Diagnostic Imaging Common Service (DICS)

Phase I Evaluation Final Report

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DATE:
September 10, 2019

ACRONYMS

CDHE: Centre for Digital Health Evaluation

cSWO: Connecting Southwest Ontario

CT: Computerized Tomography

DICOM: Digital Imaging and Communications in Medicine

DICS: Diagnostic Imaging Common Service

DI-rs: Diagnostic Imaging Repositories

eHO: eHealth Ontario

EHR: Electronic Health Record

EMR: Electronic Medical Record

ENITS: Emergency Neuro Imaging Transfer System

FEM: Foreign exam management

GTA West DI-r: Greater Toronto Area West Diagnostic Imaging Repository

HDIRS: Hospital Diagnostic Imaging Repository Services

HIPAA: Health Insurance Portability and Accountability Act

HIS: Hospital Information System

HRM: Health Report Manager

HL7: Health Level 7

IHF: Independent Health Facility

LHIN: Local Health Integration Network

MOHLTC: Ministry of Health and Long-Term Care

MRI: Magnetic Resonance Imaging

NEODIN: Northern and Eastern Ontario Diagnostic Imaging Network

PACS: Picture Archiving and Communications Systems

RIS: Radiology Information Systems

SWODIN: Southwestern Ontario Diagnostic Imaging Network

VNA: Vendor Neutral Archive

VPN: Virtual Private Network

WIHV: Women's College Hospital Institute for Health Systems Solutions and Virtual Care

XDS-I: Cross-Enterprise Document Sharing for Imaging

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Executive Summary

The Centre for Digital Health Evaluation (CDHE) at Women's College Hospital Institute for Health Systems Solutions and Virtual Care (WIHV) conducted a third-party, clinically focused, qualitative evaluation of the Diagnostic Imaging Common Service (DICS). The objectives were to explore healthcare provider engagement and integration of DICS into clinical workflows, identify enablers and barriers of access to images, understand if healthcare providers are perceiving clinical value from DICS as it is currently constructed, identify opportunities to support the evolution of DICS to optimize the clinical value and better support the user base, and inform future investment strategies. Forty-two interviews were conducted with a variety of stakeholders across Ontario including healthcare providers and administrators working in regional diagnostic image repositories (DI-rs) and hospitals. Unique use cases for access to diagnostic imaging data (and therefore DICS) were identified for three distinct healthcare provider groups: a) radiologists; b) specialists (outside radiology); and c) primary care providers. The key findings were:

1. **Current provider engagement with DICS:** From usage data provided by eHealth Ontario, over 570,000 reports and 135,000 images were viewed from September 2018 and April 2019 using one of three clinical viewers.
    - **Radiologists:** Did not routinely engage with DICS due to the lack of functionality offered and inability to import images onto their Picture Archiving and Communication System (PACS).
    - **Specialists:** While some commented that DICS improved their ability to access outside images, the majority were dissatisfied by the slowness of the viewer, lack of features for comparing images side-by-side, and technical challenges with the clinical viewer.
    - **Primary Care Providers**: Predominately accessed DICS for reports (not images) and were interested in a repository that provided complete access to a patient's imaging history.

2. **Enablers to engagement with DICS:**

Provider engagement with DICS was supported:

- When clinical viewers were easy to access and/or launch from their electronic health records or PACS; and
- When providers had access to all images (including relevant priors) needed for their clinical decision-making.

3. Barriers to engagement with DICS:

Barriers to provider engagement with DICS included:

- *An incomplete data set*: Independent Health Facilities (IHFs) contribution gap and clinical images that were not included within the scope for DI-rs (e.g. specific clinical specialties outside of traditional radiology including cardiac, vascular, obstetrics and gynecology);
- *Technical issues with clinical viewers*: viewers were described as slow, requiring multiple steps to access, and frequently off-line;
- *The functionality of clinical viewers do not fully support clinical workflow needs*:
    - **Radiologists**: require high resolution capabilities of a PACS to produce a diagnostic report that leads to a certain standard, and therefore need the ability to import images directly into the local PACS;
    - **Specialists**: when the side-by-side viewing feature is not enabled on all three access channels it is more time consuming to monitor change over time and inform clinical decision-making; local integration with PACS is preferred;
    - **Primary Care Providers**: a lack of efficient and comprehensive access to full patient reports decreases the effectiveness of navigating the patient through the healthcare system;
- *Lack of awareness and access*: there is a general lack of knowledge of DICS as well as difficulties obtaining access to the provincial viewer (required for DICS access);
- *Multiple channels of access*: due to the multitude channels for accessing local, regional and provincial imaging, providers' preference will be to use whatever system is the most efficient and meets their workflow requirements.

