Healthcare IT: The Nuances of Integration & Interoperability

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Introduction

Interoperability is the combined effort of technology and protocols to enable the easy transfer of clinical information across a healthcare ecosystem. It has multiple benefits, not just for individual departments or healthcare institutes, but also in supporting the activities of registries and research initiatives.

Pathology is just embarking on its digitisation journey, and there are multiple ways that departments can promote interoperability in partnership with industry. Standardising whole slide image formats and promoting tight integration between different software systems will benefit not just individual users but also healthcare systems. Interoperability is closely related to investment in the future and will be integral to improving both pathologists' workflow and the standard of care available for patients today.

> *Interoperability: "the ability of different information systems, devices, and applications to access, exchange, integrate, and cooperatively use data in a coordinated manner, within and across organisational, regional, and national boundaries, to provide timely and seamless portability of information and optimize the health of individuals and populations globally."*
>
> **- Healthcare Information and Management Systems Society (HIMSS)**

Interoperability in healthcare is a topic frequently discussed as an important enabler of high-quality care, but the term often has different connotations for IT professionals, chief technology

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officers, physicians, and vendors. Relating directly to healthcare software, HIMSS has produced a comprehensive definition which also possesses many facets and nuances. To further guide providers, the maturity of healthcare interoperability was further defined across a series of stages:

- **FOUNDATIONAL (LEVEL 1):** one system connects to another.
- **STRUCTURAL (LEVEL 2):** defines data exchange systematically for interpretation.
- **SEMANTIC (LEVEL 3):** common underlying models and codification, standardized definitions from publicly available value sets and coding vocabularies.
- **ORGANIZATIONAL (LEVEL 4):** Includes governance, policy, social, legal and organizational considerations to facilitate the secure, seamless and timely communication and use of data both within and between organisations, entities and individuals.

The above framework mainly relates to generalised clinical IT systems, with interoperability in medical imaging being further outlined in a joint project by the European Society of Radiology (ESR) and HIMSS. This is referred to as the Digital Imaging Adoption Model (DIAM).

DIAM refers to a spectrum of development for digital imaging adoption from no electronic management whatsoever to the full ability to manage all imaging related processes digitally, including importing/exporting images to external parties. These processes when most sophisticated include structured data storage which allows for the addition of advanced analytics tools like natural language processing for clinical and organisational measurements that offer additional insight to internal and external parties. Ultimately it encourages institutions to be able to achieve multidisciplinary interactive collaboration that includes multiple healthcare stakeholders and engages patients directly.

Institutions can vary between stages numbered 0-7, with a lot of heterogeneity existing between different regions and sub-markets. Some institutions can still be considered stage 0, whereas the first healthcare provider worldwide to reach stage 7 was only recognised as recently as March 2023[1].

Whilst both frameworks consider healthcare across a whole hospital, because of the high number of dedicated software systems a singular institution may have, healthcare providers also each have variation and challenges affected by both the combination of software already in use at their

1 https://www.himss.org/news/himss-worlds-first-stage-7-diam-samsung-medical-center-south-korea

