India's National Digital Health Mission

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Abstract

India is using Information and Communication Technologies (ICTs) to leapfrog economic development in key sectors: health, education, infrastructure, finance, agriculture, manufacturing, and perhaps most important, governance. In doing so, India is increasing Internet penetration by increasing Internet subscribers and digital literacy. These have acted as the key drivers for the Indian Government to envision digitalization in its various sectors including health care. The Government of India laid emphasis on digitalization in India's healthcare sector in its National Health Policy, 2017. The National Digital Health Blueprint, 2019 recognized the need to put together a National Digital Health Mission (NDHM) which can act as the foundation on which national digital health ecosystem can be built. On the nation's 74th Independence Day, the Government of India embarked on its journey to achieve Universal Health Coverage by launching the National Digital Health Mission. NDHM intends to create a holistic and comprehensive digital health ecosystem that will lay the foundation of a strong public digital infrastructure, digitally empower individuals, patients, doctors, health facilities, and help streamline the delivery of healthcare services and related information. However, it is important to emphasize that the success of NDHM is dependent on its adoption by the centre and states, by public and private entities and by individuals and decision makers. It is also crucial to analyse international experiences in order to learn from their achievements and mistakes.

Introduction

In July 2018, the National Institution for Transforming India (NITI Aayog) proposed the development of a digital platform called 'National Health Stack (NHS)' with the aim to create digital health records for all the citizens of India by the year 2022(NITI Aayog, Government of India 2018). Though NHS will be built in the context of India's flagship scheme 'Pradhan Mantri-Rashtriya Swasthya Suraksha Mission (PM-RSSM)', but it will also bring all the health verticals existing at the central and state levels under one roof. In July 2019, NITI Aayog came up with a report 'National Digital Health Blueprint (NDHB)' which outlines the action plan to realize the development of National Health Stack(Ministry of Health & Family Welfare, Government of India 2019). The vision of National Digital Health Blueprint is "To create a National Digital Health Eco-system that supports Universal Health Coverage in an efficient, accessible, inclusive, affordable, timely and safe manner, through provision of a wide-range of data, information and infrastructure services, duly leveraging open, interoperable, standards-based digital systems, and ensuring the security, confidentiality and privacy of health-related personal information" (Ministry of Health & Family Welfare, Government of India 2019). The National Digital Health Blueprint (NDHB) report recommends the establishment of 'National Digital Health Mission (NDHM)' as an entity responsible for the successful implementation of National Digital Health Blueprint.

On the occasion of India's 74th Independence day, on August 15, 2020, Prime Minister Narendra Modi announced the launch of National Digital Health Mission (Press Information Bureau, Government of India 2020).

The Prime Minister said that "*From today a new campaign is going to start in the country. It is the National Digital Health Mission, which will bring a new revolution in the health sector in India*" (NDTV 2020).

The Prime Minister further added that "*Every Indian will get a Health ID card. Every time you visit a doctor or a pharmacy, everything will be logged in this card. From the doctor's appointment to the medication, everything will be available in your health profile*" (NDTV 2020).

"NDHM is envisioned to create a national digital health ecosystem that supports universal health coverage in an efficient, accessible, inclusive, affordable, timely and safe manner, that provides a wide-range of data, information and infrastructure services, duly leveraging open, interoperable, standards-based digital systems, and ensures the security, confidentiality and privacy of health-related personal information" (National Informatics Centre, Ministry of Electronics & Information Technology, Government of India. 2020)*.*

The Union Minister for Health & Family Welfare, Dr Harsh Vardhan wrote:
"The mission will go down in history as one of the game-changing policy initiatives launched in 21st-century India" (Vardhan 2020)*.*

"Based on the principles of health for all, inclusivity, accessibility, affordability, education, empowerment, wellness, portability, privacy and security by design, the NDHM will build the backbone necessary to create an integrated digital health infrastructure", Dr Harsh Vardhan further added (Vardhan 2020).

In addition, Dr Harsh Vardhan said that *"NDHM is also a purposeful step towards the achievement of the United Nations' Sustainable Development Goal of Universal Health Coverage- it encompasses key aspects of this goal including financial risk protection, access to quality essential healthcare services, medicines and vaccines for all."* (Vardhan 2020)*.*

The National Digital Health Mission (NDHM) is a part of the Ayushman Bharat Pradhan Mantri Jan Arogya Yojana (AB PM-JAY). The mission builds on the principle of *"Think Big, Start Small, Scale Fast"* (Vardhan 2020). It is the result of years of policy research and is informed by similar e-Health initiatives in other countries (Vardhan 2020). It is the first step towards self-reliance and Atma Nirbhar Bharat(Vardhan 2020). The NDHM will leverage open digital systems to integrate various digital health services and create an environment than can merge existing health information systems (Hindustan Times 2020). The ongoing COVID-19 pandemic has made the country realize the need of accessing patient's entire medical history at the click of a computer key (The Indian Express 2020). The basic idea is that patient would not require taking his/her entire medical records in polythene bags from one doctor to another for seeking medical care (Balsari 2020).

The Principal highlights of National Digital Health Mission (NDHM), as shared by Dr Harsh Vardhan, are as below:

First, National Digital Health Mission will be a voluntary scheme and citizens may choose to generate their Health ID either using Aadhaar number or mobile number and other personal details. The use of Aadhaar will not be mandatory.

Second, personal health records will be accessed and shared only after the consent of the Health ID holder. The information can be shared for a minimum of one hour to unlimited time and there will also be provision to withdraw consent at any time.

Third, the mission has been built under the umbrella of fundamental rights and other legislations such as the Personal Data Protection Bill 2019, the IT Act 2008 and the Aadhaar Act. It is also informed by the core democratic principles of cooperative federalism and the entire gamut of Supreme Court judgments. The National Digital Health Blueprint acts as a strategic and technical foundation of the mission.

Fourth, in the true spirit of 'Sabka Saath, Sabka Vikaas', there will be provision of specialized systems and off-line modules to reach out to the unconnected, marginalized, remote, tribal, hilly and digitally illiterate populations. The networks of our panchayati raj institutions, Accredited Social Health Activists (ASHAs), and Anganwadi workers (AWWs) will be leveraged to enable and empower citizens with digital technologies.

Last, but not the least, the NDHM has been designed on the principle of partnership with all the key stakeholders- citizens, technology solution providers, doctors and other health service providers. Their trust, belief, adoption, and stewardship will help this mission achieve the desired results.

The National Digital Health Mission have the following components:

Health ID (HID)
Each citizen will receive a digital health ID, a digital format of his/her entire health records which will be linked to the health facilities and registry of doctors in the nation(Hindustan Times 2020). The Health ID will help in unique identification of the individual. Each HID will be linked to a health data consent manager to seek patient's consent and allow flow of their health records across various stakeholders and systems (Drishti The Vision Foundation 2020). HID will be created using a person's basic information and mobile number or Aadhaar number(First Post 2020), It will be in the form of a mobile application and applicable across states, hospitals, pharmacies and diagnostic laboratories (First Post 2020).

