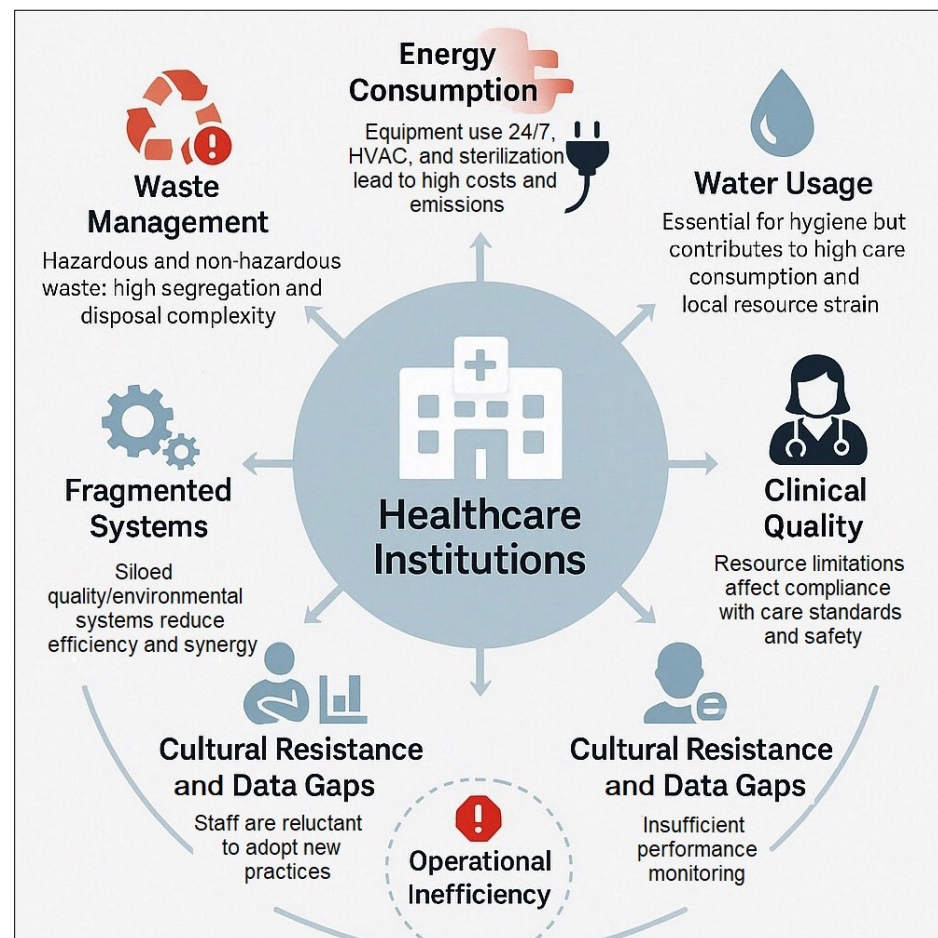


Figure 2. Key environmental and quality challenges in healthcare institutions.

5. Methodology

5.1. Methodological Framework for Comparative Evaluation of IMS in Healthcare

This study adopts a comparative qualitative research design supported by a combination of a literature review, case study analysis, and indicator-based evaluation. The primary objective is to examine the measurable impacts of implementing integrated quality and environmental management systems (IMSs) in healthcare institutions, with a focus on institutional performance, sustainability, and stakeholder satisfaction. The methodology is structured around three core components: (i) a systematic literature review; (ii) case study selection and analysis; and (iii) a comparative evaluation based on selected performance metrics in a multi-method approach (Figure 3). Data collection and analysis were guided by four categories of key performance indicators, environmental, quality, engagement, and process, ensuring a comprehensive assessment of IMS outcomes.

This study adopts a comparative multiple case study design, following the methodological principles articulated by Yin [77] and Eisenhardt and Graebner [78]. This approach is appropriate for investigating complex and context-dependent phenomena where explanatory “how” and “why” questions guide inquiry. The selection of three diverse European hospitals enabled an exploration of IMS implementation across varying institutional environments, offering insights into causal mechanisms, process interactions, and outcome variations. The study design emphasizes theoretical replication, allowing a comparison of patterns across cases rather than statistical generalization. The triangulation of qualitative and quantitative data collected from institutional documents, sustainability reports, and internal audits, supports construct validity, while cross-case synthesis enhances analytical robustness.

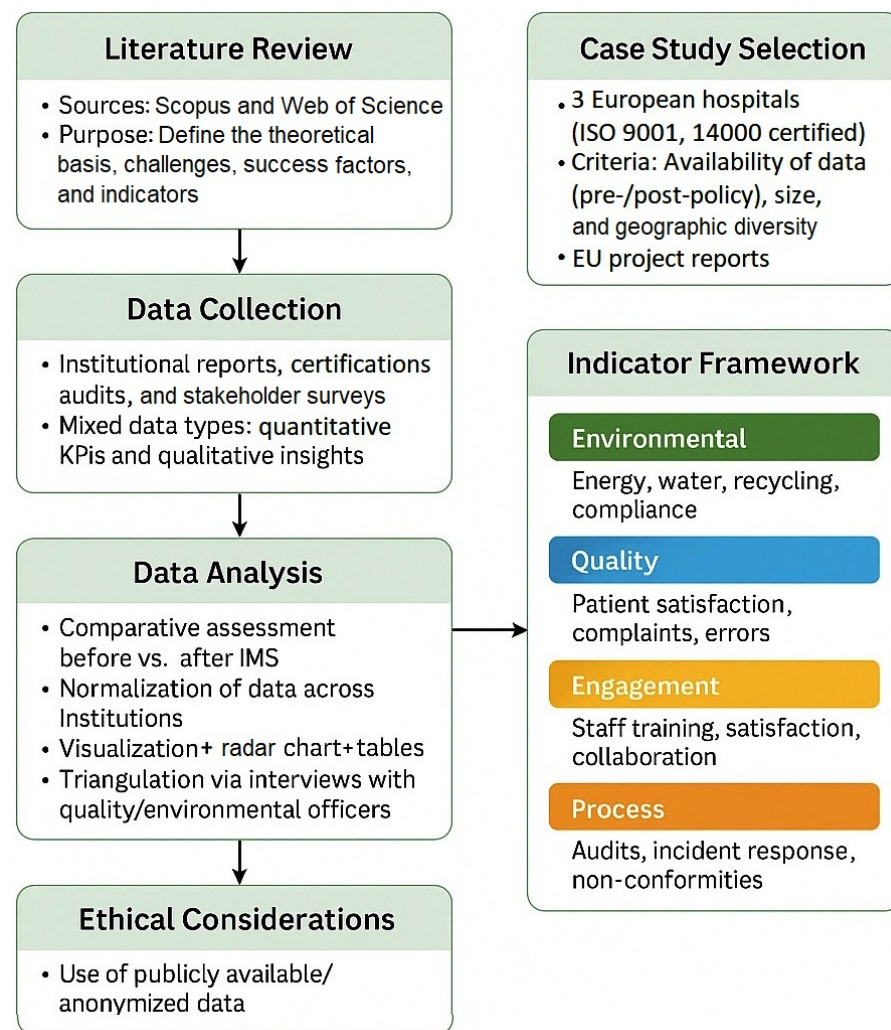


Figure 3. Methodological framework for assessing the impacts of integrated quality and environmental management systems (IMSS) on healthcare institutions.

Although this study did not involve primary data collection through interviews or questionnaires, a structured analytical protocol was followed to ensure consistency and traceability across the three case studies. Performance indicators were extracted from institutional records using predefined categories aligned with the study’s conceptual framework: environmental (e.g., energy, water, and waste), quality (e.g., compliance and audit results), stakeholder engagement (e.g., patient satisfaction), and process efficiency (e.g., error reduction and workflow documentation). Where data formats differed across hospitals, normalization techniques and comparative tables were used to standardize reporting. A consistent document review process, based on the nature and scope of available reports, was applied to ensure repeatability.

5.2. Literature-Informed Framework and Review Strategy

To inform the conceptual and methodological foundation of this study, a focused literature review was conducted to identify current trends, challenges, and performance dimensions associated with integrated quality and environmental management in healthcare institutions. This review also supported the design of the indicator framework and the selection of relevant case studies.

The literature search was conducted across major databases, including Scopus, Web of Science, and PubMed, using keywords such as “integrated management system”, “ISO 9001 in healthcare”, “ISO 14001 implementation”, “healthcare sustainability”, and “quality-

environmental integration”. Peer-reviewed articles, institutional reports, ISO documentation, and publications from global organizations such as the WHO and Health Care Without Harm were analyzed. Priority was given to sources that provided empirical data, conceptual frameworks, or implementation experiences within hospital settings. In addition to peer-reviewed publications and official standard documentation, selected grey literature sources, such as policy briefs, institutional reports, and publicly available audits were also considered, particularly where they provided contextual or implementation-specific insights. The selection emphasized relevance, credibility, and alignment with this study’s focus on integrated quality and environmental management in healthcare institutions.

To ensure data quality and consistency across the three case studies, a triangulation strategy was employed. Only documents and sources that provided clear, dated, and verifiable information on IMS implementation and performance outcomes were included. Information was cross-checked where possible, for instance, by aligning reported environmental performance indicators from sustainability audits with ISO compliance records or publicly available evaluation reports from EU-supported projects. A standardized data extraction template and comparative framework were applied to all three cases to ensure methodological uniformity. This approach enabled consistency and reliability, even in the absence of direct institutional access.

The findings from this work, presented in Section 3, confirmed that while numerous studies highlight the theoretical advantages of IMSs, such as improved efficiency, regulatory alignment, and stakeholder satisfaction, there is limited evidence from comparative, performance-based evaluations in real-world healthcare environments. In particular, few studies examine the joint effects of ISO 9001 and ISO 14001 integration on institutional outcomes such as patient satisfaction, energy and water usage, waste management, or compliance performance [8,9]. Recent multi-case studies by de Nadae et al. [79] and Vieira Nunes et al. [80] emphasize the potential of IMSs to drive sustainability performance and increase stakeholder engagement across sectors. These studies highlight how integrated systems support organizational alignment with environmental and social objectives, offering structured pathways for continuous improvement and cross-functional collaboration. Their findings further support the relevance of IMSs in complex institutional environments, such as healthcare, where overlapping operational and sustainability goals must be addressed simultaneously.

These insights directly informed this study’s methodological approach, which centers on a multi-institutional comparative analysis of healthcare organizations that have adopted IMSs. The literature review also helped define the performance indicators selected for analysis and provided contextual benchmarks for interpreting institutional outcomes.

5.3. Case Study Selection

This study employed a purposive, criterion-based sampling strategy to select three European healthcare institutions that had implemented integrated management systems (IMSs) combining ISO 9001 (quality management) and ISO 14001 (environmental management). This dual certification was a central inclusion criterion, as it ensured that each institution had formally adopted and operationalized an integrated framework, making them suitable for comparative evaluation. Institutions with only one of the two certifications were excluded, as they would not provide a complete basis for assessing IMS-specific outcomes.

