Enterprise Architecture Blueprint for Bhutan Health System
(Health Sector Development Program)
Progress Report (Blueprint for HIS)

Presented to

Ministry of Health,
Royal Government of Bhutan
&
Asian Development Bank
Manila, Philippines

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List of Abbreviations Used

1. DHIS2 – District Health Information System V2
2. DITT – Department of Information Technology & Telecommunications
3. DMS – Department of Medical Services
4. DOMSHI – Department of Medical Supplies and Health Infrastructure
5. DoPH – Department of Public Health
6. EA - Enterprise Architecture
7. eHealth - Information and communications technologies in healthcare
8. ePIS - electronic Patient Information Systems (HIS Project of MoH)
9. HIS - Hospital Information System
10. HMIS – Health Management Information
11. ICTD - Information Communications and Technology Division (MoH)
12. JDWNRH – Jigme Dorji Wangchuck National Referral Hospital
13. MCH – Maternal and Child Health
14. MoH – Ministry of Health (Bhutan)
15. MOIC – Ministry of Information and Communication
16. NEWARSIS – National Early Warning Alert & Response Surveillance Information System
17. PHC - Primary Health Centres
18. PPD – Policy Planning Division (MoH)
19. RCDC – Royal Centre for Disease Control 2
20. RGoB – Royal Government of Bhutan 21. RRH – Regional Referral Hospitals

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1.0 Purpose

The purpose of this report is to provide a blueprint for the Health Information System/Electronic Patient Information System for the Bhutan Government Ministry of Health. The blueprint provides schematic diagrams of current and target architectures using an EA framework based on the TOGAF-enabled OpenHIE framework.

2.0 Background

According to the Bhutan Constitution, the “State shall provide free access to public health services in both traditional and allopathic medicines”. In order to realize this mandate, the RGoB has been using ICT as an enabler to deliver health services. The MoH, RGoB has introduced various digital solutions and platforms in its efforts to improve quality of health care services. The MoH also has developed the ‘eHealth Strategy and an Action Plan’ in the context of the 12th Five Year Plan for Bhutan (2018-23). Phase 1 of the Action Plan spanning over 2018-19 emphasized ehealth governance framework and improvements to existing public health reporting systems. Phase 2 of the Action Plan requires the development of an enterprise architecture (EA) for health information systems (HIS).

The National Health Policy 2011 states, "use of e-Health and telemedicine shall be pursued as alternative and complementary methods to enhance access to quality diagnosis and care to the people in the periphery" and "digitized health record and information systems shall be instituted in all the health facilities for faster and effective health information generation to support decision making".

MoH has embarked on the development of a comprehensive health information system (HIS) to store medical records of all patient visits to the Referral hospitals and community health clinics. This system will be integrated with existing data collection systems promoting population health. The development of HIS is one of the flagship projects in Bhutan’s 12th Five Year Plan. The MoH sought proposals for the development of such a system known as Electronic Patient Information System (ePIS). The MoH is currently evaluating the proposal.

CC and C Solutions (CC&C) was awarded a contract

- To map the current digital health ecosystem, by undertaking a review of the existing health information systems.
- Develop the Blueprint for health information system (HIS) and outline an implementation framework for the same describing the interoperability standards to be used. It has been suggested to develop the blueprint using an appropriate framework such as the OpenHIE framework.

The Blueprint and associated technical standards will be used for the development of the HIS.

CC and C Solutions provided a ‘Project Inception and ehealth Readiness’ report to Bhutan MoH and ADB in June 2020 documenting existing systems after extensive virtual online consultations with ICT and health professionals.

This Progress Report (blueprint for HIS) was developed after extensive consultation with MoH ICT staff, OpenHIE reference architecture, and reviewing the terms of reference referred to in the tender for ePIS.

3.0 Bhutan eGovernment Architecture

Bhutan has embarked upon a journey of a networked government through initiative of Electronic Government Interoperability Framework (e-GIF). The e-GIF, in the broad sense, is a Government Enterprise Architecture (GEA) to define standards and best practices to enable ICT systems to better integrate and interoperate across the Royal Government of Bhutan (RGoB), and to align IT investment to the government business functions. Its objective is to serve as an overarching framework comprising of standards, guidelines, artefacts and best practices for government agencies to comply and re-use.

The four domain architectures for Royal Government of Bhutan are:

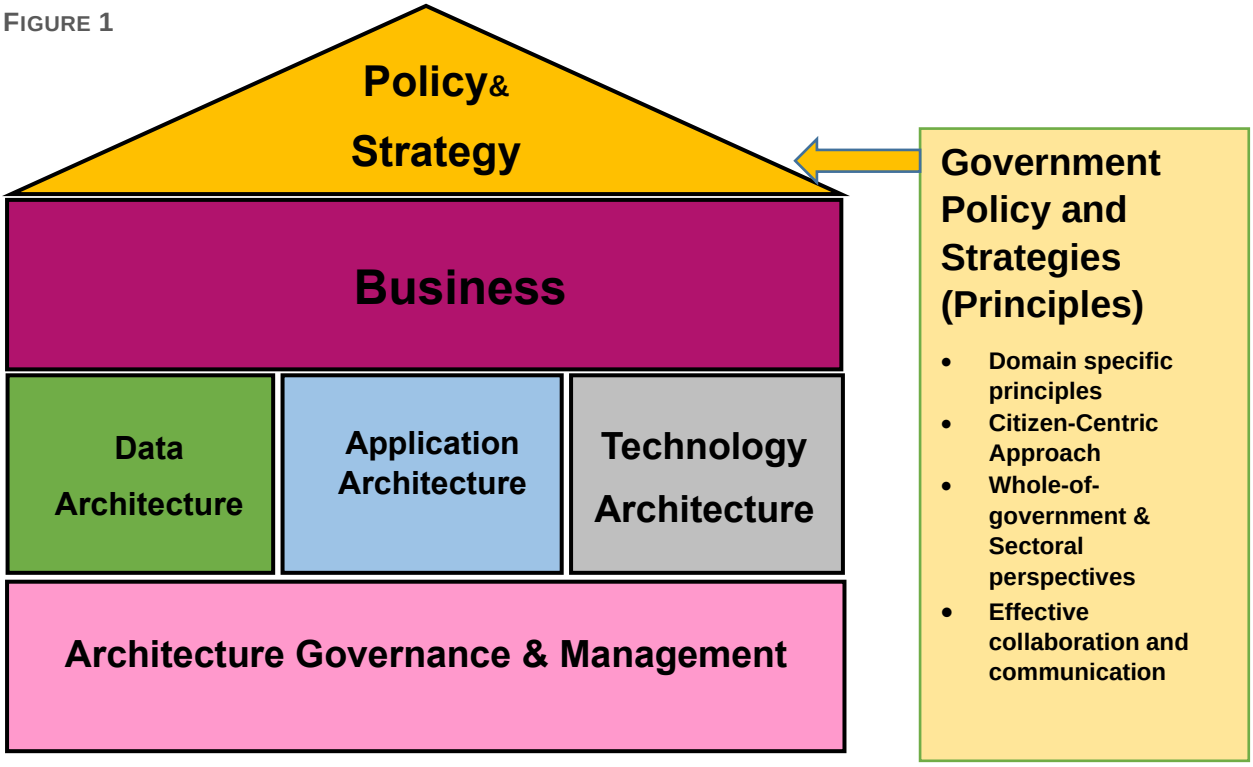
- Business Architecture
- Data Architecture
- Application Architecture
- Technology Architecture

In addition to the architectures, e-GIF have Technology Standards, Enterprise Data Dictionary, and Data steward & Ownership guidelines.

The high-level diagram of eGovernment Interoperability framework is presented below.

It can be observed from the diagram that policies and strategies drive the business architecture. The business architecture and functions determine the data architecture and associated applications which are implemented with technologies using service-oriented architecture.

FIGURE 1



The figure below is a high-level representation of Bhutan eGovernment Business Architecture. The business architecture diagram has a placeholder for the Ministry of Health which is responsible for all health-related functions.

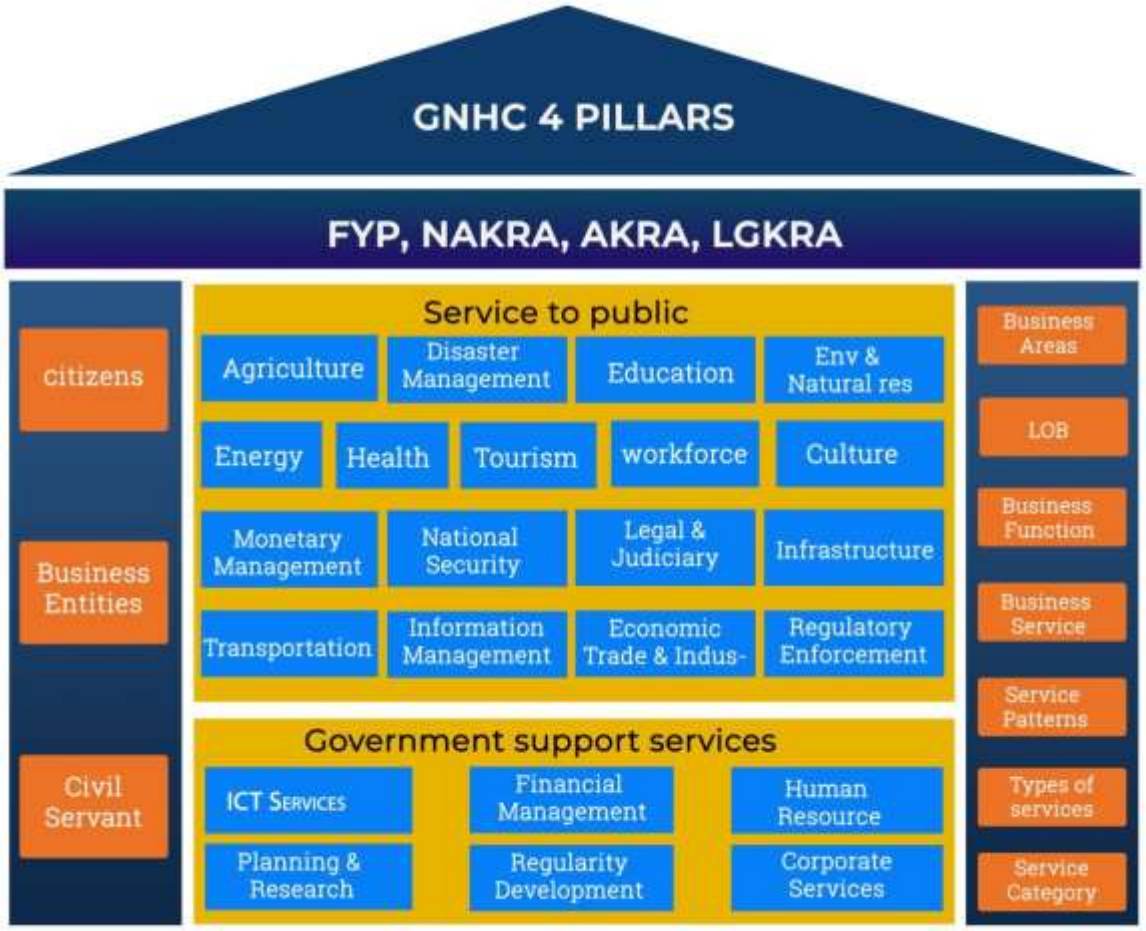


FIGURE 2

This document on EA blueprint describes the MoH functions and how it fits into the overall eGov architecture.

