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# Healthcare Information Exchange (HIE) In Relation To Diagnostic and Medical Images Sharing/Exchange: A Study across the Globe Focus on Challenges Such as Interoperability, Infrastructure, Security, Privacy and Benefits

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**Abstract**

The availability of the consultant and or specialist in the right time and place to carry out the interpretation and reading of medical images such as Radiology, Cardiology, Pathology, Ophthalmology, Dermatology and other type of images is challenging in the world of Healthcare Information Exchange. Without a standards-based, interoperability, well-defined governance and protected privacy approach, it would be difficult to share data among clinics, referral physicians and service providers.

Proper Medical Images sharing will results in efficient patient care, reduction of unnecessary medical images tests, improve quality of treatment and reduce the cost. Furthermore, Patient Matching, Infrastructure, Security, Costing, Data Integrity and Values are the most considerable challenges for moving data into and out of the Image exchange platform.

Medical image exchange and or sharing will highlight the challenges and issues of integrating imaging systems and electronic medical records or electronic healthcare records to engage both healthcare practitioners and patients.

With the massive growth of medical images, there is large need for Enterprise Imaging strategy and governance, which is an emerging need in health enterprises to enhance the image exchange, and sharing and looking to grow and govern a program to optimally capture, store, index, distribute, view, exchange, and analyze the images of service provider enterprise platform to take the right decisions at point of care.

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## Introduction

One of important reasons to have healthcare information exchange is decision-making which part of everyday healthcare practice life is. In addition, these decisions are shaped by industry standards, physician's knowledge, the demands of the patient, and the therapeutic possibilities. Billions of new medical images are generated daily based on official requests by referral physician who suspect a clinical issue in certain body part. However, the availability of the consultant and or specialist in the right time and place to carry out the interpretation and readingof these images is big challenge.

These images are different from clinical content, standard compliance and reporting formatthat provided to referral physician to help them in making the decision. Digital Imaging and Communications in Medicine (DICOM) is a comprehensive specification of information content, structure, encoding, and communications protocols for electronic interchange of diagnostic and therapeutic images and image-related information like Radiology, Cardiology, Pathology, Ophthalmology, Dermatology, Gastro and other type of images. Without a standards-based approach, it would be difficult to share data between different imaging devices and platforms because they would need to interpret multiple image formats. With DICOM, physicians have easieraccess to images and reports, allowing them to make a diagnosis, potentially from anywhere in theworld.

In addition, the goal of any Healthcare Information Exchange (HIE) is while the patient at the center, the platform will facilitate the exchange of patient health information, financial and administrative data sharing to connect providers and payers through a managed service providing visibility and transparency to all stakeholders. Creating, searching, and managing digital images has become constantly encountered.

With contemporary smart phones, it only takes a few seconds to take a photo and share it with friends via e-mail, social media, or image-sharing web sites, but it is not the case when it comes to the medical images like Radiology, Cardiology, Pathology, Ophthalmology, Dermatology, Endoscopy and other clinical ones.

Diagnostic and Medial images tests, especially point-of-care diagnostic image interpretation, and related HIE are necessary for patient management during the healthcare journeysetting, where clinic-hospital cooperation and interprofessional collaboration are important.

When a patient in healthcare facility is admitted to the facility due to a sudden disease condition, and medical images were acquired at the side of modality, and there is no specific consultant to provide the diagnosis, HIE should be suitable for sharing clinical information including medical images between and or among the healthcare facilities that provide the diagnostic, interpretation and reporting for these medical images and return it back to the originalsource. Or if one provider is referring the patient to another provider, the patient's health information could be sent to the preferred provider securely via the HIE.

This results in efficient patient care and the reduction of unnecessary medical images tests upon hospital admission. Furthermore, HIE should be suitable for sharing clinical information notonly in cooperation between clinic and hospital physicians, but also in collaboration between various medical and welfare staff. Although the consultant and or specialist is available to provide clinical report to referral physician, there are several global shared challenges and concerns that face HIE and in specific medical images exchange as follows:

Interoperability, Patient Matching, Infrastructure, Governance, Privacy, Security, Costing, Data Integrity and Values. These are the most considerable challenges for moving data into and out of the Image exchange platform. This research will discuss these challenges from different prospective such as technical, economic, policy, etc. and opportunities of using image exchange platforms through the right approach.

## Literature Review

Medical Image exchange throughout the Healthcare information exchange comes along with changing roles of doctors, nurses, service providers, and patients. For example, online searches for health information by physicians or patients are well known today and complement visits to the doctor or request from provider to help in reporting and giving second opinion. At the same time, the increasing importance of chronic diseases, the ubiquitous spread of mobile devices,and the need for immediate picture or medical image are key drivers of mobile health. These are key elements as well as challenges to healthcare medical images and information exchange amongof doctors and service providers group to take the right decisions.

Medical image exchange and or sharing will present the concepts surrounding the challenges and issues of communication between imaging systems and electronic medical records(EMR) or Electronic Healthcare Records (EHR). The Picture archiving and communication systems (PACS) were developed to combine capturing of modality images, viewing of modality images, archiving, and distribution of images with its report and diagnostic interpretation by the right specialist. When PACS is integrated/interfaced with EMR or EHR, it can view the image with its report among different stakeholders inside and outside the service providers. To address several challenges and issues surrounding such communication between PACS and EMRs/EHRs and to make interface development easier and faster, various organizations have developed aside of standards governance including policies and processes to enable that formatting and transfer of clinical data throughout the right channels and paths.

The organizational governance frameworks and committees are more recent developments in healthcare. The successful governance may be defined where there is active cooperation and approval of clinicians in implementation of clinical systems and may include critical metric around physician and nurse leaders serving on an institution's or group's governance bodies. Accordingly, there is large need for Enterprise imaging governance, which is an emerging need in health enterprises today to enhance the image exchange, and sharing and looking to grow and govern a program to optimally capture, store, index, distribute, view, exchange, and analyze the images of service provider enterprise platform.

Additional work continues to better -handle these challenges and issues by providing secure access with clear authorizations and authentication monitoring the privacy of patient according to Health Insurance Portability and Accountability Act (HIPAA) regulations. Private Health Information (PHI) and record files should only be shared with authorized parties. Typically,an authorized recipient is another physician or physician's office. To minimize the risk of a HIPAA violation, a good strategy should always include minimizing the number of actual copies of PHI that service providers create. Any photo or medical image that shows individually identifiable information is considered PHI.

This can be something such as a patient's CT, MRI, US, etc. modalities or face, name or initials, their date of birth, the date of their treatment or photos of anybirthmarks, moles or tattoos.

Communication protocol Health Level 7 (HL7) is a standard application protocol used forelectronic text data exchange in health care by most EMRs/EHRs. The imaging communication protocol for PACS is the DICOM standard specification protocol that describes the means of formatting and exchanging images and associated information.

1. The image exchange standard process with any modality that produce an image has three major services that shall be in place: **Patient Management:** This service will handle the patient's data and status from admission to discharge including all demographic and identifiable data elements.

**2. Study Management:** This service will create schedules and track studies acrosssingle or multiple organizations. It follows the patient and complements the patient management.

**3. Results Management:** This service gives access to actual captured image and its reportof the patient's study.

In the last decade, the exchanging of images outside a specific health information exchangedomain and exchanging of images within a specific health information exchange domain have been developed and grown dramatically especially for DICOM and Non-DICOM compliant images throughout high interoperability maturity level. This helped some of physicians when face the most common issues while treating their patients include:

- Figuring out where their patients were previously treated
- Consuming the mass amounts of data they have on their patient and picking outwhich parts are relevant to their current case
- Accessing text, notes, or medical images in a timely and efficient manner

Attempting to navigate through numerous regulatory requirements while avoidingfinancial penalties from non-complian.

## Methodology

The initial method of this research paper is searching for data from peer-reviewed articlesabout image exchange challenges. The searching was limited to articles published in English language only. Moreover, the study conducted by using more than 40 articles published in the last ten years then short-listed into 18 articles published in the last five years from 2016 to 2022.

In this research paper, will be reviewing, examining, assessing, arguing and explaining thatmain challenges across the globe in regard of medical images exchange throughout proper resolved interoperability, patient matching, infrastructure, governance, privacy, security, costing, data integrity and other different healthcare information exchange challenges that can indeed improvedecision-making in all these dimensions and provide valuable decision support along the patient pathway.

This brought from studying and analyzing the short-listed 18 different papers and articles at even different countries and experiences as follows:

Canada, Republic of Austria, United States "Radiological Society of North America ImageShare Network", Netherland, Brazil, Japan and Middle East.

Sacred Heart University (SHU) Library was the primary database used for the research, and it led to several databases and journals. In addition, articles were collected from various databases and journals:

Journal of Digital Imaging.

ELSVIER.

All selected articles based on some criteria. It should support the challenges of medical image exchange and health information exchange, focus on the technology side, interoperability side, governance side, and privacy/security side. The collected data from different articles were grouped from the following qualitative and quantitative figures and themes:

Observations, documents and records, Case studies, Surveys (online or physical surveys), sample of interface or integration, sample of governance been implemented, sample of physician/patient satisfaction measurements, size or volume of image exchange and other related factors to the research.

The collected data have assessed to measure the improvement of medical image exchange of patients after the utilization of right approaches and methodologies to cover interoperability, technology, and governance and privacy/security challenges across different counties and experiences.

## Result

In Canada, there was two different standards-based approaches utilized for Image Exchange in Ontario (East Toronto and West Toronto). Both approaches have utilized a centralized "diagnostic image repository" to store a copy of the images generated in that Ontario region. However, each diagnostic image repository have used different method and approach to identify patients, discover images, and retrieve reports. The main challenge was verifying patient identifierat each repository while first approach is deterministic match based on provincial Ontario Health Card Number, the second approach is probabilistic patient matching based on a scorecard of key demographics. The patient identity scorecard indicating the weighting values assigned for each Healthcare Card Number and Gender attributes was exact. And these repositories were a heterogeneous vendor environment, in which the 38 separate PACS feeds that are connected to HDIRS represent a variety of PACS vendors [1-4].

For the exchange of outside imaging to be considered successful, foreign exams were found that to meet the following requirements: 1. Display in the local patient jacket; 2. will not re-archive back to the DIR; 3. will not remain a permanent record in the local PACS [1-4].

All sharing examples from Canada aligned with the Province's Personal Health Information Protection Act, 2004. The results reveal that providing seamless access of foreign exams directly into a local PACS has improved access to a patient's longitudinal record and has mitigated the concern of accessing exams from physical media. Additionally, the "repeat imaging" study conducted validates that the access of foreign exams has prevented patients from repeat imaging. (See Table # 1, 2, 3, 4, 5, 6, 7 , 8 and Figure 1, 2 in the Appendix) [1-4].