"***It will be like a digitised "swasth khata" (health book) for a patient and will contain details of their medical history, physicians consulted, tests done etc.***"(First Post 2020)

Patient Health Record (PHR)
"A PHR is an electronic record of health-related information of an individual that conforms to nationally recognized interoperability standards and that can be drawn from multiple sources while being managed, shared, and controlled by the individual"(National Informatics Centre, Ministry of Electronics & Information Technology, Government of India. 2020). Unlike EHR and EMR, PHR allows patients to manage and control their own health information. The patients will be the primary account holders of their personal health record. During each hospital visit or consultation, patients will give one-time limited access of their personal health record to their doctor or healthcare providers for seeking medical care.

Electronic medical record (EMR) web application
An EMR will provide a comprehensive digital view of patient's medical and treatment history from a single health facility. This will help clinician in taking any further decisions related to the patient's follow up care. The general approach to create EMR web application will be that it should work on certain set of standards such as the data construct, medical terminologies and interoperability.

Digi Doctor Platform (Doctor's Directory)
Digi Doctor Platform is "A single, updated repository of all doctors enrolled in nation with all the relevant details of the doctors such as name, qualifications, name of the institutions, qualifications, specializations, registration number with State medical councils, years of experience, etc."(National Informatics Centre, Ministry of Electronics & Information Technology, Government of India. 2020). Doctor's Directory would be one of the essential building block of the national e-health architecture.

Health Facility Registry

The Health Facility Registry is "a single repository of all the health facilities in the country"(National Informatics Centre, Ministry of Electronics & Information Technology, Government of India. 2020). The registry would be maintained centrally and facilitate storage and exchange of standardized data from both the public and private health facilities in the nation. Health facilities would have provision of electronic processing of documents for various purposes like for empanelment, claims processing, e-signature etc.

Table 1 outlines various benefits of NDHM.

Table 1: Benefits of NDHM

| 1.	It is expected that NDHM will improve the transparency, efficiency and effectiveness of health service delivery
2.	It will allow patients to securely store and access their medical records such as diagnostic reports, prescriptions and discharge summaries in the form of a digital Health ID
3.	It will allow patients to share their medical records via digital health ID with health care providers to seek appropriate treatment and follow-up care.
4.	Patients will have access to more accurate information related to health facilities and healthcare service providers
5.	It will allow patients to access health services remotely via tele-consultation and e-pharmacies along with other health-related benefits
6.	It will empower individuals with accurate information and enable them to make informed decisions
7.	It will help improve accountability of healthcare services and of the healthcare providers
8.	It will provide access to both public and private health services
9.	It will ensure compliance of laid down guidelines and protocols for the health services
10.	It will ensure transparency in pricing of health services

Source: National Informatics Centre, Ministry of Electronics & Information Technology, Government of India. 2020. "Name Logo and Tagline Contest for National Digital Health Mission." 2020. https://www.mygov.in/task/name-logo-and-tagline-contest-national-digital-health-mission-0/.

Suggested Model for NDHM

The National Digital Health Mission will be a government owned organization with the vision "***To be the best healthcare network globally***" and the mission "***To provide every Indian with access to digital health services***"(Ministry of Health & Family Welfare, Government of India 2019). The NDHM will be set up as a new organization with joint owners or stakeholders at both the Central and State Governments. The Government will have the complete ownership of data, however the private sector could be involved as appropriate at various levels of implementation, with adequate safeguards. The structure of NDHM will comprise of two arms: one regulatory arm and the other operational arm.

Suggested Model for the NDHM is depicted in Figure 1.

Figure 1: Suggested model for NDHM
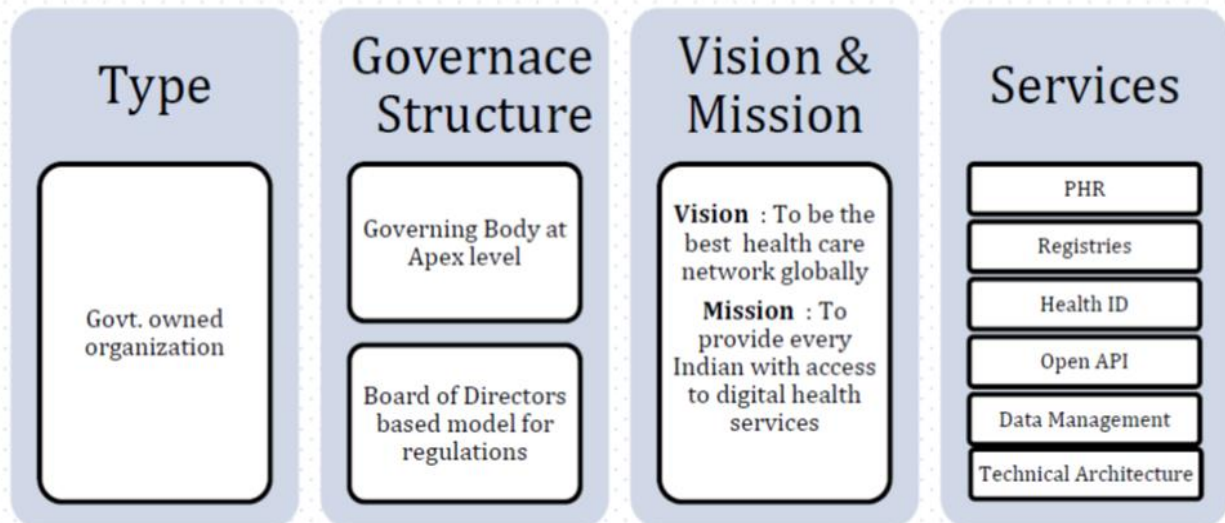
Source: Ministry of Health & Family Welfare, Government of India. 2019. "National Digital Health Blueprint Report Comments Invited." https://www.nhp.gov.in/NHPfiles/National_Digital_Health_Blueprint_Report_comments_invited.pdf.

Essential Elements

The institutional framework of the NDHM will be operational at two levels: the Governance level and the implementation level. The key elements of the the Governance architecture and the implementation architecture are given in Figure 2.

Figure 2: Key elements of NDHM

Governance architecture	Implementation architecture
• Clear and well-defined leadership structure with reasonable autonomy • Clear demarcation of roles and responsibilities • Separation of policy, regulatory and operational functions • Decentralized leadership and decision making • Robust and transparent processes and systems	• Clear leadership structure • Convergence between core ministries and departments • Citizen-centric approach and services • Conductive policies, legal and regulatory frameworks • Appropriate technology architecture, information management and security • Infrastructure expansion, planning, monitoring and evaluation in a comprehensive manner

Source: Ministry of Health & Family Welfare, Government of India. 2019. "National Digital Health Blueprint Report Comments Invited."
https://www.nhp.gov.in/NHPfiles/National_Digital_Health_Blueprint_Report_comments_invited.pdf.