4.0 Bhutan Ministry of Health Architecture

4.1 Architecture Drivers

The MoH vision is to become a nation with the 'Best Health'. The mission statement highlights the following important areas:

- To provide quality healthcare services in both traditional and modern medicines.
- To prevent, control, eliminate and eradicate diseases.
- To rehabilitate and promote healthy living.
- To ensure, sustainable, responsible, equitable, accessible, reliable, and affordable health services.

The mandate is to ensure access, equity, and quality health services.

WHO Framework on integrated people-centred health services addresses the following:

- **Equity in access**: For everyone, everywhere to access the quality health services they need, when and where they need them.
- **Quality**: Safe, effective, and timely care that responds to the people's comprehensive needs and are of the highest possible standards.
- **Responsiveness and participation**: Care is coordinated around people's needs, respects their preferences, and allows for people's participation in health affairs.
- **Efficiency**: Ensuring that services are provided in the most effective setting with the right balance between health promotion, prevention, and in- and -out patient care, avoiding duplication of resources.
- **Resilience**: Strengthening the capacity of health actors, institutions, and population to prepare for, and effectively respond to public health crisis.

The following architecture drivers can be derived from above to achieve the desired vision.

1. Provide quality, efficient, and affordable healthcare services in both traditional and allopathic medicine.
2. To promote interoperable ehealth systems so that health information can be shared between operational and planning staff of MoH.
3. To enhance disease surveillance systems, and promote healthy living amongst citizens

4.2 As-IS (current) Architecture

A detailed description of existing applications and their functions were presented in the Inception and eHealth Readiness report. The list of applications is listed in Appendix A.1.

The existing architecture is described in business, data, application, and technology layers in Table 1

The existing applications satisfy the requirements of public health reporting and disease control.

4.3 Gap Analysis

The information processing at the Referral hospitals is mostly manual. It is difficult to get historical medical record information of a patient visit to multiple clinics and hospitals. Also, any disease data from the medical records are compiled manually and submitted to DHIS2 for public health reporting purposes.

JDWNRH hospital staff are able to access the Lab and Radiology (PACS) information online. Staff at other Referral hospitals and some District hospitals have online access to Lab information from the stand-alone LIS system installed in their facility only. Currently this information is not able to be shared with other hospitals.

From the Table below, it may be observed that there is no data integration layer. It is also possible that there is duplicate information stored in DHIS2.

'As is' Architecture (Current State)

Domain/ Responsible Deapartments	Business Domain	Data Domain	Application Domain	Technology Domain
Responsible Department & Business Function	Public Health/Policy Planning Division Population Health	Aggregate Data for Diseases	DHIS2/Locally Developed applications	Servers in DITT Facility internal network
	DOMSHI Medical/Non-Medical Supplies	Inventory/Orders of Medical/Non-medical Supplies	eBMSIS	Servers in DITT Facility internal network
	Public Health/RCDC Early Disease warning & control	Notifiable Diseases Events	DHIS2/NEWARSIS/ Manual	NEWARS server in RCDC
	DMS JDWNRH Referral/District Hospitals Health Service Delivery	Medical Records Patient Demographics History Procedures	Manual	Manual
	DMS JDWNRH Health Service Delivery	LAB Results PACS	Online viewing LIS software Ostrich foundation software	Semi-automatic
	Other Referral Hospitals/District Hospitals Health Service Delivery	LAB Results	Online Viewing LIS Software	Semi- automatic

TABLE 1

The information from the health systems is used by many divisions within the Ministry of Health. The data for producing the information is collected by front line staff manually. At times multiple forms are filled to satisfy the requirements of different divisions.

5.0 Reference Architecture

In EA, the concept of reuse is supported through the use of Reference Architectures. Refence architecture is a template architecture, reusable pattern, for a specific architectural subject area. Reference architecture provides detailed architectural information so that solutions can be repeatedly be designed and subsequently deployed in a manner that is consistent, high quality and supportable.

The blueprint for MoH enterprise architecture has been developed using TOGAF®-enabled OpenHIE as a reference architecture. OpenHIE architecture is described below:

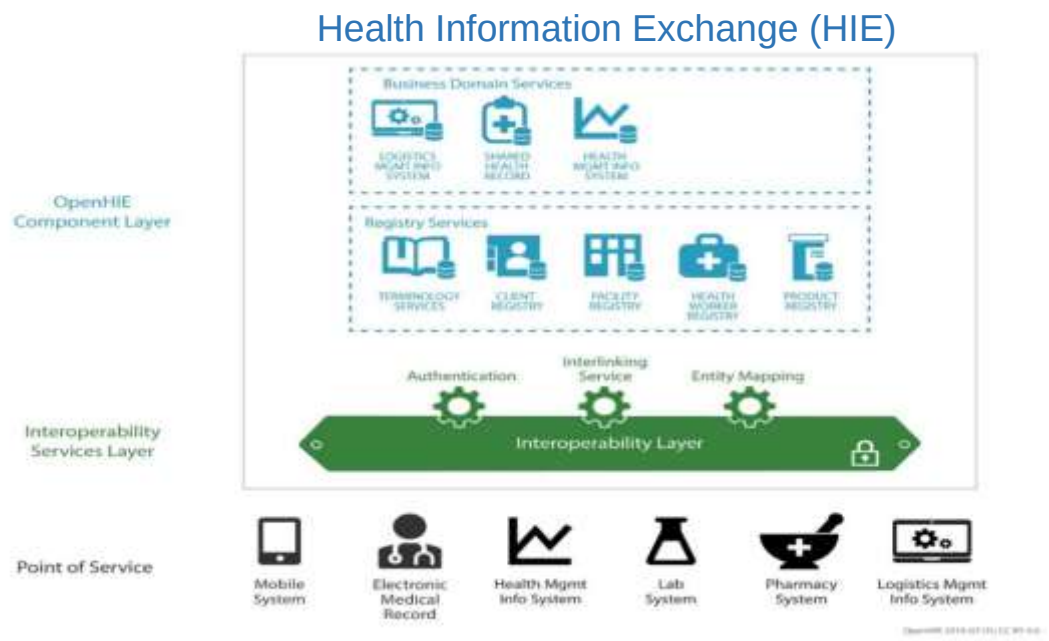


FIGURE 3 SOURCE: OPENHIE 2019-07-01; CC BY4.0

A Health Information Exchange (HIE), the shared infrastructure in the figure above, makes the sharing of health data across information systems possible. Like a universal translator, an HIE normalizes data and secures the transmission of health information throughout databases, between facilities, and across regions. OpenHIE's architecture is made up of conceptual software components, all interacting/interoperating to ensure that health information from various external systems is gathered into a unified person-centric medical record. To accomplish this, the exchange normalizes the context in which health information is created across multiple dimensions:

1. Who received health services,
2. Who provided those services,
3. Where did they receive the services,
4. And what specific care did they receive.

By focusing on the "For Whom"," By Whom," "Where," and "What" of a patient's health visit, OpenHIE helps to bring relevant information directly to the point of care. This supports enhanced decision-making, improves the quality, safety, and continuity of care, and facilitates appropriate use of information to improve population health.

A brief description of the architecture components is provided below:

a) Client Registry
   An enterprise master patient index (EMPI), or ***Client Registry*** manages the unique identity of citizens receiving health services with the country – "For whom"
b) Facility Registry

A ***Health Facility Registry*** serves as a central authority to uniquely identify all places where health services are administered within the country – "Where?"

c) Health Worker Registry

A ***Provider Registry*** is the central authority for maintaining the unique identities of health providers within the country – "By whom"

d) Product registry

A ***Product Registry*** is a repository containing the medical and non-medical products, e.g. Medicines and linen.

e) Terminology Services

A ***Terminology Service*** serves as a central authority to uniquely identify the clinical activities that occur within the care delivery process by maintaining a terminology set mapped to international standards such as ICD10, LOINC, SNOMED, and others – "What?"

f) Shared Health Record

A ***Shared Health Record*** (SHR) is a repository containing the normalized version of content created within the community, after being validated against each of the previous registries. It is a collection of person-centric records for patients with information in the exchange.

g) Health Interoperability Layer

A Health Interoperability Layer receives communications from point of service applications and orchestrates message processing between the point of service application and the hosted infrastructure elements.

All the above logical components are contained in a physical form and can integrate using service-oriented architecture (SOA) concepts.

5.1 Healthcare Capabilities with people, process, and technology

The capabilities define how people, process, and technology work together to achieve a range of desired outcomes thereby making healthcare more effective, safer, responsive, accessible, efficient, and sustainable.

The healthcare capability model consists of:

- Foundations
- eHealth solutions
- eHealth services

The foundations consist of patient registry, provider registry, secure messaging, authentication, access control, clinical terminology directory and template services. Foundations provide the common infrastructure and standards crucial to enabling a consistent approach to interoperability.

The ehealth solutions consist of pathology, diagnostic imaging, medications management, telehealth, care planning and coordination.

eHealth services can be provided effectively and efficiently if people are trained and skilled to make use of the foundations and solutions.

6.0 Proposed Blueprint for MoH HIS Architecture

Traditional development of ICT applications exhibited a disconnect between business objectives and application function. On the other hand, the EA development method ensures that the business goals and requirements are developed from the architecture drivers and vision and mission statements. The business requirements determine the business functions performed in the MoH. The business functions will in turn determine information needs. Applications will be designed to capture and store the required information using appropriate technology.

The blueprint for the HIS is described in terms of business, information, and technology areas. The health service management and reporting functions of MoH is summarised below as the business architecture view.