RECOMMENDATIONS

Overall, as currently constructed, DICS does not fully align with provider workflow, and therefore, does not optimize provider experience and the quality of patient care across the healthcare system. The following high-level recommendations would facilitate DICS optimization:

Short-Term/Low-Resource Recommendations:

1. Optimize the functionality of DICS for high priority clinical areas:

Taking into consideration current usage, the heterogeneity of clinical roles and needs for diagnostic imaging access, DICS may not be suitable as a "one-size fits all" approach. Further identification of high-value specialist areas, providers and workflows is needed.

2. **Make changes to the current tool to improve workflow and meet the needs of the user**:

Implement technical changes to the current tool highlighted from the provider interviewees to improve workflow for radiologists and specialists. System availability and performance issues should also be addressed as required.

3. **Increase awareness and advise on proper use of existing tools using current change management channels:**

As part of the change management activities (dedicated or otherwise), develop a communication and education plan that includes suggested workflows for better use of the tools based on care setting.

Mid-Term/Mid-Resource Recommendations:

4. **Early stage optimization within the Ontario Health Teams (OHTs)**:

Given that the Ontario healthcare system is moving towards integrated care through the OHTs, there is value in ensuring the functionality and purpose of DICS and the larger diagnostic imaging strategy fit into the needs of the OHTs. High impact clinical areas should undergo robust workflow mapping and a streamlined system for accessing imaging (alongside other digital health resources) and supporting the flow of data should be developed.

Long-term/High-Resource Recommendations:

5. **Develop a strategy to create a comprehensive data set**:

The image contribution gap from IHFs and specific clinical specialties was reported as a significant barrier to DICS utilization, indicating a need for a provincial strategy to increase the comprehensiveness and consistency of available imaging. This may include the consideration around incentives for IHFs to integrate with DI-rs and DICS and/or policy changes around mandatory reporting for any imaging studies receiving public payment. Additional diagnostic test data to support other clinical specialties should be investigated as part of recommendation #1 and included here as appropriate.

6. **Develop and implement a provincial strategy for centralized imaging data sharing**:

The numerous channels of access to outside diagnostic imaging data can lead to image duplication and fragmented data sets. A provincial strategy is needed to share images in a standardized format that has interoperability with local systems. Consideration should be

given to implementing standardized terminology as a way of supporting data consistency across regions and future value added use for advanced analytics.

Phase II Evaluation:

A subsequent Phase II evaluation would provide the opportunity to assess the implementation of the recommendations. This includes evaluating provider satisfaction and engagement with DICS after changes to the current tool are implemented, engaging an upcoming OHT to evaluate patient and provider satisfaction, cost-effectiveness, and patient outcomes, exploring methods and developing policies around onboarding IHFs and private clinics with multiple stakeholders and identify regulatory standards that could improve interoperability to develop and support a provincial strategy.