While in Austria, there were several imaging repositories that are linked by means of the Centralized Master Patient Index to ensure unambiguous patient identification. But there was another challenges from interoperability prospective how to integrate these repositories utilizing different standards to allow user order the procedure and view at the end of workflow the image with its reports. Also another challenge that how to manage privacy and data protection which is regulated by Austrian and European law and regulation while exchange the image with its report [4].

The federal entity (Republic of Austria) and Austria's nine provinces, as well as social security, committed themselves to setting up and implementing an electronic health record in Austria (ELGA). The ELGA architecture is implemented as a distributed, decentralized IT systemwith several centralized components. The decentralized components include: 1. Health data: withthe exception of images, health data is stored locally as CDA documents in decentralized XDS repositories in each Austria region (Affinity Domain).; 2. Images: the original images may remainin the PACS/VNA in the Austria region where they were originallycreated or they may be archivedin AURA (Austrian Radiology Archive) if the local radiology practice has contracted with AURAIn either case, an imaging manifest is created as a DICOM KOS for each study and stored in the XDS repository. For that region. Note that for images stored in AURA, AURA acts as its own region (Affinity Domain).; 3. XDS Registry: an XDS registry provides a list of documents available for each patient in that region "(Affinity Domain).; 4. XCA Gateway: supports an outside query (against the local XDS registry) and retrieval (from the local XDS repository) of documentsavailable for each patient [4].

The centralized components provided for: 1. Identification of the patient: The decentralized XDS data repositories (XDS Affinity Domains) are linked by means of the Centralized Master Patient Index (C-MPI) to ensure unambiguous patient identification. 2. Identification of the healthservice providers: The Austrian implementations included the governance and sustainable core infrastructure that provide most of the "factors for success"[4].

In Netherland, the story was different, an IHE based, nationwide infrastructure allows Dutch hospitals to quickly, safely and securely share digital medical information. Several factors influenced the journey in Netherland, however, not only privacy and security concerns but also the political factors that shaped the infrastructure in the years that followed [5].

In 2009 the National Breast Cancer Screening network have started to exchange this screening data using IHE Profile standard XDS-I. In many ways, this pilot identified the challenges with IHE XDS-based information sharing that had to be tackled in the years to come. In parallel to the mostly regionally developed sharing infrastructures a national debate had started in the Dutch parliament about the realization of a National EHR system [5].

As a result, XDS-based regional health information exchange networks quickly emerged across the Netherlands. One of the accelerating growth factors that IHE had anticipated was a quick and widespread adoption of IHE profiles by vendors, as IHE was a joint initiative of users and vendors [5].

In addition, as a result of the Senate ruling on the national EHR a fierce public debate led to the notion that query based, "pull"-type exchange networks such as XDS required informed patient consent to be explicitly obtained before any information could be exchanged. For "push"-type, point-to point information exchange (e.g., DICOM Mail) on the other hand, implicit consentwould be sufficient to share information with peer healthcare providers [5].

In March 2020 at the onset of the COVID pandemic in the Netherlands the available IHE XDS-based infrastructure showed its value as an IHE XDS-based National COVID- 19 Patient Exchange Portal. The National Portal was set up within 2 weeks, connecting to 95% of the Dutchhospitals in that period (See Figure # 3, 4, 5 and Table 9 in the Appendix)[5].

Japan had initiated development of digital medical information exchange before international standards were stated. Health information sharing started development by Ministry of Health, Labour and Welfare subsidy, before IHE XDS. This resulted in Japan vendors' proprietary protocol sharing system scattered in more than 200 networks. Some of them were well designed as they are really used daily, such as Fuji-no-kuni described here. However, naturally, nointer-community exchange between typical active 34 regions is realized. Japan initialized the digitization of healthcare information for images before it did for medical records. In 1994, the Ministry of Health and Welfare issued a notification titled "Storage of Radiographs and Other Images on Optical Disks and Other Media." In 2000, the Japanese government announced the "e-Japan" strategy. In this strategy, the government recommended digitization in healthcare and implemented policies to promote the introduction of an electric medical record (EMR) system. After this strategy was implemented, PACS was gradually introduced in real world clinical practice [6].

However, the 2008 revision of medical service fees included a "management fee for electronic imaging." When this fee enabled hospitals to recover the costs of introducing the PACS as a part of patient care costs, the number of hospitals introducing PACS suddenly increased [6].

In 2010, Ministry of Health and Welfare (MHLW) has initiated standards for the first time to promote appropriate informatization in healthcare. These standards clearly indicate that medical image data should be stored and exchanged in the DICOM format [6].

When patients were transferred between medical institutions with portable data for imaging(PDI), physicians at the referred hospital can treat the patients while viewing images captured at the referring hospital [6].

The basic data and data in EMR are partially shared in all 34 networks, whereas image dataand data on dispensed drugs are shared in 31 and 17 networks, respectively. The data-sharing systems used are proprietary products provided by major EMR vendors in 32 networks. Only twonetworks use the cross-enterprise document sharing (XDS), which is a profile developed by the IHE as a protocol for regional healthcare information exchange, and XDS for imaging (XDS-I), which is the image data version of XDS [6].

Overall, the 25 out of 26 regional healthcare information exchange networks in Japan wereimplemented on proprietary systems provided by EMR vendors or systems uniquely developed and built by system integrators(See Figure 6,7, and Table 10 in the Appendix)[6].

While, in Brazil information infrastructures involve the nation of a shared, open infrastructure, constituting a space where people, organizations, and technical components associate to develop an activity through journey. The current infrastructure for medical image sharing, based on PACS/DICOM technologies, does not constitute an information infrastructure since it is limited in its ability to share in a scalable, comprehensive, and secure manner [7].

The simulated environment experiment evaluated DICOMFlow's ability to synchronizethe content of PACS infrastructures located in different domains. An environment composed of three interconnected computers was set up at the edge of a metropolitan network with atransmission capacity of 5 Mb/s, 5 km apart and protected by firewalls. The DICOMFlow is an architectural model that aims to foster the formation of an information infrastructure for sharingimaging exams and teleradiology based on the PACS/DICOM infrastructures of radiologydepartments and internet e-mail. In order to build on an installed base, it is essential to obtaininformation on it to take advantage of its strengths and overcome its limitations [7].

A key aspect of this solution, which acts as a gateway, is to use the installed base of internete-mail, the strong point of which is the high connectivity. In practice, it is able to exchange messages between a wide diversity of professionals and health organizations, without the need to modify their firewalls, thereby enabling the integration of the radiology workflow to a global scale.Furthermore, e-mail is asynchronous and allows the content of messages to be safely transmitted (with confidentiality, integrity, and authenticity), making it possible to implement protection policies on clinical data [7].

The Sharing service shares the URLs and the access credentials for one or more exams with the recipient. In a network of hospitals, such sharing will allow patients at one hospital to access imaging exams they performed at another, i.e., in principle, from one hospital, it is possible to access exams from other hospitals in the network and vice versa, without needing to duplicatethe raw data (DICOM objects) (See Table 11 and Figure 8, 9 in the Appendix)[7].The Radiological Society of North America (RSNA) in United States, which had extensive experience working on interoperability issues in medical imaging, began to look for opportunities to address the issue. In 2007, in the wake of the financial crisis, the National Institute of Biomedical Imaging and Bioengineering (NIBIB) issued an RFP to address Internet-based exchange of medical images. The RFP defined requirements for the network, including that it needed to be patient controlled and standards based. The RSNA was awarded funding for what came to be known as RSNA ImageShare [8].

Over the next 15 years, the RSNA worked in partnership with several vendors and academic institutions to create a network for sharing image-enabled personal health records (PHR). The foundation of interoperability standards used in ImageShare was provided by IHE, a standards-development organization with which RSNA has had a long association. The IHE Cross-Enterprise Document Sharing (XDS) and Cross-Enterprise Document Sharing for Imaging (XDS-I) profiles were the technical specifications employed [8].

- The proposed the architecture and security mechanisms had been defined from the beginning of the project Edge Server that implemented these specifications. The Edge Server enabled site personnel to enroll patients and make their imaging data available for secure access. The provided solution from vendors was able to provide the following A secure environment to which imaging exams from; local radiology systems could be transferred via the Edge Server; • Web browser–based access and viewing of DICOM imaging exams for the patient; • Access to the radiology report; • The ability to download the DICOM images [8].

Security and privacy were a shared imperative (and, of course, legal requirement), and the implementation tended toward highly restrictive policies and technical solutions in order to satisfy the requirements of all participating institutions and entities. The implemented solution avoided any data breaches, but it placed obstacles on patients' participation that likely limited use of the network. The solution employed avoided the problem of sharing and reconciling patient identifier across sites that complicates data sharing in the absence of a universal patient identifier in the United States health system. Exams were sent directly from a radiology office to the patient's PHR account, and the patient was provided an alphanumeric security code they could use to access theimaging study and add it to their account [8].

On 2015, by the end of close of the first phase of the project, 35,572 patients had enrolled in ImageShare at 20 participating sites across the United States, and 145,672 exams had been distributed (See Figure 10, 11, 12 in the Appendix) [8,9].

Middle East Region have another great experience in medical imaging sharing across multi-specialties like Radiology, Cardiology, and other images. The main countries that have suchplatforms are Turkey, Saudi Arabia, United Arab Emirates, Qatar and Oman. They have the image-sharing platform across universal, private, governmental healthcare services and shared the same concerns, and challenges have faced other countries in the other side of the world like but not limited to: 1- Lack of enterprise imaging governance at the early stage of implementation, which will organize the who, when, and how. In addition, any fees and or payment involved for physicians. 2- Infrastructure availability to handle such large volume of data. Growing from mega-byte to petabyte per year is challenge for infrastructure. In addition, the debate on cloud against on premises-installation implementation model. 3- Interoperability and integration to connect multi specialties from different systems (See Figure 13, 14 in the Appendix).

There were several recommendations from highly respected working groups and experts in the field supported by HIMSS-SIIM organizations summarized in the following categories have made and found guidelines that enhance the image exchange challenges have discussed in this research:

First: 10 Steps to strategically to build and implement any organization Enterprise Imaging (EI) System as key and core for image exchange (See Figure 15 in the Appendix) [10].

Second: Guidelines for an Enterprise Imaging platform provides the standards-based, enterprise infrastructure to support departmental imaging workflows.(See Figure 16,17 in the Appendix) [11].

Third: Lessons learned in the digital transformation of radiology and pathology can serve as a basis for interactive multimedia reporting (IMR) across image-centric medical specialties by correlating textual descriptions of image findings linked to the actual images and avoid that both image and report stay as silos. This can be linked into EI and to an enterprise image viewer and enhanced for sharing by EI infrastructure. (See Figure 18,19 in the Appendix)[12,13].

