

A multi-country review of the governance of hospital information systems interoperability

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Abstract

Background: Weak governance of hospital information systems interoperability can impede data accuracy, security and accessibility.

Aim: To review and synthesise published literature on governance of hospital information systems interoperability.

Methods: Using the preferred reporting Items for systematic reviews and meta-analyses method, we reviewed on Scopus, PubMed and ScienceDirect literature on governance of hospital information systems interoperability published between June 2014 and June 2024, across Africa, Asia, Americas, Middle East, Europe, and Oceania.

Results: The key governance strategies are classified into 3: policy and regulation, standards and frameworks, and sustainable funding and resources. Policies and regulations governing hospital information systems interoperability are typically established at national, regional and organisational levels to safeguard patient data privacy. Interoperability frameworks typically address system structures, core functions and interoperability standards, while some also incorporate access to open-source digital tools. Human and technical resources are often recognised as influential and essential factors for efficient interoperability.

Conclusion: Effective governance is essential for building and operating integrated interoperable hospital information systems as well as for improving efficiency, optimising resource use and advancing health outcomes.

Keywords: hospital information governance, hospital information system, interoperability, information exchange, digital health, integrated health information

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Introduction

Hospital information systems (HIS) are effective and economic tools introduced to address challenges faced by health care providers through the integration of information and communication technology (ICT) for the collection, processing, reporting and use of essential data in the health care sector. The term HIS is sometimes confused with the broader concept of health information system. In this study, HIS refers to computer-based systems used within hospitals to coordinate care, manage clinic data, and improve the timeliness, accuracy and completeness of information (1,2).

Information sharing across levels of care is closely linked to the quality, efficiency and safety of service delivery. The ability of systems to interconnect and share data without restriction is referred to as interoperability, which is critical for effective health system management and improved quality of care (3). Interoperability may be internal – enabling seamless data exchange among components, such as patient registration, pharmacy dispensing and electronic health records (EHRs), within a single HIS – or external, involving data sharing across

hospitals, health care networks or geographic regions. It enables key systems such as patient administration, laboratory information systems, EHRs, or pharmacy systems to communicate efficiently, thereby supporting decision-making and improving patient outcomes (32,33). Conversely, poor interoperability results in redundant, fragmented and inaccessible medical information, undermining the quality of care and wasting financial resources (4).

Despite its importance, many health care institutions struggle with fragmented governance, which contributes to inconsistent data management practices, limited system connectivity and suboptimal use of HIS. Effective governance is essential for managing information flow and safeguarding data security. Previous research has proposed frameworks for health information governance, emphasising its role in data management and interoperability (31). This study builds on that foundation by examining governance mechanisms specifically aimed at HIS interoperability. While earlier work addressed governance broadly, this review focuses on operational and policy-level challenges in the health care context.

In this study, HIS interoperability governance refers to frameworks and standards that guide the meaningful exchange of data across organisational boundaries to deliver effective health care services (5). Ideally, this facilitates timely and secure transfer of patient information between institutions. However, in the absence of standardised governance, implementation is often fragmented and duplicative across different institutions and settings.

Scoping reviews are particularly suited for mapping key concepts and identifying evidence gaps. By examining governance strategies such as policy and regulatory frameworks, standardisation efforts, and resource optimisation, this study aims to identify actionable strategies for improving HIS interoperability and advancing health system performance.

Methods

Study design

A scoping review was conducted to identify scientific publications examining governance of HIS interoperability using the Arksey and O'Malley framework, which includes 5 key stages: formulating the research question, searching for relevant literature, selecting eligible studies, extracting data, and analysing and reporting results (30,31). The preferred reporting items for systematic reviews and meta-analyses guideline was applied to ensure transparent reporting.

Electronic literature search

The search was conducted in August 2024, covering a 10 year period from June 2014 to June 2024, on Scopus (<https://www.scopus.com>), PubMed (<https://pubmed.ncbi.nlm.nih.gov>), and ScienceDirect (<https://www.sciencedirect.com>). Studies published as early as 2014 were included to capture the initial discussions, planning, and preliminary research that shaped governance practices for HIS interoperability. Although some countries implemented interoperability in later years, foundational activities such as stakeholder consultations and pilot studies began earlier. These efforts provide valuable insights into the challenges, perceptions and readiness of HIS for achieving interoperability.

A standardised search strategy was developed to identify studies focusing on the governance of HIS interoperability. Keywords included “governance,” “interoperability,” and “hospital information system”. Query strings combined these terms and their synonyms (e.g. “governance” AND “interoperability” AND “HIS”) to ensure comprehensive coverage across databases.

