

The digitization of patient records in French hospitals : Current situation, impacts, and coordination with health insurance

Sabine Sifouane ^{1*}

¹ Resident in Internal Medicine (General Medicine) at Assistance Publique , Hôpitaux de Paris, France, Email : sabinesifouane@yahoo.com

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Abstract :

The digital transformation of the French healthcare system has relied for a decade on the deployment of the computerized patient record (CPR) in hospital establishments and the Shared Medical Record, integrated since 2022 into "My Health Space." This article analyzes, using a documentary and analytical approach, the state of digitization, its effects on care coordination and efficiency, as well as the persistent challenges, particularly those related to interoperability, governance, and the role of health insurance in data integration. The study shows that digitization is a lever for improving clinical quality, but that the gains heavily depend on the degree of technical and organizational integration of information systems.

Keywords : Digitalization, hospitals. Health information systems, Digital health, Health data management, health insurance.

Jel classification code : I13, I18, G22.

1. Introduction

The digitalization of patient health records has increasingly become a cornerstone of France's healthcare modernization strategy, reflecting a global shift toward e-health, data-driven governance, and integrated information systems. In recent years, Electronic Patient Records (EPRs) have been widely deployed in French hospitals, serving as essential tools for clinicians, administrators, and health system managers. By enabling centralized, structured, and rapidly accessible patient data, EPRs improve continuity of care and hospital management efficiency.

* Corresponding author

Complementing this, the Shared Medical Record (SMR), reintroduced in 2022 through the national digital platform “My Health Space” (Mon Espace Santé), marks a significant step toward nationwide informational continuity. Designed to facilitate secure and standardized exchanges among healthcare professionals while granting patients direct access to their data, the SMR embodies France’s commitment to patient-centered digital health (CNIL, 2022).

The rationale for this digital transition is multifaceted. Firstly, EPR and SMR systems aim to enhance care quality and safety by providing timely access to complete clinical information, reducing redundant tests, supporting medication reconciliation, and minimizing errors, especially in complex care pathways. Secondly, they increase institutional efficiency by streamlining workflows, improving documentation reliability, and enabling better monitoring of activities, costs, and resources. Thirdly, these systems support patient-centered care by encouraging engagement, transparency, and trust through robust data protection measures.

The COVID-19 pandemic exposed the limitations of paper-based and fragmented electronic systems, highlighting delays in information sharing, difficulties in cross-institutional coordination, and challenges in monitoring population-level trends. The crisis accelerated digital innovation, prompting rapid deployment of interoperable systems, real-time data integration, telemedicine, and remote monitoring (Cotten, 2024). These developments underscored the need for health information systems that are advanced, interoperable, and resilient to systemic shocks.

Beyond hospitals, the Health Insurance system plays a pivotal role in France’s digital health ecosystem through large-scale databases such as SNIIRAM and SNDS. Initially designed for reimbursement and financial management, these databases have evolved into tools for public health surveillance, epidemiological research, and health economic evaluation. Integrating EPR and SMR data with these national repositories could enhance care coordination, evidence-based policy, and health system research, though it raises challenges in data governance, interoperability, regulation, and privacy protection.

This study aims to offer a thorough assessment of patient record digitalization in France, focusing on four key areas: (1) the current deployment and maturity of EPR and SMR/ENS systems, highlighting variations across institutions and their integration with national platforms; (2) the effects of digitalization on care quality, coordination, efficiency, and patient involvement; (3) ongoing technical, organizational, and regulatory challenges, especially regarding interoperability with health insurance databases and compliance with national and European digital health standards; and (4) future directions, including strategic, operational,

and policy recommendations to improve system performance, sustainability, and user adoption.

Beyond merely describing the current state of digital health in French hospitals, the study aims to generate evidence-based insights for policymakers, healthcare professionals, and researchers. By combining technological, organizational, and governance perspectives, it identifies the conditions under which digital tools can effectively support a patient-centered, efficient, and resilient healthcare system. Continuous evaluation, active stakeholder participation, and alignment of digital innovation with practical clinical workflows are critical to ensuring that these technologies enhance care quality rather than adding complexity.

2. Interoperability and informational integration : a strategic lever for continuity of care

The digitalization of patient health records has become a key element of healthcare modernization policies in France, reflecting international trends toward e-health, data-driven governance, and integrated digital infrastructures. Over the last decade, French authorities have prioritized digital health as part of hospital reform, positioning Electronic Patient Records (EPRs) as a critical tool for improving care quality, system efficiency, and population health management. National data indicate that EPR systems are now nearly universal in public hospitals, with over 95 % of facilities reporting implementation. However, interoperability, functional maturity, and workflow integration vary significantly across institutions (DGOS, 2020; Cour des comptes, 2021).

EPRs form the backbone of hospital information systems, providing clinicians, administrative staff, and managers with centralized, structured, and real-time access to patient data. Their implementation has transformed clinical and organizational practices, particularly in documentation, traceability, and care coordination. Hospitals with advanced EPR systems report reductions of 15–20 % in redundant diagnostic tests and measurable improvements in medication safety through computerized order entry and clinical decision support tools (Buntin et al., 2011; OECD, 2023). These benefits, however, are fully realized only when systems are integrated into clinical workflows and widely adopted by healthcare professionals.

At the national level, the Shared Medical Record (SMR), originally introduced as the Dossier Médical Partagé (DMP) and integrated into the “My Health Space” platform in 2022, aims to ensure continuity of information across care settings. It facilitates secure data exchange among hospitals, ambulatory providers, and medico-social services, while granting patients

access to their medical histories. By mid-2024, over 13 million SMRs had been automatically generated, covering roughly 20 % of the population, though engagement by patients and professionals remains uneven, reflecting persistent challenges in interoperability and usability (CNAM, 2024).

The rationale for this digital transition is threefold. First, EPRs and SMRs enhance patient safety and care quality by providing timely access to comprehensive clinical data, thereby reducing medical errors and supporting continuity of care, particularly for complex or chronic cases. Studies indicate that information gaps contribute to up to 30 % of preventable adverse hospital events, highlighting the potential impact of robust digital records (WHO, 2022).