Fourth: Clinical specialties have widely varied needs for diagnostic image interpretation, and clinical image and video image consumption. Enterprise viewers are being deployed as part of electronic health record implementations to present the broad spectrum of clinical imaging andmultimedia content created in routine medical practice today. (See Table 12 in the Appendix) [11].

Fifth: With the advent of digital cameras, there has been an explosion in the number of medical specialties using images to diagnose or document disease and guide interventions. In many specialties, these images are not added to the patient's electronic medical record and are not distributed so that other providers caring for the patient can view them [14,15,16].

## Discussion

Regardless the location of medical image capture, or image storage and image viewing with request for second opinion or interpretation across different healthcare services, there are several factors and challenges that will face all users, patients and organization administration in way to share them as they do share the image. Technology, People and Governance are the core of these challenges that will affect the image sharing workflows including interoperability and privacy/security concerns minute by minute. No Under the Image Sharing rules, which are crucial to make the enforcement of obtaining patient image and report in the right time for the right person at the right location.

In the Canadian example, integrating the Healthcare Enterprise (IHE) profiles are leveraged to help achieve interoperability and successful image exchange. In the province of Ontario, each DIR publishes to a provincial XDS registry, which is leveraged by provincial viewers as reference point for image and document access. The Import Reconciliation Workflow (IRWF) IHE profile defines the workflow to successfully import patient data from an external source (i.e., CD-ROM, transmitted electronically, delivered from film, etc)[1-4].

The Canadian-HDIRS membership across Ontario Province represents over 40 unique patient identity groups. To avoid Patient ID collisions, the DICOM tag "Issuer of Patient ID" (0010, 0021) is leveraged to identify the source of the Patient ID and ensure uniqueness. This ensures that if disparate organizations use the same value for Patient ID, data collision will not occur as the DIR distinguishes uniqueness based on a data couplet of Patient ID and Issuer of Patient ID. Using ClinicalConnect (which is a secure, web-based provider-facing portal that provides real-time access to patients' health records, including diagnostic images and reports, generated by acute and community-based healthcare facilities across the province.), the concept of images or, more broadly, data exchange should be considered from two perspectives. Radiologists and other DI healthcare professionals access Clinical Connect to view a patient's DI data when generated at sites outside their own, but also to view non-DI health records that complement their diagnostic work. ClinicalConnect users are effectively accessing and viewing diagnostic imagingdata directly from two main sources: SWODIN (regional DIR) and the provincial DI Common Service, each with their own viewer. Within the List view of Clinical Connect's Radiology module,those reports that have an image associated with them display a camera icon. Clicking on the icon opens a new web browser window and retrieves the image from either SWODIN or the DI Common Service. Patient portals provide secure, online access to their personal health informationand can be used by patients to help manage aspects of their own healthcare. They are also becoming a tool for image exchange between healthcare organizations and their patients. In Ontario Health'sWest Region, currently patients can register for a patient portal account and access their diagnostic maging reports from acute care hospitals within the region (See Table # 1, 2, 3, 4, 5, 6, 7 , 8 and Figure 1, 2 in the Appendix[1-4].

While the Austrian experience in image exchange, several significant factors for successcan be provided by the governing body in Austria:

a. Specification of the standards that must be used, so everybody does it the same—is critical toenabling interoperability.

b. Creating a nation-wide, or region-wide, program that encourages participation can address anumber of the key governance factors such as:

- Providing a single shared trust framework for all participants that mandates and protects availability of the data and access to it, so that individual legal agreements do not need to be negotiated between each pair of exchange partners.
- Defining what data is to be exchanged and in what standard formats it will be encoded.
- Defining the breadth of participants (international/national/ regional/state/organizational/individual).
- Specifying how access is managed, secured, and audited.
- Creating a national or regional patient identifier, or standing up a patient identifiercross-referencing service, to aid in discovering, associating, and accessing the right imagesfor the right patient [4].

In Netherland, early 2000s, PACS penetration in Dutch hospitals reached nearly 100%. The transition from analogue to digital imaging not only led to significant process improvements within the imaging departments, but also triggered widespread adoption of image accessibility through PACS workstations and enterprise wide digital image viewers. In 2004 the Dutch chapter of the international IHE is founded as a joint initiative of PACS vendors and the Dutch Associationof Radiologist. Since IHE is firmly rooted in the radiology domain, from a very early stage the emerging IHE XDS profile is considered to be a viable answer to the challenges associated with sharing radiology images between PACSs from different vendors [5].

Despite the need to exchange radiology information the first image sharing project using IHE XDS emerged in the cardiology domain. This XDS-based sharing infrastructure is implemented in less than a year, and led to quite some interest from other cardiac departments andhospitals throughout the Netherlands. Among the factors that drove the popularity of the XDS-I profile is that XDS itself is easy to understand by clinical informaticians, architects, and to some extent the hospital C-suite. Each of the "actors" in the XDS profile can be easily mapped to real- world systems such as PACS, EMRs, and other clinical information systems playing a role in the exchange of diagnostic information. This bring a legal discussion started on the information ownership and related governance responsibilities of the XDS Registry and Repository actors. These new challenges are quickly picked up by regional health information exchange (HIE) organizations. HIE legal entities such as Gerrit, RijnmondNet,and ZorgnetOost considered IHE XDS as an opportunity, and took ownership of the XDS Registries and Repositories [5].

Driven by political ambitions the Dutch Ministry of Health had developed a plan for creating a national IT infrastructure allowing the exchange of medical information in general. By 2011 the debate had heatened up, and narrowed down to a discussion about privacy. On April 5 the Dutch Senate voted for a motion to immediately halt the National EHR program since it is not convinced these privacy concerns are adequately addressed [5].

The following years it turned out that this ruling had both positive and negative effects on the adoption of IHE-based exchanges in the Netherlands. Since establishing any kind of central information exchange infrastructure on a national level is no longer possible because of the Senate ruling, hospitals started to explore alternative solutions to efficiently exchange medical information. This led to a growing interest in IHE [5].

By 2015 a number or regional networks joined forces in the "RSO Netherlands" organization to address these concerns and obstacles. Despite these legal and organizational obstacles, the market matured and more and more hospitals adopted IHE XDS, either by joining aregional XDS-based HIE network or by implementing their own XDS network. Another development is that more -ologies started using this novel form of information exchange, with referring patterns requiring more and more cross-regional information exchange. The traditional boundaries of a traditional HIE (or region) started to fade. In parallel, regulations for privacy andconsent stabilized with the introduction of the GDPR [5].

Rapidly all Dutch XDS vendors turned their XDS solutions into cloud-based offerings lowering the effort to onboard hospitals to their sharing infrastructures. Hospitals start to move their on premise XDS infrastructures to hosted environments provided by different vendors. One HIE network in particular stands out in the Netherlands. The 3 northern provinces (of which one is the first adopter of XDS in the Netherlands) organized themselves into a health information exchange connecting 9 hospitals. With a combined population of approximately 1.6 million inhabitants the exchange volume of XDS(-I) documents grew from 76,000 in 2015 to (an estimated) 1,000,000 by the end of 2021. Initially only DICOM studies are exchanged. Over timeradiology reports, discharge, and mental health summaries are added [5].

There are many lessons from Dutch experience such as Lesson #1 Do not focus on image sharing per se when you are building a HIE Diagnostic images are only one of the many clinical information objects that are relevant when providing patient care. Lesson #2 Get your agreements in place the increased focus on security and privacy that resulted from the Senate ruling to abandon the Dutch National EHR made it very clear that organizations sharing clinical information had to comply with regulations concerning these two factors. Lesson #3 Building trust in your end the statement by Any sharing infrastructure can only be successful if there is trust among the participants. Without this trust, security and privacy concerns will block sharing of information (See Figure # 3, 4, 5 andTable 9 in the Appendix) [5].

The Japanese journey in image exchange, at the beginning, only a limited number of hospitals are able to introduce PACS. In Japan, the government controls the costs of medical services under a nationwide fixed fee-for-service system. However, the 2008 revision of medical service fees included a "management fee for electronic imaging." When this fee enabled hospitals to recover the costs of introducing the PACS as a part of patient care costs, the number of hospitalsintroducing PACS suddenly increased [6].

In 2010, Ministry of Health and Welfare (MHLW) is initiated standards for the first time to promote appropriate informatization in healthcare. These standards clearly indicate that medical image data should be stored and exchanged in the DICOM format. The standards also included portable data for imaging (PDI), which is a profile for sharing medical images stored in portable media between facilities. This profile is defined by IHE, which is an international project organization that develops a workflow to determine how to apply these standards in accordance with clinical practice. The use of PDI laid the groundwork for sharing image data in the DICOM format and a uniform format for the DICOM directory [6].

When patients are transferred between medical institutions with PDI, physicians at the referred hospital can treat the patients while viewing images captured at the referring hospital. Hence, repetition of the same imaging examinations is unnecessary. The use of PDI is conferred significant benefits to patients and hospitals. However, sharing image data in the PDI format requires the import of data from a recording media, such as CD or DVD, to a hospital PACS. Furthermore, importing image data may take time depending on the size of images. Japan comprises many isolated islands that have only small- to medium-sized hospitals or clinics and many settlements in the mountainous areas that are isolated from cities in lowland areas. To ensure a healthcare system that provides continuity of healthcare after emergency and acute phases, medical and image data between smaller medical institutions and large-sized hospitals must be shared in a more timely manner. To meet this requirement, a system that connects medical institutions online and allows them to share healthcare information should be developed [6].

In the 2016 revision of medical service fees, the MHLW created a new fee that allowed specialized and large sized hospitals to charge a certain amount of additional fee to patients visiting without a referral. This new fee helped address problems associated with patients with mild healthconditions who unnecessarily visited large-sized hospitals for initial treatment because of free access to medical institutions. From the results of a survey conducted by the MHLW across networks that suggests possible increased need for online information exchange between medicalinstitutions, mainly in rural regions where medical institutions are sparsely located, compared withthe three metropolitan areas: Tokyo, Nagoya, and Osaka. The establishment of such a network is much more needed in prefectures in rural regions. At later stage, MHLW introduced 34 regional healthcare information exchange networks, including the 26 networks on its special website, the data broken into four categories (i.e., basic data, numeric data, exchange information, and system structure) [6].

The "Fuji-no-kuni Net," one of Japan's 34 networks that is operated throughout ShizuokaPrefecture. This network became operational in fiscal year 2011 and connects a total of 145 facilities, including 34 hospitals (i.e., 18 hospitals are showing and receiving data, and 16 hospitalsonly view data), 75 clinics (i.e., 1 clinic discloses data, and 74 clinics only request data), 30 pharmacies, 1 care facility, and 5 others, as of the end of June 2021 (Fuji-no-kuni Net Survey, June2021). The number of registered patients is 2500 (MHLW survey, March 2020). The shared data included basic patient information, disease name, summary, operative notes, various test orders,laboratory test results, and images [6].