Key Components

As per the National Digital Health Blueprint (NDHB), key Components of NDHM are shown in Table 2.

Table 2: Key Components of NDHM

National Health Electronic Registries	to create a single source of truth for and manage master health data of the nation;
A Federated Personal Health Records (PHR) Framework	to solve twin challenges of access to their own health data by patients and to healthcare service providers for treatment, and availability of health data for medical research - critical for advancing our understanding of human health;
A National Health Analytics Platform	to bring a holistic view combining information on multiple health initiatives and feed into smart policy making, for instance, through improved predictive analytics;
Other Horizontal Components	Including, and not restricted to, Unique Digital Health ID, Health Data Dictionaries and Supply Chain Management for Drugs, payment gateways. Shared across all health programs.

Source: Ministry of Health & Family Welfare, Government of India. 2019. "National Digital Health Blueprint Report Comments Invited."
https://www.nhp.gov.in/NHPfiles/National_Digital_Health_Blueprint_Report_comments_invited.pdf.

Roles and Responsibilities

The role of NDHM will be to provide a technology infrastructure for the purpose of collection and storage of data through various registeries which will act as backbone of information to various health ecosystem components to work together. The responsibilities of NDHM are outlined in Table 3.

Table 3: Responsibilities of NDHM

1.	Providing the technology platform for collection of core health data from the providers and patients
2.	Provide a platform for interoperability of health care data through a unique identifier for the provider and patient across the health system
3.	Improving the quality of health data collection, storage and dissemination for purposes of research and policy decisions
4.	Publish national indicators for health, to measure quality of care and progress against policy initiatives and SDG Goals
5.	Capacity building on health informatics, safety and security

Source: Ministry of Health & Family Welfare, Government of India. 2019. "National Digital Health Blueprint Report Comments Invited." https://www.nhp.gov.in/NHPfiles/National_Digital_Health_Blueprint_Report_comments_invited.pdf.

The roles and responsibilities at various levels of NDHM: Apex level, Board of Directors, CEO and Operations are outlined in Table 4.

Table 4: Roles and Responsibilities at various levels of NDHM

Level	Roles	Responsibilities
Apex Level	• Policy formulation and regulation related to National Digital Health Mission • Supervising the function of the entire National Digital Health Mission • Providing guidance to the National Digital Health Mission at the highest level	• Provide policy direction
Board of Directors	• Administrative leadership to the National Digital Health Mission • Develop policy direction for National Digital Health Mission • Develop models for self-financing of National Digital Health Mission	• Develop financing mechanism for sustainability of National Digital Health Mission
CEO	• Implement policies and decision approved by the Board of Governors at ground level • Identify models for funding Operation • Coordinate with MoHFW and the States/UTs • Engage with private sector to ensure their participation in the National Digital Health Mission • Resolve technical and operation issues at ground level • Policy administration	• CEO to have overall Execution responsibility of the National Digital Health Blueprint • Ensure private sector participation in National Digital Health Mission
Operations	• Manage Day to Day Operation at the ground level • Capacity building of Health Informatics • Ensure smooth implementation of National Digital Health Infrastructure	• Overseeing all the activities of operation including implementation, training, support and modifications

Source: Ministry of Health & Family Welfare, Government of India. 2019. "National Digital Health Blueprint Report Comments Invited." https://www.nhp.gov.in/NHPfiles/National_Digital_Health_Blueprint_Report_comments_invited.pdf.

Digital Services Provided by NDHM

The NDHM will act as the technology arm of India's Health Sector and therefore it's primary function will be to deliver technical services to various organizations in the National Digital Health Ecosystem(NDHE). A comprehensive list of services envisioned to be provided by the NDHM is given in Table 5.

Table 5: List of Digital Services provided by NDHM

S.No.	Name of the Digital Service provided
Citizen/Patient Services	
1	Single, Secure Health Id to all citizens
2	Personal Health Record
3	Single (National) Health Portal
4	App Store
5	Specialized Services for Remote Areas/ Disadvantaged Groups
6	NDHM Call Centre
7	Digital Referrals & Consultations
8	Online Appointments
9	e-Prescription Service
10	Digital Child Health
11	National "Opt-out" (for privacy)
Services by/for Healthcare Providers/ Professionals	
10	Summary Care Record
11	Open Platform to access Emergency Services
12	Technology for Practitioner (GP) Transformation
13	Digital Referrals, Case Transfers
14	Clinical Decision Support (CDS)
15	Digital Pharmacy & pharmacy Supply Chain
16	Hospital Digitization (HIS)
17	Digital Diagnostics
Technical Services	
18	Architecture & Interoperability
19	Health Information Exchange
20	Standards
21	Health Network
22	Data & Cyber Security
23	Information Governance

Source: Ministry of Health & Family Welfare, Government of India. 2019. "National Digital Health Blueprint Report Comments Invited." https://www.nhp.gov.in/NHPfiles/National_Digital_Health_Blueprint_Report_comments_invited.pdf.

NDHM Action Plan

Purpose

The proposed NDHM action plan serves various purposes as outlined in Table 6.

Table 6: Purpose of NDHM Action Plan

1.	The Action Plan enables crystallization and definition of the **Scope** and **Outcomes** of the initiative and to identify the **Methods** to be deployed for the implementation of the Blueprint;
2.	It provides the approach to **Prioritization** of various activities required to fulfil the vision and objectives of the initiatives;
3.	It paves the way for the establishment of the **Institutional Structure** at the earliest;
4.	It identifies the **Core Building Blocks** of the Blueprint and guides the action to put them in place in a logical sequence;
5.	It forms the rallying post around which can be created a widespread **awareness** of NDHB;
6.	It speeds up the process of creation of the critical mass of **capacities** and **capabilities** required for a smooth implementation of NDHB.

Source: Ministry of Health & Family Welfare, Government of India. 2019. "National Digital Health Blueprint Report Comments Invited."
https://www.nhp.gov.in/NHPfiles/National_Digital_Health_Blueprint_Report_comments_invited.pdf.

Scope

The requirements as outlined in the Table 7 defines the scope of NDHM more precisely.

Table 7: Scope of NDHM

1.	Health and Well-being for ALL;
2.	Health and Well-being at ALL Ages;
3.	Universal Health Coverage;
4.	Citizen-centric Services;
5.	Quality of Care;
6.	Accountability for Performance;
7.	Efficiency and Effectiveness in delivery of services;
8.	Creation of a holistic and comprehensive health eco-system.

Source: Ministry of Health & Family Welfare, Government of India. 2019. "National Digital Health Blueprint Report Comments Invited."
https://www.nhp.gov.in/NHPfiles/National_Digital_Health_Blueprint_Report_comments_invited.pdf.

Expected Outcomes

All the stakeholders involved at various levels of NDHM should work towards achieving a common set of goals. The NDHM action plan should be designed to achieve the expected outcomes as outlined in Table 8.