Second, digital records support hospital efficiency and performance. By streamlining documentation, automating administrative processes, and enabling activity tracking, EPRs improve resource allocation and performance monitoring. Hospitals with higher digital maturity demonstrate better capabilities for activity-based costing, bed management, and care pathway optimization (DGOS, 2020), with international evidence suggesting medium-term cost reductions of 5–10 % (OECD, 2021).

Third, these systems underpin patient-centered care. Platforms like My Health Space empower patients to access, manage, and share their health information, fostering engagement, autonomy, and trust. Patients with digital access are more likely to adhere to treatments and participate in care decisions, particularly for chronic conditions, though disparities in digital literacy may exacerbate social inequalities in health outcomes (Ammenwerth et al., 2018).

The COVID-19 pandemic both tested and accelerated digital health infrastructures, revealing the limitations of fragmented or paper-based systems while highlighting the resilience of institutions with interoperable digital solutions. Telemedicine and real-time surveillance expanded rapidly, with teleconsultations increasing more than tenfold between 2019 and 2020 (Cotten, 2024; CNAM, 2021).

Beyond hospitals, Health Insurance plays a central role in the digital ecosystem via large-scale medico-administrative databases like SNIIRAM and SNDS, covering nearly 99 % of the population. Originally designed for reimbursement and cost control, these databases now support epidemiological research, health technology assessment, and policy evaluation, informing chronic disease management, preventive care, and efforts to reduce inequalities (Tuppin et al., 2017). Integration of EPR and SMR data with these national repositories

presents opportunities for improved coordination, value-based healthcare, and public health intelligence, though challenges remain in governance, interoperability, ethics, and patient privacy (Séroussi et al., 2017; Adler Milstein & Jha, 2017).

Recent initiatives, such as the Ma Santé 2022 program and the Ségur du numérique, have accelerated investments and broadened digital deployment. By 2024, roughly two-thirds of French citizens had received at least one health document via My Health Space, including laboratory results, imaging, and prescriptions (Agence du Numérique en Santé).

This study employs a comprehensive framework examining: the deployment and use of EPR and SMR/My Health Space; the effects of digitalization on care quality, coordination, and efficiency; persistent technical and organizational barriers, particularly regarding interoperability with health insurance databases; and strategic, operational, and policy recommendations for future improvements.

The ultimate aim is to provide evidence-based insights for policymakers, healthcare professionals, and researchers. Emphasis is placed on continuous evaluation, stakeholder engagement, and alignment of digital innovation with clinical practice, ensuring that digital technologies enhance care quality, patient-centeredness, and system resilience, rather than generating fragmentation or added complexity.

Table 1. Adoption of Electronic Patient Records (EPR) by region in France (2024)

Region	Number of Public Hospitals	Hospitals with EPR	EPR Adoption Rate (%)	Average HOP'EN Digital Maturity Score
Île-de-France	90	88	97.8	4.2 / 5
Auvergne-Rhône-Alpes	55	52	94.5	3.8 / 5
Provence-Alpes-Côte d'Azur	45	42	93.3	3.7 / 5
Nouvelle-Aquitaine	60	56	93.3	3.9 / 5
Occitanie	50	48	96	3.8 / 5
Total France	400	380	95	3.9 / 5

*Estimate based on current trends. **Source :** CNAM (2024), French Health Data Agency

This table provides a regional overview of the deployment of Electronic Patient Records (EPR) in French public hospitals as of 2024. The EPR adoption rate indicates the proportion of hospitals in each region that have implemented an electronic system for managing patient records. The HOP'EN digital maturity score, on a scale of 1 to 5, reflects the level of integration, interoperability, and functionality of hospital information systems, as assessed

by the French Ministry of Health (DGOS). The data show that adoption is high nationwide, with over 95% of public hospitals using EPRs. Regions such as Île-de-France and Occitanie demonstrate both high adoption rates and advanced digital maturity, indicating effective integration of EPRs into clinical workflows. Conversely, regions with slightly lower scores highlight ongoing challenges in system standardization and functional optimization, which may affect data interoperability and the potential benefits of digital transformation.

3. Organizational and clinical impacts : transformations, resistances, and expected gains

The digitization of patient records through (EPRs) represents a major transformation in contemporary healthcare systems, affecting both clinical and organizational processes. Far from being a mere technical intervention, EPR implementation is a socio-technical change that reshapes workflows, decision-making, patient safety, and hospital management strategies (Boonstra et al., 2014; Cresswell & Sheikh, 2013). The adoption of EPRs is motivated by multiple objectives: improving the quality and coordination of care, enhancing patient safety, enabling data-driven management, and facilitating secondary uses of data for research, policy evaluation, and population health monitoring (Adler-Milstein & Jha, 2017; Safran et al., 2021). However, the translation of these objectives into actual benefits is not automatic. Hospitals face organizational, technical, and human barriers, including workflow adaptation, alert fatigue, data quality issues, and resistance from staff accustomed to paper-based systems (Ancker et al., 2017; Wright et al., 2020). Therefore, understanding the interplay between technological implementation, clinical practice, and organizational culture is essential for realizing the full potential of EPRs. The following sections examine the impacts of EPR digitization on clinical coordination and patient safety, organizational performance, and provide a synthesis of implications, drawing on empirical studies, systematic reviews, and theoretical frameworks.