At Hamamatsu University Hospital, in the netPDI protocol, image data are uploaded to a delivery storage server, rather than being saved in external storage media. According to the originalIHE PDI protocol, image data to be shared are saved in external media (e.g., CDs and digitalversatile disks [DVDs]) at a hospital that captured the images, and patients bring the external mediato referred hospitals that use the image data. The netPDI is implemented according to the communication protocol used for the IHE XDS profile. The IHE Information Technology Infrastructure (ITI) 41 transaction (Provide & Register Document Set-b), which is developed inthe ITI domain, is used when hospitals must upload image data to the delivery storage server. Thetoken information that is transported to the referred hospitals by patients can substitute for the ITI-18 transaction (Registry Stored Query). It is pretend on paper as a barcode and the referred hospital can identified the token easily using barcode reader in Hamamatsu example [6] .Overall, the 25 out of 26 regional healthcare information exchange networks in Japan are implemented on proprietary systems provided by EMR vendors or systems uniquely developed and built by system integrators. In other countries (e.g., the United States, Canada, and Austria), healthcare information networks are built on the basis of international standards, such as IHE, HL7, and DICOM. And this is due to four factors: 1- Adaptation to the Higher Requirements Specifications by Free Access System; 2- Technological Maturity of EMR Vendors and an Oligopoly Situation with Regard to Introduction into Large Hospitals; 3- Establishment of a Regional Healthcare Information Exchange Network and Preparation of Standard Procedures 4- Unique Evolution into a Multivendor of the Information-Exchange Portal and Others (See Figure 6,7, and Table 10 in the Appendix) [6].

While, the Brazilian, the DICOMFlow is an architectural model that aims to foster the formation of an information infrastructure for sharing imaging exams and tele-radiology based on the PACS/DICOM infrastructures of radiology departments and internet e-mail. In order to build on an installed base, it is essential to obtain information on it to take advantage of its strengths andovercome its limitations [7].

The strengths of the PACS/DICOM infrastructure include the widespread use of the DICOM protocol as a communication standard between devices encountered in radiology departments; and it is the basic support for radiology workflow. One limitation related to the PACS/DICOM infrastructure is that it is designed between the mid-1980s and 1990s, in a contextof local networks, a fact that in practice makes it impossible to transmit images with the DICOM protocol via Internet, both through the presence of firewalls, amongst other security issues, as well as communication overhead. The idea, therefore, has been to take advantage of the strengths of thePACS/DICOM infrastructure and overcome its limitations. Thus, it is necessary to obtain a solution that acts as a gateway between the PACS/DICOM-installed base and the Internet, capable of safely transporting information in DICOM standard via the internet using protocols accepted by the access policies contained in firewalls. All this is carried out without significantly altering the local PACS/ DICOM structure, while making it possible to transpose the radiology workflow froma local to a global context, i.e., to achieve image sharing and tele-radiology [7].

Due to the large size (> 30 MB), an examination in DICOM e-mail is fragmented into multiple e-mails in order to be transmitted. To overcome this difficulty, the DICOMFlow is chosen for an asymmetrical approach. E-mail is used to notify the recipient with a message on the availability of an exam in order to perform some action (e.g., issue a report), based on a service request protocol incorporated in the e-mail itself. In addition to the request, the e-mail only includes light data, such as metadata, a summary of relevant clinical information, and information on accessing the exam (URL and access credentials), i.e., the raw data of the images are not transmitted as e-mail attachments. The receiver retrieves the images (the DICOM object) via the transmission content protocol (e.g., HTTP/REST) specified in the URL and meeting part-by-part security [7].

The Request service notifies the receiver to perform an action on one or more of the exams.For example, notifying a radiologist to write a report or a medical image processing company to perform a specific processing. Once the action has been completed, the recipient returns a messagewith the result to the sender. In this case, either the written report or the URL to download the exam after processing. The DICOMFlow adapter reduces the need for local changes, thus facilitating its integration into the installed base, regardless of the existing heterogeneity. The microarchitecture of the DICOMFlow adapter is organized into two main modules: DICOM Message and DICOM Move. The DICOM Message deals with the communication and security aspects of sending and receiving messages, while DICOM Move manages the transmission of medical images (DICOM objects) and their safety aspects [7].

The experiments demonstrated to observe the technical and operational feasibility of the macroarchitecture of DICOM Flow with the construction of adapters for the proposed service protocol. The performance and volume of data trafficked in the experiment in the simulated environment indicated the feasibility of using this implementation in real environments. In turn, the results of the experiments carried out in real environments reinforced this indication. Furthermore, the DICOMFlow adapter may be installed without significantly interfering with thecurrent infrastructure of the participating entities and its operation did not require changes in the existing firewall policies, despite the heterogeneity present in those infrastructures [7].

Compared to other solutions, such as those based on cloud computing or in IHE integration profiles standards, the main factor that distinguishes the DICOMFlow is that its architecture doesnot presuppose central authority or elements, since its control and coordination are distributed. Thepresence of central elements hinders the free association of arbitrary entities, generally requiring the satisfaction of policies for federalization (See Table 11 and Figure 8, 9 in the Appendix) [7].

The Radiological Society of North America (RSNA) in United States is carried out a survey of patients conducted during the project demonstrated a high level of satisfaction among participants and a preference on the part of these patients for Internet-based exchange over distribution via electronic media. The RSNA thus explored the best approach for identifying and driving adoption of standards for image exchange, determining that the following steps are needed:

1. Identify the standards; 2. Gain community consensus around the standards; 3. Publish implementation guides for the standards; 4. Establish a means for technology vendors to validate their implementation of the standards [8].

The IHE profiles addressed patient identity, security and authentication, audit trails, and the transport mechanism. The profiles are based upon DICOM 3.0 and HL7 v2.x transactions, both widely deployed. While these profiles are based on aging transaction technologies (ebXML), there is ongoing work to bridge them to standards based on RESTful services, including HL7 FHIR and DICOMweb [8].

The United States Office of the National Coordinator for Health Information Technology (ONC) is mading interoperability a priority, and the US Center for Medicare & Medicaid Services (CMS) is putting rules and regulations behind these efforts. The Sequoia Project had been incubating two initiatives, Carequality and the eHealth Exchange, that both support standards- based HIE mechanisms and governance that would enable exchange of healthcare data. These initiatives are growing and gaining success at clinical document exchange, but image exchange is still lacking. In 2018, the Sequoia Project spun off these initiatives into two separate organizations with their own governance structure and leadership. RSNA expanded their partnership to include Carequality. This partnership that began in early 2019 resulted in an image exchange implementation guide being published and tested to allow the use case to be recognized by the Carequality Steering Committee for production use by implementers in March 2021 [8].

Finally, this allows implementers to deploy a standards based image exchange use case within their customer base. As a Carequality Connected Agreement (CCA) signee, each implementer agrees to common rules of the road and technical specifications to support various use cases as their technology allows. While there is tremendous technical infrastructure development to support standards-based image exchange through organizations like Integrating the Healthcare Enterprise, Carequality, DICOM, and HL7 FHIR, the human operationalization of intuitive standards-based applications remains central to effective and reliable electronic image exchange. The operational challenges associated with coordination and communication, release of information, staffing, technology, information localization, and analytics can create unexpected individual image exchange slowness or failures. Image library staff members managing the ingressand egress of images work in a complex, highly transactional role and should be recognized for their efforts to support continuity of care for all patients (See Figure 10, 11, 12 in the Appendix) [8,11].

Middle East Region is implemented the latest standard like DICOM, HL7, FIHR, IHE Profiles in different domains like Radiology, Cardiology, Dental and others. Furthermore, few quite good number of Vendor Neutral Archive implementation are in place. And not least like other part of the world, they are sharing the same benefits of such images sharing like but not limited to: 1-Fast access to both image and report. 2- Enable tele-services for second opinion, consulting and reporting. 3-Improve patient journey, workflow and diagnosis. 4- Allowed more patient engagement to be in place (See Figure 13, 14 in the Appendix).

There are several recommendations from highly respected working groups and experts inthe field supported by HIMSS-SIIM organizations summarized in the following categories are madding guidelines that enhance the image exchange challenges that is discussed in this research:

First: 10 Steps to strategically to build and implement any organization Enterprise Imaging(EI) System as key and core for image exchange as follows; Step 1: Access to all the Images and Documentation for Better Decision-Making to Impact Patient Outcomes, Step 2. Demonstrate how EI Is a Powerful Strategy, Step 3: Understand the Specialties and Their Clinical Workflow Challenges as It Relates to Imaging, Step 4: Create a High-Reliability Healthcare Strategy to Improve Quality of Care and Patient Safety with EI, Step 5: Demonstrate how EI Can Reduce Costs, Step 6: Show how EI Can Help Enhance Patient Experience, Step 7: Enhance the Work Lifeof Caregivers, Step 8: Develop EI Governance, Step 9: Implement an EI Project and Step 10: Understand Cybersecurity for EI (See Figure 15 in the Appendix)[5].

Second: An Enterprise Imaging platform provides the standards-based, enterprise infrastructure to support departmental imaging workflows. This includes modality worklist services, image archival, index, enterprise viewer application viewing within or outside the EHR, query/ retrieve of imaging content from most departments, as well as image exchange capabilities (See Figure 16,17 in the Appendix) [11].

Third: Lessons learned in the digital transformation of radiology and pathology can serve as a basis for interactive multimedia reporting (IMR) across image-centric medical specialties by correlating textual descriptions of image findings linked to the actual images and avoid that both image and report stay as silos. IMR will create interactive reports with multimedia elements and embedded hyperlinks in reports that connect the narrative text with the related source images andmeasurements. IMR shows a schematic representation of how the relationship between text and images by context sharing during report authoring so that this context is unambiguous for the reportconsumer. IMRs is shown to provide more robust communication with clinicians while reducing the ambiguity of findings. This can be linked into EI and to an enterprise image viewer and enhanced for sharing by EI infrastructure (See Figure 18,19 in the Appendix)[12,13].

Fourth: Clinical specialties are widely varied needs for diagnostic image interpretation, andclinical image and video image consumption. Enterprise viewers are being deployed as part of electronic health record implementations to present the broad spectrum of clinical imaging and multimedia content created in routine medical practice today. Every physician, nurse practitioner,physician assistant, nurse, and imaging technologist of a health organization needs to review and manipulate images, image metadata, and associated imaging reports through the electronic healthrecord (EHR) as part of routine activities. Patients are interested and increasingly savvy enough to navigate their own diagnostic images. Enterprise viewer integration may require third party integrations to several enterprise specialty PACS viewers, potentially a vendor neutral archive, enterprise imaging, one or more information systems or electronic health records, document storage, as well as reporting and workflow tools (See Table 12 in the Appendix)[17].