Level of Integration Today	Radiology - Common	Radiology - Specialist	Cardiology – Non-invasive	Cardiology – Invasive	Oncology	Pathology
Intra-Department/ Primary Diagnostic	DICOM + IHE Enterprise profiles' increasingly FHIR	DICOM specialists (releases post 2014)	DICOM(+ IHE but less mature); limited FHIR	Proprietary + DICOM specialist	DICOM + IHE	Proprietary + nascent basic DICOM
Registries (reporting of data to national or condition specific monitoring institutions)	Required – localised Automated workflow Mature process	Required – localised Automated workflow Mature process	Required – localised Automated workflow Mature process	Required – localised Automated workflow Mature process	Limited requirement Semi-automated Emerging	No requirement Report – basic image thumbnail (basic) or no image
EMR + Secondary Clinical Review	Radiology report access (text) Thumbnail image	Radiology report access (basic) No thumbnail	Cardiology report access Limited media	Cardiology report access Limited media	Report and core treatment pathway Limited specialist media/content	LIS/Bi-directional LIS Oncology IT (Limited) Enterprise Imaging (Limited)
Other Enterprise IT systems	Billing systems Clinical Viewer Wider EI platform VNA	Billing system Limited non-specialist viewer integration	Billing systems Clinical Viewer + Radiology PACS Wider EI platform VNA	Billing systems Limited Clinical Viewer	Billing systems LIS/Bi-directional LIS	Low maturity
Maturity of Open Exchange	High Maturity	Mid maturity	Mid-high maturity	Low – mid maturity	Low – mid maturity	Low 5-10 years or more before commoditised
Commercial Value of Interoperability Competence	Very High Commoditised	High Commoditised in 2-4 years	Mid/High Commoditised in 2-4 years	Mid/Low 5-10 years or more before commoditised	Mid/Low 5-10 years or more before commoditised	Low 5-10 years or more before commoditised

Figure 1: A comparison of maturity in interoperability between different clinical imaging departments.

institution and other strategic or clinical initiatives.

This problem exists because historically much of IT purchasing for providers has been co-ordinated by separate clinical and imaging departments, which has resulted in vastly different levels of interoperability between clinical 'ologies, as shown in figure 1 at the top of this page.

Whilst frameworks provide useful guidance in clarifying clear steps to improve interoperability in a way which allows institutions to plan a wider strategy, decision making at the individual product level can still be extremely difficult.

Oftentimes individual departments, and a to a lesser degree broader healthcare institutions, are faced with finite budgets and existing infrastructure which would need to be significantly altered to advance interoperability. Such tasks present weighty challenges, with urgency often dictated by contract renewal timelines, national/ regional policies, key stakeholder buy-ins, overall and individual departmental budgets, and competing executive initiatives.

To move forward on interoperability therefore, providers must conduct planning with inter-department co-ordination in mind; often this involves including stakeholders at higher positions of management, which must consider realistic timelines and budgets for renewals.

But whilst a framework for interoperability exists for providers, such a spectrum doesn't exist for vendors of IT applications, and this can make selecting new systems very difficult.

How do institutions know that the product they select will be able to support both their long-term and short-term strategies?

This is difficult in part because levels of interoperability are so heavily influenced by individual provider circumstances, which can heavily dictate what individual vendors are able to do. Some deployments may be easily co-ordinated, whereas others which involve vendors working with a multitude of 3rd party partners may take years to culminate effectively.

SO WHY SHOULD HEALTHCARE INSTITUTIONS BE SO CONCERNED ABOUT ADVANCING INTEROPERABILITY, ESPECIALLY WHEN IT IS SO COMPLEX TO CO-ORDINATE IN LARGER HEALTHCARE SYSTEMS AND NETWORKS?

There are several benefits to higher levels of interoperability. At the systems level, by connecting IT systems together and facilitating easy access to data, institutions enable individuals to understand a patient's complete care history more quickly and easily, increasing productivity. Thus, these individuals are also less likely to make errors such as duplicate testing. Once this effect begins to accumulate in large workforces it quickly translates to both better outcomes for more patients and thus also a significant reduction in 'avoidable' costs.

Some cases are too complex even for individual diagnosticians, and this is when the ability to draw data from multiple systems, allowing expertise to be pooled, proves useful. The use of multi-disciplinary tumor boards (MDTBs) is becoming more common worldwide; however, MDTBs are conducted in analog formats currently, with limited efficiency for participating physicians. A lack of interoperability and consolidated scheduling can mean that MDTB stakeholders are presented cases which have not yet had all results reported. This can then result in participants wasting valuable time identifying discrepancies, or alternatively coming to conclusions without all the necessary data. When information sharing is enabled however, each expert can retrieve results in real-time to discuss treatment plans, creating a complete view of the patient. Such interactive information sharing can also enable the creation of more quality teaching aids to improve educational activities.