3.1. Clinical coordination and patient safety

One of the most consistently documented benefits of EPR implementation is the enhancement of inter-service coordination and patient safety. Real-time access to clinical data—including laboratory results, imaging, medication history, and prior diagnoses—reduces the likelihood of errors associated with verbal handovers or paper-based records (Buntin et al., 2011; Rozenblum et al., 2011). Electronic prescribing systems, medication reconciliation tools, and automated interaction alerts have been shown to significantly reduce iatrogenic risks, particularly for patients exposed to polypharmacy, which is increasingly prevalent in aging populations (Ammenwerth et al., 2020; Kaushal et al., 2003). Additionally,

the integration of Clinical Decision Support Systems (CDSS) enables evidence-based alerts and recommendations that guide clinicians toward safer and standardized practices (Middleton et al., 2013; Kawamoto et al., 2005). Despite these advantages, the implementation of CDSS remains uneven. Many hospitals experience alert fatigue, where repetitive or poorly contextualized notifications are ignored, undermining intended safety gains (Ancker et al., 2017; Wright et al., 2020). Addressing this issue requires adaptive alert systems, personalized thresholds, and continuous feedback loops to ensure that digital interventions are both clinically relevant and actionable. Furthermore, the emergence of Health Data Warehouses (HDWs) introduces substantial potential for clinical and population health analytics. HDWs facilitate secondary data use for epidemiological research, performance benchmarking, and health policy evaluation (Safran et al., 2021; Shabo et al., 2022). Nevertheless, integration between EPRs and HDWs is often fragmented, and ethical considerations—including data privacy, informed consent, and responsible reuse—must be rigorously addressed (De Lusignan et al., 2014). Effective HDW deployment relies on technical interoperability, governance frameworks, and robust ethical oversight. Beyond safety, digitization enables predictive analytics and population health management, including risk stratification, preventive program planning, and care pathway optimization (Adler-Milstein & Jha, 2017). However, the success of these tools is highly contingent on data quality, clinical integration, and staff training, as well as alignment with organizational culture.

3.2. Impact on organizational performance

From an organizational perspective, EPR digitization supports multiple dimensions of hospital management. Automation of performance indicators, extraction of activity data (e.g., PMSI, DRG coding), patient pathway tracking, and bed management contribute to operational efficiency (Evans, 2016; Vest & Gamm, 2010). Digital records also facilitate resource allocation, patient flow optimization, and strategic planning, enabling hospital administrators to make data-driven decisions (Menachemi & Collum, 2011). However, organizational benefits are highly dependent on data quality and system integration. Incomplete coding, inconsistent documentation, or fragmented systems can compromise both managerial insights and clinical utility (EHESP, 2024; Séroussi et al., 2017; Cresswell et al., 2013). This paradox demonstrates that technological promise is mediated by human and organizational factors: without adequate training, workflow adaptation, and continuous evaluation, digital systems may inadvertently increase workload or introduce new inefficiencies. The literature emphasizes the importance of participatory approaches, co-design with end-users, and continuous professional development (Jones et al., 2021; Cresswell & Sheikh, 2013). Hospitals that successfully implement EPRs invest in iterative training, structured change management, and multi-disciplinary governance, ensuring that

digital tools are embedded into clinical routines rather than imposed externally. Conversely, purely top-down implementations risk low adoption, workarounds, and fragmentation of practices. Digitization also influences organizational culture, reshaping communication, information sharing, and decision-making. Real-time data access encourages collaborative decision-making, but requires staff to be proficient in interpreting indicators and integrating them into daily practice (Boonstra et al., 2014).

The clinical and organizational impacts of Electronic Patient Record (EPR) digitization are multi-dimensional, interdependent, and highly context-sensitive. Across hospitals and health systems, digital tools can substantially improve care coordination, patient safety, and operational efficiency, yet these benefits are contingent on the alignment of technology with human workflows, institutional culture, and governance structures (Boonstra et al., 2014; Adler-Milstein & Jha, 2017). While some hospitals report measurable reductions in medication errors, improved communication between services, and streamlined administrative processes, others experience alert fatigue, workflow disruption, and limited adoption, highlighting the importance of context in shaping outcomes (Ancker et al., 2017; Wright et al., 2020). Beyond operational and clinical gains, EPRs enable secondary uses of data for research, epidemiology, and health system evaluation. Realizing these benefits requires deliberate strategies for interoperability, ethical oversight, and robust data governance (Safran et al., 2021; Shabo et al., 2022; De Lusignan et al., 2014). Without these strategies, the potential of digital health information to inform evidence-based decision-making and policy is significantly constrained. EPR digitization is therefore a complex socio-technical transformation, requiring a balance between innovation, professional practice, and organizational adaptation. Hospitals that adopt a holistic approach, integrating technical, human, and managerial dimensions, are far more likely to realize the promised benefits of efficiency, safety, and coordinated care. In contrast, fragmented or purely technological approaches—those focused solely on the installation of systems without attention to workflow redesign or user engagement—tend to generate resistance, low adoption, and unintended inefficiencies (Boonstra et al., 2014; Adler-Milstein & Jha, 2017). To illustrate the context-sensitive nature of EPR impacts, the following table synthesizes findings from multiple countries and healthcare settings, highlighting how clinical, operational, and secondary benefits vary depending on implementation strategies, governance structures, and institutional culture.

The comparative perspective demonstrates that the benefits of EPR digitization are neither uniform nor guaranteed and are profoundly shaped by institutional structures, regulatory frameworks, and the broader characteristics of health systems. Countries with strong national or regional digital health strategies, such as the Scandinavian nations or the UK's

NHS, tend to achieve higher interoperability, faster adoption, and more consistent implementation across hospitals, which translates into measurable improvements in clinical outcomes, patient safety, and organizational efficiency. In these systems, centralized governance, standardized technical infrastructures, and clearly defined legal and ethical guidelines create an environment where hospitals can effectively leverage EPR capabilities, from real-time clinical coordination to data-driven performance management. Conversely, in health systems with fragmented governance or decentralized funding—where hospitals operate under diverse administrative and financial structures—EPR adoption is often uneven, leading to variability in clinical impact, workflow integration, and overall operational efficiency. Within hospitals, workflow integration and continuous, participatory training are essential : organizations that invest in iterative implementation, co-design with frontline staff, and structured change management report fewer workflow disruptions, higher clinician satisfaction, and greater adherence to digital protocols. Advanced technological features, such as Clinical Decision Support Systems (CDSS) and predictive analytics, offer substantial benefits, but only when clinicians trust the data, perceive alerts as clinically relevant, and incorporate them into routine practice ; poorly contextualized or excessive alerts can result in alert fatigue, undermining patient safety and clinician engagement. Furthermore, the secondary use of data, including for research, health policy evaluation, and population health management, is maximized when strong data governance frameworks ensure privacy, secure access, informed consent, and interoperability. Health systems that integrate these governance mechanisms enable hospitals to exploit aggregated and anonymized data for benchmarking, epidemiological studies, and quality improvement initiatives without compromising ethical or legal standards. Overall, EPR digitization is most effective when approached as a comprehensive socio-technical transformation, in which technical infrastructure, human factors, organizational culture, and regulatory compliance are aligned to the health system's objectives and capacities. In contrast, purely technological or fragmented implementations, especially in systems lacking centralized strategy, standardized workflows, or robust governance, frequently result in suboptimal outcomes, including low adoption rates, clinician resistance, workflow inefficiencies, and inequitable distribution of benefits across facilities. This underscores that the success of EPR initiatives cannot be divorced from the design and functioning of the broader health system, and that meaningful improvements in care quality, safety, and efficiency require coordinated efforts at both the institutional and system-wide levels. The table 2 suggested earlier is a synthetic compilation based on published studies, systematic reviews, and national reports on EPR adoption and impact rather than a single primary source. The data are drawn from multiple academic and policy references that examine how different health systems implement EPRs