Fifth: With the advent of digital cameras, there are an explosion in the number of medicals pecialties using images to diagnose or document disease and guide interventions. In many specialties, these images are not added to the patient’s electronic medical record and are not distributed so that other providers caring for the patient can view them. There are key workflow challenges related to enterprise imaging and to be taken in consideration for potential solutions tothese challenges as follows: 1- Workflow: Each specialty acquires and uses images differently. 2-Patient Identification: The correct images must be placed within the correct patient’s medical record every time. In DICOM, this identification is automatically applied with an order selected from the modality worklist supplying the necessary metadata 3- Information Needed in an Image:If images are used to diagnose an abnormality or to help provide an objective measure for long- term follow-up, the images must have certain qualities to allow for further study and comparison.4- Reporting: While a medical provider can describe portions of an image, specialists are needed to provide the exquisite detail in describing the image. Therefore, it is crucial to be able to link thetext describing an image or an encounter with each image. 5- Metadata: Reports are not the only information to give image context, metadata also serves this purpose. In DICOM-based imaging, metadata is applied at the patient, study, series, and image level. 6- Legal Concerns: Patient Privacy and Access Control, Maintaining Images, Image Fidelity and File Format. 7- Mobile Devices: providers are currently using their devices to capture images, videos, and sounds from their patients. This practice raises concerns related to patient privacy [14,15,16].

**Table 1:** (HDIRS in Canada by the numbers).

| **Number of PACs feeds** | **38** |
|---|---|
| Number of HL7 feeds | 47 |
| Number of studies stored (as of august 2021) | 70,065,106 |
| Number of reports stored (as of august 2021) | 72,561,105 |
| Number of exams shared in fiscal 2021-2022 | 4,923,287 |

**Table 2:** (Contributing PACS vendors)

| Vendor | Qualification for Transfer to DIR |
|---|---|
| Agfa | 11 |
| Careview | 1 |
| Change Healthcare | 1 |
| Coral | 5 |
| Fuji | 2 |
| GE | 15 |
| IBM Watson Health | 2 |
| Intelerad | 23 |
| Phillips | 15 |
| Sectra | 5 |
| Velox | 3 |
| Siemens | 3 |
| SIMMS | 36 |

**Table 3:** (Breakdown of each retrieval volume of foreign exams across the Canadian DIR's membership in fiscal 2021–2022)

| Site | Total IDEP/foreign exam management ingestion |
|---|---|
| Hospitals | |
| Hospital I | 35,079 |
| Hospital 2 | 53,081 |
| Hospital 3 | 172,695 |
| Hospital 4 | 30,568 |
| Hospital 5. 6 (two hospitals share PACS) | 371,945 |
| Hospital 7. 8 (two hospitals share PACS) | 43,293 |
| Hospital 9 | 232,823 |
| Hospital 10 | 502 |
| Hospital 11 | 232,679 |
| Hospital 12 | 257,871 |
| Hospital 13 | 149,634 |
| Hospital 14, 15 (two hospitals share PACS) | 82,085 |
| Hospital 16 | 301,628 |
| Hospital 17. 18. 19 (three hospitals share PACS) | 2* |
| Hospital 20 | 176,799 |
| Hospital 21 | 654 |
| Hospital 27. 28 (two hospitals share PACS) | 350,204 |
| Hospital 29. 30 (two hospitals share PACS) | 108,818 |
| Hospital 31, 32 (two hospitals share PACS) | 71,096 |
| Hospital 33 | 285,304 |
| Hospital 34 | 15,057 |
| Hospital 35. 36. 37 (three hospitals share PACS) | 771,417 |
| Hospital 38 | 38,021 |
| Hospital 39 | 148,318 |
| Clinics | |
| Clinic 1 | 63,556 |
| Clinic 2 | 548 |
| Clinic 3 | 15,057 |

Hospitals 17,18,and 19 have not enabled the IDEP solution.

**Table 4:** (Number of Registered ClinicalConnect Users (as of August 31, 2021)-Ontarion-Canada).

| Sector/HIC type (no. of participant organization sites) | No. of participant organization sites | No. of registered users | No. of registered users with access to DI-CS via ClinicalConnect |
|---|---|---|---|
| Hospital (sites) | 74 | 35,443 | 31,191 |
| Primary care organizations (e.g., group practices) | 143 | 1,632 | 948 |
| Primary care-sole practitioners | 1,433 | 2,450 | 1,164 |
| Community organizations (e.g., MH&A, CSS) | 349 | 4,173 | 2,919 |
| Community pharmacies | 257 | 353 | 332 |
| Public health units | 38 | 848 | 34 |
| Totals | 2,294 | 44,899 | 36,558 |

*All have access to diagnostic images and reports generated by acute care hospitals located in OH West Region.

**Table 5:** (Difference between the environments of DIR1 and DIR2 in Canada).

| Comparision of DIR1 and DIR2 | | |
|---|---|---|
| **Item** | **DIRI** | **DIR2** |
| Patient identification | Deterministic: match based on provincial Ontario Health Card Number | Probabilistic: EMPI patient matching based on a scorecard of key demographics |
| Number of contributing sites | 98 | 29 |
| Total number of registered patients | ~12,370,000 total patients | ~7,500,000 total patients |
| Annual exam volume | ~5 million exams annually | ~3 million exams annually |
| Number of patient identity pools | 40 | 21 |

**Table 6:** (Patient demographics- Canada).

| Attribute | Weight | |
|---|---|---|
| Health number | 22.46 | Exact |
| Last name | 14.54 | Distance |
| First name | 11.54 | Distance |
| Middle name | 7.95 | Distance |
| Gender | 7.39 | Exact |
| Date of birth | 17.86 | Date-Distance |
| Postal code | 7.64 | Distance |
| Home phone | 10.62 | Distance |

**Table 7:** (Results of potential false positive patient matches).

| DIR | Total number of patient pairs | Last name, first name, and DOB mismatch |
|---|---|---|
| DIR1 | 14,009,674 | 6,906 (0.05%) |
| DIR2 | 6,911,272 | 3,576 (0.052%) |

**Table 8:** Diagnostic Image Repository2 (West Toronto): patient identity scorecard indicating the weighting values assigned for each attribute. "Distance" indicates that a calculation is made for that attribute to determine how close it is to exact. The full weighted value would be assigned if there is an exact match. Something less than the weighted value will be assigned if the match is not exact).

| Attribute | Weight | Match |
|---|---|---|
| Health Card Number | 22.46 | Exact |
| Last Name | 14.54 | Distance |
| First Name | 11.54 | Distance |
| Middle Name | 7.95 | Distance |
| Gender | 7.39 | Exact |
| Date of Birth | 17.86 | Date-Distance |
| Postal Code | 7.64 | Distance |
| Home Phone | 10.62 | Distance |

**Table 9:** (Relative exchange volume by hospital size in Netherland).

| Type | Beds | Average volume | Relative |
|---|---|---|---|
| Academic hospital | > 1000 | 49.369 | 16% |
| General hospital (large) | > 500 | 83.642 | 27% |
| General hospital (small) | < 500 | 179.003 | 57% |

**Table 10:** (Japan- HIE networks (34) in MHLW website " Healthcare Information Exchange Network Support Navigation (Archive)").

**Table 1** HIE networks (34) in MHLW website "Healthcare Information Exchange Network Support Navigation (Archive)"

| # | Basic data | | | | Exchange information | | | | | System structure | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Name of HIE Network | Prefecture | Area | Since | EMR | Order | Study | Image | Dose | Server | Type | Protocol | +SSMIX |
| 1 | Ajisai Net | Nagasaki | Pref | 2004 | ○ | | ○ | ○ | ○ | Fa | Product | IDL, HB | |
| 2 | Pika-Pika Link | Saga | Pref | 2010 | ○ | ○ | ○ | ○ | | Fa+Cl | Product | IDL | ○ |
| 3 | Azalea Net | Fukuoka | ? | 2012 | ○ | ○ | ○ | ○ | | Fa | Product | IDL | |
| 4 | Sado Himawari Net | Niigata | Oth | 2013 | ○ | | ○ | ○ | ○ | Cl | SI | Original | ○ |
| 5 | Hareyaka Net | Okayama | Pref | 2013 | ○ | ○ | ○ | ○ | ○ | Fa+Cl | Product | IDL, HB | ○ |
| 6 | Mame Net | Shimane | Pref | 2013 | ○ | ○ | ○ | ○ | ○ | Ce | SS-MIX | SS-MIX | ○ |
| 7 | Biwa lake Asagao Net | Shiga | Pref | 2014 | ○ | ○ | ○ | ○ | ○ | Fa | Product | IDL, HB | ○ |
| 8 | Yamashina Medical and Care Collaboration Network | Kyoto | ? | 2015 | ○ | ○ | ○ | | | Ce | Intl Std | IHE | ○ |
| 9 | Okinawa Shinryo Network | Okinawa | Pref | 2015 | ○ | | ○ | ○ | ○ | Cl | SI | Original | |
| 10 | To-Net | Saitama | Sec | 2012 | ○ | | ○ | ○ | | Cl | Product | IDL | ○ |
| 11 | HM Net | Hiroshima | Pref | 2013 | ○ | ○ | ○ | ○ | ○ | Fa | Intl Std | HL7 | ○ |
| 12 | Cyokai Net | Yamagata | Sec | 2012 | ○ | | ○ | ○ | | Ce | Product | IDL | |
| 13 | Usuki Sekibutsu Net | Ooita | City | 2008 | ○ | | ○ | ○ | ○ | Cl | Product | IDL | |
| 14 | Ehime Medical Association HIE Network | Ehime | Pref | 2012 | ? | ? | ? | ? | ? | Ce | ? | ? | ? |
| 15 | Oshidori Net 3 | Tottori | Pref | 2009 | ○ | ○ | ○ | ○ | | Cl | Intl Std | IHE | ○ |
| 16 | Kiyosu Link | Wakayama | Pref | 2013 | ○ | ○ | ○ | ○ | ○ | Cl | SS-MIX | SS-MIX | ○ |
| 17 | Fuji-no-kuni Net | Shizuoka | Pref | 2011 | ○ | ○ | ○ | ○ | | Fa+Cl | Product | HB | ○ |
| 18 | Shinsyu Medical Net | Nagano | Pref | 2011 | ○ | ○ | ○ | ○ | | Fa+Cl | Product | IDL, HB | ○ |
| 19 | Ishikawa Medical Information Sharing Network | Ishikawa | Pref | 2014 | ○ | ○ | ○ | ○ | | Fa | Product | IDL | ○ |
| 20 | Tochimaru Net | Tochigi | Pref | 2013 | ○ | ○ | ○ | ○ | ○ | Cl | Product | IDL, HB | ○ |
| 21 | OKInet | Yamagata | Sec | 2011 | ○ | ○ | ○ | ○ | ○ | Fa+Ce | Product | IDL | |
| 22 | Mogami Net | Yamagata | Sec | 2013 | ○ | ○ | ○ | ○ | | Ce | Product | IDL | ○ |
| 23 | Benibana Net | Yamagata | Sec | 2014 | ○ | ○ | ○ | ○ | | Fa | Product | IDL, HB | |
| 24 | Akita Heartful Net | Akita | Pref | 2014 | ○ | ○ | | ○ | | Fa+Ce | Product | IDL, SI | |
| 25 | Kumamoto Medical Network | Kumamoto | Pref | 2014 | ○ | ○ | ○ | ○ | ○ | Ce | Product | Original | ○ |
| 26 | Tobiume Net | Fukuoka | Pref | 2014 | ○ | ○ | | ○ | ○ | Fa+Cl | Product | HB | ? |
| 27 | K-MIX+ | Kagawa | Pref | 2014 | ○ | ○ | ○ | ○ | ○ | Fa+Cl | Product | HB | ? |
| 28 | Mie Medical Safety Network | Mie | Pref | 2010 | ○ | | ○ | ○ | ○ | ? | Product | IDL | ? |
| 29 | Gifu Seiryu Net | Gifu | Pref | 2015 | ○ | ○ | ○ | ? | ? | ? | Product | IDL, HB | ? |
| 30 | Fukui Medical Net | Fukui | Pref | 2014 | ○ | ○ | ○ | ○ | ? | ? | Product | HB | ? |
| 31 | iSN: Ibaraki Safety Net | Ibaraki | Pref | 2015 | ○ | ? | ○ | ○ | ? | Ce | Product | Original | ? |
| 32 | Kibitan Health Net | Fukushima | Pref | 2015 | ○ | ? | ○ | ○ | ○ | ? | Product | IDL, HB | ? |
| 33 | MMWIN: Miyagi Net for everyone | Miyagi | Pref | 2013 | ○ | ○ | ○ | ○ | ○ | Ce | SS-MIX | SS-MIX | ○ |
| 34 | Aomori Medical Net | Aomori | Pref | 2015 | ○ | ○ | ○ | ○ | | ? | Product | HB | ? |