6.1 Business Architecture View

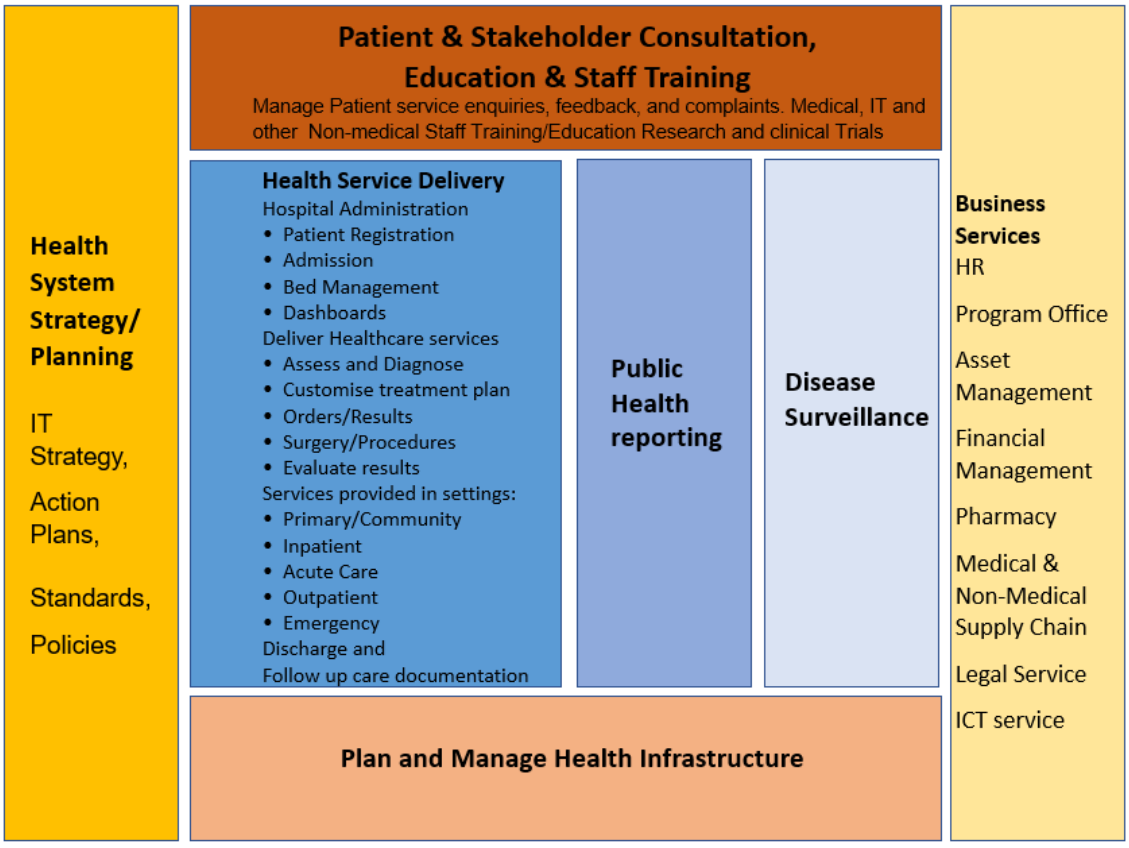


FIGURE 4

The business functions of MoH are described below

Health Systems Strategy/Planning:

This function provides policy and strategy direction to health services implementation in the MoH.

Health Service Delivery:

Administer Care – Register patient, assess (triage urgent care), diagnose, plan and provide care. Complete documentation, access record history, track patient and record location, and manage documentation processes.

Provide Care - Perform triage or assessment, update health history, and assess patient needs. Request diagnostic tests, manage worklist, and order test, and report. Evaluate results and symptoms and diagnose. Select protocol and care plan, customise and schedule services. Request pharmaceutical, nutrition and therapeutic services. Schedule maintain drug administration record, report consultations, and chart care services. Evaluate care, request diagnostic test monitoring, and modify care plan as required. Manage adverse events and infection control programs.

Transition Care - Plan discharge/follow-up, including coordination with patient, family, community programs and primary care provider. Prepare discharge summary and manage documentation deficiencies and completion.

Provide health promotion materials & Execute Prevention Measures

Assess consumer needs, identify, and deliver the appropriate health promotion and / or prevention services, and coordinate with community services and other programs. Track services and maintain history. Maintain registers (immunisation) and other public health indices.

Coordinate Care Delivery

Assess and select clinical program, customise treatment plan and co-ordinate delivery across multiple sites and multi-discipline team. Appoint care team and manager. Track progress and modify plan

Manage Referrals

Referrals are of two types i.e. from a clinic to a referral hospital known as vertical referrals or from one speciality to another speciality within a hospital, or between two hospitals known as lateral or horizontal referral. The system should cater for both types of referrals.

Request and schedule a service delivery event from other settings/specialists to inpatient or outpatient or community health settings. Manage coordination and re-scheduling across multiple settings. Mitigate adverse drug events. Monitor patient compliance with clinic and pharmacy referrals.

The health service delivery function is performed in several specialities in both Outpatient (OPD) and Inpatient (IPD) settings. These specialities are listed in Appendix A.2

Many of the functions described above are common to all the specialities. The content of the information collected for medical records may vary with the speciality.

However, in carrying out the above functions, the following activities are common in all the specialities.

Suggested Architecture Building Blocks	
1	Appointment Scheduling
2	Patient Identification/Registration
3	Bay/Queue Management

4	Diagnosis
5	Care/Treatment planning
6	Orders/Procedures
7	Results Review
8	Referrals/Discharge Summary

TABLE 2

Thus, the above activities form architecture building blocks for providing services in different specialities.

Business Services:

Plan and deliver business processes such as facility and asset management, human resources, financial management, supply chain, communications, and security.

Plan and Manage Health Infrastructure:

Manage enterprise ICT services, deliver operational services, plan, and deliver solutions, manage IT assets and infrastructure.

Patient & Stakeholder Consultation, Education & Staff Training:

Provide Education, training, development, and research for staff & consumers (covering both patient and non-patient).

Plan and deliver education, training to staff, clinicians, patients, and the public.

Knowledge Management

Identify and manage knowledge bases e.g. MIMS, provide access to knowledge services.