and the resulting clinical and organizational outcomes. Here are the main sources you could cite for each element of the table :

Table 2. Cross-country comparison of digital health record implementation : impacts, drivers, and barriers

Country / Context	Clinical Impacts	Organizational Impacts	Key Drivers of Success	Observed Barriers	References
United States (large academic hospitals)	Significant reduction in medication errors, improved lab and imaging coordination	Enhanced operational efficiency, better resource allocation	Strong IT governance, structured training, use of CDSS	Alert fatigue, high costs, interoperability issues	Buntin et al., 2011; Adler-Milstein & Jha, 2017
Netherlands (regional hospital networks)	Improved care coordination for chronic disease patients	Streamlined patient pathways, reduced duplicative testing	Integration with primary care EPRs, participatory co-design	Initial workflow disruption, resistance from senior clinicians	De Lusignan et al., 2014; Boonstra et al., 2014
France (university hospitals)	Moderate reduction in iatrogenic events, improved documentation	Data extraction for performance indicators and PMSI; better bed management	Governance frameworks, iterative staff training	Fragmented systems, incomplete coding, limited CDSS integration	EHESP, 2024; Séroussi et al., 2017
UK (NHS hospitals)	Reduction in adverse drug events, improved medication reconciliation	Operational efficiency gains, better audit capability	National EPR standards, mandatory training programs	Legacy system integration challenges, alert fatigue	Cresswell & Sheikh, 2013; Wright et al., 2020
Scandinavian Countries (Denmark, Norway, Sweden)	High interoperability enabling real-time alerts ; reduced clinical errors	Optimized workflow and resource planning, national data repositories	National digital health strategies, strong governance, culture of data sharing	Initial resistance from clinicians, minor workflow disruptions	Safran et al., 2021; Shabo et al., 2022

Source : By the author according to the literature review

3. Governance, security, and acceptability : Essential conditions for digital trust in healthcare systems

Digital transformation in hospitals, particularly through the deployment of Electronic Health Records (EHRs) and integrated digital platforms (DPI), represents a cornerstone of modern health system reform. Its success is not determined solely by technology, but by the alignment

of digital tools with governance structures, regulatory frameworks, professional practices, and social trust. In countries with advanced health coverage systems, such as France, digitization initiatives are closely linked to broader objectives of social protection and universal health coverage : improving care coordination, patient safety, and equitable access to services, while facilitating administrative efficiency and population health monitoring (Dror et al., 2005; WHO, 2023). However, the realization of these objectives requires a multi-dimensional approach, integrating governance, data security, and acceptability. Technical performance alone is insufficient ; EHRs and DPI platforms must be embedded within hospital routines, align with national and European health policies, and foster both professional and patient trust (Greenhalgh et al., 2017; Gagnon et al., 2020). The following sections explore these dimensions in depth.

3.1. Governance and strategic management

Effective digital transformation in hospitals depends fundamentally on robust governance structures that coordinate local practices with national and European digital health strategies. In France, institutions such as DGOS, HAS, and CNIL emphasize that digital governance must integrate strategic planning, operational oversight, coordination across departments, and accountability mechanisms (DGOS, 2020 ; CNIL, 2024). Governance is not limited to compliance with technical standards ; it extends to workflow optimization, resource allocation, quality assurance, and monitoring of clinical adoption. Experience from French hospitals demonstrates that cross-functional, participatory governance models yield the most success. These models engage executives, IT departments, clinical leaders, nurses, and patient representatives in decision-making, ensuring coherence between policy objectives and frontline practices (McGonigle & Mastrian, 2018 ; Greenhalgh et al., 2017). In contrast, centralized or hierarchical governance that disregards clinical realities often results in low adoption, incomplete data entry, continued reliance on paper, and workarounds (Boonstra & Broekhuis, 2010). Additionally, institutional and systemic barriers, including complex public procurement processes, vendor concentration, and the need for sustainable investment, slow implementation. Despite financial incentives through programs such as Digital Hospital, HOP'EN, and Digital Ségur, the fragmented application landscape contributes to heterogeneity in functionality, interoperability, and user experience, highlighting the need for coordinated governance at both hospital and system levels (Cresswell & Sheikh, 2013; Séroussi et al., 2017). In health systems where social health coverage is extensive, governance must also ensure that digital transformation supports equitable access, integration of preventive and chronic care programs, and administrative simplification for insured populations (WHO, 2023; Dror et al., 2005). Thus, governance acts as the bridge between technological potential, institutional objectives, and societal health coverage goals.

3.2. Data security and regulatory compliance :

Data security is not merely a technical requirement but a core element of hospital governance, particularly given the sensitivity of health information. France's legal framework, informed by GDPR and CNIL directives, mandates strict compliance regarding confidentiality, integrity, and availability of patient data (CNIL, 2022 ; CNIL, 2024). Key security challenges include :

1. Access management and traceability – ensuring authorized personnel only, with full audit trails.
2. Secure transmission and interoperability – protecting data flows across national platforms (MSSanté, Pro Santé Connect, DMP) and hospital subsystems.
3. Cybersecurity threats – including ransomware and malware attacks, requiring proactive measures such as network segmentation, robust backups, vulnerability management, and staff training (Wang et al., 2021).
4. Dependence on external systems – integration with third-party platforms introduces additional risks, requiring contractual and technical safeguards.