In cases where second opinions or consultations become necessary, sharing data across or even outside of a network (to out of hospital imaging centres/multiple external specialists/patients/general practitioners) is also becoming increasingly common as workforces become more strained. By providing optional out-of-network image sharing, institutions can either leverage in-house rare expertise to create additional revenue streams, or supplement deficits in staff resource near instantaneously, thereby reducing further delays in diagnosis and treatment. This can help institutions allocate resources more effectively and better predict demand peaks.

The cumulative benefit of interoperability for institutions can additionally be supplemented as resource allocation can also be managed through the deployment of large-scale predictive analytics. These can analyse clinical and logistical data across what previously would have been siloes of data to help measure performance and drive value-based care. Everything from clinical guideline compliance, outcome metrics, image ordering patterns and staff workflows can be measured, but such software deployments do rely on continual access to detailed data for feedback.

BUT INTEGRATED DIAGNOSTICS DOES NOT JUST BENEFIT SYSTEMS, INDIVIDUAL HEALTHCARE PROVIDERS ALSO BENEFIT DIRECTLY…

Workforce shortages across departments is one of the greatest challenges to healthcare today, and so it is important to be able to manage individual workflows as smoothly as possible. Inputting data multiple times can exhaust personnel and contribute to physician burnout. Having a harmonised common interface to look at data (achieved by conducting tight feature integrations) and enabling auto-population of reports can ease work tasks as providers no longer have to click in and out of windows to review relevant information. Once this is achieved, the use of adaptive tools that display appropriate data can also start to layer in workflow balancing and exam prioritisation and help to further reduce fatigue. This produces fewer errors and improves patient care as physicians spend less time looking for information and more time focused on patients.[2]

The following page features a diagram of a typical healthcare IT journey for a 65 year old patient at low risk of breast cancer. As is seen, multiple IT systems, users and settings are required to interface to gain a complete view of the patient journey

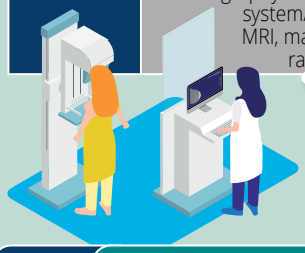
2 Garcia CL, Abreu LC, Ramos JLS, Castro CFD, Smiderle FRN, Santos JAD, Bezerra IMP. Influence of Burnout on Patient Safety: Systematic Review and Meta-Analysis. Medicina (Kaunas). 2019 Aug 30;55(9):553. doi: 10.3390/medicina55090553. PMID: 31480365; PMCID: PMC6780563.

TYPICAL HEALTHCARE IT JOURNEY

AN IT JOURNEY FOR A 65 YEAR OLD PATIENT AT LOW RISK OF BREAST CANCER INVOLVES MULTIPLE IT SYSTEMS. USERS AND SETTINGS ARE REQUIRED TO INTERFACE TO GAIN A COMPLETE VIEW OF THE PATIENT JOURNEY.

POPULATION BASED SCREENING

STAKEHOLDER	TECHNOLOGIST
SYSTEM	Regional/Local Imaging Centre. mammography unit, ultrasound system/ABUS, breast MRI, mammography/ radiology PACS.



Setting: Regional or local Imaging Centre

INVASIVE TESTING/ CONFIRMATION OF SUB-TYPE

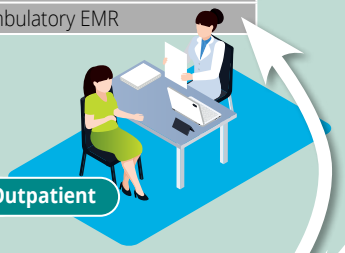
STAKEHOLDER	PATHOLOGIST, LAB TECHNOLOGIST
SYSTEM	Acute EMR, pathology scanner, IMS, diagnostic AI, LIS/ Bi-directional LIS.