Public Health Reporting:

Current systems using DHIS2 for public health reporting will continue and will be integrated with the ePIS. Opportunities for transferring some person-based applications like TB and HIV monitoring, and Maternal and Child Health, to ePIS, will need to be considered for migration to the target architecture.

Suitable process reviews will have to be conducted to consolidate and simplify the data collections from multiple forms into a single one before integration with ePIS.

Disease Surveillance:

NEWARSIS which is currently used as Early Warning system for communicable diseases will be integrated with ePIS.

6.2 Information Architecture View

The functions described in the Business Architecture will require the collection, storage, and update of information. The information will consist of data collected at/from source and managed and controlled with proper governance.

The information presented below in coloured boxes correspond to the relevant business function. The information presented under the common box is used as a reference by all the business functions.

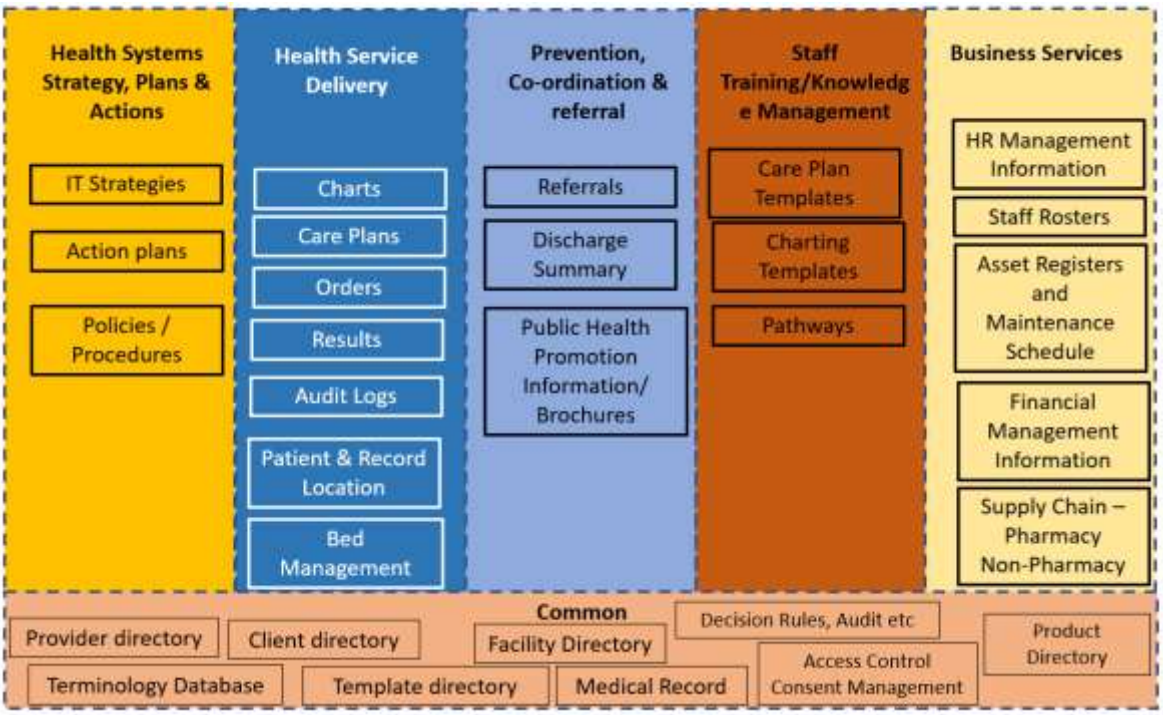


FIGURE 5

6.3 Application Architecture View

The **logical** view of the modules is presented below. On discussion with MoH staff, it is found desirable to have a distributed architecture i.e. Each hospital will maintain a master patient information (MPI) and medical records for the patients treated in that hospital. Because it is more likely to find an Open source software for a single hospital operation.