Inclusion and exclusion criteria

Articles addressing health information interoperability governance, research focused on developing governance models or mechanisms for hospital information systems interoperability and articles published in English were included in the analysis while those addressing only

governance without interoperability and articles without full text access were excluded.

Article screening and selection

Articles were selected systematically based on predefined inclusion and exclusion criteria. The review included studies reporting HIS interoperability governance, encompassing both quantitative and qualitative designs. Only full text articles published in English were included. Studies focusing solely on technical aspects of interoperability without discussing governance mechanisms such as policies, regulatory frameworks, or decision-making processes, were excluded.

Since this review specifically examines governance in the context of HIS interoperability, studies addressing only technical or operational interoperability without governance-related insights were not considered eligible. Titles were initially screened for relevance, followed by abstract review to confirm alignment with the focus of the review. Where abstracts provided sufficient information, the corresponding full texts were analysed for eligibility. The PRISMA flowchart (Figure 1) provides an overview of the selection process.

Data extraction

Information related to key findings on governance was extracted, focusing only on data directly relevant to the research question. For over 40% of the included studies, data extraction was conducted independently by 3 reviewers, with discrepancies resolved by consensus. For the remaining studies, a reviewer extracted the data, which was then checked by another reviewer for accuracy.

All data were organised and analysed using Microsoft Excel 2010. The quality of each study was evaluated through post-extraction discussion between the 2 lead reviewers and a third reviewer to ensure consistency and objectivity.

Descriptive synthesis of results

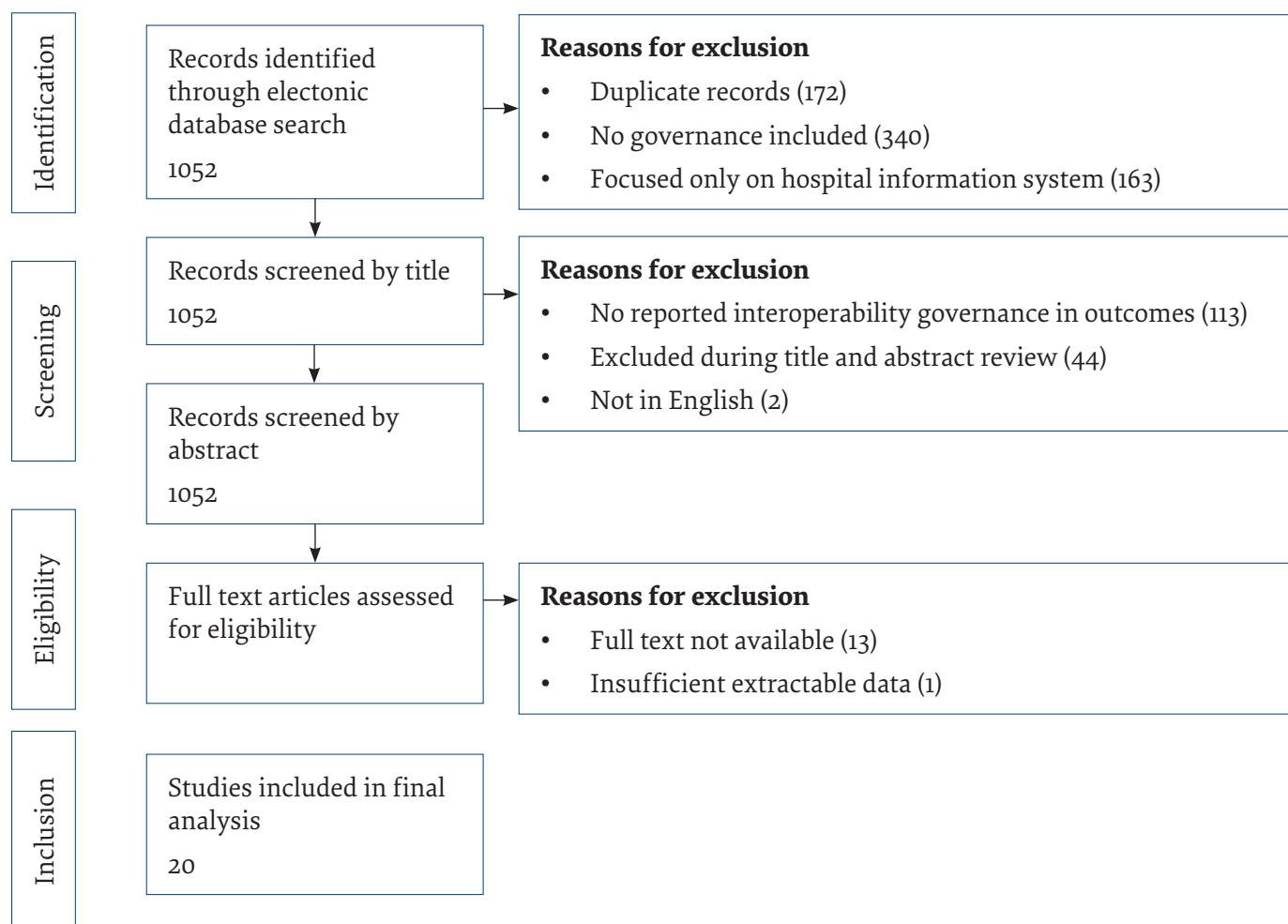
To strengthen credibility and reduce bias, 2 independent reviewers performed data extraction and synthesis. First, study characteristics were reviewed and documented to establish the context and scope of each study. This helped identify key themes and governance-related trends. The synthesis then focused on categorising governance practices and mechanisms as experienced across different institutions and health care settings.