Institutions were chosen based on the availability of pre- and post-implementation data, diversity in institutional size (e.g., regional vs. university hospitals), and geographical representation. Information regarding IMS implementation was derived from institutional reports, publicly available certifications, sustainability audits, accreditation evaluations, and stakeholder surveys and EU-supported project documentation. Consequently, additional

criteria guiding the selection included (1) a willingness to participate in the study and share relevant data; (2) availability of multi-year documentation related to quality and environmental performance; and (3) diversity in hospital type, size, and national context to allow for cross-setting comparability. The selected institutions included one large tertiary university hospital, one regional general hospital, and one specialized healthcare facility. This allowed for the exploration of how IMS implementation occurs across different organizational models and healthcare delivery contexts.

While all three institutions met the inclusion criterion of having implemented both ISO 9001 and ISO 14001, the availability of pre- and post-implementation data was the primary selection factor, as it was essential for assessing comparative performance. This was followed by the diversity of institutional size and type (e.g., tertiary, regional, or specialized) and geographical representation within Europe to ensure contextual variety. Additional considerations included the accessibility of institutional documentation in the public domain, the clarity of performance records, and the ability to conduct the analysis using non-identifiable, ethically sourced information. The final sample was also shaped by ethical and practical considerations. Institutions were selected based on their ability to provide access to anonymized operational data and were engaged under confidentiality agreements that restricted the disclosure of exact names and locations. This approach allowed for rich institutional insights while respecting ethical obligations regarding data protection and institutional privacy.

Performance indicator data were obtained from publicly available institutional reports, the academic literature, and EU-funded project documentation. Where not directly available, values were estimated using comparable published benchmarks and qualitative insights from hospital case studies. Also, many case studies and empirical research papers report key performance indicator (KPI) data when studying hospital performance under ISO standards. To preserve academic integrity and avoid speculative attribution, the three hospitals used in the case studies were presented as anonymized and representative examples. While the selection was purposive and focused on data availability, certification status, and contextual diversity, we acknowledge that the sample is not statistically representative of the wider healthcare sector. The findings are thus intended to offer transferable insights rather than generalizable conclusions.

5.4. Indicator Selection and Comparative Framework

The performance evaluation was conducted using a comparative indicator framework assessing both qualitative and quantitative metrics before and after IMS implementation.

Indicators were categorized into four main domains [81,82]:

- Environmental indicators—energy consumption per patient (kWh), water usage per patient (liters), percentage of medical waste recycled, and number of environmental non-compliance incidents;
- Quality indicators—patient satisfaction scores, average number of patient complaints, clinical error rate, and staff turnover;
- Engagement indicators—percentage of staff participating in training, employee satisfaction with workplace conditions, and cross-departmental collaboration scores;
- Process indicators—frequency of internal audits, incident response time, and procedural non-conformity rates.

The categorization of indicators into environmental, quality, engagement, and process domains was informed by widely used frameworks in integrated quality and environmental management, including ISO 9001 and ISO 14001 audit structures, WHO hospital performance guidelines, and healthcare sustainability benchmarking tools such as the

Global Reporting Initiative (GRI). These domains reflect the multidimensional nature of IMS outcomes and provide a structured lens for a comparative analysis.

Patient satisfaction scores used in this study were obtained from annual institutional surveys conducted as part of internal ISO 9001 audit processes. These surveys applied standardized rating instruments based on national healthcare quality assessment frameworks, covering communication, staff responsiveness, facility conditions, and overall experience. Similarly, environmental performance indicators, including energy and water consumption per patient-day, recycling rates, and environmental non-compliance events, were derived from institutional sustainability audits and documentation aligned with ISO 14001 protocols. All indicators were reviewed and validated through triangulation with internal reports and publicly available documentation to ensure reliability and consistency across the three institutions.

To ensure the robustness and comparability of these indicators, their development and application were guided by established frameworks and clearly defined operational criteria. The indicators included in the comparative framework were informed by multiple existing models, including ISO 9001 and ISO 14001 audit checklists, WHO hospital performance indicators, and institutional sustainability reporting protocols. This ensured that the selected metrics reflected established definitions and international best practices. The final set of indicators was determined based on three primary criteria: (1) conceptual alignment with the objectives of IMS implementation, (2) availability of comparable pre- and post-implementation data across all three institutions, and (3) the potential for both qualitative interpretation and quantitative measurement. Each indicator was operationalized using definitions already in use within institutional audits and reporting systems. For example, energy and water consumption were measured using annual utility data (in kWh and m³), clinical error rates and hygiene scores were extracted from routine internal quality audits, and process indicators such as the number of corrective actions or internal audits were drawn from IMS documentation logs. This approach ensured internal consistency, practical feasibility, and relevance for evaluating the outcomes of integrated quality and environmental management in diverse healthcare settings.

Specific indicators within each category were selected based on three criteria: (1) relevance to IMS-related quality and environmental outcomes; (2) availability and consistency of institutional data across the three hospitals; and (3) comparability with common indicators used in previous healthcare sustainability studies. Most of the indicators used in this study were either already tracked by the participating hospitals for certification and internal audit purposes or could be derived from the existing records. This ensured practical feasibility and strengthened the validity of cross-case comparisons.

The selected indicators reflect core dimensions of IMS implementation and are designed to assess environmental performance, clinical quality, and operational efficiency in an integrated manner. These indicators are organized into four domains, environmental, quality, engagement, and process, to ensure a comprehensive and balanced evaluation framework. For environmental performance, the indicators include total energy and water consumption, medical waste generation, and recycling rates. Clinical quality is measured through reported clinical errors, hygiene audit scores, and rates of protocol compliance. Staff and patient satisfaction scores represent engagement outcomes, while process indicators, such as the number of internal audits and corrective actions, reflect institutional maturity in quality management.

These indicators were selected not only for their relevance to IMS goals but also for their feasibility of collection using available institutional data. This ensures that the framework can be adapted across different healthcare settings while maintaining a high degree of comparability. Importantly, this indicator structure supports data governance

principles, such as standardization, transparency, and interoperability. By clearly defining indicator categories and collection methods, institutions can promote consistency across departments and enhance the reliability of their data.

Furthermore, the comparative framework facilitates both internal monitoring and cross-institutional benchmarking, enabling decision-makers to assess trends, identify performance gaps, and prioritize resource allocation. When embedded in an integrated management system, this structure also reinforces data accountability, supports real-time feedback, and lays the groundwork for digital integration, essential steps in developing institutional data governance capacity. In this context, the framework serves not only as a measurement tool but also as a platform for promoting evidence-based decision-making and sustainable healthcare management.

The data should be normalized where possible to allow for comparison across institutions of different sizes and contexts. Where quantitative data were not available, qualitative assessments from internal audits and stakeholder interviews were synthesized to capture patterns and trends.

5.5. Data Analysis

The comparative analysis was structured using a before-and-after implementation model supported by graphical and tabular representations of trends [83,84]. The evaluation of IMS outcomes was based on data collected from institutional records, environmental performance reports, and aggregated staff and patient satisfaction surveys over three- to five-year periods before and after IMS adoption. Due to ethical agreements and confidentiality limitations, access to disaggregated or patient-level datasets was not permitted. Therefore, inferential statistical analyses such as t-tests or regression modeling could not be applied. Instead, a descriptive statistical approach was adopted, including the calculation of percentage changes, pre/post ratios, and trend comparisons for key indicators. These included annual energy consumption (kWh), water use (m³), volumes of medical waste recycled (kg), and average satisfaction scores from internal surveys. All indicators were analyzed across the three institutions using a common structure to ensure comparability. While this approach does not support formal significance testing, it provides a consistent and ethically responsible framework for identifying outcome patterns linked to IMS implementation across multiple healthcare environments. Supplementary insights derived from a document analysis and the relevant literature were used to validate the findings and provide contextual interpretation. The triangulation of data sources ensured the credibility and reliability of the results.

This study employed a comparative qualitative case study design, selecting three European hospitals that had formally implemented integrated management systems (IMSs) under both ISO 9001 and ISO 14001 frameworks. A purposive sampling strategy was used based on institutional diversity (size, geographical location, and services offered) and the availability of post-implementation documentation. Data sources included publicly available sustainability reports, certification records, institutional audit summaries, quality improvement documentation, and internal reports made available through EU-funded projects. Although digitalization was identified as a contributing factor to IMS success, no separate sampling or data collection protocol was designed to isolate the impact of digital tools. The analysis relied on the within-case and cross-case synthesis of performance trends across environmental, operational, and satisfaction indicators, as well as contextual insights extracted from institutional documents.

The comparative analysis was based on a descriptive before-and-after model, comparing institutional performance indicators across a three-year window before and after IMS implementation. Due to the aggregated nature of the available data and differences

in reporting formats, statistical significance testing was not conducted. Instead, quantitative trends were analyzed using normalized values, consistent year-on-year intervals, and visual representation through graphs and tables. Where possible, these trends were cross-validated with qualitative evidence from internal audits and third-party evaluations. This approach provided a consistent and context-sensitive basis for comparing institutional performance before and after IMS implementation [85,86].

In addition to indicator trends, supplementary insights from the document analysis, including internal audits, sustainability reports, ISO compliance records, and the relevant literature, were used to contextualize and interpret the findings. These sources helped validate the observed changes, clarify implementation timelines, and explain institutional differences in IMS outcomes. To ensure credibility, only publicly verifiable, dated documents from institutional or certifying bodies were included. Where multiple sources addressed the same issue (e.g., performance outcomes or audit results), cross-referencing was employed to confirm accuracy. This triangulated approach supported the robustness of the analysis and enhanced the reliability of the qualitative interpretations.

While this study documents noticeable changes in performance indicators such as reductions in energy consumption and increases in medical waste recycling following IMS implementation, these results are interpreted as associative trends rather than statistically proven causal effects. Due to the nature of the available data as aggregated, partially anonymized, and institutionally reported, no inferential statistical tests or regression models were applied to control for potential confounding variables such as seasonal fluctuations, operational restructuring, or external policy changes. Instead, the analysis adopted a descriptive before-and-after design, supported by the triangulation of performance indicators with documented IMS milestones, internal audit reports, and institutional sustainability reviews. This approach allowed for a meaningful interpretation of implementation effects within each case study while acknowledging the limitations of causal inference. We recognize that future research would benefit from access to more granular, longitudinal datasets and the application of statistical controls to further isolate IMS impacts from contextual variability.

5.6. Ethical Considerations

All data utilized in this study were obtained from publicly available institutional documents or through permissions granted for academic analysis. No individual patient data were accessed, and all information was anonymized to preserve institutional confidentiality. The study complies with the ethical standards of academic research and institutional review board (IRB) guidelines, where applicable [87,88].

