

# Interoperability In Healthcare: Revolutionizing Data Integration In India

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## Abstract:

Interoperability in healthcare is vital for enhancing patient care and optimizing decision-making processes through effective data exchange across health systems. In India, the Ayushman Bharat Digital Mission (ABDM), launched in September 2021, aims to establish a national digital health ecosystem that facilitates interoperability with standardized protocols, improving healthcare accessibility and efficiency. This study evaluates ABDM's alignment with global practices like Spain's Electronic Health Record Project, underscoring the impact of digital technologies in transforming Indian healthcare. The study conducts a detailed review of policy documents, technical reports, and existing health IT frameworks relevant to ABDM. It analyzes key components such as the Ayushman Bharat Health Account (ABHA), Health Professional Registry (HPR), and the Health Claim Exchange (HCX) platform. A comparative analysis with international health systems offers insights into global interoperability practices and the challenges and successes of India's digital health initiatives. ABDM has driven significant innovations, including the HCX platform for insurance services and the NOTTO for organ donation, showcasing India's commitment to technological integration in healthcare. However, challenges such as data privacy, system compatibility, and the need for comprehensive professional training persist. Insights from other countries highlight the necessity for continuous adaptation to achieve full interoperability. India's advancement towards a digital health ecosystem through ABDM marks a substantial progression in healthcare interoperability. Addressing challenges like data privacy, system compatibility, and training is crucial for the success of these initiatives. Lessons learned from India's ongoing digital transformation provide valuable guidance for other nations pursuing similar healthcare reforms.

**Keywords:** Interoperability, healthcare, ABDM, india,

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## I. Introduction

In February 2018, the Indian government launched the National Health Protection Scheme (NHPS), targeting to cover 500 million citizens with a comprehensive health insurance plan (Balsari et al., 2018). This ambitious initiative underscores the critical role of technology in scaling services, ensuring quality, and maintaining accountability within the healthcare sector (Balsari et al., 2018). However, the journey towards a fully integrated health data system in India faces significant challenges. The country's digital health ecosystem is still in its early stages, characterized by non-digitized health data, lack of standardization, and minimal interoperability (Balsari et al., 2018). Interoperability in healthcare is crucial for the seamless integration of disparate data sources, enhancing patient care, and facilitating decision-making processes.

The Indian healthcare sector stands on the brink of a digital revolution, primarily challenged by the absence of interoperable Electronic Health Records (EHRs) and Hospital Information Systems (HIS) (Swetha, 2023). This cannot be achieved unless there is a system in place to be able to track each and every patient, be it for acute care or for chronic disease management. With the recent momentum towards a national health insurance scheme, there is going to be cutthroat competition between the private and public sectors to provide healthcare services to the population of the country. This increases the likelihood of transfer of patients between various locations of healthcare. For example, a patient with heart disease needing to get care at a specialty hospital will travel from the rural area to an urban location. All his health records need to be available at the location where he is going to get the care. This again is not possible with the current state of information storage and exchange. But with crucial patient data often constrained within non-digital mediums, the urgency for adopting a data-centric approach in EHR systems emerges as a pivotal step towards achieving a patient-centric healthcare ecosystem. This shift is further bolstered by the anticipation surrounding the National Health Protection Scheme (NHPS), which promises to act as a catalyst for widespread digital health adoption across the country (Balsari et al., 2018). However, the journey towards transforming health data into a digitized, standardized, and easily accessible format presents substantial hurdles.

Currently, health data interoperability in India is constrained by a lack of standardization and the limited accessibility of data to clinicians, researchers, and policymakers (Balsari et al., 2018). To counter these challenges, a federated, patient-centric, API-enabled health information ecosystem is being proposed, aiming to align with global best practices and the principles of data minimization and open standard APIs, such as FHIR and HL7, to facilitate seamless data exchange across platforms (Balsari et al., 2018).

## **II. Literature Review**

Understanding the layers of interoperability in healthcare is crucial for grasping its importance and complexity, according to the Healthcare Information and Management Systems Society:

- **Foundational Interoperability:**

- Represents the most basic level, allowing data exchange from one information technology system to be received and stored by another. However, it does not imply the ability for the receiving system to interpret the data.

- **Structural Interoperability:**

- This intermediate level defines the structure or format of data exchange (i.e., the syntax of the data exchange). It ensures that data exchanges between information technology systems can be interpreted at the data field level.

- **Semantic Interoperability:**

- The highest level of interoperability, enabling two or more systems or elements to not only exchange information but to use the information that has been exchanged. Semantic interoperability takes advantage of both the structuring of the data exchange and the codification of the data including vocabulary so that the receiving information technology systems can interpret the data (Torab-Miandoab, 2023).