Table 8: Expected Outcomes of NDHM

S.No.	Expected Outcomes
1.	All citizens should be able to access their Electronic Health Records in a convenient manner, preferably **within 5 clicks**;

2.	Citizens need to undergo any diagnostic test **ONCE ONLY**, during the course of an episode, despite taking treatment from different health service providers;
3.	Citizens should get **Integrated Health Services** at a single point, though multiple agencies/ departments/ services providers are involved;
4.	NDHM shall assure **Continuum of Care** to the citizens, across primary, secondary and tertiary care and across public and private service providers;
5.	A framework for **Unified Communication Centre** will be prepared to facilitate voice-based services and outreach;
6.	NDHM shall support **national portability** for healthcare services;
7.	**Privacy** of personal and health data, and **consent-based access** of EHRs will be the inviolable norm that shall be complied by all systems and stakeholders;
8.	NDHM will be aligned to the **SDG's** related to health;
9.	NDHM will enable **evidence-based interventions** in the area of public health;
10.	Above all, the analytical capabilities of NDHM will support **data-driven decision-making and policy analysis**.

Source: Ministry of Health & Family Welfare, Government of India. 2019. "National Digital Health Blueprint Report Comments Invited."
https://www.nhp.gov.in/NHPfiles/National_Digital_Health_Blueprint_Report_comments_invited.pdf.

Methods and Instruments

The National Digital Health Board (NDHB) recommends the methods outlined in Table 9 for the systematic implementation of the National Digital Health Blueprint. It is recommed that activities needs to be initiated parallelly on all the items mentioned in Table 9.

Table 9: Methods and Instruments as recommended by NDHB

| 1.	Federated Architecture
2.	Universal Health Id (UHID)
3.	Electronic Health Records (EHR)
4.	Metadata & Data Standards (MDDS)
5.	Health Informatics Standards
6.	Registries for NCDs
7.	Directories of Providers, Professionals and Para-medicals
8.	Legislation and Regulations on Data Management, with focus on Privacy and Security
9.	Data Analytics

Source: Ministry of Health & Family Welfare, Government of India. 2019. "National Digital Health Blueprint Report Comments Invited."
https://www.nhp.gov.in/NHPfiles/National_Digital_Health_Blueprint_Report_comments_invited.pdf.

Suggested NDHM Action Plan

The suggested action plan for NDHM is shown in Figure 3.

Figure 3: Suggested Action Plan for NDHM
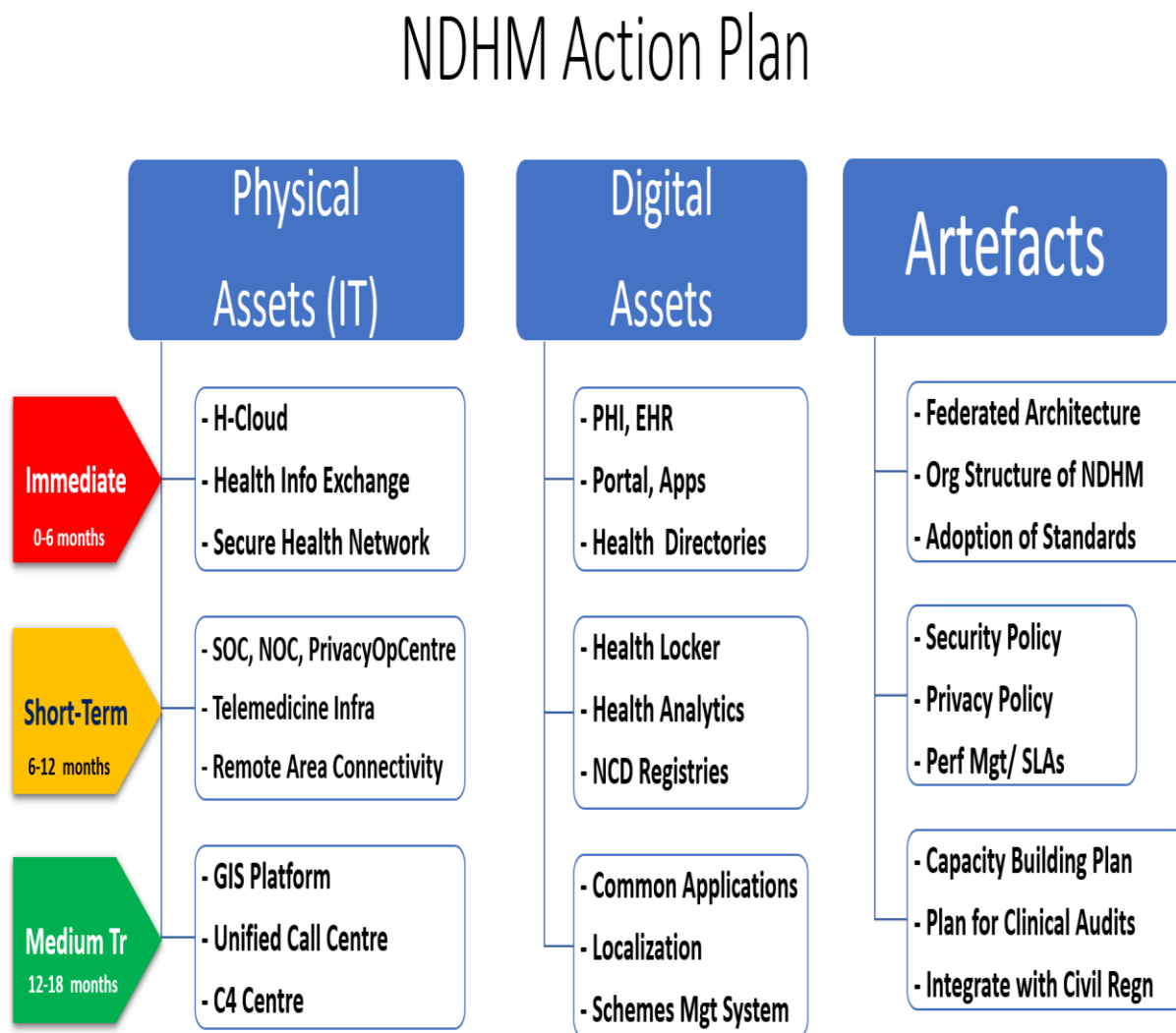
Source: Ministry of Health & Family Welfare, Government of India. 2019. "National Digital Health Blueprint Report Comments Invited." https://www.nhp.gov.in/NHPfiles/National_Digital_Health_Blueprint_Report_comments_invited.pdf.

Deliverables and Timelines

The NDHM action plan for 2019-2020 as outlined in the National Digital Health Blueprint is shown in the Table 10.