Results

Study characteristics

The literature search yielded 1052 articles. After removing duplicates, 880 titles were screened. Following title and abstract review, 1018 articles were excluded for not meeting the inclusion criteria. An additional 14 articles were excluded after full text screening due to insufficient extractable data. The final analysis included 20 quality-assessed studies, which represent various regions of the

Figure 1 PRISMA flowchart of paper selection



world: Africa (Democratic Republic of Congo, Ethiopia, Tanzania, Uganda), Asia (Bangladesh, Indonesia, Malaysia), Australia, Europe (Belgium, France, Germany), the Middle East (Jordan, Lebanon), North America (Canada, United States of America), and South America (Brazil) (Table 1). Study settings varied, including national health systems, hospitals and specialised healthcare initiatives.

HIS interoperability governance at the national level was highlighted in a study from the United Republic of Tanzania, where a national initiative applied the “Mind the GAPS” framework to integrate 15 systems, focusing on public health leadership and capacity-building (6). Similarly, in Indonesia, a study involving government, private sector and health facilities highlighted fragmented maternal and child health information systems, emphasising the need for stronger governance and information technology infrastructure. In Brazil, research focused on hospital-level maturity frameworks to enhance internal coordination and reduce inefficiencies (7). Canada reported integration across multiple levels of care, highlighting the role of policies and leadership in national systems (14).

Hospital- and system-level interoperability challenges were prominent in studies from the United States of

America [e.g. integration of single vs. multi-electronic medical record systems and evaluation of government-managed system-level record sharing (SLRS) platforms] (9,12). In Germany, one study examined hospital-based governance challenges, while another highlighted fragmented national decision-making frameworks (23).

In rural and low-resource settings, additional barriers were identified. In Ethiopia, studies reported a lack of interoperability between digital health systems, where platforms were incompatible and unable to exchange data effectively. Socio-cultural constraints further hindered adoption and use of these systems. In Australia, one study examined primary care settings, emphasising the role of policymakers and general practitioners in supporting patient-centred care (13). Research from Jordan, Lebanon and Uganda explored governance challenges in integrating refugee health data into national HIS, highlighting the importance of multi-entity collaboration and data stewardship in fragile settings (24).

Bangladesh investigated interoperability within national e-health initiatives, proposing Health Level Seven (HL7)-compliant frameworks for use in health care facilities (16). A study from Belgium addressed governance challenges and data fragmentation in national electronic health records (EHR) systems (18). In France, research

Table 1 Summary of findings from reviewed studies on hospital information systems interoperability