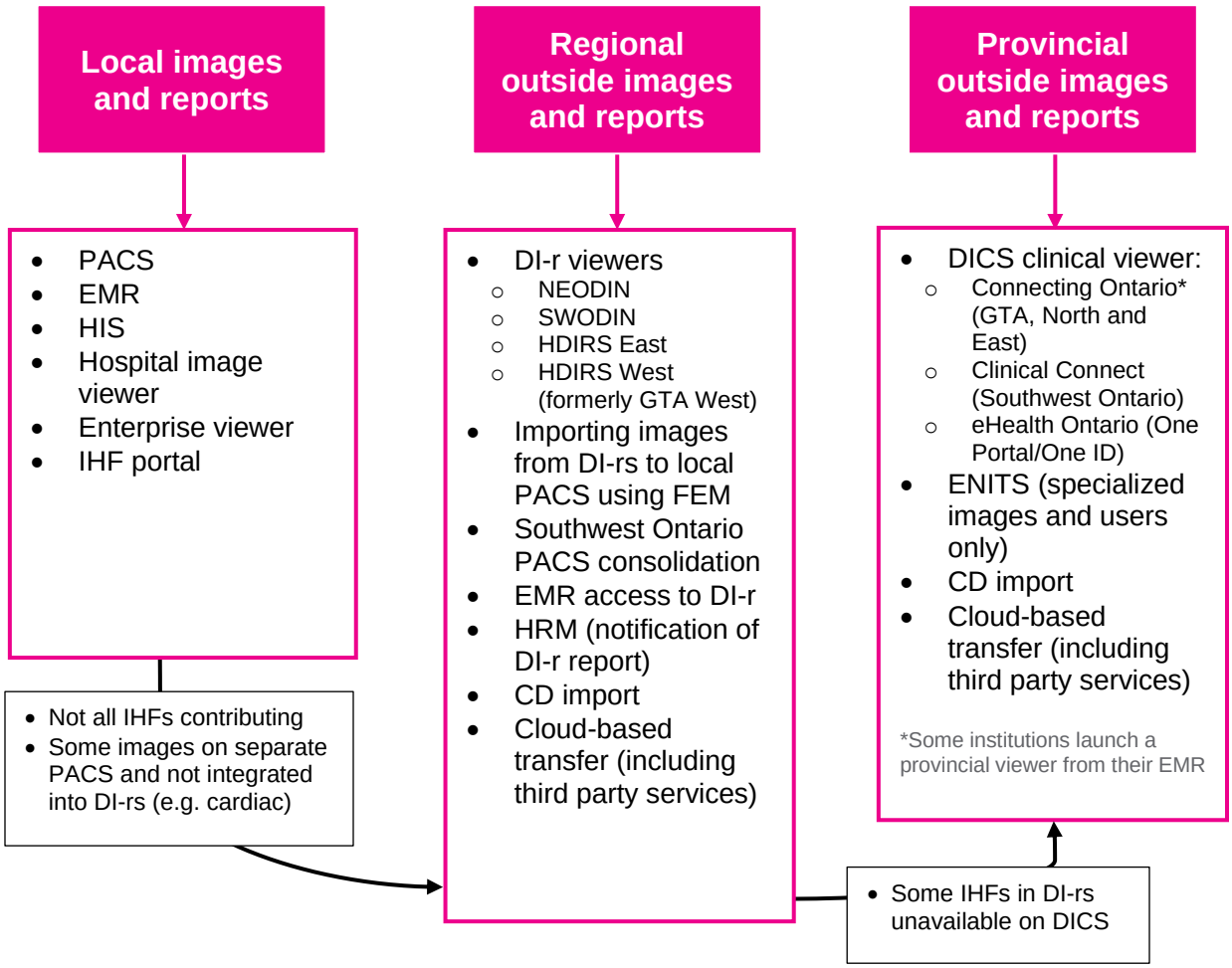
1. Background

As the Ontario health system transitions towards integrated models of care, there is an urgent need to improve health information exchange among healthcare providers and patients across geographic and institutional boundaries. Cross-institutional image sharing for diagnosis, treatment and procedural planning continues to be an inefficient and time-consuming process. Current literature indicates that rapid sharing of imaging data can create value across the quadruple aim (enhance patient and provider experience, improve population health and reduce healthcare costs). For instance, empirical evidence suggests that image sharing technologies decrease the likelihood of duplicate imaging, reducing costs and improving provider workflows and efficiency.[1–6] At the patient level this translates into reduced wait-times for imaging, more timely access to treatment, and reduced risk of unnecessary exposure to radiation.[1,5,7] At the system level, two studies found that this produces significant cost savings by minimizing redundant health resource utilization.[6,8]

It is estimated that more than 20 million diagnostic imaging procedures are delivered each year in Ontario hospitals and independent health facilities (IHFs) by diagnostic imaging specialists responding to requests from healthcare providers.[9] An environmental scan revealed a variety of technology-enabled models of image sharing including multi-institutional regional picture archive and communication systems (PACS), foreign exam management (FEM), onsite vendor neutral archives (VNAs), cloud-based image transfer, offsite cloud-based VNAs, cross-enterprise

document sharing for imaging (XDS-I) and enterprising imaging. **Figure 1** summarizes common channels of access to local and outside images. Within Ontario, the most utilized models of image sharing include uploading images onto compact discs (CDs) for transfer onto local PACS, accessing historical images via one of four original Diagnostic Imaging Repositories (DI-rs), and the newly developed Diagnostic Imaging Common Service (DICS). In addition, there are specialized uses cases for shared diagnostic imaging, such as the *Emergency Neuro Imaging Transfer System* (ENITS) - a centralized web-based image temporary archive that provides access to 'on demand' neurological, vascular and cardiac CT, MRI and ultrasound images for urgent and/or critical care for seven days.[10] More broadly, image sharing technologies can lead to the redistribution of radiological services to establish local, regional, national and even international networks to achieve different levels of consultation, care coordination and resource sharing.[11]

Figure 1. Methods of accessing diagnostic images and reports within Ontario.



Despite the emergence of various diagnostic image sharing solutions, there is a lack of empirical evidence evaluating image exchange use cases and their impact on related workflows and clinical outcomes. Rather, the majority of the literature to date offers theoretical benefits and use cases alongside a more thorough discussion of the technical requirements of successful platforms. Further investigation of the utilization of diagnostic imaging repositories and potential barriers to utilization are essential to ensure the full benefits of these systems are realized.

2. Project Overview

DICS is a foundational program created to improve provider experience and the quality of patient care by connecting imaging data across the health system and enabling real-time access.[12] A key objective of the DICS project was to enable healthcare providers in all care settings with expanded access to patients' publically funded/insured diagnostic imaging reports and images from across the province. The DICS project was proposed to be delivered in four major releases, of which the first two releases have been planned, funded and successfully implemented. These releases included i) the implementation and acquisition of digitally enabled diagnostic reports for storage in a centralized repository and ii) enablement of access to diagnostic reports and images stored in the DI-rs via three provincial clinical viewers (ONE Portal, ConnectingOntario and ClinicalConnect). Prior to DICS, hospital-based providers were only able to access images through their local PACS when the image was completed at their hospital (or a hospital within their network). Hospital imaging and reports were also inaccessible to most community and primary care providers. External images were only available if patients transported them using a CD (which comes with its own unique viewing system) or if the images were requested to be directly imported into a local PACS from a DI-r. Images in DI-rs were previously not accessible beyond regional boundaries **(Table 1).** Provincial level access to external images became available on ONE Portal as of March 2017, and DICS was integrated with ConnectingOntario and ClinicalConnect in August 2018.