Table 10: NDHM Action Plan for 2019-2020

Timelines	Physical Deliverables	Digital Deliverables	Artefact Deliverables
Immediate (0-6 months)	1. Design, Procure H-Cloud	1. Design and establish Personal Health	1. Develop Federated Enterprise

	2. Establish Secure Health Network for accessing Core and Critical Health Data 3. Establish Health Information Exchange (HIE) for Interoperability and integration.	Identifier (PHI) 2. Design and establish Electronic Health Record (EHR) system 3. Design and Develop Core APIs 4. Design, develop and establish Consent Manager 5. Establish MyHealth App 6. Design, develop and populate Health Directories (Master data of professionals, institutions)	Architecture, adopting Agile IndEA Framework 2. Develop approach to working with States/UTs 3. Develop approach to working with private sector (health & IT service providers) 4. Assessment of Legacy Systems for conformance to NDHB 5. Design Organization Structure for NDHM 6. Design and implementation Plan for Adoption of Health Informatics Standards, including a system of incentives for adoption.
Short-term (6-12 Months)	4. Establish SOC, NOC and Privacy Operations Centre (POC) 5. Establish special connectivity and IT Infrastructure for identified Remote Areas. 6. Establish Telemedicine Infrastructure	7. Establish National Health Portal 8. Design and establish Health Locker 9. Design and Develop Health Analytics system 10. Design and Develop Anonymizer 11. Integrate PMJAY with NDHM 12. Establish NCD Registries	7. Design and notify NDHM Security Policy 8. Design and notify NDHM Privacy Policy 9. Design Performance Management System and SLAs
Medium Term (12-18 Months)	7. Establish GIS/ Visualization Platform(s) 8. Establish Health Call Centre(s) 9. Establish C4 (Command, Control & Communication Centre).	13. Design, develop and launch Common Applications including • Hospital Info Sys • Emergency Mgt Sys • E-Pharma • Wellness Centres • Mgt • Ayush • Screening • MEDucation	10. Design and implement Capacity Building Plan 11. Design and implement Plan for Clinical Audit. 12. Architecture for Integration with CRS of Registration of Births & Deaths

		• CDS(Clinical Decision Support System) 14. Localization Tools 15. Design and Develop Health Schemes Mgt system(s)	

Source: Ministry of Health & Family Welfare, Government of India. 2019. "National Digital Health Blueprint Report Comments Invited."
https://www.nhp.gov.in/NHPfiles/National_Digital_Health_Blueprint_Report_comments_invited.pdf.

Pilot launch

The National Health Authority (NHA) under the guidance of the Ministry of Health & Family Welfare is responsible for the implemention of the National Digital Health Mission (NDHM). The NDHM has been rolled out on pilot mode in six Union territories, namely, Chandigarh, Lakshadweep, Ladakh, Puducherry, Dadra and Nagar Haveli and Daman and Diu and Andaman and Nicobar Islands(DD News 2020; Press Trust of India 2020). In the first phase, four systems will be developed(Department of Public Relations & Cultural Affairs, Chandigarh, Government of India 2020). These four systems are outlined in Table 11.

Table 11: Four systems to be developed in the phase 1

Swasthya Account	Digital Health Identifier for all individuals to create their identity in the national healthcare system for ease of access to their personal health information
Digi Doctor	A comprehensive central repository of all health care providers and practitioners (HCPs), uniquely identified in India, to provide a one-stop solution for streamlined medical practice
Health Facility Registry	A comprehensive central repository of all health care facilities uniquely identified in India, which will maintain, store and facilitate exchange of standardized data
Personal Health Records	The system will digitize health records of patients' inclusive of various documents such as diagnostic report, discharge summary, prescription, etc. shared by various health establishments and doctors to help patients effectively manage their care

Source: Department of Public Relations & Cultural Affairs, Chandigarh, Government of India. 2020. "National Digital Health Mission for UT." 2020.
http://chdpr.gov.in/dashboard/?q=node/82067

International Experiences

Many nations across the world have taken initiatives to establish a nationwide digital health architecture in their countries.

Canada

In Canada, provinces and territories were responsible for delivering their health information systems. As a result, Canada developed a number of Electronic Medical Record (EMR) systems which lacked interoperability. In the year 2001, the federal Government established Canada Health Infoway (CHI) to lead e-health initiatives across Canada(Canada Health Infoway 2020a (Ministry of Health & Family Welfare, Government of India 2015). Canada Health Infoway was established with two strategic goals: first, "Providing safer access to medications, starting with PrescribeIT, a multi-jurisdiction eprescribing service" and second, "Providing Canadians and their health care providers with access to personal health information and digital health services"(Wikipedia 2019b). Canada Health Infoway provided funding to provinces for the development of interoperable e-health systems. However, the decentralised system could not succeed and in fact Canada Health Infoway (CHI) was seen as a funding agency and not as a policysetting body. The lack of a national strategy to guide the adoption, investment and implementation was seen as a problem. Some of the other problems identified include:

- There is no national patient identifier;
- The lack of interoperability of EMR offerings for hospitals, pharmacies, and clinics;
- The need for information in both French and English, which reduces the number of suitable systems;
- Patient access to personal medical records has not been standardized and varies across jurisdictions;
- Inadequate involvement of clinicians and inflexibility in approach; and
- A focus on national rather than regional interoperability.

A single comprehensive national health record system is being developed by the Canada Health Infoway (Canada Health Infoway 2020b). The 2018 Canadian Physician Survey (CPS) provide insights into how electronic medical record system could be improved. It suggests accommodating emerging patient preferences, robust billing code system, improved technology, guidelines to ensure privacy and security etc.(Canada Health Infoway 2018; Safarov 2019). In November 2018, a new initiative called 'ACCESS 2022' was launched by Canada Health Infoway. ACCESS 2022 has two strategic initiatives: ACCESS Health and PrescribeIT™[1] (Neumeier 2019). Under this initiative, all the Canadians will be able to access their own health information(Canada Health Infoway 2020a). One of the major challenges faced by Canada is the adoption and utilization of digital health by healthcare providers. To address this, Canada Health Infoway (CHI) has launched an education campaign called "Better Health Together" to raise awareness about the benefits of e-health among Canadians.

Denmark

Since 1968, all the citizens in Denmark had a unique personal ID, called the Central Person Register (Ingersoll 2016). This provided a strong advantage to Denmark while initiating the digital health initiatives in 1990s. The bottom up strategy was adopted and a large number of small projects were merged into a network of integrated projects. In 1999, a national body was formed and government issued various guidelines to further e-health initiatives in the country. In

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[1] PrescribeIT™ is a national e-prescribing service that enables prescribers to electronically transmit a prescription to a patient's pharmacy of choice. https://cjni.net/journal/?p=5972

the year 2003, Denmark launched the national e-Health portal 'Sundhed.dk'(Keutel 2018). It is an internet-based public portal which collects, distributes and exchange health care information among citizens and health care workers(sundhed.dk 2016). It provides a national access point for personal health-related data for communities, hospitals and general practitioners. A mandate was passed in the year 2004 which required General Practitioners (GPs) to use Health Information Technology (HIT). Various factors such as experience of early adopters, peer pressure and strong engagement across different sectors facilitated widespread adoption of Electronic Health Records (EHRs). The basis for digital health success in Denmark is its culture which is deep rooted in trust and the personal data being open access. The Denmark's national eHealth Portal follows the principle that healthcare issues should be resolved at the primary care level, particularly by the general practitioners (GPs).