No.	Author (year)	Reference	Country	Publication type	Information system	Key findings
1	Nsaghurwe (2021)	6	United Republic of Tanzania	Report	Tanzania Health Information Exchange	A five-step framework enabled interoperability across 15 systems, improving data sharing and saving time on administrative processes.
2	Lazuardi (2021)	7	Indonesia	Research	Digital maternal and child health systems	18 systems developed by various stakeholders had limited interoperability, mainly restricted to routine reporting .
3	Vasques (2024)	8	Brazil	Research	Unified health system	Implementation of the maturity framework was challenging; however, standards and protocols has established to support coordination and cost reduction.
4	Shrivastava (2021)	9	United States of America	Research	Electronic medical records	Interoperability gaps persisted between single and multi-hospital Electronic medical records systems; policy enhancement needed to enhance data privacy and security.
5	Kadry (2010)	10	United States of America	Report	Health information technology	Lack of integrated standards hampered communication across clinical systems; further development of medical data standards is required.
6	Faulkenberry (2021)	11	United States of America	Report	OpenMRS	Locally-tailored interventions in low-resource settings can mitigate digital health system failures.
7	Azarm (2023)	12	United States of America	Research	System level record sharing	Government-managed SLRS platforms enhanced interoperability, despite contextual, procedural and evidence-sharing challenges.
8	Sasie (2024)	13	Ethiopia	Research	Health information sharing system	Interoperability was hindered by technical, financial, and socio-cultural barriers, as well as system functionality.
9	Juzwishin (2009)	14	Canada	Report	Not specified	Leadership and policy challenges were addressed; interoperability requires integrated health care health care processes and systems across levels of care.
10	Chen (2023)	15	United States of America	Research	Health information exchange	Many-to-many health information exchange models were adopted, but limited use was observed with external entities.
11	Rinty (2021)	16	Bangladesh	Research	Electronic medical records	Poor interoperability remained a primary barrier to eHealth adoption in developing countries.
12	Dixon (2014)	17	United States of America	Commentary	Electronic medical records	Despite standardised processes, semantic interoperability remained limited due to system fragmentation.
13	Bogaert (2021)	18	Belgium	Research	Health information systems	Barriers included data fragmentation and limited reuse, EHR* implementation challenges with EHRs, unclear governance, legal gaps, and staff shortages.
14	Steel (2024)	19	Australia	Research	Information sharing system	Leadership in primary care improved provider confidence in patient-centred information sharing.
15	Mukala (2024)	20	Democratic Republic of the Congo	Research	Not specified	Integration success factors included leadership, mental health awareness, use of protocols, and adequate primary care workforce.
16	Rajagopal (2024)	1	Malaysia	Research	Health information systems	Data security and privacy were the main enablers of interoperability.
17	Gaucher (2024)	21	France	Research	PROSPERO	Interprofessional collaboration was critical for successful interoperability between hospital and community care.
18	Anywar (2024)	22	Germany	Research	Medical data integration centre	Health Level 7 version 2 data conversion presented technical challenges; strong data governance was emphasised.
19	Schmitt (2024)	23	Germany	Report	Integrated health system	System fragmentation led to higher costs, disrupted the continuity of care, and reduced the effectiveness of interventions.
20	Bou-Karroum (2024)	24	Jordan, Lebanon, Uganda	Research	Health information systems	Efficient data management, inclusive governance, and improved national-level integration were highlighted.

focused on collaborative platforms such as PROSPERO, which aim to bridge community- and hospital-based care teams and foster interprofessional collaboration (21). Studies from Malaysia and the Democratic Republic of Congo examined governance across hospital and primary care settings, focusing on data privacy, security, and the integration of mental health services into primary care (1,20).

These findings illustrate the scope of contexts addressed – from national health systems to localised care environments – and targeted initiatives in low-resource and fragile settings. This diversity underscores the complexity of HIS interoperability governance globally and the need for context-specific strategies to overcome distinct challenges across healthcare systems.

Key findings on governance of hospital information systems interoperability

Our analysis of the literature identified key governance strategies, persistent challenges and opportunities for strengthening the implementation of HIS interoperability, as well as recommendations. The majority of included studies were research articles that incorporate both qualitative and quantitative designs, as well as reports.

Three core elements of governance of HIS interoperability emerged from the synthesis: policy and regulation, standards and frameworks, and funding and resources. These categories reflect the diverse perspectives and approaches presented in the literature, offering insight into governance mechanisms in this domain.

Policy and regulation of hospital information systems interoperability

Policies and regulations governing HIS interoperability are typically established at national, regional and organisational levels to safeguard patient data privacy. They specify how patient data should be collected, processed and shared for medical purposes, ensuring compliance with data protection rights. Several studies reported that privacy regulations may pose barriers to interoperability at the technical, semantic and organisational levels (9). In particular, hospital-level requirements for data access or consent were identified as constraints, limiting the capacity of EMR systems to process and share data. Such challenges are often linked to weak or fragmented governance structures (7,26).

Frameworks of hospital information systems interoperability

Frameworks that support interoperability typically address various system designs, core functionalities and interoperability standards. Some also incorporate access to various open-source digital tools. One study highlighted the success of the mind the GAPS framework (governance, design, programme management, and standards) in enabling data exchange across 15 separate information systems (6). Other studies examining maturity models in health care institutions revealed that

defining maturity stages can improve system structures by enhancing planning, control and formalisation of processes (8). Although implementation in complex institutions can be challenging, standardised references for interoperability protocols can support coordination, strengthen data exchange and reduce implementation costs (25).