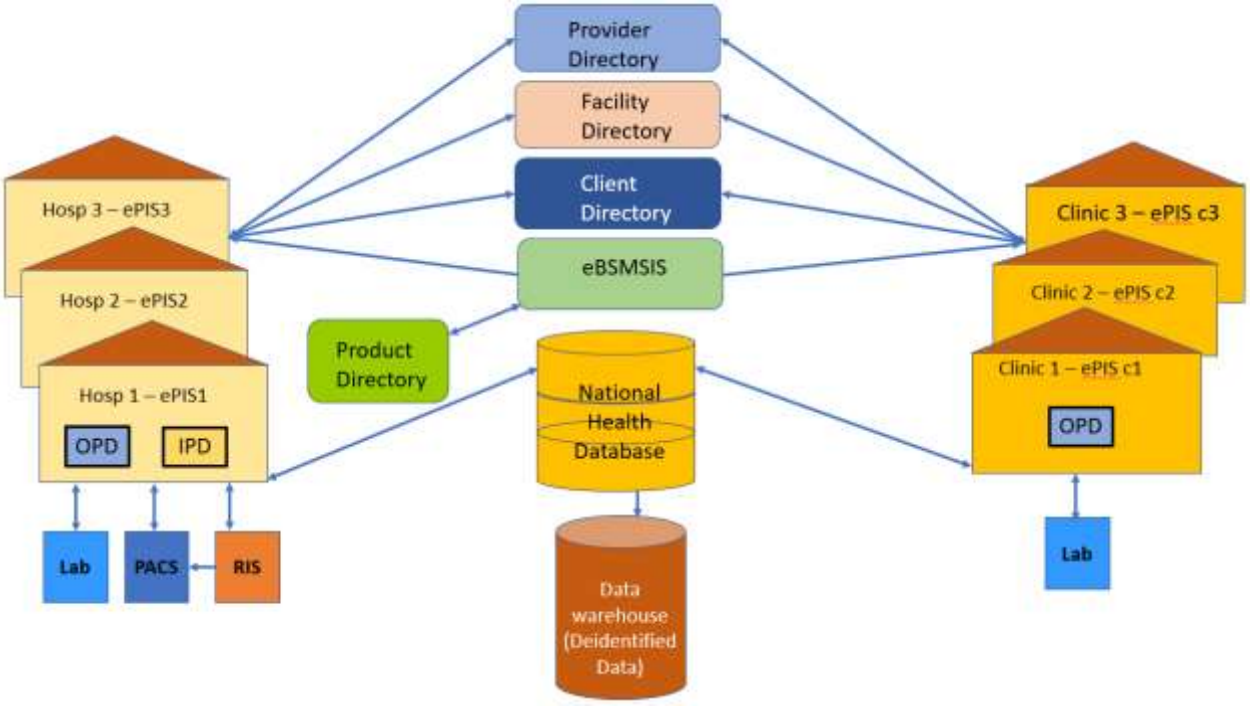


FIGURE 6

ePIS at the Regional hospitals and at other hospitals and clinics will send a summary health information to the National Health Database in normalised form at the end of each episode (encounter). In other words, the National Health database will be the repository of summary health information of all citizens and will maintain enterprise master patient index (EMPI). The summary health information can also be made available for the patient to see his health summary.

Client Directory: This is a logical representation of Client demographic details along with any specific identification information like biometric identification. The Client Directory includes both patients and blood donors who are registered in the system. This directory could be built progressively as and when the patients present at a hospital or a clinic. It is also possible to populate this directory with data from other Bhutan eGovernment systems like Citizens database

Provider Registry: This contains all the health professionals' data ie their name, qualifications, specific skills, training, certifications and any other relevant information relating to their work at the hospital/Clinic.

Facility (Hospital/Clinic) Registry: This will contain a listing of all the health facilities including hospitals, clinics, etc., their address, Geographical Information system (GIS) data. This can also include any facility related information like number of beds if a hospital facility.

ePIS1: This is an instance of the software package which contains both OPD and IPD modules in a hospital setting with both OPD and IPD. In remote clinics with only OPD facility, this may contain only OPD modules. This is shown as a logical representation at the hospital/facility level. The physical implementation of ePIS can be at the Government data centre (GDC). ePIS1 will contain the Master Patient index (MPI) for the patients at hospital1 only and their medical records.

National Health Database: This will contain the health summary of all the patients and their visits to the hospitals and clinics. Thus, the national database will contain the full history of the clinic and hospital visits of a patient.

Since this contains only summary information, it is possible to provide access to the citizens to view their health records.

Data Warehouse: This will contain a deidentified version of health data of all patients. Public Health, Planning and Research staff will have access to the data warehouse.

Product Directory: This is a database of all pharmaceutical products and non-medical items maintained by eBSMIS system. The consumption of these items at the health facilities can be updated by linking ePIS software to eBSMIS.

It was stated as a requirement that the three Regional referral hospitals should be able to operate with full functionality independently of the applications residing in the Government data centre (GDC). So, to achieve this objective, it is recommended that these hospitals will have fail safe servers located locally with copies of MPIs and medical records of its patients. Smaller hospitals up to 20 bed capacity will have single local server for operation.

Facilities in remote locations should be able to operate with just mobile devices using the ePIS application residing in the GDC. The functionality available to the remote facilities will be limited depending on the availability of local medical devices, e.g. Xray, Beds, etc. A few remote area clinics will be able to share an instance of ePIS running at the GDC or in the event of communications failure, be able to use the instance of ePIS at the nearest hospital.

6.4 Technology Architecture view

The technology view of the blueprint is shown in the diagram below.