Setting: Acute hospital

STAGE: PATIENT PATHWAY ANALYTICS
STAKEHOLDER: CMO, C-SUITE/LEADERS,
SYSTEM EMR, BI, POPULATION HEALTH SYSTEMS, ANALYTICS

INITIAL CONSULT/SCREENING REVIEW

STAKEHOLDER	PRIMARY CARE PHYSICIAN
SYSTEM	Ambulatory EMR



Setting: Outpatient

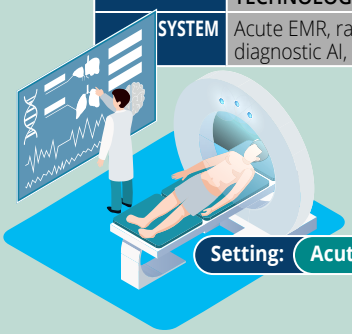
TREATMENT PLAN

STAKEHOLDER	PRIMARY CARE PHYSICIAN, PATHOLOGIST, ONCOLOGIST, SURGICAL TEAM, RADIOTHERAPIST
SYSTEM	Acute EMR, radiology PACS, RIS, dose monitoring, MDTB software**, pathology IMS, LIS/Bi-directional LIS, OIS, population health management platform, analytics, VNA.

Setting: Acute hospital

DIAGNOSTIC IMAGING: MAMMOGRAM, ULTRASOUND, MRI

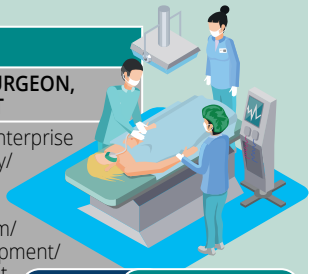
STAKEHOLDER	RADIOLOGIST, TECHNOLOGIST
SYSTEM	Acute EMR, radiology PACS, RIS, diagnostic AI, dose monitoring



Setting: Acute hospital

TREATMENT

STAKEHOLDER	ONCOLOGIST, SURGEON, RADIOTHERAPIST
SOFTWARE	Acute EMR, OIS, enterprise viewer, dosimoetry/ surgicalIS/ radiotherapy information system/ radiotherapy equipment/ patient enagement.



Setting: Acute hospital

SUCCESSFUL TREATMENT!

POST-TREATMENT SURVEILLANCE

STAKEHOLDER	ONCOLOGIST, PRIMARY CARE PHYSICIAN
SOFTWARE	Mammography information system, ambulatory EMR, surveillance software

Setting: Outpatient

SECOND OPINION

STAKEHOLDER	CONSULTANT
SOFTWARE	Acute EMR, OIS, enterprise viewer, dosimoetry/surgicalIS/radiotherapy information system/radiotherapy equipment/ patient enagement.

Setting: Out of network specialist imaging

Care pathways diseases and conditions can be extremely complex, requiring several disparate software installations before a patient even opts for an out-of-network consultation.

Pathology Digitisation and the Benefits of Interoperability

Whilst other clinical departments digitised decades ago, many institutions worldwide are just now adopting digital pathology workflows for primary diagnosis. Although pathology stakeholders can benefit from learning lessons from other departments in some cases, pathology also faces many unique challenges:

1. The pathology department has no existing infrastructure to support image acquisition, processing, review, storage, or analysis.
2. Pathology images are much larger, more complex, and difficult to deal with than most other medical imaging files. Thus, any challenges associated with the management of radiology images are compounded for pathology.
3. Pathology departments typically have access to smaller budgets than radiology for example, often being seen as a 'cost-center' rather than a profit center.
4. Pathology has a plethora of proprietary image standards in use which make image exchange much more difficult, although the industry is now moving towards open exchange.
5. Digital pathology requires the deep integration of LIS and imaging workflows, including order entry, result reporting, image storing, image manipulation, and image management to prevent duplication of labor. Without this, workflow disruption can be so significant that providers benefit minimally from implementations. Unfortunately, many LIS systems are outdated and not build for embedded integration.