The CEO of the Danish eHealth portal, Morten Elbæk Petersen views "***the healthcare digitisation as an opportunity to safeguard the personal responsibility of patients and to make citizens equal partners in their interactions with healthcare workers. This should be achieved step by step, 'so that citizens feel safe and experience the advantages of data exchange and transparency"***(Keutel 2018)*.

United Kingdom

In United Kingdom, NHS Connecting for Health (CFH) Agency was established in the year 2005 as a part of Department of Health Informatics Directorate to establish a national Information Technology(IT) infrastructure(Wikipedia 2020b). The agency was responsible for delivering 'NHS National Programme for IT (NPfIT)' for NHS England through a centralized NHS Care record system (NHS CRS) (Wikipedia 2020b). However, in March 2013, the agency stopped functioning and was taken over by the Health and Social Care Information Centre(Wikipedia 2020b). In August 2016, Health and Social Care Information Centre was renamed as "NHS Digital" (Wikipedia 2019c). The National Health Services-Digital (NHS Digital) in England is the national provider of data, IT systems and information in health and social care sector in England. Currently, NHS Digital provides centralized NHS Care record system (NHS CRS) in England(Wikipedia 2019c). NHS CRS allows patients to have control over their own records such as book hospital appointments and enables General Physicians across NHS England to access patients' electronic records (Ministry of Health & Family Welfare, Government of India 2015).

In 2011, NHS National Programme for IT (NPfIT) was stopped early because it did not deliver key benefits. Many factors were responsible for its failure such as lack of support from key stakeholders e.g. clinicians, lack of adaptive change e.g. changes in the way people work alongside the technological change etc.(The Comptroller and Auditor General, National Audit Office 2020). The National Audit office conducted a review of the progress made by NHS national bodies in mitigating the causes of the failure of the National Programme for IT (the Programme). The key findings of the review are highlighted in Figure 4.

Figure 4: National Audit Office review of progress made by NHS national bodies in mitigating the causes of the failure of the National Programme for IT (the Programme)

Progress made by NHS national bodies in mitigating the causes of the failure of the National Programme for IT (the Programme)

Although national bodies have responded to problems identified with the Programme when planning their current work, risks remain in all areas

	Problem identified by the Wachter Review	National Audit Office assessment
1	Lack of national engagement with clinical staff: focus on technology not the service change and adaptive change (by the workforce) needed.	Clinicians are now more involved in national programmes and digital leadership of trusts. But national programmes are still more focused on technology than on adaptive change.
2	Controlled, top-down approach to implement standardised IT systems, with insufficient support of local organisations and professionals.	The national approach is to prescribe standards but not IT systems (which trusts can choose). It is likely there will be more diversity in the approaches used. There is little national support available for local implementation of systems and the corresponding adaptive change required by trusts' workforces.
3	Felt to be politically-driven with a rushed deployment. Unrealistic expectations and too much additional work was added to the original scope.	There is a target to reach a 'core level of digitisation' by 2024 but the implementation plan has not yet been produced. Implementation is likely to take many years, during which time there might be pressure to increase the scope to incorporate new technological advances.
4	Trusts felt they lacked central support to implement the systems (despite a substantial funding allocation).	It is unclear whether national bodies have allocated sufficient funding to deliver the strategy. Even the existing cost estimate assumes trusts will meet £3 billion of the costs, but they might not be willing or able to do so.
5	Procurement and contracting arrangements were problematic, with nearly-impossible delivery timeframes and contracts in which scope was unclear.	National procurement arrangements are more flexible, with national bodies providing a non-mandatory framework for trusts. There could be significant procurement and contract risks at a local level.
6	Continuous leadership changes and a shortage of individuals with relevant skills.	There has been a high turnover of senior staff at the national level, and NHSX is not fully staffed. There is a general shortage of digital skills in the NHS.

Note

1   The full reference of the Wachter Review is: National Advisory Group on Health Information Technology in England, *Making IT Work: Harnessing the Power of Health Information Technology to Improve Care in England*, 2016.

Source: National Audit Office analysis of the Wachter Review

Source: The Comptroller and Auditor General, National Audit Office. 2020. "Digital Transformation in the NHS," 57. https://www.nao.org.uk/wp-content/uploads/2019/05/Digital-transformation-in-the-NHS.pdf

United Kingdom approach to develop national e-health architecture provides a number of lessons for other countries for implementing e-health initiatives. Some of them are as below:

- The government in United Kingdom followed a highly centralized top down approach for building NHS National Programme for IT (NPfIT). In the hastle to realise the expected benefits, the program implementation failed to adequately collaborate with key stakeholders in the political, technical, clinical, academic and other sectors
- Rather than focusing on the delivery of clinical services, the program had a narrow focus of delivering an Information Technology (IT) system
- The required foundations such as clinical coding and standards, information system architecture and information governance were not established by the UK government at first which could have helped in procuring big commercial contracts for IT services
- The fundamental changes which were needed in the clinical protocols, organizational cultures and ways of working were not adequately taken into consideration

In 2011, when NHS National Programme for IT (NPfIT) was abandoned, the Minister for Health, Simon Burns, stated that "a centralised, national approach is no longer required, and that a more locally-led plural system of procurement should operate, whilst continuing with national applications already procured"(Marsh 2011).

United States

In United States of America, the Office of National Coordinator for Health Information Technology (ONC) was established in the year 2004 as a part of the U.S. Department of Health and Human Services to lead national digital health initiatives across the country(Ministry of Health & Family Welfare, Government of India 2015). The mission of the ONC is to "Improve the health and well-being of individuals and communities through the use of technology and health information that is accessible when and where it matters most"(HealthIT.gov. 2019). In the year 2009, Health Information Technology for Economic and Clinical Health (HITECH) Act was passed under which the ONC was given the task of developing a national health information system in the country(Ministry of Health & Family Welfare, Government of India 2015).

To accelerate the adoption of health information technology, the U.S. Federal Government launched the 'meaningful use' incentive program as a part of the Health Information Technology for Economic and Clinical Health (HITECH) Act in the year 2009(Center for Surveillance, Epidemiology, and Laboratory Services (CSELS), U.S. Centers for Disease Control and Prevention (CDC) 2019). In 2011, five largest health systems in the United States, namely, Kaiser Permanente, the Mayo Clinic, Geisinger, Intermountain Healthcare and Group Health, announced a plan to share patient data through a collaboration called the Care Connectivity Consortium with the mission to deliver patient-centred, high-value health care to US citizens. It was believed that to realize the mission of Care Connectivity Consortium, electronic health information interoperability and connectivity would be critical. However, the nationwide interoperability still remained a challenge. Several barriers remained that inhibited the nationwide interoperability. Some of them are enlisted below:
- There is no universal patient identifier
- Electronic health information is not structured or standardized to the extent that it can be fully computerized
- Lack of financial motives to share information

- Differences in relevant statutes, policies and regulations
- Lack of reliable and systematic method to establish trust across different networks
- Patient portals don't connect with multiple providers and therefore provide less value for patients, especially for those who receive treatment from multiple providers for chronic or complex conditions.