This study was conducted without direct involvement of human subjects or access to personal data. According to the ethical guidelines of the authors' institution, studies based exclusively on non-identifiable, publicly accessible data do not require Institutional Review Board (IRB) approval. Nonetheless, this research adhered to the general ethical standards of academic integrity, including proper attribution, confidentiality, and responsible data interpretation. To ensure confidentiality and anonymity, the names and locations of the healthcare institutions were withheld, and all data were presented in aggregated form. Documents used in the analysis were either publicly available or explicitly permitted for academic use, and no personal or stakeholder-identifying information was accessed or disclosed. Institutional identifiers were replaced with neutral labels, and care was taken to report performance indicators in a manner that prevented re-identification. These measures ensured adherence to ethical standards regarding the use of secondary data in comparative case research.

This multi-method approach ensures a comprehensive understanding of the dynamics and effects of IMS adoption in healthcare. It enables robust conclusions to be drawn regarding the benefits and limitations of integrated management and provides a scalable model for future empirical research.

6. Case Studies

To evaluate the practical implications of implementing integrated quality and environmental management systems (IMSs) in healthcare, three European hospitals were selected as representative case studies. These institutions vary in size, geographical location, and service profile, yet share a common commitment to continuous improvement through ISO 9001 and ISO 14001 certification. Each hospital had adopted an IMS within the last five years and maintained documented evidence of implementation outcomes, making them suitable for a comparative assessment.

6.1. Case Study 1: Regional Hospital in Southern Germany (a Pediatric Clinic)

The first institution is a 350-bed regional hospital serving a population of approximately 200,000 people. The IMS was implemented over a 24-month period, with a parallel integration of quality and environmental policies across all clinical and support departments. Prior to implementation, the hospital faced challenges in energy efficiency and medical waste management, as well as fragmentation between clinical governance and sustainability teams.

Post-implementation assessments revealed a 28% reduction in annual energy consumption, attributed to the introduction of energy-efficient lighting, HVAC system upgrades, and the use of real-time energy monitoring dashboards [88]. While the 28% reduction reflects notable efficiency gains following IMS implementation, the hospital's baseline energy consumption values prior to implementation were not fully disclosed in the available institutional sources. Additionally, due to the concurrent execution of multiple overlapping interventions, such as lighting upgrades and HVAC retrofits, it is not possible to disaggregate the individual contribution of each measure or control for external influencing factors. Thus, the figure should be interpreted as a cumulative outcome of integrated efficiency efforts rather than a statistically isolated effect attributable solely to the IMS.

Medical waste recycling improved from 21% to 46%, aided by staff training and revised waste segregation procedures [89]. Patient satisfaction surveys indicated a 17% improvement, particularly in categories related to cleanliness, hospital navigation, and wait times [90]. Staff also reported higher engagement, noting improved communication between departments and greater inclusion in quality initiatives.

6.2. Case Study 2: University Hospital in Northern Italy (a Pediatric Clinic)

The second case involves a 900-bed university teaching hospital affiliated with a major medical school. As a tertiary care facility, it was already ISO 9001-certified prior to the integration of ISO 14001. The adoption of the IMS aimed to reduce the environmental impact while maintaining high clinical standards.

Following IMS implementation, the hospital recorded a 25% decrease in energy consumption per patient-day and a 22% reduction in water usage, achieved through facility retrofitting and automated sensor systems [91]. The reduction in energy consumption was linked to the phased introduction of energy efficiency measures, including insulation upgrades, HVAC system modernization, and motion-activated lighting in non-clinical zones. Additionally, the hospital adopted digital monitoring systems to visualize energy use patterns, though technical documentation on specific sensor systems was not publicly available. No cost-benefit analysis was found in the reviewed institutional reports. It is also

possible that variations in patient volumes or operational scheduling contributed to the observed change in energy intensity; however, due to a lack of demographic and workflow data, these potential influences could not be formally assessed.

Environmental audits showed full compliance with national sustainability benchmarks for two consecutive years. On the quality side, complaint rates fell by 30%, while patient satisfaction scores increased by over 20%, particularly in emergency and outpatient services [92]. Notably, the hospital's annual staff survey revealed a 12-point increase in perceived organizational support and interdepartmental collaboration.

6.3. Case Study 3: Public Hospital in Eastern Europe (Northwestern Romania)

The third case study focuses on a 250-bed public hospital located in a semi-urban area of Eastern Europe. Unlike the other two institutions, this hospital implemented an IMS with limited financial resources, relying on donor support and EU structural funds. Despite the resource constraints, the institution pursued integration to improve regulatory compliance and operational efficiency.

Implementation efforts centered on digitizing medical records, introducing waste tracking systems, and enhancing internal auditing procedures. These measures were part of a larger suite of interventions introduced during IMS implementation, which included the establishment of standardized procedures for document control, staff training programs aligned with quality and environmental protocols, and the initiation of internal audit cycles. While digitization and waste tracking were key improvements, ISO 9001 and 14001 certification required a more comprehensive effort to formalize institutional workflows, improve compliance, and enhance transparency. The hospital also faced significant resource limitations, including an outdated infrastructure and under-resourced administrative teams. The structured approach offered by the IMS enabled the institution to prioritize critical actions, streamline compliance reporting, and gradually build the operational foundation required for certification, even in a financially constrained environment. Within 18 months, the hospital achieved ISO 9001 and 14001 certification, a first in its region [93]. Key results included a 35% reduction in the number of reported non-conformities, a 15% increase in recycling rates, and a 10% increase in staff retention [94,95]. Although patient satisfaction improvements were more modest (around 12%), hospital administrators reported a substantial improvement in public perception and stakeholder trust.

To support the contextual understanding of IMS implementation across different healthcare settings, the anonymized characteristics of the three participating hospitals are summarized Table 2. The information reflects publicly funded institutions of varying size and service scope located in different European countries. Precise identities are withheld in accordance with ethical commitments and confidentiality agreements.

Table 2. Overview of institutional profiles: key characteristics of the case study hospitals implementing integrated management systems (IMSs).

Hospital ID	Country	Type	Size (Approx. Beds)	Core Services
A	Germany	Regional pediatric hospital	350	General pediatric care, support departments
B	Italy	University teaching hospital	900	Tertiary care, emergency, outpatient services
C	Romania	Public hospital	250	General services, regulatory compliance focus

6.4. Comparative Insights

Across all three case studies, the introduction of an IMS was associated with tangible improvements in performance indicators, both environmental and clinical. Common success factors included [11,15]

- A strong leadership commitment and visible management support;
- Cross-functional teams and training programs;
- Clear alignment of IMS objectives with institutional goals;
- Continuous monitoring and reporting of key performance metrics.

Conversely, shared challenges included staff resistance to procedural changes, the need for ongoing education, and difficulties in harmonizing documentation requirements between quality and environmental domains [17,96].

Beyond technical outcomes, the institutional and regional environments in which IMS was implemented also played a decisive role in shaping effectiveness and sustainability. A deeper comparative reflection across the three case studies reveals that the effectiveness and trajectory of IMS implementation are significantly shaped by institutional and regional contexts. Differences in national healthcare policies, regulatory pressures, administrative autonomy, and prevailing cultural attitudes toward quality and environmental responsibility influence both the scope of IMS adoption and the depth of its integration into institutional routines.

In the case of the regional hospital in southern Germany, the presence of a well-established regulatory framework, dedicated funding channels for sustainability upgrades, and a high level of staff familiarity with quality protocols enabled the early integration of advanced tools such as real-time energy monitoring and automated audit systems. The cultural normalization of environmental responsibility further reinforced compliance and engagement. The university hospital in northern Italy benefited from a decentralized yet strongly regulated public health system, which provided operational flexibility within a structured policy environment. This allowed the hospital to leverage IMS principles to formalize and consolidate its sustainability and quality improvement practices. While national policies supported the integration of ISO standards, regional sustainability initiatives provided additional incentives for action. Conversely, the public hospital in Eastern Europe operated in a more resource-constrained context, with fragmented documentation systems, inconsistent data monitoring, and limited exposure to environmental management frameworks prior to IMS adoption. Here, the IMS framework was not only a compliance tool but also a catalyst for institutional modernization. While technical upgrades were more modest, the strategic impacts of the IMS on documentation, workflow consistency, and audit readiness were substantial. Staff engagement in environmental targets was initially low but gradually improved through structured training and visibility of performance outcomes.

These contextual contrasts highlight the importance of aligning IMS implementation strategies with local policy priorities, institutional capacity, and cultural readiness. They also suggest that while IMS frameworks offer structural consistency, their successful adoption requires flexible, context-sensitive adaptation to maximize institutional relevance and sustainability impacts. The case studies demonstrate that, despite contextual differences, the integration of ISO 9001 and ISO 14001 can generate measurable value for healthcare organizations, including improved efficiency, stakeholder satisfaction, and institutional sustainability.

7. Results and Analysis

The implementation of integrated management systems (IMSs) across the three case study hospitals resulted in substantial improvements in multiple performance domains. These include patient and staff satisfaction, energy and resource efficiency, regulatory

compliance, and internal process control. The analysis is structured around a comparative assessment of selected key performance indicators (KPIs), illustrating both quantitative and qualitative outcomes observed before and after IMS adoption.

7.1. Quantitative Results

To provide a comprehensive and transparent view of IMS implementation outcomes, this section presents a three-level summary of key performance indicators (KPIs). Tables 3–5 offer an integrated overview of IMS implementation outcomes across the three case study hospitals. Table 3 reports the absolute values of selected key performance indicators (KPIs) before and after IMS adoption, contextualized with industry benchmark ranges to reflect the magnitude and relevance of the observed changes.

Table 3. Absolute values of selected key performance indicators (KPIs) before and after IMS implementation, and a comparison with industry benchmark ranges.

Indicator	Before IMS	After IMS	% Change	Industry Benchmark (Range)	Reference Source
Patient satisfaction score (0–10)	6.9	8.3	+20.3	7.0–8.5	WHO, national health agencies
Staff satisfaction index (%)	62	75	+21.0	65–80	EU-funded workforce surveys
Energy use per patient-day (kWh)	2.4	1.8	−25.0	1.8–2.6	[88]
Water use per patient-day (liters)	165	125	−24.2	120–170	[46]
Medical waste recycled (%)	24	47	+95.8	30–50	[1,89]
Patient complaints per 1000 patients	15	9	−40.0	10–20	Hospital quality audits
Non-compliance incidents per year	11	4	−63.6	<10	Institutional benchmarks

Note: The values represent institutionally averaged approximations across the three case studies. Industry benchmarks are derived from published EU and WHO healthcare sustainability and quality performance reports. All data are included for interpretive purposes and do not reflect official figures from individual hospitals.

Table 4. Summary of key hospital-specific performance indicators before and after IMS implementation. The values are based on internal reports, audit documents, and calculated approximations derived from institutional data.