The data are as of the time of the MHLW survey and may not be current as of 2021.
For some of the HIE networks, there was almost no data other than the name and prefecture in the survey report.
Therefore, these were supplemented by manually collecting information from websites or other sources.
As for Yamagata, the entire prefecture is covered by four networks of secondary medical care areas on the list.
*IDL* ID Link proprietary HIE product of NEC Company, *HB* HumanBridge proprietary HIE product of FujitsuCompany, *Original* proprietary HIE protocol of Japanese vendor, *SS-MIX* Standardized Structured MedicalInformation eXchange, *IHE* Integrating the Healthcare Enterprise, *SI* System Integration, *HL7* HealthLevel 7, *Pref* prefecture wide, *Sec* secondary medical area, *City* city wide, *Oth* other, *Fa* facility, *Cl* cloud, *Ce* datacenter
"?" is used to indicate that the information is unclear. A blank field means not applicable and is different from "?".

**Table 11:** (Brazil- DICOM Flow services and the main actions. Each message sent contains only one service and one action. For each request action (Request, Put, Verify Services) there is a result action (Result, Confirm, Verify Result)).

| Service | Action | Description |
|---|---|---|
| Certificate | Request | Request for digital certificate |
| | Result | Response containing the digital certificate. |
| | Confirm | Confirming receipt of the digital certificate. |
| Storage | Save | Request for storage of the study. |
| | Result | Result of the storage operation. |
| Sharing | Put | Signaling that the study is available for sharing. |
| | Result | Result registering information on sharing metadata. |
| Request | Put | Request to perform an operation on an study (e.g., written report). |
| | Result | Result of action (e.g., written report completed and returned to requester). |
| Discovery | Verify Services | Requesting lists of available services. |
| | Verify Result | Result containing a list of services. |

**Table 12:** (Commonly addressed use cases and commonly not addressed use cases by an enterprise image viewer, by HIMSS-SIIM Working Group).

| Specialty/location | Enterprise viewers commonly accommodate review of.. | Enterprise viewers may not include |
|---|---|---|
| Cardiology | Echocardiography; MRI; fluoroscopic and CT angiography | Advanced and specialty toolset functionality and calculations, such as nuclear cardiology gated SPECT image and ECG integration, ejection fraction determination, coronary vessel tracking, and structured data export for reporting |
| Dermatology | Most handheld camera images | Efficient presentation of salient image metadata, such as laterality and anatomy |
| Gastroentology | Fluoroscopy; endoscopy; image-based reports | Image-based report creation |
| HIM | Most scanned documents | (None) |
| Mobile device users | Many image sets needing only limited manipulation or interactivity with the user at point of care or off site | Advanced and specialty toolset functionality and calculations; adequate image resolution, ease of use, or screen real estate |
| Obstetrics and gynecology | Endoscopy; hysterosalpingography; fetal and gynecologic ultrasound | Advanced and specialty toolset functionality and calculations, such as 3D/4D imaging, growth chart tracking and dating |
| Ophthalmology | Orbit ultrasound; secondary captures such as from retina and slit lamp modalities | Advanced and specialty toolset functionality and calculations, such as optical coherence tomography and automated image-based biometry; presentation of many proprietary image formats |
| Pathology | Gross sample intake and prep; secondary captures from whole slide, FISH, and cytogenetics | Advanced and specialty toolset functionality and calculations, such as common lab automated image-based cell counting and percentage analyses; adequate whole slide rendering speed; presentation of many proprietary image formats |
| Patient portal | Most images of interest to patients | Ease of use necessary for patient population deployment; image/exam data download |
| Preoperative planning | Operative template secondary capture | Operative template creation |
| Radiology | Radiography; ultrasound; MRI; CT; fluoroscopy | Advanced and specialty toolset functionality and calculations, such as breast tomography, tissue perfusion, dataset fusion, standard uptake value determination, image registration, lesion tracking, and structured data export for reporting |
| Referrer portal Research | Most images of interest to primary care The established use cases above | Many needs not met for subspecialists, such as those above Advanced and specialty toolset functionality and calculations being investigated |

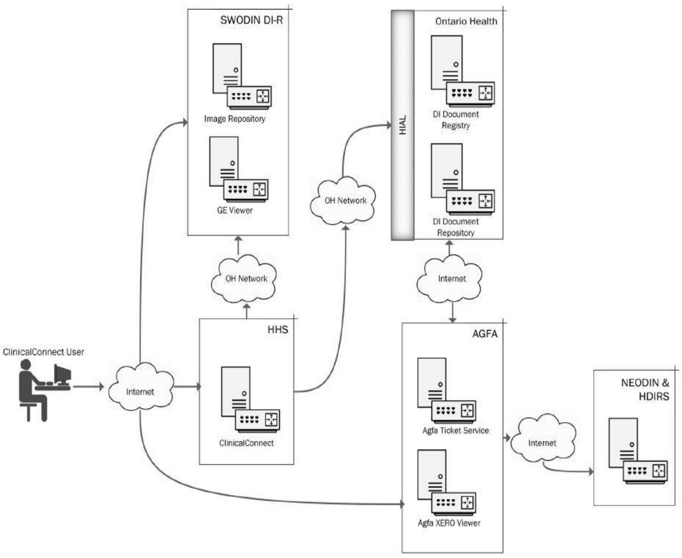


Figure 1: (Opening of a new web browser window upon clicking the icon and retrieval of the image from either SWODIN or the DI Common Service).

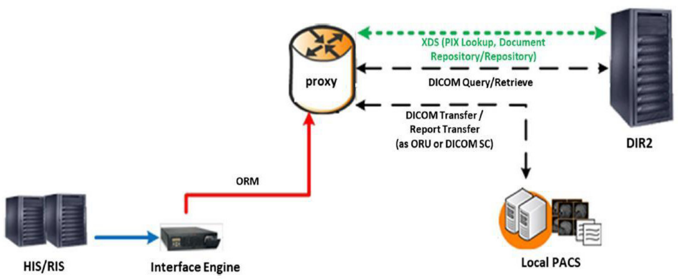


Figure 2: (Diagnostic Image Repository2 (West Toronto): data flow for discovery and retrievalof outside exams into local PACS. The retrieval flow provides both the images and report and precedes these with order if the PACS requires it).

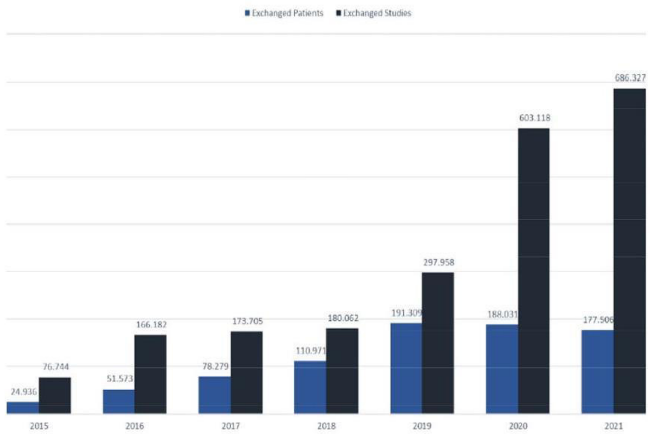


Figure 3: (Exchange volume XDS Network North Netherlands).

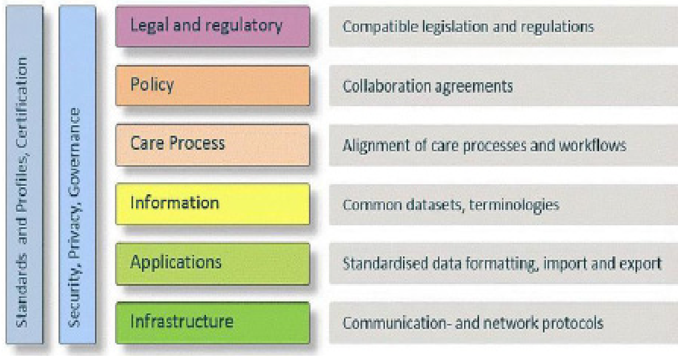


Figure 4: (The Dutch Interoperability Framework (original version)).