This layered approach highlights the progression from merely sharing data to fully utilizing shared data in a meaningful way, emphasizing the critical nature of interoperability for efficient and effective healthcare delivery.

### **The State of Healthcare Data Integration in India**

Many healthcare facilities in India continue to operate with fragmented, non-data-centric systems, where crucial patient data is often trapped in paper and text formats, making it challenging to access and analyze efficiently (Swetha, 2023). This fragmentation leads to data silos, as different stakeholders within the healthcare ecosystem maintain their systems with varying data architectures. As a result, interoperability, which is essential for the seamless sharing of data across the healthcare industry, is hindered by the absence of widely accepted standards.

To overcome these challenges, the Indian government has initiated the National Digital Health Mission (NDHM), aiming to create an integrated digital health infrastructure. This includes the development of a Unique Health ID, Healthcare Professionals Registry, Health Facility Registry, and Personal Health Records, paving the way for improved data integration and accessibility. Furthermore, the adoption of Electronic Health Records (EHRs) has marked a significant step toward efficient data management, reducing manual data entry errors and administrative burdens, thereby enhancing care coordination (Apurva, 2023).

The rapid adoption of telemedicine and remote monitoring, driven by the COVID-19 pandemic and the proliferation of smartphones, along with the establishment of Health Information Exchanges (HIEs) that enable secure data exchange among healthcare providers, are instrumental in bridging the gap between different healthcare systems. Additionally, the integration of data analytics and artificial intelligence in healthcare decision-making is enhancing accuracy and efficiency, signifying a move towards a more cohesive and interoperable healthcare ecosystem in India (Apurva, 2023 & Arogya M. 2022).

### **Challenges Faced in Achieving Interoperability in India**

In addressing the challenges faced in achieving interoperability in healthcare in India, several critical issues emerge:

1. **User Input Variance and Data Quality:**

- The variance in user input is a significant challenge, impacting the consistency and quality of healthcare data (Das, 2021).
- Adoption of structured clinical examination forms within electronic medical records (EMRs) could enhance data quality, ensuring uniformity across different healthcare settings (Das, 2021).

2. **Outcomes Documentation and Data Utilization:**

- Healthcare outcomes vary considerably across disciplines, necessitating a time-based approach to documentation (Das, 2021).

- Real-time data pipelines facilitated by data visualization tools can capture disease trends and treatment outcomes effectively, providing crucial insights for clinical decision-making and disease surveillance (Das, 2021).

### **3. Infrastructure and Privacy Concerns:**

- The lack of ICT infrastructure in government hospitals and the high cost of EHR system implementation pose significant barriers, especially for smaller healthcare facilities (Rashmi. 2020).
- Concerns surrounding data security and privacy, particularly with the use of Aadhaar Card as an ID, further complicate the adoption of EHR models in private healthcare settings (Jain. 2021).

These challenges underscore the need for a concerted effort towards standardization, privacy assurance, and infrastructure development to realize the full potential of interoperability in healthcare within India.

## **AI and ML in Enhancing Healthcare Data Interoperability**

Artificial Intelligence (AI) and Machine Learning (ML) are pivotal in enhancing interoperability in healthcare, offering innovative solutions to the challenges faced in India's healthcare sector. Their roles can be broadly categorized into:

### **1. Improving Healthcare Access and Efficiency:**

- AI-powered telemedicine platforms are revolutionizing healthcare by enabling remote consultations and accurate diagnoses, making healthcare services more accessible, especially in remote areas (Jagriti, 2023).
- Predictive analytics powered by AI are identifying risk factors and enabling proactive healthcare measures, thereby optimizing the efficiency of healthcare professionals (Jagriti, 2023).

### **2. Enhancing Patient Care:**

- AI and IoT integration are transforming traditional medical equipment, with AI-powered tools such as diagnostic algorithms and predictive analytics improving disease detection and treatment outcomes.
- AI-based portable screening devices are expanding the capacity for eye screenings, enabling access in remote places across the country, and AI-based prediction of cardiovascular events through eye scans is potentially replacing conventional methods (Jayapriyanka, 2023).

### **3. Challenges and Recommendations:**

- Despite the potential, the adoption of AI in healthcare faces challenges including unstructured data sets, interoperability issues, and regulatory weaknesses (Nirupam & Manisha, 2020).
- Recommendations for overcoming these obstacles include government support for AI investment, public-private partnerships, and effective legislation enforcement to ensure data protection and privacy (Nirupam & Manisha, 2020).

AI and ML technologies hold the promise to revolutionize healthcare delivery in India, addressing critical issues such as access to quality healthcare and the imbalance in the doctor-to-patient ratio, while also enabling personalized healthcare solutions (Claire & Urvashi, 2020).