Organisational capacity and resources for hospital information systems interoperability

Organisational factors such as resources, trained staff, coordination, defined roles, policy involvement, training, technology and incentives were recognised as influential, but less than half of the studies assessed these elements positively (13). In one study that used the strengths, weaknesses, opportunities and threats (SWOT) analysis, the burden on data collectors for entering, managing and reporting health data was reported as a barrier, due to increasing complexity or excessive reporting requirements. Computer literacy was also recognised as a constraint on effective HIS use. E-health developments require information technology professionals and health data engineers, but a shortage of specialists with information technology expertise – or combined information technology and health system skills – was noted as a limitation in the SWOT analyses (18,27). Training was considered an enabler of effective HIS interoperability, particularly through capacity-building in data collection, reporting and public health analysis. In terms of funding, lack of sustainability was a recurrent barrier, often due to underfunding or project-based financing. The analysis showed a lack of financial resources for HIS interoperability (18,28).

Recommendations for strengthening governance of hospital information systems interoperability

The literature identified numerous recommendations to improve HIS interoperability governance, including opportunities to enhance data sharing among hospitals during emergencies and the need for centralised data systems and feedback loops. Several studies emphasised the importance of strategic investments in technology interfaces, cost optimisation, cultural alignment and relationship-building to support effective health information exchange (13). Recommendations from this review also highlighted the need to accelerate health system reforms to overcome political, social and policy barriers.

Key policy priorities include achieving national consensus on governance structures and functions, defining and standardising terminology related to high-performing healthcare systems, and supporting adoption of global standards such as the International Classification of Diseases (ICD), HL7 and Systematised Nomenclature of Medicine Clinical Terms (SNOMED CT). Other recommendations emphasise the importance of establishing a policymaking framework centred on population health, with clear goals and performance

indicators that are transparent and publicly accessible. Further, systems should grant the public ownership of and access to secure personal health records, and provide incentives for innovation among health care providers while removing disincentives that hinder effective service delivery and information sharing.

Discussion

A well-governed HIS is essential for navigating the complexities of modern health care delivery and achieving broader system-wide goals. For example, HIS tools play a critical role in strengthening infectious disease surveillance and integrating human resource management into digital systems, ensuring that health systems are better equipped and more efficient (6). However, the success of HIS implementation depends heavily on robust governance structures that can effectively address technical, semantic and organisational interoperability challenges. For instance, while privacy regulations safeguard patient data, they can also introduce technical constraints and semantic inconsistencies (29). This underscores the need for governance frameworks that balance data security with seamless information exchange.

In addition to these challenges, fragmented governance structures significantly hinder HIS interoperability (10,17,18). Establishing centralised management mechanisms is therefore essential for standardising data protocols, allocating resources effectively and monitoring progress across interoperability initiatives. Cross-sector collaboration – between health care organisations, technology providers and policymakers – is critical to fostering coordination and achieving shared goals. Proven models, such as Mind the GAPS, show how structured frameworks can facilitate data exchange and improve overall system efficiency. Adopting such models offers practical guidance for enhancing governance, promoting system integration and reducing operational costs.

Strategic resource allocation and sustainable financing are foundational to effective HIS interoperability governance. However, many settings remain constrained by recurrent underfunding and reliance on short-term, project-based support. To address these challenges, governance frameworks must integrate policies, standardised protocols and strategic resource management. When aligned, these elements can ensure

comprehensive, interoperable and sustainable HIS – enabling efficient data sharing, high-quality service delivery and improved health outcomes across health systems worldwide.

Study limitations

The limitations of this scoping review primarily relate to its scope and methods. A notable limitation is the exclusion of grey literature, which may have led to the omission of important insights from unpublished reports, policy documents or other non-peer-reviewed sources. The focus on studies published in English and specific databases may have excluded research published in other languages or available through other platforms, introducing potential language and publication bias. While the 10 year timeframe (2014–2024) is appropriate for capturing contemporary developments in HIS interoperability governance, it may have excluded recent studies that have not yet been indexed. Despite these limitations, the review provides a comprehensive overview of the governance of HIS interoperability, consistent with the objectives of a scoping review.