Whilst these issues are slowly being addressed, a lack of widespread adoption of any imaging standards remains an issue that will slowly become more prominent as usage scales and demand for access and storage increases.

Facilitating Interoperability through Digital Pathology Image Standardization

Standards in healthcare provide a common language set of expectations that enable interoperability between systems and/or devices.

One example which is discussed frequently today is Digital Imaging and Communications in Medicine (DICOM), a standard that permits the sharing and storage of medical imaging data and related

metadata regardless of product or vendor. While well established in medical imaging, DICOM has both benefits and challenges for Digital Pathology.

Widespread adoption of any standard will allow providers flexibility when purchasing different vendor solutions, as committing to one product line would have negligible impact in later years if an alternative were brought in. Instead, seamless integration of digital pathology scanners with viewers and AI applications will suddenly become much more feasible; however, DICOM also offers unique advantages compared to other imaging formats. Firstly, for many potential customers, it enables digital pathology images to more easily become incorporated into radiology PACS and legacy VNAs*, supporting cross-modality collaboration between pathology and other imaging modalities which already frequently use the standard.

*WHILST MORE SOPHISTCATED VNA SOFTWARE DOES EXIST TODAY WHICH CAN INGEST AND MANAGE ANY MULTIMEDIA, REGARDLESS OF DICOM/ NON DICOM STANDARDS, THERE EXISTS A LEGACY INSTALLED BASE OF SOFTWARE WHICH REQUIRES DICOM WRAPPERS TO PROPERLY MANAGE INFORMATION.

As digital images are expected to become the medium upon which diagnoses are made, so too will the expectation that these images be stored long-term. DICOM then offers a significant advantage over other types of digital pathology image format, as it has the added benefit of allowing institutions to make significant savings on IT infrastructure by leveraging existing radiology storage solutions.

DICOM does also offer more potential to facilitate image analysis at scale for research, due to its associated metadata and use in radiology. Multi-modality studies are becoming much more frequent, and by participating institutions can support disease study and ultimately, help shape improvements in standards of care. This can be further improved through the adoption of DICOM structured reporting, a more technical standard, which succinctly defines metadata and how it is presented - however, even in radiology today, structured reporting is much less common.

DICOM is however not without its pitfalls today. The standard originally was developed for radiology images decades ago, and this has had important implications on its application within digital pathology because radiology images have several distinct characteristics from the whole slide images (WSIs) used in digital pathology.

One such example is the difference in image size, as shown in figure 2 below. Digital pathology images, even when scanned at 20x will be significantly larger than most radiology counterparts, which can make viewing and transmitting the images more complex.

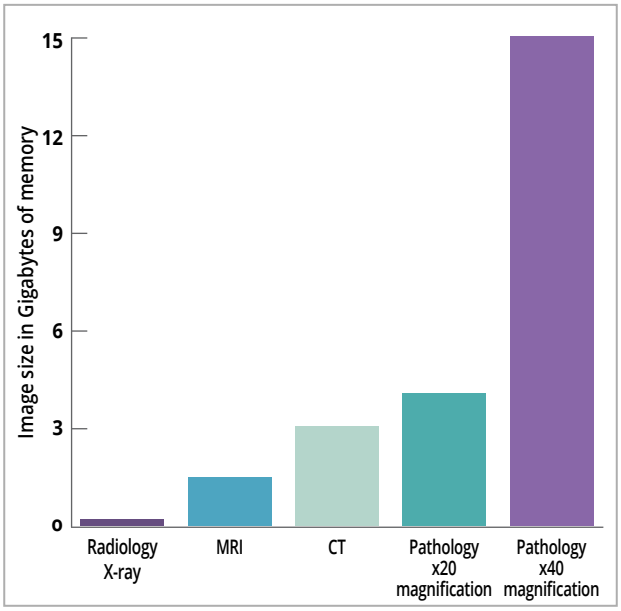


Figure 2: Size of radiology images compared to whole slide digital pathology images

Another differentiating factor is that DICOM was originally designed for images in grayscale, whereas WSIs are coloured and employ different stains depending on the investigation. Technical differences like these introduce complexity and mean that the DICOM standard must be retroactively altered to be optimally used in digital pathology.