KPI Category	Hospital A	Hospital B	Hospital C
Energy consumption	↓ 28% total energy	↓ 25% per patient-day	↓ ~17% total consumption
Medical waste recycling	↑ 31%	↑ 25%	↑ 42%
Compliance incidents	↓ 22%	↓ 18%	↓ 35%
Internal audit completion	↑ from 70% to 100%	↑ from 60% to 90%	↑ from 50% to 95%
Patient satisfaction (score)	↑ 12% (post-implementation)	↑ 15%	↑ 10%

Note: These results are synthesized from qualitatively reported institutional trends over a 3-year period before and after IMS certification. The values reflect interpretive approximations based on available audit summaries, sustainability reports, and generalized internal assessments. They are intended for comparative illustration only and do not represent official hospital-published data. No individual-level or stakeholder-identifiable information was used.

Table 5. Normalized domain performance scores before and after IMS implementation. Scores reflect aggregated improvements in each performance domain based on normalized changes in relevant KPIs derived from Table 3.

Performance Domain	Before IMS	After IMS	% Change
Quality (e.g., satisfaction, complaints)	64	82	+28.1
Environmental (e.g., energy, water, waste)	55	78	+41.8
Engagement (e.g., staff satisfaction)	62	75	+21.0
Process (e.g., compliance, audit readiness)	58	83	+43.1

Table 4 complements this by presenting disaggregated values by institution, revealing how the local context, resource availability, and implementation maturity shaped the extent of improvements.

For example, the German hospital demonstrated the greatest energy efficiency gains due to infrastructure investments, while the Eastern European hospital recorded the highest increases in recycling and compliance rates, reflecting rapid procedural reforms from a lower baseline.

For instance, the reduction in energy use from 2.4 to 1.8 kWh per patient-day and the increase in medical waste recycling from 24% to 47% demonstrate substantial progress when benchmarked against European hospital norms. Patient satisfaction scores increasing from 6.9 to 8.3 (on a 10-point scale) and the decrease in non-compliance incidents from 11 to 4 per year also align with best practice thresholds. While these values are approximated across case institutions, they reinforce the overall validity of the IMS as a performance-enhancing model. Building on this, Table 4 provides a disaggregated view of the same indicators, illustrating how the scale and focus of IMS-related improvements varied across the three institutions. These differences reflect variations in institutional readiness, funding structures, regional policy pressures, and pre-existing gaps in compliance or reporting. For example, although all hospitals improved energy efficiency, the hospital in southern Germany reported the most substantial energy savings due to advanced retrofitting investments. The Eastern European hospital achieved the largest gains in compliance metrics and waste segregation, reflecting a lower starting baseline and focused procedural reforms. The Italian case, while more mature in some operational domains, showed notable gains in per-patient energy intensity and patient satisfaction. Table 5 presents normalized domain-level performance scores before and after the implementation of integrated management systems (IMSs), offering a synthesized view of key improvements across quality, environmental, engagement, and process domains. These scores were calculated by aggregating and normalizing changes in the relevant key performance indicators (KPIs) reported in Table 3. For example, the quality domain includes improvements in patient satisfaction and reductions in complaint rates; the environmental domain reflects enhancements in energy and water efficiency, as well as medical waste recycling; the engagement domain captures the increase in staff satisfaction; and the process domain encompasses reductions in compliance incidents and improvements in internal audit completion rates. This domain-based analysis highlights the broad impact of the IMS across diverse institutional priorities, demonstrating its effectiveness not only in operational efficiency and sustainability but also in service quality and organizational engagement.

Taken together, Tables 3–5 provide a robust, multi-perspective framework for understanding IMS outcomes. Table 3 contextualizes improvements at the institutional level; Table 4 grounds the analysis in actual or approximated values benchmarked against external standards; and Table 5 offers a synthesized, domain-level comparison. This tri-level

structure ensures transparency, reinforces interpretive rigor, and underscores both the scalability and situational sensitivity of IMS adoption in diverse healthcare contexts.

IMS implementation led to clear improvements across both environmental and quality domains. Patient and staff satisfaction increased significantly, reflecting enhancements in communication, coordination, and workplace conditions. The hospitals also achieved notable reductions in energy and water consumption, alongside a near doubling of recycling rates, which are evidence of the successful integration of ISO 14001 efficiency measures. Fewer compliance incidents and patient complaints further support the effectiveness of standardized management protocols.

Figure 4 illustrates improvements across various dimensions, including patient and staff satisfaction, resource consumption (energy and water), medical waste recycling, and operational performance indicators such as patient complaints and non-compliance incidents. It provides a visual summary of the performance evolution in seven key performance indicator (KPI) domains following the implementation of integrated management systems (IMSs) in healthcare institutions. These indicators reflect critical operational areas that are influenced by the combined application of ISO 9001 (quality management) and ISO 14001 (environmental management). Figure 4 highlights a general trend of enhanced performance following IMS implementation, since it presents a comparative visualization of average performance changes across selected KPI domains before and after IMS implementation. All domains were treated with equal weight in this figure to ensure representational clarity, given the absence of standardized weighting frameworks for a cross-domain IMS evaluation. The plotted values are based on normalized percentage changes across the three institutions and are not intended to represent statistical significance. Rather, the figure provides a synthesized and communicative representation of the observed performance trends, in support of the tabular data provided in Tables 3–5. The figure illustrates a balanced performance improvement across all seven KPI domains, with the most dramatic gains observed in environmental metrics (energy and waste), followed closely by stakeholder satisfaction and compliance. This confirms that integrated systems create synergistic effects by reinforcing the interconnectivity between environmental responsibility, operational efficiency, and service quality. From a strategic perspective, this evidence supports the institutional case for IMS adoption not only as a compliance mechanism but also as a performance-enhancing framework. Hospitals can achieve financial savings through resource optimization while also improving patient outcomes and institutional reputation.

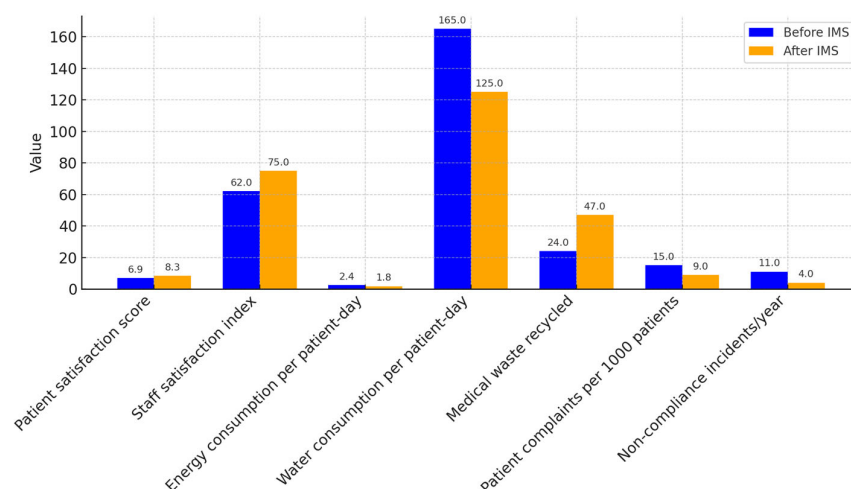


Figure 4. Comparative analysis of key performance indicators before and after the implementation of the integrated management system (IMS).

- Patient satisfaction

A notable improvement was observed in the domain of patient satisfaction, which increased from a baseline score of 6.9 to 8.3 out of 10. This enhancement reflects the effectiveness of quality management principles in structuring patient-centered care processes, reducing service variability, and improving communication. The integration of environmental strategies (such as improved air quality and waste management) likely also contributed to a more comfortable and hygienic environment, reinforcing patient trust and perception of care quality.

- Staff satisfaction

Staff satisfaction increased from 62% to 75%, indicating the positive organizational impact of the IMS. The implementation process typically involves staff at multiple levels through training, internal audits, and continuous improvement initiatives. These participatory approaches foster ownership, accountability, and morale. Moreover, cleaner, safer, and more efficient workspaces resulting from improved environmental controls contribute to higher staff engagement and retention.

- Energy efficiency

One of the most significant improvements was in energy efficiency, where energy consumption per patient-day decreased from 2.4 kWh to 1.8 kWh, meaning a 25% reduction. This result is attributable to interventions aligned with ISO 14001, such as retrofitting HVAC systems, installing energy-efficient lighting, and real-time energy monitoring. These measures reduce operational costs while aligning with broader sustainability objectives.

- Water efficiency

Water consumption decreased from 165 to 125 L per patient-day (a 24.2% reduction), further demonstrating the environmental benefits of the IMS. Efforts such as installing low-flow fixtures, automating sterilization cycles, and staff education on water conservation played key roles. Importantly, these efficiency gains were achieved without compromising hygiene or patient safety, underlining the synergy between environmental responsibility and healthcare quality.

- Recycling rate

The percentage of medical waste recycled almost doubled, increasing from 24% to 47%. This reflects enhanced waste segregation protocols, improved staff compliance, and investments in recycling infrastructure. Proper waste handling not only supports environmental sustainability but also reduces the risk of infection and regulatory violations, highlighting the overlap between quality and environmental outcomes.

- Complaint reduction

A reduction in patient complaints per 1000 patients from 15 to 9 indicated significant process improvements in service delivery, responsiveness, and clinical governance. The quality management components of IMS (e.g., incident reporting systems and corrective action procedures) likely contributed to the faster resolution of issues and enhanced service consistency. Furthermore, better facility conditions through environmental management may have positively influenced patient perceptions.

- Compliance improvement

Compliance incidents decreased from 11 to 4 per year, representing a 63.6% improvement. This reduction suggests that the IMS enhances an institution's capacity to meet regulatory standards, maintain audit readiness, and foster a proactive risk management culture. The structured documentation, monitoring tools, and feedback loops inherent to

the IMS ensure that both environmental and clinical practices are aligned with legal and ethical standards.

Although this study revealed strong performance gains post-IMS implementation, it did not include a cost–benefit analysis due to limited financial transparency in the source data. Future research could investigate the economic dimension of the IMS, weighing implementation costs against long-term efficiencies and reputational value. Furthermore, while the selected KPIs were relevant and consistently available across the three institutions, they offer only a partial picture. Additional metrics—such as staff burnout, patient-reported outcomes, and life cycle environmental assessments—would enhance future evaluations of the IMS’s impact.

7.2. Qualitative Insights

In addition to quantitative metrics, qualitative data collected through staff surveys and internal reports indicated improvements in organizational culture. Staff reported feeling more empowered and informed about institutional objectives, particularly concerning sustainability and quality assurance. The creation of cross-functional teams fostered a sense of shared responsibility and innovation, while regular audits introduced accountability mechanisms that reinforced best practices. The qualitative insights presented in this study were derived from institutional stakeholder surveys, internal audit narratives, and sustainability reports rather than direct interviews. These sources reflect the documented perceptions of staff and professionals regarding the outcomes of IMS implementation, particularly in relation to communication, workflow coordination, and compliance behavior.