As a requirement under HITECH Act, the ONC is required to submit report to the congress on annual basis to update on the progress made on the adoption of nationwide health information system. As per 2018 report to the congress: "As of 2015, 96 percent of nonfederal acute care hospitals and 78 percent of office-based physicians adopted certified health IT"(The Office of National Coordinator for Health Information Technology (ONC),The U.S. Department of Health and Human Services 2018). The report provided further recommendations to accelerate the progress of adoption of national health information system such as upgradation of technical capabilities, improved transparency, collaboration etc.

New Zealand

New Zealand government has moved gradually from a regional to a national approach. All the General Practitioners (GPs) across the nation already use electronic medical record system to maintain patient clinical records. Also, a universal unique patient identifier governed by a robust legal health information privacy code is well established in New Zealand. However, different regions use different systems and the overall landscape is highly diverse. In 2010, the National Health IT Board has put forward a four-year plan to build on already proven successes. They looked at what had already been achieved in various parts of New Zealand and planned to lift all the regions up to their strengths. In October 2015, the government of New Zealand announced plans to develop a national electronic health record (EHR) system with the aim to increase the productivity and quality of care(Information & Data Manager (IDM) 2015). The ministry has planned to use a phased approach to lift all the regions up to the standard of good practice(McBeth 2019). An independent review of New Zealand's electronic health strategy states that before beginning the implementation of the technology, it is crucial to spend significant time on various aspects such as strong leadership, design thinking, clinical standardization, process harmonization etc.(Deloitte 2015).

Singapore

With the aim of "One Patient, One Health Record", the Ministry of Health (MOH), Singapore launched National Electronic Health Record (NEHR)(Integrated Health Information Systems (IHIS) 2020). The system is managed by the Integrated Health Information Systems (IHiS). The deployment of NEHR was initiated in the year 2011 and as of September 2014, the system has been rolled out in all the public hospitals, nursing homes, specialist centers, polyclinics, 230 General Practitioners (GPs) and several community hospitals(Integrated Health Information Systems (IHIS) 2020; Ingersoll 2016). The system provides a national patient identifier through which patient's health records could be accessed after taking patient's consent.

Singapore is following a phased approach to implement the National Electronic Health Record (NEHR) system. Singapore will incorporate lessons learnt during each phase, make technology changes and build Information Technology (IT) capacity of the healthcare workers and clinicians accordingly. It will take another five to ten years to fully implement the NEHR System in the

country. The key factors behind Singapore's success include incremental, multi-stakeholder approach, strong government support and the reluctance to rush the implementation of NEHR system. Further, Singapore has additional advantages like its small size and practice of sharing patient data by public hospitals since 2004.

Australia

In Australia, the National e-Health Transition Authority (NEHTA) was established in July, 2005 with the aim to explore new ways of collecting and exchanging electronic health information (Wikipedia 2019a; Ministry of Health & Family Welfare, Government of India 2015). It was formed conjointly by the federal, state and territory governments with the purpose "to lead the uptake of eHealth systems of national significance and to coordinate the progression and accelerate the adoption of eHealth by delivering urgently needed integration infrastructure and standards for health information"(Wikipedia 2019a). In the year 2010, NEHTA began the work to develop a national e-health architecture and Personally Controlled Electronic Health Record (PCEHR) system in the country(Wikipedia 2019a). In the year 2012, the PCEHR system was turned on(Wikipedia 2020a). However, in November 2013, when the Australian government undertook a review of PCEHR system, it was suggested that NEHTA should be discontinued(Australian Government 2020). Following, the 2015-2016 federal budget announced the establishment of Australian Digital Health Agency which took over the work of NEHTA from 1st July, 2016 (Australian Government 2020). Australian Digital Health Agency extended the work of establishing PCEHR system, now called as "My Health Record" system(Wikipedia 2020a). "My Health Record" is a centralized patient electronic records system in Australia which allows patients to have control over their own health information and help doctors access patient's health records(Nishith Desai Associates 2020).

The report by National E-Health Transition Authority (NEHTA) outlines the achievements, lessons and opportunities during the course of its ten-year work (Ingersoll 2016). Three main themes were discussed in the report.

Theme 1: Multi-level tensions
There are key tensions that affect e-Health initiatives at various levels: the system, organization, and program levels. Some of these are: whether e-Health initiatives should be more technology centric or clinical community led; whether e-health initiatives should be led by centralized command and control or it should have diffused power; whether there should be open, community-led development of the e-Health architecture or there should be directed development; whether participant should be involved in the health system or stand apart as a bystander; and which approach should be adopted - market intervention approach or free market approach.

Theme 2: Organizational and system competencies
The organizational and system competencies that are crucial for the success of e-Health initiatives are outlined in Table 12.
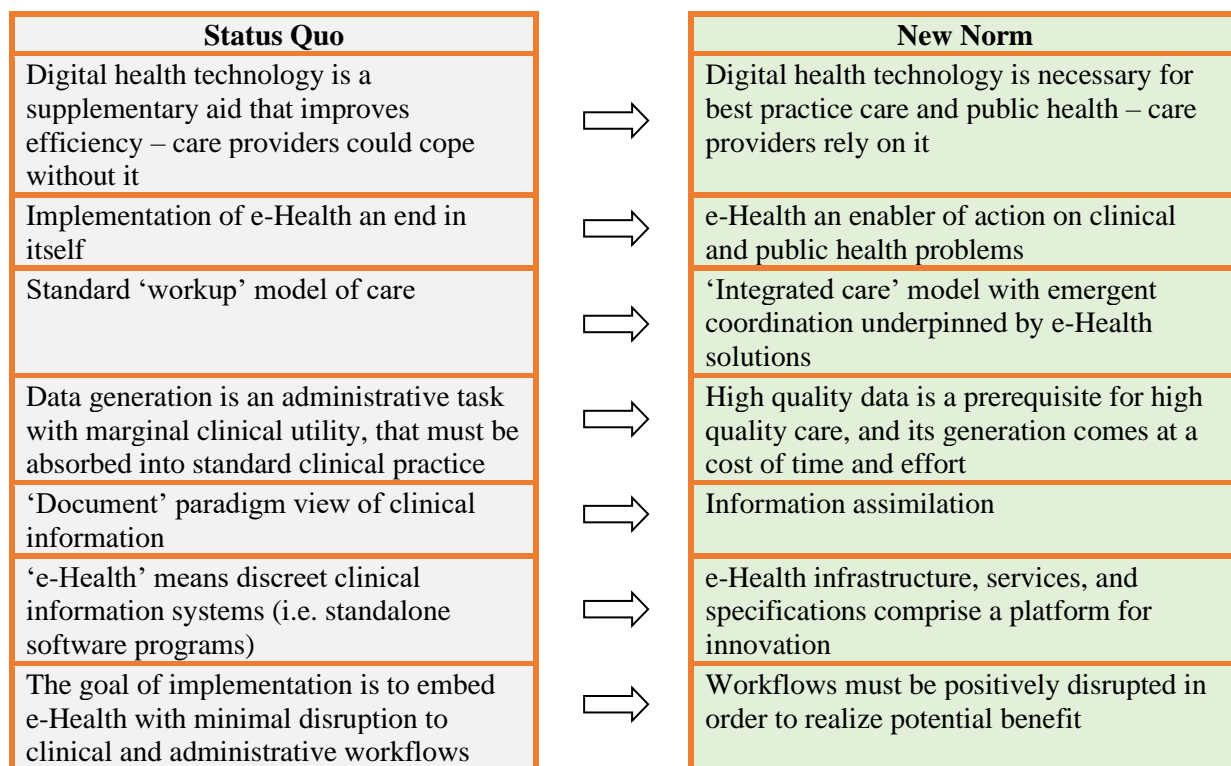
Table 12: Key Competencies