Table 1. State of diagnostic imaging access prior to summer 2018

User	Method of viewing local images	Method of viewing external images on regional DI-r	Method of viewing external images not on DI-rs
Non-radiologist provider in hospital	PACS / Enterprise Viewer	PACS / Enterprise Viewer (variable success)	CD Import to PACS/Enterprise Viewer
Radiologist	PACS with import to radiology workstations	PACS (variable across sites depending on integration of local PACS with DI-rs and regional FEM)	CD import to PACS
Provider in primary & community settings	Reports only (no images) on a clinical viewer CD import	Reports only (no images) on a clinical viewer CD import	CD Import

The DICS project participants were limited to those that met the following key prerequisites: diagnostic systems that are digitally enabled, contribution of reports and images to one of the DI-rs and contribution of their patient identity to the Provincial Client Registry. As of May 2019, 138 hospitals and 76 independent health facilities (IHFs) in Ontario contribute MRI, CT, ultrasound, general X-ray, nuclear medicine, and mammography images and reports to the DI-rs on a daily basis that are available to access via DICS. Current expansion efforts involve onboarding of some new IHFs for the purpose of regional data sharing only. According to usage data from eHealth Ontario as of May 30, 2019, 100% of registered Connecting Ontario users access DICS, 29% of registered ClinicalConnect users access DICS and 28% of registered ONE Portal users access DICS.

The objective of this clinically-focused evaluation was to understand if healthcare providers are perceiving value from DICS as it is currently constructed, specifically as it relates to clinical efficiency, access to existing images, provider experience and patient care. This evaluation focused on clinical use of DICS and healthcare provider workflow rather than assessing the technology, in order to identify opportunities to support the evolution of DICS, inform strategies to optimize the clinical value and provide insight into how to direct future investment decisions. The first phase of this project, the results of which are presented in this report, included:

- Exploration of opportunities to improve efficiencies through access to digital images/radiology reports and identification of value propositions across a range of relevant provider groups (including, but not limited to, inpatient, emergency/urgent care, ambulatory, surgical, specialty, primary, and community care).
- Prioritizing provider specialties into high and low-value users of DICS and exploring potential approaches to increase adoption in high-value users.
- Understanding how contextual factors (i.e., system, site, and provider) may impact the potential scale-up of DICS.

Opportunities for further investigation in a Phase II are also outlined in this report.

3. Evaluation Methodology

This mixed-methods study triangulated findings from an environmental scan, key informant interviews and quantitative usage data from eHO to address the evaluation objectives. The Center for Digital Health Evaluation (CDHE) standardized approach was applied to interpret and synthesize the data. The CDHE framework considers the existing problem(s) the solution is attempting to solve from the perspective of all relevant stakeholders (i.e., providers, patients, institutions, and/or health system) with a focus on understanding workflows and identifying pain points that are limiting impact.

3.1 ENVIRONMENTAL SCAN

A broad and rapid scoping review of the academic and grey literature was performed. The environmental scan identified: a) current technological models of diagnostic image sharing and their associated advantages and disadvantages; b) their potential impact for patients, clinicians and health systems; c) high-value clinical areas that would benefit from such technologies; and d) implementation challenges. The environmental scan is presented in a separate report.

3.2 KEY INFORMANT INTERVIEWS

Semi-structured and exploratory qualitative interviews were undertaken in person or by telephone with providers and administrators from the DI-rs, IHFs and radiology IT departments within hospitals. The interview guide was aligned conceptually and methodologically with the CDHE framework and reviewed by project partners **(Appendix A)**.

Participant Recruitment and Data Collection

Initial recruitment utilized purposive sampling of providers identified by clinical experts and WIHV innovation fellows. We contacted operations managers from the DI-rs, primary care leads and Local Registration Authorities from Local Health Integration Networks (LHINs), representatives of the Ontario College of Family Physicians and clinical champions and clinical working group members of ConnectingOntario and ClinicalConnect. Snowball recruitment was performed by asking interviewed participants to refer colleagues or contacts that could provide relevant insight. We also explored data-driven recruitment, reaching out to high end users of DICS based on eHO usage viewing statistics. Although we had originally targeted healthcare providers (primarily physicians), we expanded interviews to administrative stakeholders to gain more knowledge on

the infrastructure and legacy issues regarding the implementation of DICS and the DI-rs, and to understand the various access channels to diagnostic imaging and reports that may be unfamiliar to healthcare providers. All interviews were audio recorded and professionally transcribed.