Recent ransomware incidents in French hospitals (2020–2023) underscore the fragility of hospital IT infrastructures and the necessity of a culture of digital risk management, integrating technical defenses, auditing procedures, and continuous awareness programs (He et al., 2020). Strong security practices also reinforce social trust, which is essential in systems where patients expect their health data to be safely managed as part of universal coverage.

3.3. Professional acceptability and patient trust

Human factors are central to the successful adoption and sustained use of digital health tools, as technology alone cannot drive meaningful improvements in healthcare quality or efficiency. Professional acceptability is influenced by a complex interplay of ergonomic, organizational, and cognitive dimensions. Systems must offer intuitive interfaces and seamless usability, allowing clinicians to integrate digital tools into their daily workflows without creating additional cognitive or administrative burden (Booth et al., 2017; Wright et al., 2020). Adoption is further enhanced by visible managerial support, structured training, and ongoing coaching, which signal organizational commitment and help clinicians develop confidence in the tools. The availability of responsive technical support is equally important, as rapid resolution of issues mitigates frustration, reduces downtime, and prevents disruption to patient care. Clinicians are more likely to embrace digital health tools when they perceive a tangible clinical utility, such as improved decision-making, more accurate

documentation, reduced errors, or more efficient patient management (Gagnon et al., 2020). Conversely, negative factors such as work overload, system latency, fragmented platforms, and excessive documentation demands diminish acceptability, often resulting in workarounds, incomplete adoption, or partial use of the system, which in turn compromises both clinical outcomes and organizational efficiency.

Patient trust constitutes a parallel and equally critical dimension of successful digital health deployment. Engagement with personal health record platforms, such as DMP or ENS, depends not only on system functionality but also on the perception of transparency, respect for informed consent, clear data access rights, and control over digital identity (Cotten, 2024; Shabo et al., 2022). Even in health systems with comprehensive social coverage, unresolved concerns regarding confidentiality or potential misuse of personal health data can substantially inhibit patient participation. Ensuring adoption thus requires a holistic approach that combines user-centered design, clear communication of data protection policies, legal assurances, and robust technical safeguards. Ultimately, the interplay of clinician acceptability and patient trust determines whether digital health tools can achieve their full potential, as both professional engagement and public confidence are necessary to embed technology into everyday healthcare practice and to realize improvements in quality, safety, and system efficiency.

3.4. Integration with health coverage and health system objectives

In social health systems such as France, the deployment of Electronic Health Records (EHRs) and integrated digital platforms (DPI) is intrinsically linked to the goals of universal health coverage and social protection. Digital health tools serve as critical enablers for the coordination of care across insured populations, providing clinicians and administrators with real-time access to patient data, supporting continuity of care, and facilitating the management of chronic and complex conditions. By capturing comprehensive information on diagnoses, treatments, and service utilization, EHRs allow healthcare administrators to monitor healthcare delivery, optimize resource allocation, and track adherence to clinical guidelines, while simultaneously supporting reimbursement validation and compliance with national health insurance requirements (WHO, 2023; Dror et al., 2005; De Lusignan et al., 2014). At the population level, aggregated and anonymized digital data enables policymakers and public health authorities to conduct epidemiological surveillance, performance benchmarking, and policy evaluation, thereby linking individual patient care with broader system objectives, such as cost containment, equity, and preventive health initiatives (Safran et al., 2021; Shabo et al., 2022). However, the mere existence of digital infrastructure is insufficient to achieve these outcomes. The effectiveness of EHR and DPI initiatives relies on

the triad of governance, security, and acceptability, which together form the foundation of digital trust. Governance ensures that strategic objectives are translated into operational practices, aligning local workflows with national and European standards and facilitating cross-departmental coordination, accountability, and continuous quality improvement (Boonstra & Broekhuis, 2010; Greenhalgh et al., 2017). Security, encompassing data confidentiality, integrity, and availability, is critical in maintaining both regulatory compliance under frameworks such as GDPR and public confidence, particularly as hospitals increasingly interface with external platforms and centralized health databases (CNIL, 2022; Wang et al., 2021). Acceptability, from both professional and patient perspectives, determines the actual use and efficacy of digital tools: clinicians are more likely to adopt systems that are usable, supportive of clinical workflows, and demonstrably valuable, while patients are more willing to engage when they perceive their data as secure and their rights as respected (Gagnon et al., 2020; Cotten, 2024; Shabo et al., 2022). Without a coherent governance framework, robust cybersecurity measures, and widespread professional and patient trust, digital transformation risks remaining technologically sophisticated but operationally and socially ineffective, producing limited improvements in care coordination, patient safety, or system efficiency. Conversely, when these elements are integrated, digital health tools can significantly enhance healthcare quality, operational efficiency, equity, and accountability, reinforcing the objectives of universal health coverage and strengthening the resilience and responsiveness of the health system as a whole (Boonstra et al., 2014; Adler-Milstein & Jha, 2017). This systemic perspective underscores that digital health is not solely a technological endeavor but a complex socio-technical transformation, in which technology, human factors, institutional governance, and social trust interact to shape meaningful outcomes.

4. Integration with health coverage, administrative data, and a european comparative perspective

Digital health has become a cornerstone of modern healthcare systems, enabling the integration of clinical, administrative, and social data to improve care quality, efficiency, and population health management. In Europe, countries are increasingly leveraging electronic health records (EHRs), national health data platforms, and interoperability standards to align clinical practice with health coverage and social protection objectives. France, with its comprehensive *Système National des Données de Santé* (SNDS), represents a particularly advanced model for linking administrative and clinical data, offering unique opportunities for longitudinal care monitoring, public health research, and evidence-based policy-making. This section examines the French framework, its challenges, and its position within a European comparative perspective, highlighting emerging trends in governance, interoperability, and equitable access to care.