1.	Having a strategy, and then working to it;
2.	Relationship building and collaboration;
3.	Capacity to rapidly iterate;
4.	Taking into account clinician and end-user experience;
5.	Using structural adjustment and market alignment mechanisms;
6.	Change management;
7.	Measurement, evaluation, and benefits management;
8.	Implementation capability.

Source: Ingersoll, Andrew. 2016. "Achievements, Lessons, and Opportunities," 70.
https://www.digitalhealth.gov.au/about-the-agency/publications/reports/benefit-and-evaluation-reports/evolution-of-ehealth-in-australia-achievements-lessons-and-opportunities/Evolution%20of%20eHealth%20in%20Australia_Publication_20160517.pdf

Theme 3: Necessary cultural shifts

There are a number of important cultural shifts that are needed across the health system in order to realize the full benefit of e-Health. The necessary cultural shifts that are needed are outlined Figure 5.

Figure 5: Necessary Cultural Shifts

Status Quo	New Norm
Digital health technology is a supplementary aid that improves efficiency – care providers could cope without it	Digital health technology is necessary for best practice care and public health – care providers rely on it
Implementation of e-Health an end in itself	e-Health an enabler of action on clinical and public health problems
Standard 'workup' model of care	'Integrated care' model with emergent coordination underpinned by e-Health solutions
Data generation is an administrative task with marginal clinical utility, that must be absorbed into standard clinical practice	High quality data is a prerequisite for high quality care, and its generation comes at a cost of time and effort
'Document' paradigm view of clinical information	Information assimilation
'e-Health' means discreet clinical information systems (i.e. standalone software programs)	e-Health infrastructure, services, and specifications comprise a platform for innovation
The goal of implementation is to embed e-Health with minimal disruption to clinical and administrative workflows	Workflows must be positively disrupted in order to realize potential benefit

Source: Ingersoll, Andrew. 2016. "Achievements, Lessons, and Opportunities," 70.
https://www.digitalhealth.gov.au/about-the-agency/publications/reports/benefit-and-evaluation-reports/evolution-of-ehealth-in-australia-achievements-lessons-and-opportunities/Evolution%20of%20eHealth%20in%20Australia_Publication_20160517.pdf

South Korea

In South Korea, the Ministry of Health and Welfare (MOHW) established an organization for the development of Electronic Health Records (EHRs) system in the country. Several advisory committees were also formed for the purpose of providing expert opinions and policy directions. Two centres, namely, Implementation Center for Development and Research, and Development Center for EHR were established for the purpose of system development and carrying out the related research. Various factors such as user-friendly, reliable and cost-effective IT platform, strong support from various stakeholders, standards, budgets, law, etc. helped South Korea in establishing a successful e-health infrastructure.

Sweden

In Sweden, a company called 'Inera' is responsible for the coordination of national e-health services in the country (Lithner 2017). Inera is owned by 21 county councils and (soon) 290 municipalities (Zetterström and Marklund 2017). Inera is responsible for the provision of national e-health services, development of national health information exchange infrastructure and standards. Sweden's National Strategy for eHealth describes certain prerequisites that should be adapted in order to successfully deploy National e-Health (The Ministry of Health and Social Affairs ,Government of Sweden 2010). It states that e-Health services should be designed in ways that are accessible and user-friendly to citizens including persons with disabilities. It also highlights the importance of parallel and coordinated efforts from all the responsible actors at various levels- central, regional etc. Technical infrastructure, information structure, user-friendly and appropriate documentation, uniform terminology and standards are some of the other prerequisites. Further, it states that the laws, ordinances, regulations and guidelines which govern activities related to health and social care must reflect the technological development and should be revised regularly.

According to Sweden national e-health vision 2025 "In 2025, Sweden will be the best country in the world in using digitizing and e-health services in order to support the citizens to achieve a good and equal health and welfare, and to develop and strengthen their own resources for increased independence and social participation"(Lithner 2017). Their focus is mainly on three things, namely, terminology, technical standards and laws and regulations.

Lessons for India

International experiences provide a number of key lessons for India. Some of these are enlisted below:

- The government should plan to adopt an incremental, phased approach to implement the mission. Lessons from each phase should be incorporated for further improvement. Experiences of early adopters would be vital in scaling up the mission.
- A multi-stakeholder approach should be adopted, and national e-health system should be flexible enough to adapt to the needs of the various stakeholders involved. Parallel and coordinated efforts from all the responsible actors would be crucial.
- A national strategy should be developed to guide the adoption and implementation of the mission. The strategy must take into account the strengths and weaknesses of various regions in India and develop an approach to lift all the regions up to the standard of good practice. Further, as implementation will take many years, there should be scope to incorporate new technology advances.
- The focus should be on the delivery of improved quality of clinical services and not merely on the delivery of an Information Technology (IT) system. It is important to make necessary changes to the clinical protocols, organizational cultures and administrative workflows in order to realize the potential benefits of the mission.
- A universal unique patient identifier is the key to national interoperability and government should ensure that it is governed by a robust legal system.
- It is important to establish the required foundations such as information system architecture, clinical coding and standards, process harmonization and information governance before moving on to the implementation of the technology.
- The national e-Health services should be available in all the regional languages of India.
- The national e-Health services should be designed in ways that are accessible and user-friendly to citizens including persons with disabilities.
- The country must seriously rethink what needs to be documented, when, why and by whom in order to streamline the exchange of useful data.
- In order to enable seamless exchange of data, it is important that all users must be incentivized or mandated to use a standard language to communicate.
- To avoid straining the over-burdened doctors and health care workers, advance technologies such as voice recognition, natural language processing, and machine learning should be adopted.
- Efforts need to be directed towards building digital skills of health workers.
- The government should develop a strategy to raise mass awareness about the benefits of the national e-Health services.
- An independent review committee should be formed to review the progress of the mission on regular basis.
- The government of India must bring together the country's medical, legal, IT and other relevant systems under one roof to translate the NDHM's vision into a reality.

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