Qualitative Data Analysis

We applied a qualitative thematic analysis of the interviews to synthesize and analyze the feedback received. Two researchers independently coded three transcripts and developed a preliminary inductive coding framework that was reviewed by the research lead. Three researchers then independently applied the coding framework to the remaining transcripts using Nvivo™ 11, creating inductive codes as needed. Codes were reviewed by the project team followed by thematic mapping to understand relationships and generate final themes and subthemes. Refinements and specifications of thematic categories and subcategories and relationships between themes were discerned based on in-depth discussion and negotiated consensus between members of the evaluation team.

3.3 QUANTITATIVE DATA

eHealth Ontario provided aggregate DICS usage data for the month of February 2019 that was analyzed using descriptive summary statistics to understand the practice characteristics of high-end users. “High-end users” were defined as those who viewed more than 15 views of images or reports throughout the month (i.e. the median number of views and distribution of high-end users by geographic region and institution, professional background and physician specialty). The total number of report and image views accessed from DICS using ClinicalConnect, ConnectingOntario and ONE Portal between September 2018 and April 2019 was calculated to examine utilization after DICS was integrated with the clinical viewers.

3.4 LIMITATIONS

While most interviews were conducted with individuals who had experience with DICS, the level of knowledge and exposure to the technology varied. Few high-end users of DICS responded to the data-driven recruitment efforts. The majority of participants were providers practicing at academically-affiliated hospitals within the Greater Toronto Area (GTA) (e.g., Sunnybrook Health Sciences, St. Michael’s Hospital and University Health Network). Consequently, perspectives from rural, community-based and independent providers were less abundant in the qualitative data and insight from high-end users cannot be guaranteed.

While we sought a holistic range of providers, perspectives from some provider specialties are missing (e.g., gynecology/obstetrics). Our main focus was on physician providers, therefore perspectives from non-physician providers, such as nurses and allied health professionals are not represented. Furthermore, the majority of participants accessed DICS via ConnectingOntario and there was less feedback from those who accessed the portal via ClinicalConnect or ONE Portal. Given that a clinical viewer was a channel of access to DICS it was also difficult for some participants to differentiate between the clinical viewer and the actual DICS platform when articulating their feedback. In turn, there was some overlap in content between themes, making it difficult to classify themes into distinct categories. To avoid misclassification and to enhance the validity of the thematic analysis, the data analysis was triangulated by having at least two researchers independently review the coding framework and consulting a third researcher for any discrepancies between themes.