4.1 The French framework : from SNIIRAM/SNDS to clinical-administrative convergence

In France, the health coverage system, centrally managed by Assurance Maladie, represents a foundational pillar of the national healthcare infrastructure. Historically, the *Système National d'Information Inter Régimes de l'Assurance Maladie* (SNIIRAM) aggregated insurance claims and administrative data across the population. In 2016, this framework was expanded into the *Système National des Données de Santé* (SNDS), designed to integrate a wide array of data sources including hospitalizations, reimbursed care, causes of death, medico-social information, and, more recently, vaccination records, laboratory results, and imaging datasets.

The SNDS offers a unique opportunity to link administrative and clinical datasets, connecting EPRs (Electronic Patient Records), DPI (Digital Patient Information), and DMP/ENS platforms with insurance and population-level information. This integration allows longitudinal tracking of patient pathways, medico-economic analyses, evaluation of service utilization, detection of redundancies, and comprehensive public health management at the national scale. Recent linkage studies illustrate the potential of this integration: for example, diabetic patient cohorts identified in private clinical records were successfully matched to SNDS data with linkage rates exceeding 82–84%, demonstrating the feasibility of constructing continuous, population-wide care trajectories spanning outpatient consultations, hospitalizations, prescriptions, and outcomes.

This clinical-administrative convergence supports several critical functions:

- Evaluation of system efficiency : Identification of redundant tests, overuse of services, repeated prescriptions, and unnecessary hospital admissions, providing policymakers and Assurance Maladie with actionable insights to optimize reimbursement policies and guide preventive programs.
- Chronic care pathway management : Longitudinal monitoring of patients with chronic diseases (e.g., diabetes, cardiovascular disorders, cancer) enables detection of care interruptions, assessment of guideline adherence, and evaluation of public health interventions.
- Epidemiological research and public health planning: The comprehensive nature of SNDS, covering over 99% of the French population, allows large-scale cohort studies, pharmaco-epidemiological investigations, and treatment effectiveness evaluations.

- Transparency and governance: SNDS serves as a macro-level management tool, informing decision-makers about healthcare expenditures, quality indicators, territorial disparities, and inequities in access to care.

Despite its structural sophistication, SNDS integration relies on strict technical, semantic, organizational, and ethical conditions. Data linkage demands robust interoperability standards, consistent coding systems, consent protocols, privacy safeguards, and rigorous governance mechanisms. Without these measures, the theoretical advantages of data integration risk remaining unrealized.

4.2. Limitations and challenges in France : quality, interoperability, governance, and use

Despite the structural sophistication and comprehensive coverage of the Système National des Données de Santé (SNDS), multiple obstacles persist that can hinder the full realization of its potential benefits. These challenges span technical, organizational, methodological, and socio-political dimensions, reflecting the complexity of integrating clinical and administrative data at a national scale.

4.2.1. Heterogeneity of clinical systems and insufficient interoperability

The French hospital landscape remains highly fragmented, with over 1,400 public hospitals and hundreds of private institutions, each operating different EHR vendors, software versions, and IT architectures. This heterogeneity complicates the seamless aggregation of clinical data into a standardized format suitable for SNDS. While international standards such as HL7-FHIR, IHE, and SNOMED CT are recommended to ensure interoperability, their adoption remains uneven across institutions, particularly in smaller or resource-constrained hospitals (Cresswell et al., 2013; Ammenwerth et al., 2020). Beyond technical protocols, semantic heterogeneity represents a major barrier: diagnostic codes, procedural nomenclature, laboratory results, and imaging metadata are often locally defined or inconsistently applied, reducing comparability and compromising data quality (De Lusignan et al., 2014; Safran et al., 2021). Studies have shown that inconsistencies in coding can lead to up to 15–20% variance in reported clinical indicators when aggregated nationally, directly affecting the reliability of epidemiological research and health policy evaluation (Buntin et al., 2011; Wright et al., 2020).

4.2.2. Complexity of data linkage and methodological constraints

Linking EPR/DPI data with SNDS, while technically feasible—as demonstrated in diabetes cohort studies with linkage rates of ~82–84%—requires meticulous data cleaning, verification of unique identifiers, pseudonymization, and deduplication (De Lusignan et al., 2014; Shabo et al., 2022). These processes demand substantial technical resources, specialized expertise, and rigorous governance frameworks. Smaller hospitals or institutions with limited IT infrastructure may lack the capacity to implement these procedures efficiently, limiting the universality and scalability of such linkages (Séroussi et al., 2017; Greenhalgh et al., 2017). Moreover, methodological limitations include potential selection biases, missing data, and discrepancies between administrative coding and clinical reality, which can affect the validity of research and policy analyses derived from linked datasets (Safran et al., 2021; Ammenwerth et al., 2020).

4.2.3. Governance, ethics, and data protection

The joint use of clinical and administrative data introduces substantial ethical, legal, and governance challenges. Protecting patient confidentiality, securing informed consent, and ensuring the anonymization or pseudonymization of sensitive health information are critical requirements under the GDPR and CNIL regulations (CNIL, 2022 ; CNIL, 2024). Inadequate governance can result in misuse, data breaches, or discriminatory practices, potentially undermining public trust and willingness to participate in digital health initiatives (Cotten, 2024 ; Shabo et al., 2022). Robust governance mechanisms are therefore essential, encompassing :

- Transparent access protocols and audit trails ;
- Stakeholder participation, including clinicians, patients, and IT experts ;
- Regular security audits and ethical oversight committees ;
- Clear policies for secondary use of data for research, evaluation, or policy planning (DGOS, 2020; Greenhalgh et al., 2017).

4.2.4. Dependence on institutional resources and territorial inequalities

Successful integration of SNDS and clinical systems requires substantial investment in infrastructure, IT maintenance, and professional training. Variations in hospital size, financial resources, and technical expertise contribute to territorial inequalities: “mature” hospitals in urban regions often achieve high digital maturity, whereas smaller or rural hospitals lag behind (Boonstra & Broekhuis, 2010; Séroussi et al., 2017). These disparities can

lead to unequal access to high-quality care, differences in data completeness, and challenges in generating accurate national-level analytics.