Conclusion

HIS interoperability governance is essential for securing seamless data exchange and improved health care service delivery. Addressing the challenges associated with interoperability requires a comprehensive governance approach that emphasises long-term sustainability, capacity building, infrastructure development and inclusive stakeholder engagement. Integrated and collaborative governance structures, combined with consistent standards and protocols, can significantly enhance HIS interoperability, making health care delivery more efficient and more effective. Therefore, a cohesive governance strategy that would refine existing policies, adopt reliable frameworks and prioritise investment in critical resources is needed. Overcoming the governance challenges will enable health systems to unlock the full potential of interoperable HIS, ultimately improving efficiency, optimising resource use and advancing health outcomes.

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Analyse multipays de la gouvernance de l'interopérabilité des systèmes d'information hospitaliers

Résumé

Contexte : Une gouvernance faible de l'interopérabilité des systèmes d'information hospitaliers peut entraver l'exactitude, la sécurité et l'accessibilité des données.

Objectifs : Passer en revue et synthétiser la littérature publiée sur la gouvernance de l'interopérabilité des systèmes d'information hospitaliers.

Méthodes : En utilisant la méthode PRISMA (éléments de rapport préférés pour les revues systématiques et les méta-analyses), nous avons examiné, dans les bases de données Scopus, PubMed et ScienceDirect, la littérature

publiée sur la gouvernance de l'interopérabilité des systèmes d'information hospitaliers entre juin 2014 et juin 2024, en Afrique, dans les Amériques, en Asie, en Europe, au Moyen-Orient et en Océanie.

Résultats : Les principales stratégies de gouvernance sont classées en trois catégories : politiques et réglementation ; normes et cadres ; financement et ressources durables. Les politiques et réglementations encadrant l'interopérabilité des systèmes d'information hospitaliers sont en principe établies aux niveaux national, régional et organisationnel afin de protéger la confidentialité des données des patients. Les cadres d'interopérabilité portent généralement sur les structures des systèmes, les fonctions de base et les normes d'interopérabilité, certains incluant également l'accès à des outils numériques libres. Les ressources humaines et techniques sont largement considérées comme des éléments influents et essentiels pour assurer une interopérabilité efficace.

Conclusion : Une bonne gouvernance s'avère indispensable pour mettre en place et faire fonctionner des systèmes d'information hospitaliers intégrés et interopérables, ainsi que pour améliorer l'efficacité, optimiser l'utilisation des ressources et faire progresser les résultats en matière de santé.

استعراض متعدد البلدان لحوكمة التشغيل البيئي لنظم معلومات المستشفيات

سكينة أنيان، أيدالينا محمود، أنيتا عبد الرحمن، محمد فضلي خيري، ميسرة عمر

الخلاصة

الخلفية: يمكن أن يؤدي ضعف حوكمة التشغيل البيئي لنظم معلومات المستشفيات إلى إعاقة تحقيق دقة البيانات وأمنها وإمكانية الوصول إليها.

الأهداف: هدفت هذه الدراسة إلى استعراض المؤلفات المنشورة بشأن حوكمة التشغيل البيئي لنظم معلومات المستشفيات وتوليفها.

طرق البحث: استعرضنا، باستخدام بنود التبليغ المفضلة للاستعراضات المنهجية والتحليلات التلوية، مؤلفات بشأن حوكمة التشغيل البيئي لنظم معلومات المستشفيات والتي نُشرت في قواعد البيانات PubMed و Scopus و ScienceDirect في الفترة ما بين يونيو/ حزيران 2014 ويونيو/ حزيران 2024، في جميع أنحاء أفريقيا، وآسيا، والأمريكتين، والشرق الأوسط، وأوروبا، وأوقيانوسيا.

النتائج: تُصنّف استراتيجيات الحوكمة الرئيسية إلى 3 فئات: السياسات واللوائح، والمعايير والأطر، والتمويل والموارد المستدامة. وعادةً ما توضع السياسات واللوائح التي تحكم قابلية التشغيل البيئي لنظم معلومات المستشفيات على المستويات الوطنية والإقليمية والمؤسسية للحفاظ على خصوصية بيانات المرضى. وتتناول أطر التشغيل البيئي عادةً هياكل النظم، والوظائف الأساسية، ومعايير التشغيل البيئي، في حين يشمل بعضها أيضاً الوصول إلى الأدوات الرقمية المفتوحة المصدر. وكثيراً ما ينظر إلى الموارد البشرية والتقنية بوصفها عوامل مؤثرة وأساسية لتحقيق كفاءة التشغيل البيئي.