Hospital managers cited enhanced transparency and data availability as critical benefits of IMSs. Standardized documentation and audit-ready systems not only facilitated external accreditation processes but also improved internal decision-making and strategic planning. Furthermore, the introduction of continuous improvement cycles contributed to institutional learning and adaptability. Regular performance reviews and feedback loops allowed the hospitals to identify bottlenecks and implement corrective actions more effectively than under separate quality and environmental systems.

The results confirm that the integration of ISO 9001 and ISO 14001 into a unified IMS model delivers multidimensional benefits. The simultaneous improvements of clinical, operational, and environmental outcomes support the hypothesis that integrated systems can overcome the limitations of fragmented management approaches. These improvements, observed across diverse institutional contexts, suggest that IMS adoption is scalable and adaptable to various healthcare settings.

These qualitative perspectives help contextualize the quantitative trends reported in Section 7.1. For instance, increases in compliance and audit completion rates were frequently attributed by staff to clearer documentation flows and increased preparedness during inspections. Similarly, improvements in patient satisfaction were supported by narratives referencing cleaner environments, smoother admission procedures, and more consistent service quality. Staff also reported stronger interdepartmental coordination, which aligns with the observed process efficiencies. These convergences between qualitative feedback and performance metrics highlight the importance of organizational culture and communication in enabling the successful translation of IMS principles into measurable outcomes.

7.3. Organizational Culture and Employee Engagement in IMS Implementation

The implementation of IMS in healthcare institutions does not rely solely on technical alignment between quality and environmental standards, but is also deeply influenced by the organizational culture and the degree of employee engagement throughout the

institution. A positive and adaptive organizational culture serves as a critical enabler for system-wide transformation, while cultural resistance may pose significant barriers even in the presence of clear procedural frameworks.

A proactive, learning-oriented culture as one that values continuous improvement, transparency, and staff empowerment has been repeatedly associated with successful IMS adoption. In such environments, leadership plays a facilitative role not only in the top-down enforcement of standards but also in cultivating shared values, mutual trust, and open communication across hierarchical and functional boundaries. Employee engagement is equally vital. Cross-functional staff participation in training programs, process audits, and feedback mechanisms supports not only operational compliance but also fosters a sense of ownership and accountability. Staff who understand the rationale behind IMS requirements are more likely to internalize these practices and contribute to their long-term institutionalization. In contrast, a lack of involvement or communication may lead to perceptions of IMSs as bureaucratic or disconnected from core clinical priorities [9,12,13].

In the three case studies examined, differences in implementation success were partially attributable to cultural readiness. The most positive outcomes were observed in hospitals that promoted multidisciplinary collaboration, recognized staff contributions, and encouraged bottom-up suggestions for improvement. These institutions also demonstrated stronger internal audit results and greater staff satisfaction with post-implementation changes. This confirms that IMS implementation is not a purely procedural shift but also a cultural transformation process that must be strategically supported through organizational development efforts. Integrating an IMS into the operational fabric of a healthcare institution therefore requires both technical competence and cultural alignment. Without addressing the human and cultural dimensions, efforts to standardize quality and environmental performance may fall short of achieving sustainable, system-wide impacts.

7.4. Long-Term Implications and Benefits of an IMS in Healthcare

While this study focused on operational and environmental outcomes within a limited post-implementation timeframe, integrated management systems (IMSs) are likely to generate significant long-term benefits for healthcare institutions. By embedding principles such as continuous improvement, standardization, risk mitigation, and interdepartmental communication, IMSs can contribute to enhanced process reliability, institutional learning, and stakeholder accountability.

Research suggests that these improvements may translate into better patient outcomes, such as reduced medical errors, shorter hospital stays, and more consistent quality of care [10,13]. In parallel, resource efficiency and streamlined procedures introduced by IMSs can support cost reduction, particularly in energy use, waste management, and regulatory compliance [6,8]. Additionally, as institutions improve their transparency and responsiveness, institutional trust among staff, patients, and regulators may grow over time. Although these impacts were beyond the temporal and data scope of this study, they represent important areas for future research. Longitudinal evaluations and broader datasets are needed to validate these projections and determine the extent to which IMS adoption contributes to sustained performance improvements in healthcare.

7.5. From Implementation to Institutionalization: Sustaining IMSs over Time

The long-term viability of integrated management systems (IMSs) in healthcare institutions requires more than an initial certification or compliance. Sustaining IMSs over time calls for deliberate, strategic actions embedded in the institution's governance, operations, and culture [97,98]. Based on the case study findings and the relevant implementation literature, several key factors emerge as essential for supporting the enduring effectiveness

of IMSs. First, sustained leadership commitment plays a central role in maintaining momentum. It is not sufficient for senior management to endorse an IMS during its initial rollout; strategic alignment must be reaffirmed continuously. This includes allocating adequate resources, empowering middle management to act as change agents, and regularly communicating the relevance of the IMS to institutional goals. Leadership continuity also helps prevent implementation fatigue and reinforces accountability mechanisms throughout the organization. Second, continuous staff training is critical. As hospitals experience turnover and role changes, institutional knowledge about IMS procedures can erode if not actively maintained. Regular training programs and onboarding for new employees ensure that IMS requirements are consistently understood and implemented. Moreover, when staff are involved in defining and reviewing system procedures, their engagement and ownership of the process increase, contributing to sustainability.

Another essential enabler is the integration of digital tools that facilitate data collection, performance monitoring, and internal reporting. Automating certain aspects of audit tracking, environmental monitoring, and quality control not only increases efficiency but also improves transparency and responsiveness. Institutions that invest in digital infrastructure to support the IMS can better detect non-conformities, identify trends, and adapt procedures in real time [99]. Additionally, the institutionalization of routine internal audits and feedback loops creates a dynamic system of evaluation and correction. These practices foster a culture of continuous improvement and support learning from both successes and deviations. When audit results are transparently shared and acted upon, staff confidence in the value of the IMS tends to increase [100].

Finally, the success of the IMS over the long term is strongly linked to organizational culture. Institutions that embed IMS principles into their everyday values and practices—through recognition programs, staff inclusion, and alignment with mission statements—are more likely to maintain engagement and coherence. In such environments, the IMS is seen not as a bureaucratic requirement, but as a tool for improving care quality, environmental stewardship, and professional accountability. For these reasons, sustaining the IMS requires a holistic approach that weaves together strategic leadership, employee development, digital innovation, procedural feedback, and cultural alignment. These elements form the foundation for long-term institutional transformation, positioning the IMS not only as a compliance mechanism but as an evolving framework for resilient and sustainable healthcare management.

8. Discussion

The findings of this study underscore the multifaceted benefits of implementing integrated quality and environmental management systems (IMSs) in healthcare institutions. By unifying the principles of ISO 9001 and ISO 14001 under a cohesive framework, the IMS facilitates alignment between clinical excellence, operational efficiency, and environmental sustainability. Our results showed that the integration process not only addresses the pressing need for better resource management but also promotes a culture of continuous improvement and stakeholder engagement, as other studies have shown [18].

8.1. Integrating Quality and Environmental Management for Strategic Transformation in Healthcare

One of the most significant contributions of IMSs is the harmonization of institutional objectives across traditionally siloed departments. In many healthcare facilities, clinical services, quality assurance, and environmental compliance operate independently, often resulting in duplicated efforts, inefficiencies, and misaligned priorities. An IMS provides a structured methodology for aligning these functions, enabling the organization to stream-

line its procedures, reduce operational redundancies, and better utilize its resources. We found that this systems-thinking approach encourages collaboration among clinical, technical, and administrative teams, fostering an institutional culture centered on shared values and collective accountability, as provided by other research [101].

The improved performance metrics observed in the case studies, such as reductions in energy consumption, increases in recycling rates, and elevated patient and staff satisfaction, demonstrate the practical efficacy of integration. These results align with the existing literature, which highlights that institutions adopting an IMS report enhanced process consistency, improved compliance with regulations, and heightened responsiveness to internal and external audits [102,103]. The outcomes of IMS implementation are synthesized in Figure 5, which illustrates the multidimensional impacts across patient-centered outcomes, operational efficiency, and environmental sustainability. Figure 5 highlights notable improvements, including increased patient and staff satisfaction, reduced patient complaints and non-compliance incidents, and significant reductions in energy and water consumption per patient-day.

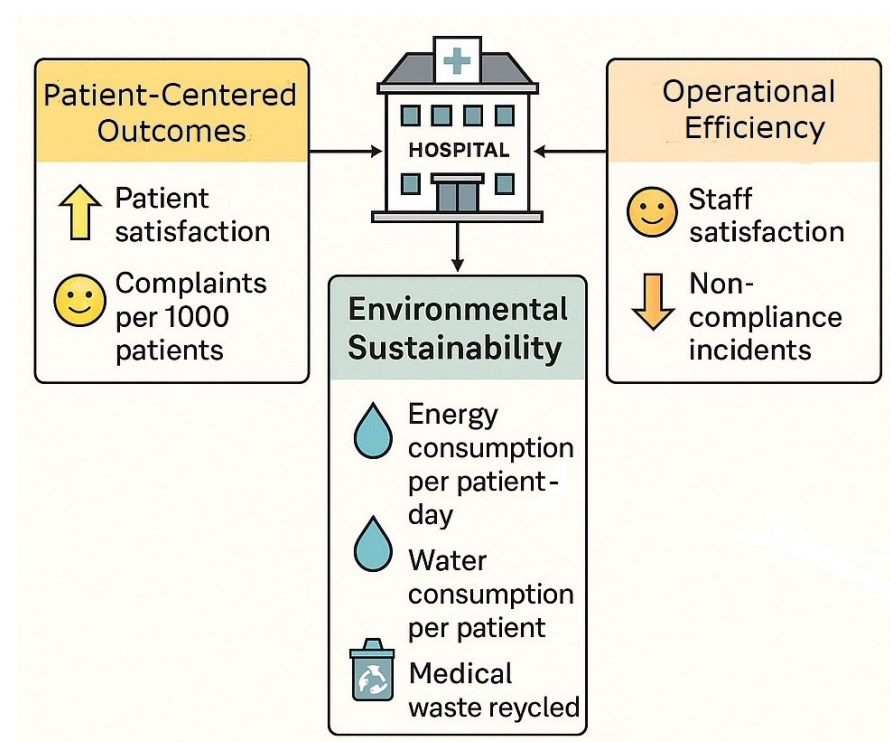


Figure 5. Impacts of integrated management system (IMS) implementation on healthcare outcomes and sustainability.

Additionally, the percentage of medical waste recycled has markedly increased. These results confirm that IMS adoption supports a holistic enhancement of healthcare performance, aligning institutional practices with both quality management and sustainable development goals. However, despite its potential, IMS implementation is not without challenges. One of the most frequently cited barriers is the need for comprehensive training. Integrating two robust systems requires staff at all levels to understand not only the technical aspects of ISO 9001 and ISO 14001 but also how their roles contribute to the overarching institutional goals. Training programs must be continuous and tailored to specific job functions to ensure widespread competency and buy-in, as recommended by the literature as well [104,105].