The DICOM working group 26 has made significant progress in achieving this since DICOM for pathology's initial introduction, but more efforts in the near-term before equipment can be fully optimised for use. DICOM as it exists today is less of an image and more of a wrapper used to retroactively package WSIs.

Thus, whilst a DICOM file format and communication protocol for pathology does exist, adoption today is still extremely low, and it will take considerable effort to address challenges that exist before the industry is able to promote widespread use.

But this does not mean that institutions should wait to invest in digital pathology workflows. As this is being tackled, vendor-neutral practices by industry partners will help to invite cohesive integration across departments, hospitals, regions, and national networks.

These networks can be both internal and external to organisations, and through interoperability labs will be more easily able to offer or access third party diagnostic consulting services. Image exchange between third party organisations will mean that no matter what type of scanner is employed between or at different institutes, image viewing and review will be possible.

As stated previously, pathology departments are just beginning to digitize and there exists an opportunity to build digital pathology networks in a way that effectively futureproofs any further investment, and in doing so, 'leapfrog' ahead of other departments.[3]

Bidirectional Interfaces are Essential to Fully Benefiting from Interoperability

An essential step in this 'leapfrogging' process also lies in ensuring that information other than imaging data is exchanged freely and bidirectionally between clinical IT software systems. The laboratory information system (LIS) is already well established within the pathology lab and helps to support everyday workflows by enabling sample tracking, test order management, result reporting and more.

When introducing a digital pathology image management system (IMS) to a department, it's integral that these functions are supported by a seamless, bidirectional integration between the LIS and IMS. When applied, this prevents duplication of efforts through negating the need to input information about how a sample has been processed into two different systems, ensuring that case mix-ups and duplicated tests are less likely to occur.

When integrating the two systems bi-directionally, benefits can be:

- A leading system can be established when overlapping functions may occur. For example, this means that reporting pathologists may not be changed on an already authorized report.
- LIS software can register expected stains to occur, meaning that additional actions, such as extra cuts for molecular biology and immunofluorescent stains can be excluded. This will enable the IMS to know when a case is complete and can be dispatched.

3 Such initiatives should also remain wary of wider organisational context and enterprise considerations.

- A bidirectional link between the LIS and the IMS can be established which allows a choice to report from the LIS or from the work list of the IMS. If the IMS is used as the guiding system, the case list will show the assigned cases. A priority tag, either accompanied by a communication from a LIMS or a manual description by a technician or pathologist, can be added. In this way, the emergency cases are clearly marked.
- An assigned profile determines the level of access and can allow the pathologist to have direct insight into what colleagues must report.
- If desired, speech recognition can be added, to complete the integrated system.

The benefit of optimal interoperability between these two systems is ultimately shown by improvements in patient safety, slide dispatching efficiency and information sharing. This enables digitizing labs to make the most out of a significant investment and enables the institution to scale scanning volumes more easily without risk of overlapping errors.

Interoperability and Investment in the Future – Closely Related

Healthcare technology has advanced exponentially over the last decade with the advent of advanced AI technologies, which will only improve year-on-year. Many start-ups today begin by developing software that is built to incorporate future updates, often being 'cloud-native' and modular in nature. Focusing on interoperability from the beginning, allows start-ups to focus more on technological development in fields like machine learning, and less on ensuring their technology is accessible to a wide enough audience. Beyond AI tools, throughout the healthcare ecosystem technologies such as digital companion diagnostics and federated learning are expected to impact clinical care in the near-term, becoming a necessity for most care providers.