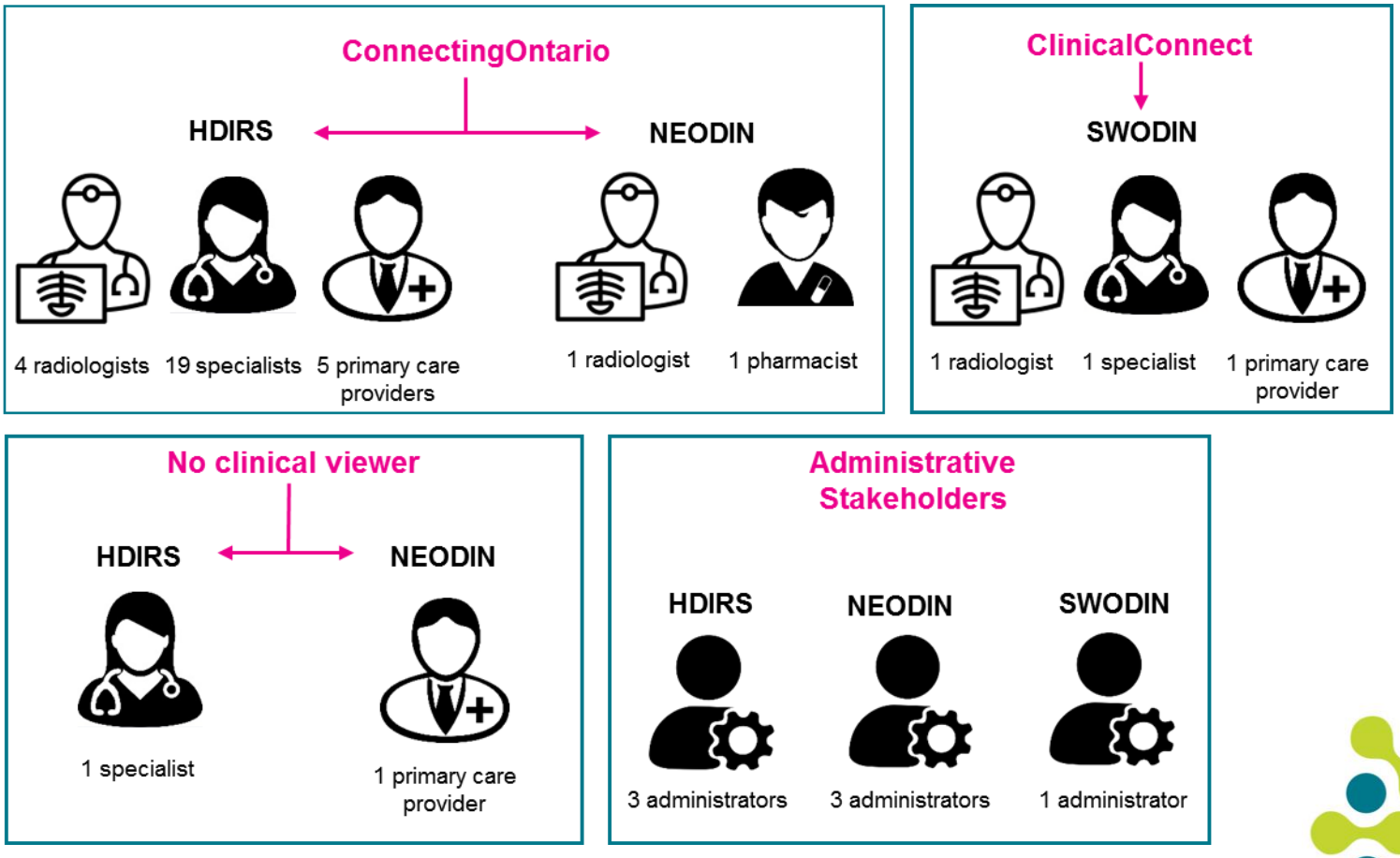
4. Results

Key themes that emerged were challenges with image sharing and the impact of delayed image access at the patient, provider and healthcare system level. In addition, the varying perspectives and experiences of radiologists, specialists and primary care providers with regards to methods of accessing images, DICS utilization, enablers to DICS engagement and value propositions of DICS were identified.

4.1 PARTICIPANT CHARACTERISTICS

We performed 42 interviews, including 35 healthcare providers (34 physicians and 1 pharmacist) from a variety of specialties and seven administrative stakeholders between February 22, 2019 and June 30, 2019 **(Appendices B and C)**. The majority of providers (83%) were from the HDIRS catchment (including HDIRS East and HDIRS West, formerly GTA West) and 86% were from hospital-based settings.

Figure 2. Participant cohort organized by clinical viewer, region and role



4.2 CURRENT DICS USAGE

Over 570,000 reports and 135,000 images were viewed between September 2018 and April 2019 using one of three provincial clinical viewers; ConnectingOntario, ClinicalConnect and ONE Portal. Report views significantly outnumber image views across all three provincial clinical viewers implying that providers place a greater value on the reports **(Appendix D).** In February 2019, the majority (86%) of high-end users were from the HDIRS catchment area (including the GTA), which corresponds to the demographic of provider interviewees (83% had access to the HDIRS East or HDIRS West viewer) **(Appendix B and E)**. The majority (56%) of high-end users were from the University Health Network, St. Michael's Hospital and Sunnybrook, which was also reflective of the providers interviewed (51.5%) **(Appendices B and F).** The majority (84%) of high-end users in February 2019 were physicians **(Appendix G)**. Radiologists, primary care providers and providers from a wide variety of specialties were high-end users of DICS **(Appendix H).** While we were not able to capture all specialties (e.g., nurse practitioners, registered nurses) in our 35 provider interviews, we did have representation from a variety of specialties in addition to radiologists and primary care providers **(Appendix B)**.

4.3 COMMON CHALLENGES WITH IMAGING DATA FLOW

While the advent of DI-rs and DICS were reported to improve diagnostic image sharing, participants identified several ongoing challenges that hinder seamless transmission of imaging information and impact the data quality of the repositories:

4.3.1 Interoperability Challenges

Despite the introduction of industry standards for expressing, sharing and archiving imaging data in a digital format (e.g., DICOM, HL7, etc.) providers and administrative stakeholders described several inconsistencies with how diagnostic imaging data is constructed, reported and shared. These inconsistencies were described to have negative downstream impacts on the accessibility of images via the DI-rs, and in turn, DICS. For instance, in the absence of provincial regulation of diagnostic imaging standards, interviewees described system variations in patient identifiers and technical rules for pulling foreign exams making it difficult to integrate clinical data into a single repository. For example, administrators from HDIRS, a governing organization of the HDIRS East and HDIRS West (formerly GTA West) repositories, explained that the architecture for pulling foreign exams on the latter DI-r was based on narrow terminology mapping while the former was based on broader rules. This has resulted in incomplete studies on the HDIRS West DI-r,

alongside challenges with integrating both DI-rs into a unified repository. Administrative stakeholders emphasized several challenges that must be resolved in order to bring these departments into a fully integrated imaging environment related to data formats and protocols, metadata and storage. While DI-r integration with local PACS through FEM is a common modality for image viewing, administrators described how this is contingent on whether a facilities' PACS vendor offers this capability. Smaller hospitals and IHFs with fewer IT resources, older software and financial constraints were said to be less likely to procure interoperable vendors.