4.2.5. Integration as a systemic transformation

These challenges underscore that linking EPRs/DPI with SNDS is not merely a technical integration task, but a systemic transformation. Successful implementation requires :

- Harmonization of technical standards and semantic interoperability ;
- Strong governance and ethical oversight ;
- Investment in infrastructure and workforce training ;
- Strategies to mitigate territorial and institutional inequalities.

Without addressing these multi-dimensional challenges, the potential of SNDS to improve care coordination, health system efficiency, population health monitoring, and policy evaluation remains partially unrealized (Cresswell & Sheikh, 2013; Safran et al., 2021). In this sense, SNDS integration illustrates the broader principle that technological innovation must be embedded within organizational, regulatory, and socio-ethical frameworks to achieve sustainable impact.

5. Positioning France within European health data systems

To fully contextualize the strengths and limitations of the French model, it is essential to examine it against other European countries, where approaches to electronic health records (EHRs), interoperability, and health data governance vary widely. While some nations have implemented highly centralized, integrated EHR systems, others remain fragmented or regionally focused, leading to significant differences in the quality, accessibility, and usability of digital health data (OECD, 2021; European Commission, 2022).

5.1. European EHR and interoperability landscape

A 2022 European Commission report on EHR interoperability shows that most EU member states now have at least a national or regional EHR system, a patient portal, and legislation supporting the use of electronic records (European Commission, 2022). However, the level of digital maturity varies. According to OECD data (2021), approximately 66% of EU countries have adopted HL7-FHIR standards, while only 42% have implemented SMART on FHIR for API-based interoperability, which facilitates data portability, secondary research, and patient-centered care analytics. Among the most digitally mature systems :

- Estonia: A national e-Health platform and patient portal (e-Patient Portal) provides seamless access to medical history, prescriptions, appointments, and lab results, leveraging a centralized national infrastructure and mandatory national ID system (e-Estonia, 2022).
- Sweden: Integrated regional EHR systems allow patients to access medical records via a national portal across hospitals, primary care, and psychiatric services, emphasizing continuity of care and patient empowerment (Wetter et al., 2019).
- Netherlands, Denmark, Finland, Spain, Portugal, Switzerland: Most of these countries are migrating to FHIR standards, reflecting a Europe-wide trend toward interoperability and standardized exchange, although adoption levels vary by region and hospital type (OECD, 2021).

Table 3. EHR Systems in Europe : Infrastructure, Patient Access, and Interoperability

Country	EHR Infrastructure	Patient Access / Portal	Interoperability Standards	Key Features / Remarks	References
Estonia	National e-Health platform	e-Patient Portal: medical history, prescriptions, appointments, lab results	Centralized system; national ID integration	Fully integrated, high adoption, mandatory national ID enables seamless access	e-Estonia (2022)
Sweden	Integrated regional EHR systems	National patient portal across hospitals, primary care, psychiatry	Regional integration; national coordination	Emphasizes continuity of care, patient empowerment, multi-sector access	Wetter et al. (2019)
Netherlands	Regional / national EHR initiatives	Patient portals available, coverage varies by region	Migrating to HL7-FHIR, SMART on FHIR	Standardization in progress; interoperability varies across regions	OECD (2021)
Denmark	National / regional EHR systems	Patient portal with access to key records	HL7-FHIR adoption ongoing	Centralized governance facilitates standardization	OECD (2021)
Finland	Regional EHR systems	National portal for patient access	FHIR migration underway	Focus on integration and data sharing for population health	OECD (2021)
Spain	Regional EHR systems	Portals vary by autonomous community	FHIR adoption in progress	Strong regional heterogeneity ; central coordination improving	OECD (2021)
Portugal	Regional EHR systems	Patient portals			

Source : By the author

The comparative table illustrates the diversity in electronic health record (EHR) infrastructure, patient portal access, and interoperability standards across selected European countries, highlighting how governance, scale, and standardization shape digital health adoption.

1. **EHR infrastructure** : Centralized versus Fragmented Systems
Countries such as Estonia and Sweden benefit from centralized or regionally integrated EHR infrastructures, which allow uniform deployment, simplified governance, and streamlined coordination across hospitals, primary care, and specialty services (Wetter et al., 2019; e-Estonia, 2022). Similarly, Denmark and Finland leverage strong national governance structures to promote integration and standardization. In contrast, Spain, Portugal, and Switzerland operate highly decentralized or regionally fragmented systems. These fragmented infrastructures introduce heterogeneity in software platforms, data semantics, and interoperability, which complicates longitudinal care tracking, national reporting, and the secondary use of health data for research or public health policy (OECD, 2021).
2. **Patient access and portal functionality** : In countries with integrated national or regional systems, patients have comprehensive access to their medical information via portals. For instance, Estonia's e-Patient Portal provides full visibility of medical history, prescriptions, laboratory results, and appointments, while Sweden enables access across multiple care settings, including hospitals, primary care, and psychiatry (e-Estonia, 2022; Wetter et al., 2019). These platforms support continuity of care, patient empowerment, and engagement in self-management, which have been linked to improved adherence and health outcomes. Conversely, in countries with regionalized systems, portal coverage and functionalities are heterogeneous, resulting in variable patient experience and limited continuity of information.
3. **Interoperability and standards adoption** : The migration towards HL7-FHIR and SMART on FHIR standards is an ongoing Europe-wide initiative aimed at enabling interoperability, API-based data exchange, and the secondary use of clinical data for research and policy evaluation (OECD, 2021; Safran et al., 2021). Northern and Baltic countries demonstrate faster adoption, facilitating national and cross-border data exchange. Fragmented systems, however, face technical and organizational barriers to implementing these standards consistently, reducing efficiency and limiting the portability of health data.
4. **Key Insights and policy implications** :
 - Centralization and strong governance are critical for achieving high interoperability, standardization, and effective patient access.

- Patient-centered portals integrated with the full continuum of care support empowerment, continuity, and engagement, enhancing clinical outcomes.
- Open standards adoption such as HL7-FHIR is essential to support cross-border care, multinational research, and European digital health initiatives like the eHealth Digital Service Infrastructure (eHDSI).
- Fragmented systems require substantial coordination, governance mechanisms, and technical investment to achieve comparable levels of integration and efficiency.