الاستنتاجات: الحوكمة الفعّالة ضرورية لبناء نظم معلومات متكاملة وقابلة للتشغيل البيئي في المستشفيات وتشغيلها، وكذلك لتحسين الكفاءة، وتحسين استخدام الموارد، والنهوض بالمخرجات الصحية.

References

1. Rajagopal S, Balakrishnan V, Chiam YK. The direct effect of institutional factors on healthcare information systems (HIS) organisational interoperability in Malaysian public hospitals. *Health Inform J.* 2024;30(4). doi:10.1177/14604582241294218.
2. Norouzi H, Mehrolhassani MH, Hajesmaeel-Gohari S, Ahmadian L, Ghaemi MM, Mohammadi M, et al. Identification and classification of indicators for evaluating health information systems. *Health Policy Technol.* 2023;12(4):100833. doi:10.1016/j.hlpt.2023.100833.
3. Miandoab AT, Samad-Soltani T, Jodati A, Rezaei-Hachesu P. Interoperability of heterogeneous health information systems: a systematic literature review. *BMC Med Inform Decis Mak.* 2023;23(1). doi:10.1186/s12911-023-02115-5.
4. Mitigating factors affecting secure interoperability of medical systems using DLTs in healthcare. *Int J Sci Eng Appl.* 2023;13(1). doi:10.7753/IJCATR1301.1001.
5. Nyangena J, Rajgopal R, Ombech EA. Maturity assessment of Kenya's health information system interoperability readiness. *BMJ Health Care Inform.* 2021;28(1). doi:10.1136/bmjhci-2020-100241.
6. Nsaghurwe A, Dwivedi V, Ndesanjo W, Bamsi H, Busiga M, Nyella E, et al. One country's journey to interoperability: Tanzania's experience developing and implementing a national health information exchange. *BMC Med Inform Decis Mak.* 2021;21(1). doi:10.1186/s12911-021-01499-6.
7. Lazuardi L, Sanjaya GY, Ali PB, Siahaan RGM, Achmad L, Wulandari H. Interoperability of health digitalization: case study on use of information technology for maternal and child health services in Indonesia. *Bus Inf Syst.* 2021;1:317–327. doi:10.52825/bis.vii.53