> *"Certainly, a big part of the data quality issues have to do with the way patients are registered in the local point-of-care system. And I know we have some best practices, but we really don't have a provincial standard. A provincial standard for how organizations will register patients, I think, would give that clear direction to organizations about the processes they need to change and how they need to change it."*
> – DI-r Administrator

4.3.2 Independent Health Facilities Data Contribution Gaps

Healthcare providers and administrative stakeholders described the lack of images from the majority of IHFs. Despite interviewees estimating 40 to 50% of imaging being performed at IHFs, very few were reportedly contributors to the DI-rs. Administrative interviewees emphasized a barrier to sharing images/reports was IHFs using system vendors who may not offer FEM and/or interoperability with regional or provincial repositories. While some administrators discussed initial incentives to onboard IHFs during the inception of the DI-rs, they also stated that there was no sustainment model implemented to motivate ongoing contribution, add new sites or reconnect those that change ownership. As a result, some IHFs are no longer contributing to the DI-rs (and thus DICS) and are re-negotiating contracts with cheaper vendors offering cloud-based services.

> *"There are a few vendors that we don't have FEM set up on yet. I know that they have reached out. They would really like to be able to do that…they don't have FEM and I know that they would be a huge, huge user of it. Once they do decide on the vendor that they are going to use, hopefully we'll be able to get FEM set up with them, which would be a really big asset."*
> – DI-r Administrator

While some cloud-based vendors are integrated with NEODIN (e.g., VELOX), IHFs have free market vendor choice and were stated to prioritize cost savings over interoperability by some interviewees. In contrast, other participants, including one stakeholder from an IHF, expressed

increasing interest for these facilities to contribute to meet the needs of local providers; however, vendor negotiations and the financial burden of contributing are likely to hinder further onboarding.

> *"You have to have a HIS, RIS, and you have to have a PACS system to be able to send to us. Some of the smaller IHF do not have that. They have a homemade RIS and they just have imaging. They can't send to us because you have to have what we call EDP, ORM, ORU and images. The EDP is the patient demographics. The ORM is the order and the ORU is the report. If you don't have those three things from an HL7 perspective, and then the digital imaging themselves, then you can't feed to a repository."*
> – DI-r Administrator

4.3.3 Clinical Image Data Contribution Gaps

In addition to contribution gaps from IHFs, participants identified image gaps from specific clinical specialties (e.g., cardiac, vascular, obstetric and gynecological images). Access to these images may complement the drug and lab data available through the provincial clinical viewers for clinical decision-making. Of particular importance is improving access to high volume cardiac images, such as echocardiograms, which are frequently used by a range of specialists and primary care providers. However, administrators explained that often these images were housed in systems separate from a hospital's native PACS, and not in scope for contribution to DI-rs (and therefore not accessible via DICS).

4.3.4 Data Quality Issues

Another challenge with image centralization is variation in the quality of images produced. Several providers described instances of poor quality images accessed on DICS, resulting in repeat imaging. One specialist also provided detail on data integrity issues with the diagnostic images and reads performed by radiologists who lack subspecialty expertise on particular anatomical regions or disease categories. One administrative stakeholder from a DI-r also discussed subpar data quality at two clinics and suggested provincial standards to improve the integrity of images uploaded onto DICS. In turn, some specialists described how they prefer to read the actual images themselves to make diagnostic conclusions due to lack of confidence in the radiologists' report.

4.4 IMPACT OF DELAYED/INADEQUATE IMAGING

Despite efforts to create regionalized and provincial networks of diagnostic imaging information, interview informants stated that image data flow processes are still inefficient and time-consuming, resulting in downstream consequences at the patient-, provider- and health system-levels **(Table 2)**.