## **III. Methodology**

The methodology comprises a series of systematic steps tailored to evaluate the establishment and operation of comprehensive health information systems, as illustrated by the Ayushman Bharat Digital Mission (ABDM) and other international benchmarks:

The study begins with a review of ABDM's inception in September 2021, aimed at creating a national digital health ecosystem in India. This evaluation focuses on key components such as the Ayushman Bharat Health Account (ABHA) number, the ABHA application, and other registries integral to the system. The analysis assesses the mission's objective to foster interoperability through open protocols and consent artefacts (Sharma, 2023). Innovations like the Health Claim Exchange (HCX) platform and the Heal by India (HBI) initiative are scrutinized for their effectiveness in streamlining health insurance services and enabling global healthcare provisions, respectively. Additionally, the digitalization of organ donation processes through the National Organ and Tissue Transplant Organization (NOTTO) is examined (Sharma, 2023).

The study incorporates a comparative analysis with projects like Spain's Electronic Health Record Project and Mexico's initiatives, including their Unified Health Record and Electronic Birth Certificate systems. This comparison aims to draw parallels and distinctions in terms of digital health successes and the extent of electronic health record (EHR) implementation (Rashmi, 2020). A critical review of the policy frameworks such as the Digital Personal Data Protection Act, 2023, and other national health authority initiatives that support the infrastructure of the ABDM. The role of these policies in shaping the privacy, security, and accessibility of digital health data is explored (Malcolm, 2023). Lastly, the methodology addresses the strategies for achieving

interoperability in healthcare data, focusing on the integration of EHRs with Aadhaar and the implementation of service-oriented architectures to ensure a seamless flow of health information across various platforms and stakeholders.

This methodological approach ensures a thorough understanding of the scope, impact, and effectiveness of digital health implementations, providing insights into the challenges and successes of integrating health technology into mainstream healthcare services.

#### **IV. Discussion: Success Stories Of Implementation**

##### **Ayushman Bharat Digital Mission (ABDM), India (Sharma, 2023):**

- **Launch Date:** September 2021
- **Objective:** To create a national digital health ecosystem fostering interoperability through open protocols and consent artefacts.
  
- **Key Components:**
  - Ayushman Bharat Health Account (ABHA) number
  - ABHA Application
  - Health Professional Registry (HPR)
  - Health Facility Registry (HFR)
  - Drug Registry
  - Unified Health Interface (UHI)
  
- **Innovations:**
  - Health Claim Exchange (HCX) platform for seamless health insurance services.
  - Heal by India (HBI) initiative for global healthcare service provision.
  - National Organ and Tissue Transplant Organization (NOTTO) for digital organ donation processes.
  
- **Kerala's eHealth Project, India (Rashmi, 2020):**
  - **Achievement:** Successfully digitized and stored electronic health records (EHR) of 2.58 crore individuals.
  - **Impact:** Enabled patients to access services in any government hospital without physical documents.
  
- **International Benchmarks:**
  - **Spain's Electronic Health Record Project:** Enabled controlled access to patient information across care points since 2006.
  - **Mexico's Unified Health Record:** Digitization and real-time shared access for patient data across 30 hospitals in Mexico City.
  - **Electronic Birth Certificate (CEN) in Mexico:** A comprehensive health record from birth, managing all health-related information throughout an individual's life.

##### **Government Initiatives and Policy Framework**

In an effort to streamline healthcare data management and enhance interoperability in India, several government initiatives and policy frameworks have been instituted:

###### **1. National Health Authority (NHA) Initiatives:**

- **EHR Standards and Guidelines:** A comprehensive set of guidelines issued to promote data standards and interoperability, facilitating a unified approach to electronic health records (EHRs) (Swetha, 2023).
- **Ayushman Bharat Digital Mission (ABDM):** Launched to establish a national digital health ecosystem, ABDM aims at increasing the availability, accessibility, affordability, and acceptability of healthcare through digital innovations (Sharma, 2023). Key components include interoperable frameworks, open protocols, and consent artefacts (Sharma, 2023).

###### **2. Digital Personal Data Protection Act, 2023:**

- A landmark legislation providing a framework for data protection in India, with specific provisions for healthcare data processing during medical emergencies and epidemics (Malcolm, 2023).
- The Act outlines duties for data fiduciaries and processors, ensuring the protection of personal data across the healthcare sector (Malcolm, 2023).

###### **3. EHR Model and Aadhaar Integration:**

- The proposed EHR model leverages the Aadhaar Card as an ID for retrieving health records, aiming at easy accessibility and interoperability across healthcare services (Jain, 2021).

- Integration with Aadhaar and initiatives like the Mother and Child Tracking System (MCTS) have significantly streamlined patient identification and reduced fraud, marking a step towards digitizing healthcare delivery.