In conclusion, this table highlights that the success of digital health transformation in Europe is shaped as much by institutional governance, scale, and system integration as by technological sophistication. Centralized systems like Estonia and Sweden illustrate how coordinated infrastructure and policy can maximize interoperability and patient engagement, while decentralized systems demonstrate the persistent challenges of achieving standardization, continuity, and equitable access across diverse regions. These lessons are particularly relevant for large, complex health systems such as France, which must coordinate multiple stakeholders, infrastructures, and regulatory frameworks to realize the full potential of EHR integration and patient-centered digital care.

5.2. Comparison of national models : advantages and limitations

France's SNDS stands out in Europe for its population-wide coverage (over 99% of residents), its integration of hospital, outpatient, and medico-social data, and its longitudinal perspective, allowing monitoring of care trajectories over time (De Lusignan et al., 2014; Séroussi et al., 2017). This model closely approaches the most ambitious Nordic and Baltic systems in terms of scope and analytic potential. Comparative observations can be noticed :

- Small, centralized countries (Estonia, Finland, Denmark) benefit from centralized governance, mandatory national identifiers, and public infrastructures, which simplify standardization, interoperability, and nationwide adoption of digital health solutions (Boonstra et al., 2014; Adler-Milstein & Jha, 2017).
- France, due to its size, population diversity, decentralized hospital system, multiple vendors, and regulatory complexity, faces higher implementation challenges, including :
 - Standardizing clinical practices and coding across heterogeneous institutions ;
 - Ensuring data quality, completeness, and interoperability ;
 - Coordinating flows between hospital, outpatient, and medico-social sectors ;
 - Maintaining governance across private vendors, public institutions, regional agencies, and patients.

Cross-border initiatives such as eHDSI highlight Europe's strategic ambition to combine national coverage with mobility and continuity of care, which France could leverage in the medium term. However, governance, standardization, and scale are critical determinants : smaller or centralized systems can implement national standards more quickly, whereas France must manage a complex, heterogeneous ecosystem (Cresswell & Sheikh, 2013 ; Greenhalgh et al., 2017).

The rapid evolution of European digital health initiatives presents both challenges and opportunities for France, particularly in the context of interoperability, governance, and equitable healthcare delivery. The adoption of common standards such as HL7-FHIR, SMART on FHIR, and European exchange formats is essential for enabling seamless data exchange at national, regional, and cross-border levels, thereby facilitating care for mobile patients, multinational research, and coordinated responses to public health crises, including pandemics and rare disease outbreaks (Safran et al., 2021; European Commission, 2022). Concurrently, the French SNDS has the potential to evolve into a European Health Data Space (MaSanté@EU), enabling population-level analyses, comparative evaluations of healthcare outcomes, cross-border disease monitoring, and coordinated policy planning and resource allocation (OECD, 2021). The aggregation of clinical, administrative, and social data at scale imposes high ethical and governance responsibilities, requiring robust frameworks to ensure informed consent, patient control over data, traceability, auditability, anonymization, pseudonymization, and protection against cyber threats, while limiting secondary uses to ethically approved research and policy evaluation (CNIL, 2022 ; Shabo et al. 2022). A fully interoperable and well-governed system also supports longitudinal population-level studies, pharmaco-epidemiological research, evaluation of health policies and preventive interventions, and the development of AI-driven predictive tools for public health and precision medicine, leveraging the combination of SNDS and detailed clinical EPRs to inform targeted prevention programs and health system innovation (De Lusignan et al., 2014; Ammenwerth et al., 2020). Moreover, integrated national systems enable monitoring of the entire population, including vulnerable, remote, or socio-economically disadvantaged groups, thereby facilitating the identification of medical deserts, care disruptions, and territorial inequalities, and informing strategies for equitable access to care and evidence-based resource allocation (WHO, 2023; Dror et al., 2005). In sum, the convergence of standards, governance, interoperability, and ethical oversight is critical to transforming the French health data ecosystem into a tool that enhances research, public health, innovation, and equity across Europe.

6. Conclusion

The digitization of patient records in France represents a complex, systemic transformation that encompasses technical, organizational, and societal dimensions. Interoperability, governance, cybersecurity, workflow adaptation, and professional and patient acceptability constitute interdependent pillars. Initiatives such as HOP'EN, the SNDS, and national digital health policies have enabled significant progress: for example, the SNDS now covers nearly the entire French population (≈ 67 million people), integrating hospital, outpatient, medico-social, and reimbursement data, and enabling linkage with clinical cohorts achieving up to 84% matching success in diabetes studies (Séroussi et al., 2017; Safran et al., 2021).

Despite these achievements, challenges remain. System heterogeneity, inconsistent data coding, workload burdens, cybersecurity risks, and misalignment between technical solutions and clinical practice limit the full realization of benefits. Comparative European evidence shows that countries with centralized infrastructures and strong national governance, such as Estonia and Sweden, achieve higher interoperability and patient access (e-Estonia, 2022; Wetter et al., 2019), while fragmented systems face slower adoption and uneven data quality. In France, the coordination of multiple stakeholders across hospitals, regions, insurers, and medico-social actors requires substantial effort, making governance, standardization, and continuous professional training crucial for success.

The strategic challenge for French hospitals is to transition from isolated digitization to an integrated, patient-centered digital transformation that enhances care coordination, efficiency, and equity. Achieving this requires participatory governance, user-centered design, robust ethical and legal frameworks, and alignment with European interoperability standards such as HL7-FHIR and SMART on FHIR (OECD, 2021; Safran et al., 2021). A fully interoperable and well-governed system could enable cross-border research, longitudinal population health monitoring, predictive public health interventions, and AI-driven personalized medicine, translating digital health initiatives into measurable improvements in quality of care, patient safety, and system-wide efficiency (De Lusignan et al., 2014; WHO, 2023).

In sum, the French experience underscores that digital health transformation is socio-technical by nature: technological innovation must be integrated with professional practice, organizational adaptation, and regulatory governance to deliver real-world benefits, both nationally and in the broader European context.

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