8. Vasques L, Rijo R, Alves D. Interoperability at healthcare institutions in Brazil: framework for identify maturity stages. *Procedia Comput Sci* [Internet]. 2024;239:2316–2321. <https://www.sciencedirect.com/science/article/pii/S1877050924016685>.
9. Shrivastava U, Song J, Han BT, Dietzman D. Do data security measures, privacy regulations, and communication standards impact the interoperability of patient health information? A cross-country investigation. *Int J Med Inform.* 2021;148:104401. doi:10.1016/j.ijmedinf.2021.104401.
10. Kadry B, Sanderson IC, Macario A. Challenges that limit meaningful use of health information technology. *Curr Opin Anaesthesiol.* 2010;23(2):184–192. <https://doi.org/10.1097/aco.0b013e328336eae>.
11. Faulkenberry JG, Luberti A, Craig S. Electronic health records, mobile health, and the challenge of improving global health. *Curr Probl Pediatr and Adolesc Health Care.* 2021;52(1):101111. doi:10.1016/j.cppeds.2021.101111.
12. Azarm M, Meehan R, Kuziemyk C. Towards a universal patient-centric health record sharing platform. *Health Policy Technol.* 2023;12(4):100819. doi:10.1016/j.hlpt.2023.100819.
13. Sasie SD, Van Zuylen P, Ayano G, Aragaw FM, Spigt M. Information sharing across institutions: practices and barriers during public health emergencies in Ethiopia. *Int J Med Inform.* 2024;186:105439. doi:10.1016/j.ijmedinf.2024.105439.
14. Juzwishin DWM. Political, policy and social barriers to health system interoperability: emerging opportunities of Web 2.0 and 3.0. *Health Manage Forum.* 2009;22(4):6–16. <https://pubmed.ncbi.nlm.nih.gov/20166516>.
15. Chen M, Esmaeilzadeh P. Adoption and use of various health information exchange methods for sending inside health information in US hospitals. *Int J Med Inform.* 2023;177:105156. <https://www.sciencedirect.com/science/article/abs/pii/S1386505623001740>.
16. Rinty MR, Prodhan UK, Rahman MM. A prospective interoperable distributed e-Health system with loose coupling in improving healthcare services for developing countries. *Array.* 2022;13:100114. <https://www.sciencedirect.com/science/article/pii/S2590005621000539>.
17. Dixon BE, Vreeman DJ, Grannis SJ. The long road to semantic interoperability in support of public health: experiences from two states. *J Biomed Inform.* 2014;49:3–8. doi:10.1016/j.jbi.2014.03.011.
18. Bogaert P, Verschuuren M, Van Oyen H, van Oers H. Identifying common enablers and barriers in European health information systems. *Health Policy.* 2021;125(9):1517–1526. doi:10.1016/j.healthpol.2021.09.006.
19. Steel A, Foley H, Graham K, Harnett J, Adams J. Patient experiences of information-sharing and patient-centred care across the broad landscape of primary care practice and provision: a nationally representative survey of Australian adults. *BMC Prim Care.* 2024;25(1). doi:10.1186/s12875-024-02359-8.
20. Mayoyo EM, Chenge F, Sow A, Criel B, Michielsens J, Van K, et al. Health system facilitators and barriers to the integration of mental health services into primary care in the Democratic Republic of the Congo: a multimethod study. *BMC Prim Care.* 2024;25(1). doi:10.1186/s12875-024-02460-y.
21. Gaucher L, Puill C, Baumann S, Hommey S, Touzet S, Rudigoz RC, et al. The challenge of adopting a collaborative information system for independent healthcare workers in France: a comprehensive study. *Sci Rep.* 2024;14(1). <https://www.nature.com/articles/s41598-024-62164-2.pdf>
22. Anywar M, Macedo M, Pazmino S, Bronsch T, Kinast B, Kock-Schoppenhauer AK, et al. Challenges and lessons learned in mapping HL7 v2 data to openEHR: insights from UKSH medical data integration center. *Stud Health Technol Inform.* 2024. doi:10.3233/SHTI240658.
23. Schmitt T. New governance of the digital health agency: a way out of the joint decision trap to implement electronic health records in Germany? *Health Econ Policy Law.* 2023. doi:10.1017/S1744133123000142.
24. Bou-Karroum L, Daher N, Jabbour M, Akhu-Zaheya L, Khater W, Alloubani A, et al. Assessing the integration of refugee health data into national health information systems in Jordan, Lebanon, and Uganda. *Confl Health.* 2024;18(S1). doi:10.1186/s13031-024-00608-2.
25. Gomes J, Romão M. Information system maturity models in healthcare. *J Med Syst.* 2018;42(12). doi:10.1007/s10916-018-1097-0.
26. Organisation for Economic Co-operation and Development. Health data governance for the digital age: implementing the OECD recommendation on health data governance. Paris: OECD Publishing; 2022. doi:10.1787/68b60796-en.
27. Croatian Institute of Public Health, Aragon Health Sciences Institute. Report on interoperability landscape in Europe. Zagreb: Joint Action on Health Information; 2021. https://health.ec.europa.eu/document/download/39fe4fc8-8820-44bf-a8a1-488aefe-908ba_en.
28. Sipido KR, Antoñanzas F, Celis J, Laurent Degos, Frackowiak R, Fuster V, et al. Overcoming fragmentation of health research in Europe: lessons from COVID-19. *Lancet.* 2020;395(10242):1970–1971. doi:10.1016/S0140-6736(20)31207-1.
29. Fennelly O, Moroney D, Doyle M, Eustace-Cook J, Hughes M. Key interoperability factors for patient portals and electronic health records: a scoping review. *Int J Med Inform.* 2024;183:105335. <https://www.sciencedirect.com/science/article/pii/S138650562300353>.
30. Arksey H, O'Malley L. Scoping studies: towards a methodological framework. *Int J Soc Res Methodol.* 2005;8(1):19–32. doi:10.1080/1364557032000119616.

31. Ghaffari Heshajin S, Sedghi S, Panahi S, Takian A. A framework for health information governance: a scoping review. *Health Res Policy Syst.* 2024;22(1):109. doi:10.1186/s12961-024-01193-9.
32. Association of Public Health Laboratories, Centers for Disease Control and Prevention. Laboratory information systems project management: a guidebook for international implementations. Silver Spring (MD): APHL; 2019. <https://www.aphl.org/about/APHL/publications/Documents/GH-2019May-LIS-Guidebook-web.pdf>.
33. US Department of Veterans Affairs. Patient advocate tracking system replacement (PATs-R) privacy impact assessment. Washington (DC): VA; 2023. <https://department.va.gov/privacy/wp-content/uploads/sites/5/2023/05/FY23PatientAdvocateTrackingSystemReplacementPATSRPIA.pdf>.