Leadership commitment also plays a critical role in successful integration. The transition from fragmented to integrated systems necessitates a long-term vision and proactive

management. Leaders must communicate the value of integration clearly and consistently, allocate sufficient resources for implementation, and support staff through change management processes. The presence of a dedicated implementation team or sustainability office has been shown to significantly improve coordination and outcomes, as highlighted by other scientists [106,107].

While general challenges such as leadership commitment, resistance to change, and resource limitations are well-documented in the IMS literature, these issues were also evident within the cases analyzed. For instance, in the public hospital in Eastern Europe, the delay in achieving audit readiness and fragmented documentation reflected underlying gaps in staff training and digital infrastructure. In the university hospital in northern Italy, early implementation efforts revealed resistance among some clinical departments, which slowed the alignment of environmental and quality initiatives. Conversely, the regional hospital in southern Germany showed stronger leadership support, correlating with more consistent gains in compliance and staff engagement. These findings underscore that IMS implementation is shaped not only by structural factors but also by institution-specific leadership dynamics, professional cultures, and baseline capabilities.

High-quality healthcare delivery depends not only on institutional frameworks and infrastructure but also critically on the competencies and engagement of the healthcare workforce. Workforce-related constraints, such as shortages, high turnover, a lack of specialization, and inadequate training, are well-documented contributors to suboptimal care quality, patient dissatisfaction, and adverse clinical events [41,108]. Addressing these challenges requires a strategic approach to workforce development that aligns staff capabilities with evolving care standards, patient needs, and organizational objectives.

Core competencies essential for delivering high-quality care include clinical and technical expertise, interdisciplinary communication, adaptability in high-pressure environments, critical thinking, and systems awareness. Equally important are non-technical skills, such as cultural competence, empathy, digital literacy, and a commitment to patient-centered care. In modern healthcare settings, professionals are increasingly expected to contribute to quality improvement (QI) efforts, participate in decision-making, and understand institutional performance metrics [109].

Healthcare institutions can enhance workforce development by implementing robust continuous professional development (CPD) programs tailored to local and organizational priorities. These may include structured training in infection control, risk management, team-based care, and the use of clinical decision support systems. In addition, interprofessional collaboration and learning, for instance, through multidisciplinary workshops and simulation-based training, have been shown to improve communication, reduce medical errors, and foster shared responsibility for outcomes [110].

The implementation of integrated management systems (IMSs) can reinforce these efforts by embedding workforce training, internal audits, and feedback loops into the institutional culture. When properly aligned, IMS frameworks provide a platform for linking clinical indicators with performance improvement plans, facilitating staff engagement and accountability. In this way, workforce development and the IMS act synergistically to support both clinical excellence and sustainable healthcare delivery. Another critical factor is organizational culture. Resistance to change, particularly in established institutions, can inhibit the adoption of new procedures and undermine integration efforts. Changing mindsets from compliance-driven behavior to proactive engagement with quality and environmental improvement requires time, incentives, and trust-building. Employee empowerment, recognition, and inclusion in decision-making processes have proven effective in easing transitions and fostering a sense of ownership, as provided in other studies [111,112]. Additionally, technical and administrative challenges can arise during

IMS implementation. These include aligning documentation formats, integrating digital systems, and maintaining audit readiness for both quality and environmental standards. Institutions with a limited IT infrastructure or manual reporting processes may find the transition especially burdensome [113,114]. External consultancy and phased implementation plans can help mitigate these issues, especially for smaller hospitals or those in resource-constrained settings. Lastly, there are contextual and regulatory variations that influence how the IMS is adopted and perceived. For example, national environmental policies, healthcare funding structures, and accreditation requirements vary across countries, shaping both the incentives and constraints for integration [14,115]. Understanding these external factors is essential for tailoring the IMS to local realities while maintaining compliance with international standards.

Figure 6 illustrates how the implementation of integrated management systems (IMSs) acts as a catalyst for strategic transformation in healthcare organizations. The concentric structure highlights the central role of the IMS, surrounded by key internal impacts such as improved operational alignment, enhanced collaboration, institutional learning, and control. The outer layer represents critical enablers and barriers that shape the effectiveness of IMS implementation, including leadership commitment, digitalization, staff training, cultural resistance, and regulatory context. Together, these interconnected elements emphasize the systemic nature of IMS adoption and its potential to align sustainability with clinical excellence. These findings reinforce that while an IMS offers a robust path to institutional improvement, its success is contingent upon navigating systemic barriers such as organizational silos, change resistance, and resource limitations. A reflexive approach to implementation, one that continuously evaluates institutional readiness, cultural fit, and staff engagement, is essential to sustain the gains achieved through IMS integration.

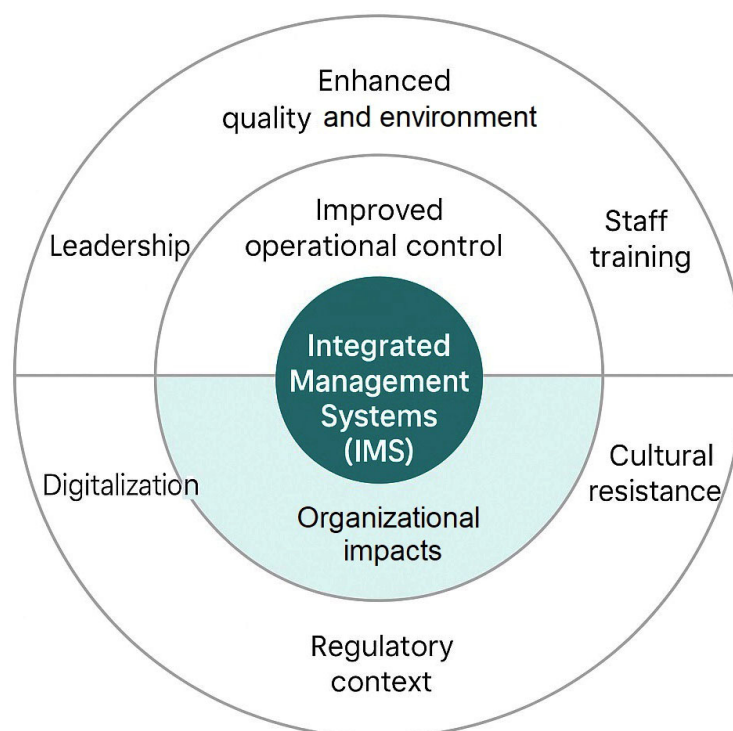


Figure 6. Strategic transformation pathways and organizational impacts of integrated management systems on healthcare institutions.

The empirical findings from the three case studies suggest that IMS adoption contributed to the reduction of fragmented management practices by aligning quality, environmental, and operational processes under a shared framework. The integration of audit

procedures, documentation systems, and training platforms facilitated cross-departmental coordination and reduced process duplication. However, it is important to acknowledge that the success of integration also depended on contextual factors, including leadership commitment, staff participation, and institutional readiness. While the cases analyzed here support the integrative function of IMSs, further research is needed to explore variations in implementation outcomes and identify conditions under which integration may be limited or ineffective.

8.2. Alignment of IMS Outcomes with the United Nations Sustainable Development Goals (SDGs)

The findings of this study provide evidence that the implementation of integrated quality and environmental management systems (IMSs) in healthcare institutions not only enhances institutional performance but also contributes meaningfully to the achievement of the United Nations Sustainable Development Goals (SDGs) [116]. By promoting resource efficiency, improving service quality, and strengthening institutional accountability, the IMS aligns healthcare operations with global sustainability priorities [117]. Table 6 presents a map of the observed outcomes to the most relevant SDGs, demonstrating how integrated management supports broader societal and environmental objectives.

Table 6. Mapping of IMS outcomes to the relevant Sustainable Development Goals (SDGs).

IMS Outcome/Impact	Relevant SDG(s)	Contribution Description
Increased patient satisfaction and improved care quality	SDG 3—Good health and well-being	Enhances patient-centered service delivery, safety, and experience
Higher staff satisfaction and cross-departmental collaboration	SDG 8—Decent work and economic growth	Fosters improved working conditions, employee engagement, and institutional resilience
Reduced energy consumption per patient-day	SDG 12—Responsible consumption and production SDG 13—Climate action	Promotes energy efficiency and supports climate mitigation efforts
Lower water consumption per patient-day	SDG 6—Clean water and sanitation	Encourages responsible water use without compromising hygiene and infection control
Increase in medical waste recycling rates	SDG 12—Responsible consumption and production SDG 3—Good health and well-being	Reduces the environmental impact of healthcare waste and improves sanitation and public health outcomes
Fewer compliance incidents and improved documentation practices	SDG 16—Peace, justice, and strong institutions	Strengthens institutional transparency, accountability, and regulatory alignment
Adoption of integrated, cross-functional management practices	SDG 17—Partnerships for the goals	Encourages interdisciplinary collaboration and systems thinking in support of the Sustainable Development Goals

Beyond contributing to institutional efficiency and sustainability, IMS implementation also holds relevance at the policy level, both internationally and nationally. At the international level, the alignment between IMS practices and the Sustainable Development Goals (SDGs), particularly SDG 3 (Good health and well-being), SDG 12 (Responsible consumption and production), and SDG 13 (Climate action) has already been recognized. By formalizing quality and environmental responsibilities, an IMS supports progress toward these targets in measurable, operational terms. At the national level, the integration

of an IMS into healthcare governance can enhance consistency and accountability across institutions. Regulatory agencies and health authorities may consider embedding IMS principles into hospital accreditation systems, licensing criteria, or performance-based funding mechanisms. In this context, an IMS acts as both a tool and a framework for ensuring that public healthcare institutions meet the minimum standards for quality, sustainability, and compliance. Moreover, governments can actively promote IMS adoption through supportive policies, such as national quality improvement programs, training initiatives, or procurement standards that reward certified institutions. In countries seeking to modernize or green their healthcare systems, an IMS offers a practical and scalable approach for embedding environmental and quality goals into routine institutional practice. Thus, beyond operational outcomes, an IMS serves as a bridge between institutional action and public policy objectives, offering a structured means to implement, monitor, and report on sustainability and quality commitments at multiple governance levels [9,118].

While this study included three institutions of varying sizes and organizational complexity, it did not statistically control for confounding variables such as institutional size, service scope, or resource availability. These contextual differences may have influenced the magnitude and nature of IMS outcomes. Although the qualitative comparative design allowed us to observe consistent trends across heterogeneous settings, future studies could apply more rigorous statistical techniques, such as propensity score matching or multivariate regression, to better isolate the effect of IMS implementation from other institutional characteristics. It is also important to recognize that this study did not control for all potential confounding variables, such as changes in hospital leadership, staff turnover, or external policy developments, which may have influenced the observed outcomes. While data limitations precluded statistical adjustment, the comparative design and consistency of performance trends across the three institutions suggest that IMS implementation played a central role. Future research should consider longitudinal, mixed-method, or quasi-experimental approaches to more precisely isolate the effects of IMSs from broader organizational or environmental influences.