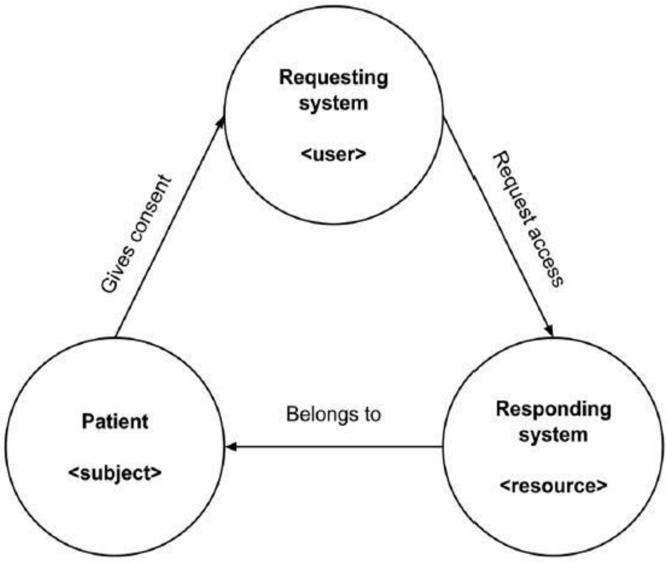


Figure 5: (The required trust relationship between a clinical "user" (e.g., medical doctor), requesting access to a medical information "resource" (e.g., DICOM study, report, discharge summary), and the patient "subject")

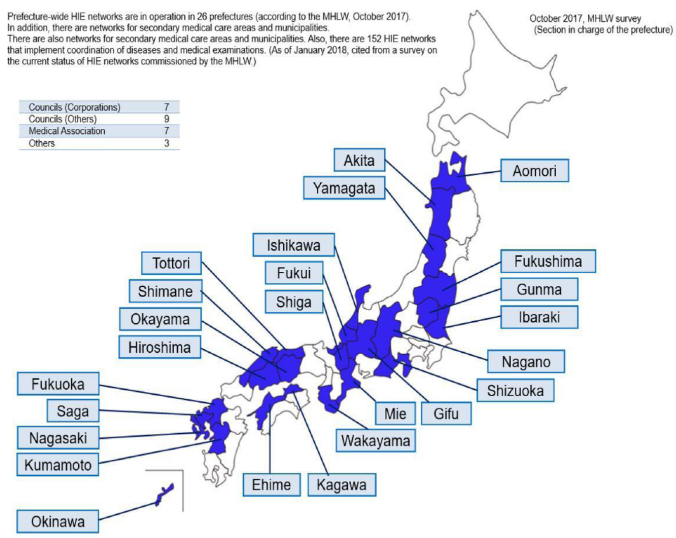


Figure 6: (Japan- Distribution of areas with a Healthcare Information Exchange network for all prefectures (Ministry of Health, Labor and Welfare, October 2017) * English translation, partial modification of figure).

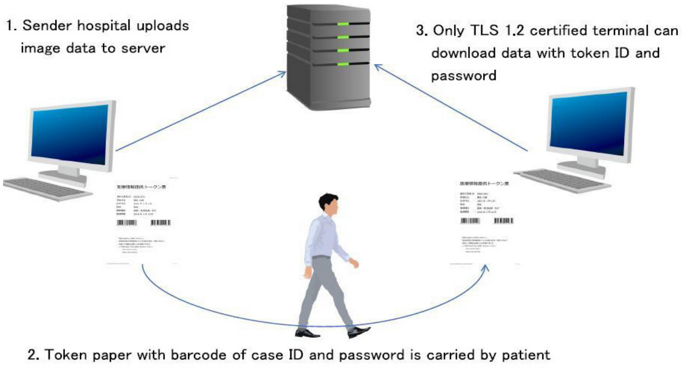


**Figure 7:** (Japan- Operational procedures for netPDI using tokens).

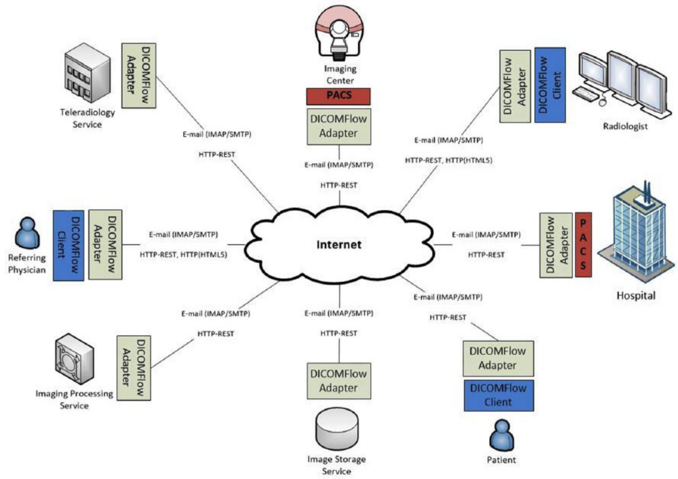


**Figure 8:** (Macroarchitecture of the DICOMFlow integrating entities from distinct domains with DICOMFlow adapters located on the edge of heterogeneous infrastructures).

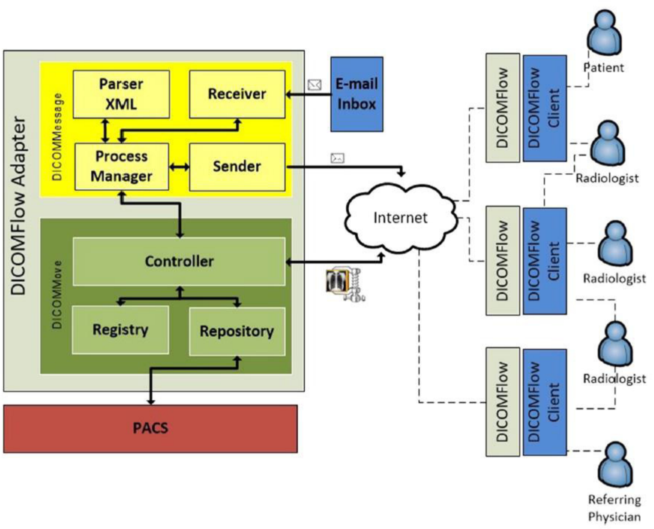


**Figure 9:** (Reference microarchitecture of the DICOMFlow adapter. The DICOMMessage deals with the safe communication of messages, and the DICOMMove handles the safe transmission of the medical imaging exams (DICOM objects)).

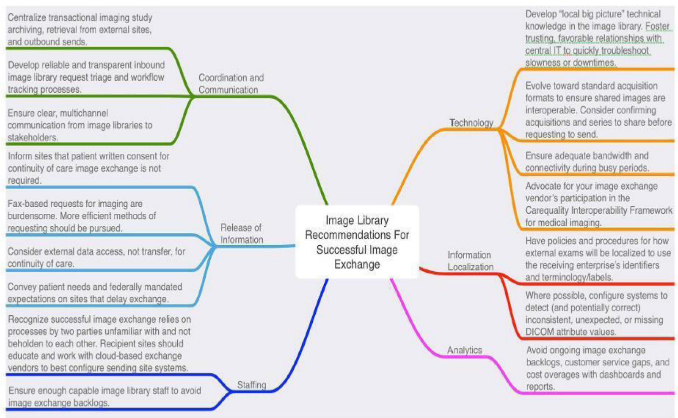


**Figure 10:** (Recommendations summary for successful image exchange operations within the Image Library)

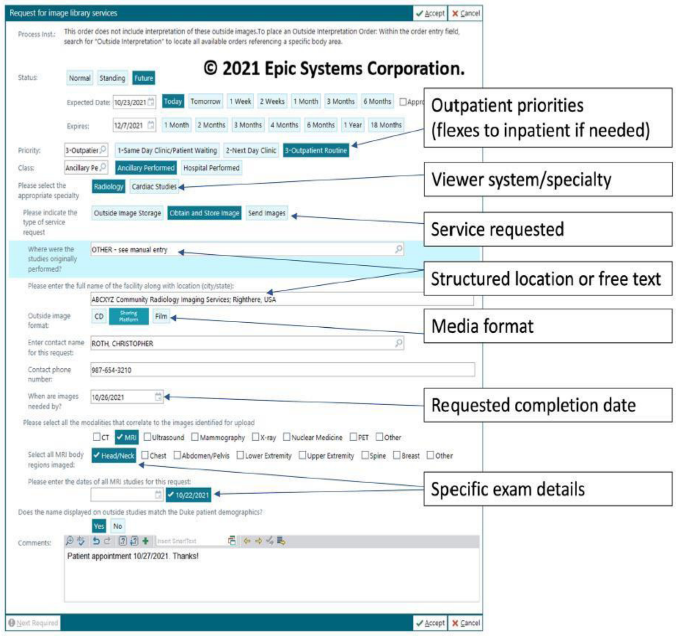


**Figure 11:** (A Request for Image Library Services EHR order can improve communication into the Image Library).

**Key Performance Indicators to Consider**

| | |
|---|---|
| Exchange platform:<br>• Number of connections<br>• Volume of studies imported per external entity and total<br>• Volume of studies externally shared per external entity and total<br>• Volume of studies retrieved from outside, per external entity and total<br>• Number, name, and type of external entities sharing images inbound (type = law practices, insurances, healthcare sites, ...)<br>• Nonfunctional/incomplete/poor image quality studies received<br>• Invalid DICOM tags/series per external entity<br>• Volume of requests received via platform compared to fax/mail/in person | CDs:<br>• Volume of CDs received per external entity and in total<br>• Average number of studies per received CD<br>• Average number of images per received CD<br>• Nonfunctional/incomplete/poor CDs received per external entity<br>• Volume of CDs, DVDs, and USBs generated<br>• Employee time cost to generate a CD<br>• Cost of CD media and case<br>• Cost of CD shipping |
| Infrastructure and Connectivity:<br>• Network bandwidth consumed by uploads<br>• Network bandwidth consumed by downloads<br>• Number of times maximum thread bandwidth was reached<br>• Time of day of thread bandwidth thresholds reached<br>• Average transfer queue depth<br>• Number of exam failures sending from cloud exchange application to archive<br>• Percent of image exchange annual quota used<br>• Number of service tickets with platform vendor<br>• Number and length of downtimes | Operations:<br>• Image library employee satisfaction<br>• Time to fulfill requests to import, retrieve, and share images<br>• Personnel errors related to incorrectly labeled studies or those uploaded to the incorrect patient record<br>• Number of phone calls<br>• Number of phone and fax requests to share patient data<br>• Compliance inquiries related to potential breach of confidentiality |
| Patient portal:<br>• Volume and procedure types of imaging studies viewed<br>• Percent of patients with a recent imaging encounter who viewed their images<br>• Percent of patients with a recent imaging encounter who viewed their images and sent a message to a care provider within two days<br>• Age and gender of patients viewing their images<br>• Length of time patients spend per session viewing images<br>• Viewer image manipulation features used by patients | Referring provider portal:<br>• Volume and procedure types of imaging studies viewed<br>• Percent of providers who viewed their patient's imaging encounter images<br>• Name of physicians and practices viewing images<br>• Length of time providers spend per session viewing images<br>• Viewer image manipulation features used by providers |

**Figure 12:** (Potential image library process key performance indicators).

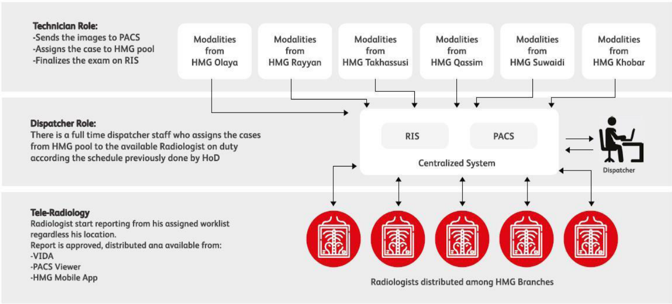


**Figure 13:** (Middle East Region- Al Habib Medical Group Hospital Medical Image Architecture Design cross 5 hospitals in the Kingdom of Saudi Arabia (source: Al Habib Medical Group)).