Pros and Cons to Enacting this Strategy Today

The advantages of prioritizing interoperability across clinical deployments are therefore clear. However, we have also outlined some significant challenges associated with deployment, with budgetary constraints and disruptions caused to practice. These are the biggest hurdles for healthcare providers. Building interoperability into plans does present a short-term significant cost to an institution, and with so much heterogeneity in deployments, a guarantee of benefits under a defined set of criteria is hard to ascertain.

There are however some important considerations which should help to smooth this transition:

- Providers are increasing able to negotiate contracts which benefit their own budgetary plans, be this through operational expenditure models, SaaS based models or leasing contracts.
- Increasingly, national and regional policies are beginning to align towards facilitating interoperability, with patient access to data soon to be a priority in most markets. By reacting now, institutions will be able to avoid even more significant disruptions later down the line should policies become mandatory.
- Stakeholders and decision makers should take care to prioritize clarity from their partners, by initiating conversations around long-term strategy up-front and clearly outlining with all involved parties (and not just new products) how integration will be achieved.

As also outlined earlier, interoperability can vary significantly between departments – so from the perspective of a customer: which should be prioritised?

- **PATHOLOGY** – a newly digitized market free of incumbent infrastructure, building systems with interoperability in mind should benefit stakeholders much more quickly than other departments. Demand for pathology images is also increasing significantly in research studies.
- **ONCOLOGY** – is already well-connected with other departments and can be valuable when included in other databases such as registries. Interoperability is less of an issue as hardware and software markets are more consolidated.
- **RADIOLOGY** – most attention being paid to this currently across healthcare as enterprise imaging tenders in mature markets require interoperability between cardiology and radiology departments. Increasingly this is including other clinical disciplines such as pathology. In addition, tenders are also increasingly requesting better integration between radiology software and Electronic Medical Records (EMRs). Immediate benefits from widespread standardisation and easier than pathology to facilitate.

Key takeaways

As outlined before, priorities will be individual to institutions based on unique circumstances; however, all providers will benefit from asking the same questions directly to their vendors:

- In the product you are supplying cloud-enabled (retroactive) or cloud native (proactive)? Do you need to install on-premise redundancy too?
- Can you point me towards some successful implementations you have conducted where a high degree of interoperability has been achieved at similar scale to my organisation?
- What kinds of implementations have you supported? Are these low or high-throughput environments?
- How are you prioritising being able to provide this in the future?
- How are you intending to work with third party collaborators to ensure that new software is adequately integrated?
- Are there trade-offs for interoperability versus best-of-breed functionality and features in our requirements? Does our organisation need a portfolio of solutions from our vendor of choice, or are we more flexible and willing to customise and work on integrating a more diverse range of products from multiple vendors to achieve the exact feature-sets we need?

An alternative consideration can also be made, as vendors likely to be better at helping providers through this transition have either large scale deployments (experience), cloud-first but also on-premise approaches (technical flexibility), and participation in interoperability focused groups such as standards organizations.

Conclusion on following page

Conclusion

In summary, the benefits in investing in interoperability within healthcare are clear for both individuals and for wider institutions.

Interoperability at its core is a goal that is integral to facilitating the betterment of healthcare for both individuals and institutions. It underpins and facilitates key trends in healthcare today such as precision medicine, improving patient access to data, facilitating patient engagement outside of healthcare environments, and enables the management of finite healthcare resources.

Whilst each institution may be at a different stage in its journey, it is clear that in order to benefit from advancements in healthcare, organisations must invest in an infastructure which supports the ability to access, exchange, integrate, and cooperatively use data.

Pathology especially is at a precipice, without the drawbacks of existing infastructure departments have the unique opportunity to proactively build a better healthcare IT ecosystem with all of this in mind. Investing in interoperability today will enable both individuals and institutions to benefit from easier workflows and improved access to patient data, whilst simultaneously providing them the opportunity to push multi-disciplinary care forward.

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