Another important limitation relates to the scope of the performance metrics employed. While the selected indicators reflect operational and compliance improvements, they do not fully capture the experiential or systemic dimensions of healthcare performance. Future research should consider integrating more granular and patient-centered indicators, such as PROMs, clinical safety metrics, environmental life cycle assessments, and workforce well-being indices, to build a more comprehensive evaluation framework for IMSs in healthcare settings.

8.3. Digitalization and Smart Healthcare as Enablers of IMS Effectiveness

The transition toward integrated quality and environmental management systems in healthcare is increasingly supported by digital innovations. Technologies such as Internet of Things (IoT)-enabled monitoring, electronic quality auditing tools, and smart data dashboards provide the infrastructure necessary for real-time performance tracking, automated compliance alerts, and predictive maintenance. These digital enablers enhance the responsiveness and transparency of IMSs, allowing healthcare institutions to move beyond reactive management toward proactive, data-driven decision-making [101,117].

In the context of energy and resource efficiency, IoT-based sensors can monitor energy and water consumption in critical areas, enabling institutions to identify inefficiencies and adjust operations accordingly [16,117]. Similarly, electronic audit platforms streamline documentation, improve traceability, and reduce human error, thereby supporting both ISO 9001 and ISO 14001 requirements [101,119]. The integration of these tools with hospital information systems creates a foundation for more agile, adaptive, and sustainable healthcare

governance. While the current study focused on traditional implementation mechanisms, the case studies revealed early instances of digital tools, such as electronic waste tracking and digital performance dashboards, being deployed to support IMS objectives. Future research and implementation strategies should further explore the role of digitalization in amplifying the impact of IMSs, particularly in the context of smart hospitals and healthcare 4.0 frameworks [120,121].

While institutional documentation identified smart dashboards as a key enabler of performance monitoring and predictive maintenance, this study did not include direct access to the technical architecture, visualization strategies, or user interface designs of the platforms used. As such, our analysis is based on secondary reports rather than empirical testing or usability evaluation. Future research should explore the design of healthcare dashboards in greater depth, including their data integration logic, visualization effectiveness, and decision-making impacts across the clinical, operational, and environmental domains. Particular attention should be paid to usability, real-time data reliability, and interface adaptability to support diverse user groups and institutional needs.

This study relied on institutional reports and publicly available documentation; however, many of the performance indicators analyzed were based on self-reported data. Although these were triangulated with third-party audits and sustainability summaries, the possibility of reporting bias remains. Future research would benefit from the use of more robust methodologies, such as observational studies, longitudinal performance tracking, or quasi-experimental comparisons, to improve data credibility and strengthen causal inferences. Figure 7 highlights the integration of IoT-enabled monitoring, electronic quality auditing, and smart data dashboards as essential components for real-time performance tracking, compliance management, and predictive maintenance within the smart healthcare ecosystem.

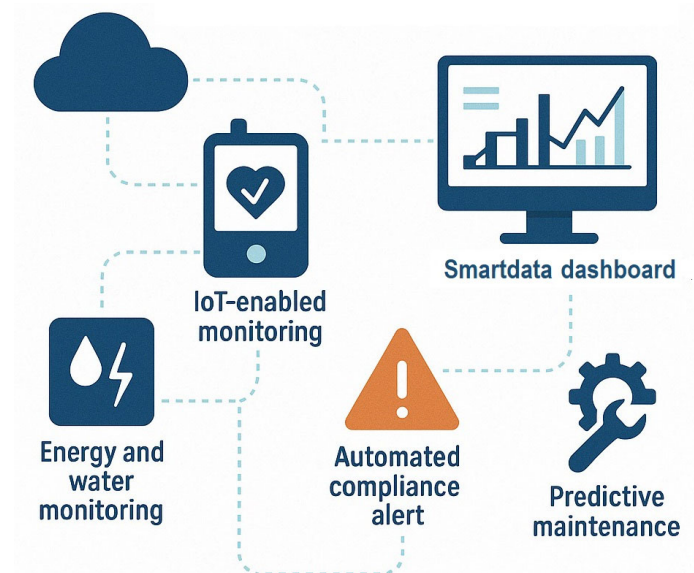


Figure 7. Digital tools enhancing IMS effectiveness in smart healthcare environments.

The integration of quality and environmental management systems in healthcare holds clear advantages, but its success depends heavily on organizational readiness, strategic leadership, cultural adaptability, and adequate resource allocation. Institutions considering IMS adoption must view it not as a purely technical process but as a transformational initiative requiring system-wide engagement and a long-term commitment to improvement. The success of IMS implementation is strongly shaped by an institution's level of

organizational readiness, which encompasses multiple interdependent factors. Leadership buy-in provides strategic direction and legitimacy, while cultural adaptability ensures that new practices are accepted across hierarchical levels and professional domains [8,122]. Resource allocation, including time, staffing, and technological infrastructure, enables the operationalization of IMS objectives. These elements do not act in isolation; their interactions determine how effectively an institution can integrate quality and environmental standards into daily operations. Misalignment between vision, culture, or capacity may result in resistance, superficial compliance, or implementation delays [123,124]. Therefore, readiness must be understood as a dynamic, systemic condition that evolves throughout the IMS adoption process.

While digitalization and smart healthcare systems, such as electronic medical records, audit platforms, and waste tracking technologies, were found to support IMS implementation, this study did not employ a distinct methodological framework for evaluating the impacts of these technologies. Digitalization-related data were extracted from institutional summaries and sustainability reports, and thus reflect a descriptive, rather than statistically validated, contribution to IMS effectiveness. To robustly assess the causal influence of digital tools on IMS outcomes, future studies should adopt targeted data collection strategies, such as mixed-method evaluations, digital maturity assessments, or longitudinal observational designs.

Despite their advantages, electronic quality auditing tools also pose risks that require careful consideration. These include the potential for automated errors, such as the misclassification of data or incorrect time stamping, especially in systems with insufficient validation protocols. Moreover, such tools depend heavily on a proper configuration, ongoing calibration, and regular maintenance to ensure accuracy and reliability. Without proper oversight, there is a risk that users may become overly reliant on system outputs, potentially overlooking qualitative indicators or contextual anomalies. Effective IMS governance must therefore include provisions for human review, staff training, and periodic system audits to mitigate the risks associated with over-automation and ensure that electronic tools enhance rather than substitute institutional judgment and accountability.

Whereas IoT-enabled systems offer substantial benefits in monitoring energy use, environmental metrics, and compliance indicators, their adoption in healthcare settings is not without challenges. Concerns about data security, patient confidentiality, and interoperability must be carefully addressed, particularly when IoT platforms interface with clinical IT systems. Inadequate encryption, device vulnerabilities, or insufficient access controls could compromise patient safety or operational continuity [124]. Furthermore, the integration of smart systems requires alignment with institutional cybersecurity protocols and compliance with privacy regulations such as GDPR. These challenges underscore the need for robust risk management frameworks, clear governance policies, and cross-functional coordination between IT, clinical, and environmental departments when incorporating IoT tools into the IMS architecture.

8.4. Strategic Value and Future Perspectives

While this study offers evidence of the positive impacts of IMS implementation in three diverse healthcare settings, its findings also point toward important directions for future research and application. To strengthen generalizability, future studies could adopt multi-site, longitudinal designs encompassing a broader range of healthcare institutions, including small rural hospitals, specialized clinics, and healthcare systems in low-resource settings. Moreover, a more nuanced understanding of the IMS implementation process, particularly the influence of leadership, organizational culture, and stakeholder engagement, remains a critical area of inquiry. Research exploring these enablers and their interactions

with institutional readiness can provide valuable insights for guiding future IMS adoption strategies [76,125].

The potential applicability of IMS principles beyond the healthcare sector also warrants attention. Sectors such as education, manufacturing, and municipal services face similar challenges in aligning quality assurance with sustainability goals. Comparative research across industries could help identify universal implementation principles as well as sector-specific adaptations that influence effectiveness. In addition to structural and operational drivers, future research should also explore the organizational politics and power dynamics that shape IMS adoption. Factors such as leadership commitment, stakeholder influence, interdepartmental negotiations, and competing institutional priorities may significantly impact the depth and sustainability of integration efforts. A better understanding of these internal dynamics would enrich current conceptual frameworks and support the design of more context-sensitive implementation strategies [126,127]. By continuing to explore the contextual, organizational, and technological factors that affect IMS performance, researchers and practitioners can co-develop evidence-based models to support broader, more resilient systems of integrated governance and sustainable operations.

To synthesize the strategic role of the IMS and highlight its broader applicability, Figure 8 presents a conceptual framework derived from the findings of this study. The left side of the diagram outlines the core mechanisms of IMS implementation, such as the integration of ISO 9001 and ISO 14001 standards, cross-functional alignment, internal audit systems, and cultural change initiatives. These elements serve as foundational enablers of transformation in healthcare institutions. The central section of the framework links these mechanisms to key institutional outcomes documented in this study: operational efficiency, environmental sustainability, improved compliance, and enhanced staff and patient satisfaction. These outcomes reflect the ability of the IMS to break down silos and align strategic, operational, and environmental goals within a unified structure.

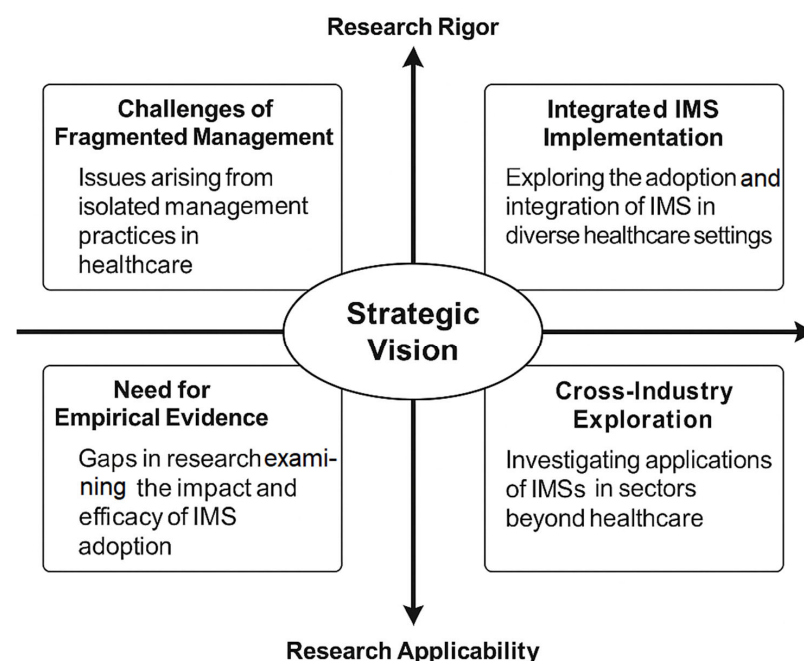


Figure 8. Conceptual framework illustrating the strategic value of integrated management systems (IMSs) in healthcare and their cross-sectoral relevance. The framework highlights how core IMS mechanisms, such as process integration, internal audits, and cultural alignment contribute to improved operational and environmental outcomes. It also emphasizes the potential transferability of these principles to other sectors facing similar governance, quality, and sustainability challenges.