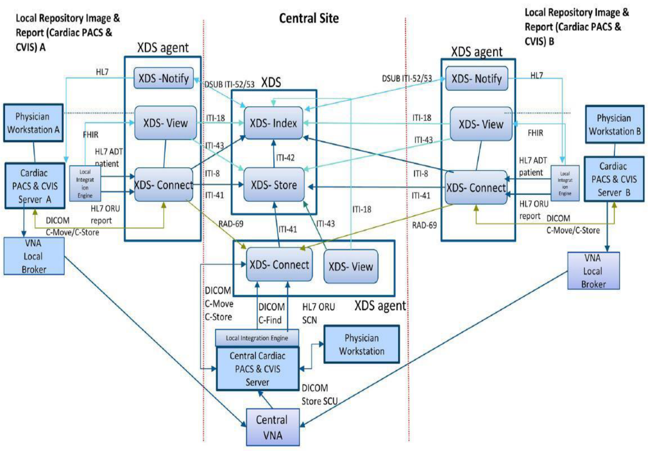


**Figure 14:** (Middle East Region- High interoperable cardiology image exchange level cross 8 cardiac centers at MOH in the Kingdom of Saudi Arabia showing the international standard utilized such as DICOM, JHL7, IHE Profiles, etc. (source: MOH cardiology)).

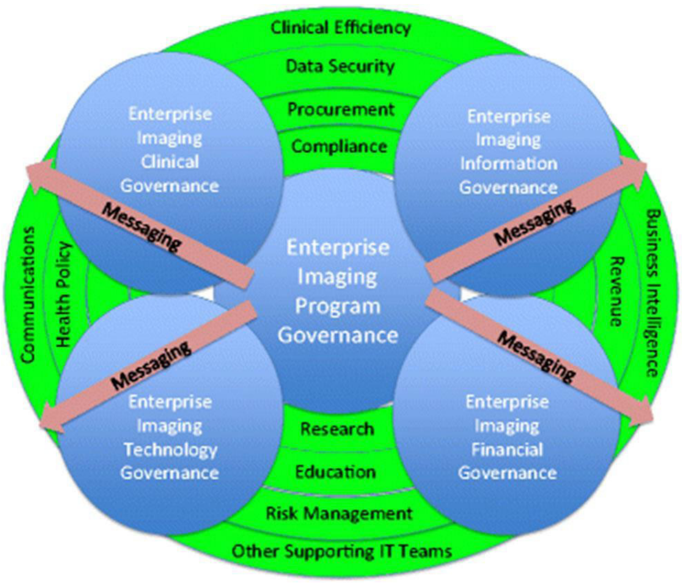


**Figure 15:** (The integrated nature of EI governance, by HIMSS-SIIM Working Group).

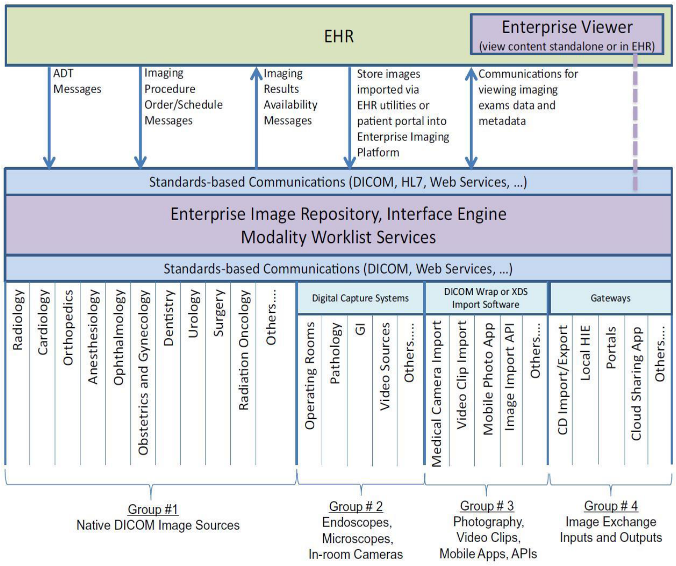


**Figure 16:** (An Enterprise Imaging platform- Standard –based, by HIMSS-SIIM Working Group).

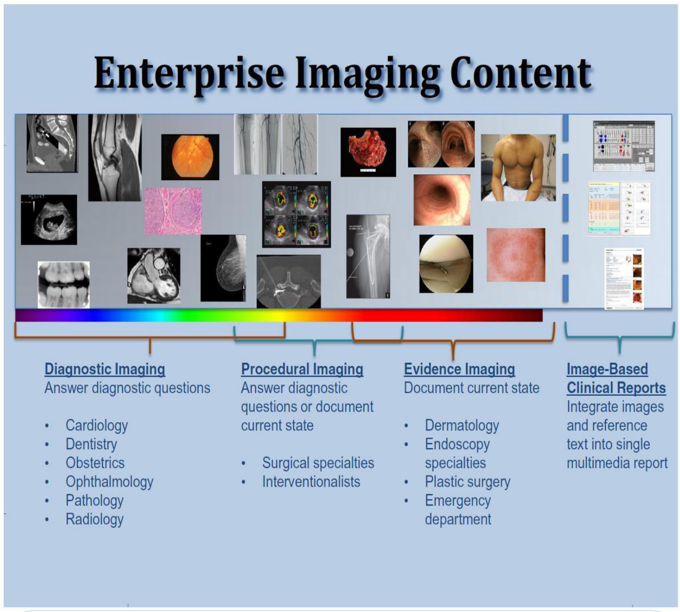


**Figure 17:** (The broad spectrum of Enterprise Imaging content and common use cases, by HIMSS-SIIM Working Group).

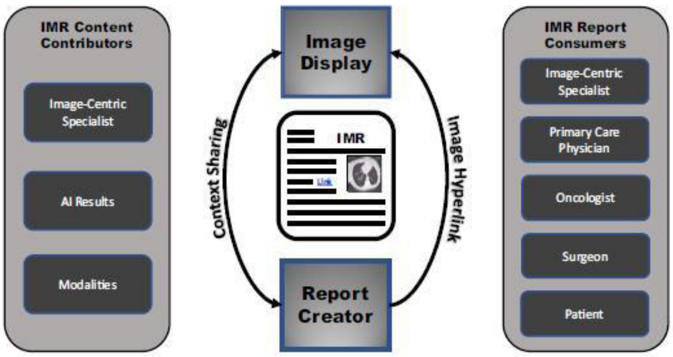


**Figure 18:** (Graphic representation of how IMR enables the communication between content contributors (image-centric specialists) and information consumers (primary care providers, patients, other specialists), by HIMSS-SIIM Working Group).

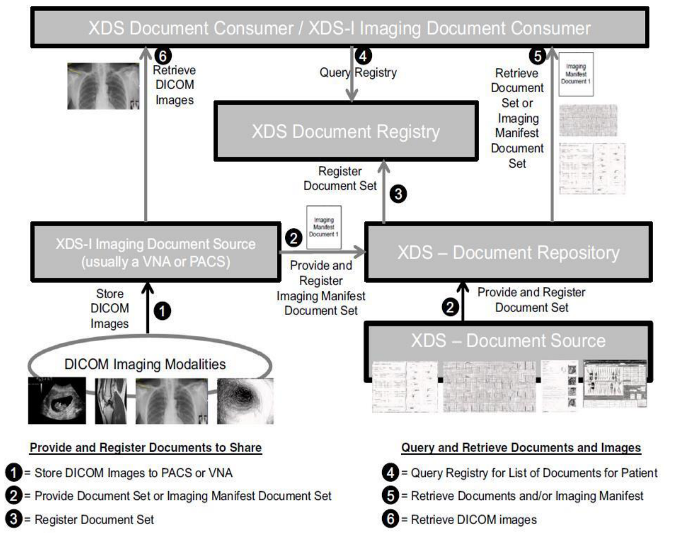


**Figure 19:** (This diagram shows how documents and images are shared between sources and consumers using actors and transactions based on the XDS/XDS-I IHE Integration Profiles. Documents are stored in an XDS document repository and registered. DICOM images are stored in an Imaging Document Source, and an Imaging Manifest Document is created, stored in an XDS document repository and registered, by HIMSS-SIIM Working Group).

## Conclusion

The knowledge that gained from the process of conducting this research includes positives and negatives experiences and lessons learned about Medical Images Exchange and sharing.

Managing inconsistent information across multiple sources, validating electronic requestsfor patient information, overcoming organizational resistance to sharing data and making data readily available in the right time for the right person are all considered as core of Interoperability that impact on Healthcare Information Exchange and in specific Medical Images Exchange.

Additional considerations while building and implementing healthcare information exchange including the medical images exchange must be taken beyond technological standards such as governance, policies, funding, adaption, quality, privacy and other dimensions that provide valuable decision support along the patient pathway.

High adaption with electronic health information exchange including medical images exchange allows doctors, nurses, specialists, consultants and other health care providers as well as patients to appropriately access and securely share images through medical information electronically which is improving the speed, quality, safety and cost of patient care.

No one under the standard roles like DICOM, HL7, IHE, FHIR, etc. to allow interoperable communications among of multi electronic healthcare information systems. IHE Connectathons events provide a detailed implementation and testing process to enable the adoption of standards-based interoperability by vendors and users of healthcare information systems. This is golden chance to all participants to validate interoperability and compliance with IHE profiles in medicalimages exchange field.

Enterprise imaging connects once-separate information siloes across multiple 'ologies enhance the entire journey and workflow for physicians and caregivers who need images and access to the EMR to guide decisions on patient care.

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