### **Implementation Strategies**

Based on the findings and themes from past studies, the implementation strategies presented for enhancing Healthcare Data Interoperability as discussed as follows:

**Technical, Syntactic, and Semantic Interoperability:** Teodoro et al. (2011) introduced a methodology that addresses interoperability at three levels: technical, using ETL processes for accessing different databases; syntactic, aligning data syntax with biomedical terminologies via natural language processing; and semantic, employing semantic web technologies for common understanding and access (Teodoro et al., 2011).

**Data Integration Techniques for E-Healthcare Systems:** The integration of data from heterogeneous systems into a comprehensive distributed information system is crucial for supporting increasingly distributed healthcare processes. Techniques for integrating data aim to facilitate data discovery and processing more effectively than traditional empirical techniques (Ying, Rong, & Xiao, 2007).

**Service-Oriented Architecture (SOA) and Data Interchange:** Batra, Sachdeva, and Mukherjee (2015) presented an interoperable healthcare information system utilizing SOA and a data interchange agent. This system enables the integration of patient information across various healthcare service providers, overcoming the challenges posed by different medical record structures (Batra, Sachdeva, & Mukherjee, 2015).

**Smart Healthcare Information Systems:** Liu, Li, and Liu (2014) focused on the challenges of integrating and ensuring interoperability in smart healthcare systems, especially within the radiology department. Their study proposes a pragmatic interoperability framework to guide system integration efforts (Liu, Li, & Liu, 2014).

**Big Data Interoperability:** Gupta and Gupta (2019) reviewed the need for data interoperability in healthcare, highlighting issues in achieving a fully interoperable system and proposing an architecture for secure patient data retrieval and sharing (Gupta & Gupta, 2019).

**Progress and Engagement in Sharing Patient Data:** Holmgren, Patel, and Adler-Milstein (2017) assessed the national trends in hospitals' engagement in interoperability, finding modest gains in the ability to find, send, receive, and integrate electronic patient information from outside providers. However, the use of external data in patient care was low, indicating slow progress toward interoperability (Holmgren, Patel, & Adler-Milstein, 2017).

**mHealth and Big Data Integration:** The integration of mobile health (mHealth) and big data analytics promises significant transformations in healthcare delivery, especially in rural areas where access to quality care is limited. These technologies can facilitate the creation of new delivery models integrated with existing health services, offering insights into the health status of the population for public health planning (Madanian, Parry, Airehrour, & Cherrington, 2019).

Based on the findings of past studies, the various aspects and solutions for achieving interoperability in healthcare systems, particularly with a focus on operational, technical, syntactic, and semantic levels, as follows:

#### **1. Proposal for a Federated Health Information Ecosystem:**

- A patient-centric approach, leveraging India's extensive mobile phone usage and unique identification systems (Balsari et al., 2018).
- Implementation of API-enabled health information systems to facilitate data exchange and improve service delivery (Balsari et al., 2018).

#### **2. Potential Benefits and Challenges:**

- Recognition of health informatics and big data's potential in transforming healthcare delivery and outcomes (Bandopadhyay et al. 2018).
- The promise of a learning health system where information seamlessly flows among healthcare professionals, researchers, and policymakers (Bandopadhyay et al. 2018).
- Despite the greater challenges in India, three key benefits are identified: increased research productivity, better health outcomes through improved data use, and addressing workforce gaps in both research and practice (Bandopadhyay et al. 2018).

## **V. Conclusion**

The study explores the significant strides India is making towards achieving interoperability in healthcare, underpinned by the integration of digital technologies and the government's robust policy frameworks. From the ambitious launch of the National Health Protection Scheme to the pioneering efforts in establishing a federated health information ecosystem, India is on the cusp of a healthcare revolution. The integration of

interoperability in healthcare systems, particularly through methods like SOA, data interchange agents, and the adoption of standards such as HL7, is critical for enhancing the quality of care and efficiency within healthcare systems.

The introduction of AI and ML in enhancing data interoperability further underscores India's commitment to transforming its healthcare landscape, promising improved access, efficiency, and patient care.

However, the journey ahead is filled with challenges that necessitate collective efforts in standardizing data, ensuring privacy, and bolstering infrastructure. The challenge remains in the implementation and widespread adoption of these interoperable systems to ensure that patient information is seamlessly shared and utilized across different healthcare providers.

As India moves forward, the implications of these efforts on healthcare delivery and outcomes cannot be overstated. The potential for a more integrated, efficient, and accessible healthcare system is enormous, signaling a new era of healthcare in India that could serve as a model for other countries grappling with similar challenges. Further research and proactive initiatives will be crucial in fully realizing the vision of a cohesive healthcare ecosystem that truly benefits all stakeholders.

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