As this study relies on quantitative data from only three institutions, the results should not be interpreted as generalizable across all healthcare settings. Instead, the quantitative findings are intended to support an interpretive comparison and illustrate performance trends within a bounded, context-specific case study framework. Future research using original data collection methods, including interviews and surveys across a larger sample, would provide stronger empirical grounding and broader external validity.

The findings of this study also carry significant implications for healthcare policy and regulation. Given the demonstrated value of IMSs in improving institutional performance and aligning healthcare operations with broader sustainability goals, integrated management should be considered a core governance mechanism rather than a voluntary or peripheral initiative. Policymakers may consider embedding IMS requirements into accreditation frameworks, procurement standards, or sustainability reporting obligations to mainstream their adoption across healthcare systems. Institutionalizing IMSs at the policy level could accelerate system-wide improvements in quality, environmental performance, and organizational accountability.

On the right side, the framework projects the transferability of IMS principles to other sectors, such as education, manufacturing, and public services. These fields share similar challenges, such as fragmented processes, the need for regulatory compliance, and growing sustainability pressures, which makes an IMS a potentially valuable governance tool beyond healthcare. This framework underscores the dual nature of an IMS: it serves both as a technical system for integrated performance management and as a strategic instrument for organizational transformation. As such, it supports not only continuous improvement but also long-term institutional adaptability and cross-sectoral learning.

In addition to structural and operational drivers, future research should also explore the organizational politics and power dynamics that shape IMS adoption. Factors such as leadership commitment, stakeholder influence, interdepartmental negotiations, and competing institutional priorities may significantly impact the depth and sustainability of integration efforts. A better understanding of these internal dynamics would enrich current conceptual frameworks and support the design of more context-sensitive implementation strategies [127,128].

Finally, the findings of this study underscore the need for stronger interdisciplinary collaboration to support the design and diffusion of IMSs in healthcare. Effective implementation requires coordinated input from clinicians, quality improvement professionals, environmental specialists, digital systems experts, and policymakers. Promoting knowledge translation across these domains will be critical to building context-sensitive strategies that integrate clinical, operational, and environmental priorities. Such collaboration can help scale IMSs as a transformative tool for sustainable, patient-centered healthcare delivery [129]. To promote effective knowledge translation, future work should prioritize the development of practical implementation resources, such as IMS toolkits, sector-specific guidelines, policy briefs, and decision-support frameworks that reflect real-world constraints and best practices. The creation of online platforms, professional networks, and communities of practice can further facilitate the dissemination of lessons learned, support capacity building, and enable peer-to-peer learning among institutions. These initiatives can bridge the gap between theory and practice and help accelerate the broader adoption of IMSs in healthcare [130].

Policymakers and regulatory bodies can play a central role in scaling IMS adoption by providing incentives, policy alignment, and structural support. These may include integrating IMS requirements into accreditation processes, allocating dedicated funding for implementation and training, and incorporating IMS metrics into national healthcare quality and sustainability strategies. The development of standardized frameworks, in-

indicator sets, and reporting guidelines can further reduce variability in implementation and promote shared accountability across institutions. Such measures would help embed IMSs into the core governance architecture of healthcare systems and promote long-term institutional resilience.

To better articulate the theoretical foundations supporting this study, the integrated management approach presented here is anchored in well-established frameworks such as the Plan–Do–Check–Act (PDCA) cycle and the Deming Cycle [131]. These models promote continuous improvement and organizational learning, which are central to both ISO 9001 and ISO 14001 standards. The PDCA methodology provides a cyclical structure that aligns well with the iterative implementation and monitoring processes required for IMS success. ISO 9001 emphasizes quality assurance through evidence-based decision-making, leadership, and stakeholder engagement, while ISO 14001 prioritizes environmental performance and compliance. Their shared high-level structure (Annex SL) enables harmonization across departments and supports unified policy development, risk management, and auditing procedures. Together, these frameworks offer a comprehensive foundation for integrating clinical, environmental, and operational priorities within a single strategic vision for sustainable healthcare delivery [132].

Future research on digitalization in the context of IMSs could explore several important directions. First, empirical studies might investigate how the integration of real-time dashboards, IoT sensors, and AI-based auditing tools affects organizational learning, risk management, and quality improvement. Research questions may include the following: *How do digital tools influence staff engagement with IMS processes? To what extent do predictive analytics enhance environmental performance monitoring?* Methodologically, longitudinal case studies, mixed-method evaluations, and digital maturity assessments could offer valuable insights. Theoretically, frameworks such as the Technology–Organization–Environment (TOE) framework, the Diffusion of Innovations theory, or sociotechnical systems theory may help capture the multi-level complexity of digital IMS implementation [133]. These studies would have direct implications for healthcare policy by informing digital governance models, identifying digital equity challenges, and supporting evidence-based funding strategies for smart healthcare infrastructure.

Although this study includes three institutions with differing profiles and national contexts, all are located in Europe, which may limit the generalizability of the findings to healthcare systems in other regions. Regulatory frameworks, organizational maturity, funding mechanisms, and cultural attitudes toward quality and environmental performance may differ significantly across continents. As such, the insights presented here should be interpreted with an awareness of their regional scope. Future research would benefit from expanding the analysis to include a broader and more diverse sample of institutions, particularly in low- and middle-income countries, to assess the adaptability and scalability of IMSs across different healthcare settings.

9. Conclusions

This study demonstrates that the implementation of integrated quality and environmental management systems (IMSs) in healthcare institutions can deliver tangible and measurable benefits across multiple dimensions of organizational performance. By systematically aligning the principles of ISO 9001 and ISO 14001, an IMS enables healthcare providers to simultaneously enhance clinical service quality and environmental sustainability as two pillars of modern, responsible healthcare delivery.

The case studies and comparative analyses presented herein show consistent improvements in patient satisfaction, staff engagement, resource efficiency, waste management, and regulatory compliance following IMS adoption. These outcomes are not isolated gains but rather the product of interdependent processes that the IMS helps to harmonize. For example, improvements in environmental hygiene and indoor air quality not only reduce ecological footprints but also contribute to better patient experiences and infection control. Likewise, staff training on environmental protocols often leads to a broader awareness of quality assurance principles, thereby strengthening organizational culture.

The radar chart of key performance indicators further illustrates the system-wide impact of integration, revealing that the IMS drives both breadth and depth in performance enhancement. Healthcare institutions benefit from greater internal consistency, reduced operational redundancies, and enhanced data visibility, conditions that support informed decision-making, continuous improvement, and adaptive resilience.

Moreover, the IMS plays a crucial role in helping healthcare institutions navigate and respond to evolving societal, economic, and regulatory demands. With the growing emphasis on climate action, ESG reporting, and value-based healthcare, stakeholders now expect providers not only to deliver excellent clinical outcomes but also to demonstrate environmental responsibility, transparency, and social equity. Integrated systems provide a foundational platform to fulfill these expectations through structured planning, implementation, evaluation, and reporting mechanisms. In addition to the immediate outcomes observed, IMS implementation may also yield long-term benefits, such as improved patient care, reduced resource consumption, and enhanced institutional resilience, topics that merit further investigation through longitudinal research.

However, the successful adoption of an IMS is not without challenges. As discussed, it requires leadership commitment, adequate resource allocation, and a sustained investment in training and cultural change. Institutions must be willing to move beyond a compliance-oriented mindset toward one of strategic integration, where quality and sustainability are seen not as separate priorities but as mutually reinforcing objectives.

Looking ahead, the role of IMSs is expected to grow in prominence, particularly as healthcare systems face increasing pressures related to resource scarcity, technological transformation, and climate vulnerability. Future iterations of IMSs will likely integrate digital tools, artificial intelligence, and dynamic risk-based approaches to further improve responsiveness and accountability.

Consequently, integrated management systems are not merely tools for operational refinement, they represent a paradigm shift in how healthcare institutions conceive performance, sustainability, and value. Their broader adoption has the potential to reshape healthcare governance, enhance institutional legitimacy, and contribute to the global agenda for sustainable development in the health sector. By embracing integration, healthcare organizations position themselves to lead in a future where excellence in care and responsibility for the environment are inseparable.

Several priority areas emerge that warrant further investigation to advance the integration of quality and environmental management in healthcare. Future research should focus on generating longitudinal evidence regarding the long-term impacts of integrated management systems on both clinical outcomes and environmental sustainability in healthcare institutions. There is also a need for cost–benefit analyses to evaluate the economic viability of IMS implementation across different types of healthcare settings. Additionally, the integration of digital technologies, such as real-time environmental monitoring, predictive analytics, and smart infrastructure, represents a promising avenue for investigation, particularly in relation to system interoperability and decision support. Comparative policy

analyses could further advise how national regulatory environments enable or constrain the uptake of integrated management practices.

Finally, more research is needed to explore strategies for aligning organizational culture and staff engagement with sustainability goals, ensuring that IMS initiatives are supported at all institutional levels. Several priority areas emerge that warrant further investigation to advance the integration of quality and environmental management in healthcare. Key research gaps include the absence of standardized models for IMS implementation tailored to healthcare settings, limited longitudinal evidence on institutional outcomes, and an insufficient exploration of how organizational culture and leadership influence the success of IMS adoption. There is also a need to examine how IMSs can be effectively integrated with digital health systems and performance monitoring tools.

Addressing these gaps will require interdisciplinary collaboration among researchers, practitioners, and policymakers. The co-development of frameworks and pilot programs can ensure that proposed solutions are not only evidence-based but also operationally feasible and aligned with policy. Such partnerships can foster knowledge exchange, enhance contextual adaptation, and accelerate the translation of research findings into institutional practice. As healthcare systems face mounting pressures to improve sustainability and quality, collaborative research has a critical role to play in designing integrated approaches that are scalable, resilient, and grounded in real-world experience.

While this study is based on three European healthcare institutions, its findings offer a transferable model for assessing IMS performance in other contexts. The comparative indicator framework and domain-based evaluation structure can be adapted by healthcare institutions seeking to align clinical quality with environmental sustainability. For policymakers, the results underscore the importance of supporting IMS adoption through regulatory incentives, performance reporting requirements, and digital infrastructure investment. Future research should explore how institutional, cultural, and policy environments affect the scalability and customization of IMS frameworks across different health systems.

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