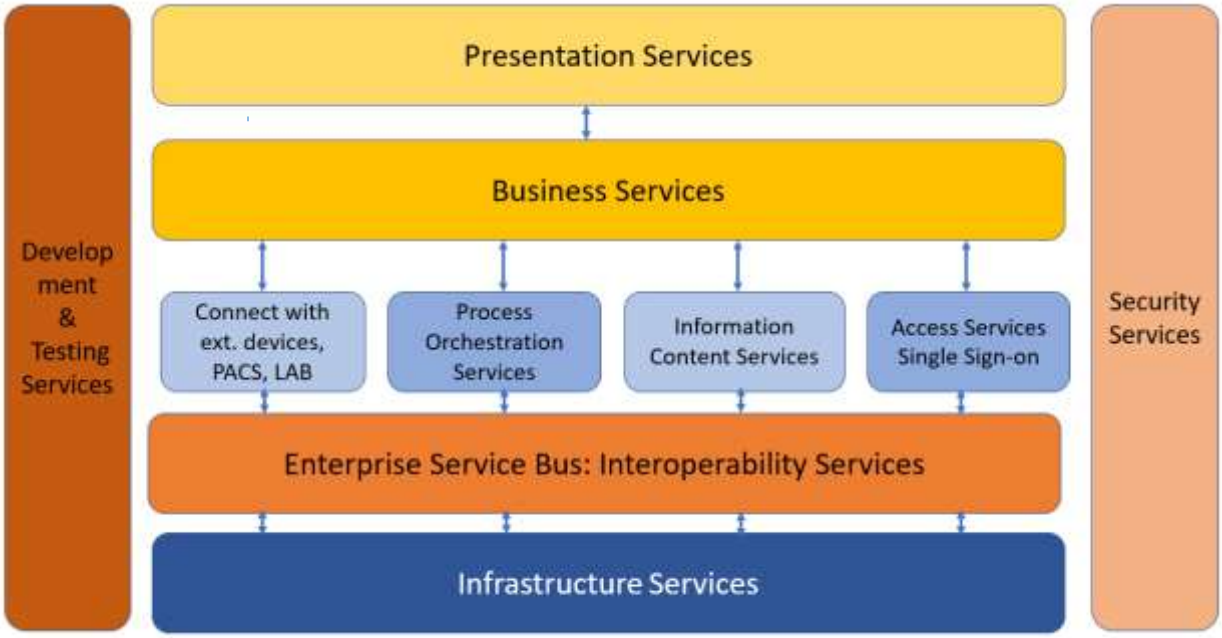


FIGURE 7

Presentation Services:

GUI - Graphical User Interface

Ability to display/present business data and information across the major platform and multiple devices including mobiles.

Pen Based Presentation

Pen based presentation services for handheld devices as well as mobile devices.

Web Presentation

Interface to Web based applications and information on the internet, intranet & extranet.

Access Services contains the following lower level services:

Internal Access Services

The users are connected within a "trusted" environment including from mobile devices using single sign on.

External Access Services

External access provides support for all authorised users from an external source, via agreed external channels via the Internet, an extranet or mobile environment, wireless, etc.

Security Services:

User security will be ensured using secure password control and biometric recognition devices.

Information Content Services:

Content retrieval and update of databases should be controlled.

Infrastructure Services:

Problem, Change and Configuration Management

The detection, analysis, recovery, resolution and tracking of potential and known problems, and managing changes to software.

Performance Management

Plans, evaluates, and controls the delivery of ICT performance to meet the needs of the business

Business Continuity/Disaster Recovery

Manages the process by which plans are made, tested and executed to enable the recovery of information and continuation of the business functions in the event of a disaster.

Application supporting Systems Management Services

Provides specific application services which support Systems Management applications

Interoperability Services using Government Data Centre (GDC) ESBs:

Standard APIs will be developed using open standards where possible to connect external devices such as Lab services and PACS/RIS services. The use of technical standards used for development of the APIs will be described in the Final Report. API development will be based on recommended international messaging standards such as FHIR or HL7 v2.4.

7.0 Change and Adoption

International experience with large scale ehealth solutions indicates that implementation of ehealth is very challenging and requiring a combination of both top down and bottom up approaches to be successful. It is recommended that a few healthcare professionals take a championship role to promote the use of ehealth amongst medical and clinical staff. Healthcare professionals should be trained on the use of ehealth systems.

Progressive implementation of core functions will also help ease the transition and adoption of new business processes.

8.0 Next Steps

This document is distributed for review and comments. Based on the feedback from MoH, further revisions to the conceptual building blocks outlined in this document will be made and a target Enterprise Architecture model will be developed including integration of HIS with

other Bhutan eGov systems. Recommendations will be made specifying standards to be used so that the systems are interoperable.

Consideration will also be given for a transition architecture and a roadmap for achieving the target architecture.

Appendix: 1

A.1 List of Applications

S.No.	Application Software	Brief description of Function	Owner
1	DHIS2	Public Health reporting/ Disease reporting system	HMIS, PPD
2	ePIS	Pilot patient management system - discontinued	DMS, MoH
3	NEWARSIS	Early Warning Alert and Response system	RCDC
4	eBMSIS	Medical and non-medical supplies and inventory system	DOMSHI
5	LIS	Laboratory Information System	JDWNRH
6	WQMIS	Water Quality Monitoring Information system	RCDC, NWRL
7	BTS	Blood Transfusion System	DMS
9	PACS	Picture Archiving and Communication System	DMS
10	BDSIS	Bhutan Diarrheal Surveillance system	
11	SIMS	Salt Iodine Monitoring System	DoPH
12	TBISIS	Tuberculosis Information and Surveillance system	RCDC?
13	ILISARIS	Influenza and severe respiratory Infection system	DoPH
14	MRSIS	Measles and Rubella Surveillance Information System	RCDC
15	HERCS	Health Emergency and Rescue Centre system	MoH IT services

Appendix: 2

A.2 List Medical Specialities

1. General Practice
2. Cardiology
3. Endocrinology
4. Gastroenterology
5. Geriatrics
6. Traumatology
7. Hepatology
8. Infectious Diseases
9. Nephrology
10. Oncology, Proctology, Pulmonology
11. Rheumatology
12. Anaesthesiology
13. Dentistry
14. Dermatology & Venerology
15. Ear, Nose, Throat (ENT)
16. Emergency Medicine
17. General Medicine
18. Anaesthesiology
19. Surgery
20. Orthopaedics
21. Intensive Care
22. Neurology
23. Ophthalmology
24. Otolaryngology
25. Paediatrics
26. Psychiatry
27. Forensic Medicine
28. Urology
29. Physiotherapy & Rehabilitation
30. Obstetrics and Gynaecology
31. Community Health
32. Audiology
33. Speech Therapy
34. Radiology
35. Pathology (Laboratory) including WHO net system

Appendix: 3

A.3 References

1. National eHealth strategy and action plan – June 2018, Ministry of Health, Kingdom of Bhutan
2. OpenHIE Framework (www.openhie.org)
3. TOGAF® 9 (The Open Group Architecture Framework, www.opengroup.org)
4. Inception Report (Status report on the state readiness of eHealth ecosystem