Table 2. Summary of the impact of delayed or inadequate access to images. *

Impact of delayed or inadequate access	Supporting Quotations
Patient-level	
Patient inconvenience and burden	*"The patients have to go to their home institution, have to get the CD and most often they have also to pay for the CD or their images. If they come to a clinic visit sometimes they may not even have it. They have to go back and come back at another appointment."* – Radiologist 1
Treatment delays	*"I would say that more often than not it will lead to one or both of the following outcomes. Number one, the patient care is delayed that day and clinics start running later. That's probably minor. It's annoying and it obviously costs patients more parking money et cetera but the more important one which is what we try to pull out of this paper that we wrote earlier was that I think clinicians just go you know what Mrs. Robinson. I can't read this fax. We can't see your CT. I'm going to call the radiologist. You clearly have an urgent problem and we're going to try to urgently book you for a new CT here within the next week. So then clinicians start calling radiologists and they're like hey, I've got a patient in clinic, she's here today, it's kind of urgent, she looks kind of jaundice, I don't know what's going on, I can't see the image from outside, can you just try and find slot."* – Oncologist 2
Radiation exposure	*"But if the patient is just there in clinic, honestly, and it's an x-ray, we'd probably just send them to our x-ray department and redo it. But those would be the ones where we knowingly redo it, but we're redoing it because it's both a benefit and a harm to the patient. So, some patients will be like I don't want that radiation and I don't want to do it. It's a small amount of radiation usually, if you're x-raying an ankle or something. So, is there a quantifiable risk to that patient from doing that? Yes. But is it tiny? Yes. So, on the balance, between that and their inconvenience of coming back with a disk on another day, usually we'll just do it. But that's an issue, right?"* – Orthopedic Surgeon 1
Reduced quality of care	*"Sometimes I don't even know that people have had imaging tests. Yesterday, I was reading an MRI of the spine on a patient who I found out had actually come from MRI at Sunnybrook, had just completed a brain MRI, a patient with cancer, and I had no way of knowing that. I would say at least one, or two, maybe three occurrences daily where the absence of prior imaging leads to unnecessary further tests or an inaccurate or incomplete diagnosis."* – Radiologist 2
Provider-level	
Inefficient clinical workflow	*"Well, it really delays workflow in the clinic. A patient will be in front of me and I can't give them the plan. I'll say, I'll have to review, get the films, and then*

	review them, and then get back to you. Sometimes it's also meant having to repeat tests because something was done somewhere else and we can't get it in a timely manner. So for many reasons it's a huge, huge problem. And then, the other part of it is that the images are there but the access to the reports are not there. So reports come by fax, and then the images might be on Connecting Ontario or they might be on a disc the family brings that I have to upload. And then, when I upload it, it's available on some computers and not others because they go under different servers. So very fragmented system and frustrating from that point of view." – Thoracic Surgeon 1
Inefficient workflow for administrative staff	*"One, there's a lot of times when patients go into the hospital, when they don't tell the family doctor. I need to get their images or I need to get their health reports, and my front staff need to go contact the hospital, get the file. That can be a nightmare in of itself, and that takes away my front staff from about 30 minutes' worth of work that could really allocate somewhere else."* – Primary Care Provider 2
Reduced quality of care delivered	*"It doesn't allow us to provide as good care, if we're giving advice over the phone, to not be able to look at the images if someone is in a really small centre, where they don't have chest radiologists, they don't have respirologists."* – Respirologist 1
System-level	
Increased wait times	*"When the referring doctor is like, oh, don't worry, I'll get the scans out here, it's like, no, please, do not. Please, just send the patient to Sunnybrook and I will get the scans here, and then I can get the scans the way they need to be and I can have my specialized radiologist look at it. The problem is we have such a wait time here because everything is going through Sunnybrook. It doesn't help the patient to have theirs done in Barrie sometimes because, sometimes, it's like, oh, that's great, I'm glad they got your scan, but we're going to have to repeat it. The patient isn't happy about that. That is more wait time."* – Oncologist 5
Duplicate imaging	*"The biggest downside to all these things is the fact that most outside community diagnostic imaging services are simply not available on any electronic format so that would be the biggest disadvantage of all the systems. In particular outside ultrasounds, the vast majority of things that we're missing that would be really sort of important and would prevent further testing. We order up a lot of repeat ultrasounds, in patients who have just had an ultrasound, which is a significant drain on resources because unfortunately the report, I mean I really don't care what the image is but the actual report is simply not available in any repository. So that's kind of the biggest disadvantage is that that community access isn't there."* – Emergency Physician 2
Reduced organizational efficiency	*"I can't read this fax. We can't see your CT. I'm going to call the radiologist. You clearly have an urgent problem and we're going to try to urgently book you for a new CT here within the next week. So then clinicians start calling radiologists and they're like hey, I've got a patient in clinic, she's here today, it's kind of urgent, she looks kind of jaundice, I don't know what's going on, I can't see the image from outside, can you just try and find slot…I think you guys now can see the downstream impact that this does for healthcare delivery efficiency, huge. And that's just one patient's story but imagine 80 clinicians all doing this all at the same time in one centre, each one individual. You can see how imaging departments across the province are going ugh."* – Oncologist 2

* Note: This is based on interviewee experience and may reflect a lack of education and training on the contributing sources to DICS and three channels of access

4.5 OVERVIEW OF CLINICAL AREAS

Due to the heterogeneity of professional roles, clinical area of focus, need for access to imaging data for diagnosis and/or clinical decision-making and variability of how diagnostic image technology is utilized, this study sought perspectives from a diverse group of providers. Use cases for diagnostic imaging data and DICS common to specific clinical areas were identified and distinguished for three provider groups:

1. **Radiologists**: both general and subspecialized radiologists who specialize in utilizing medical imaging techniques to support clinical decision-making.
2. **Specialists:** any provider outside radiology, primary or community care.
3. **Primary care providers**: providers working in community and/or primary care settings.

The specific need for diagnostic images and reports, alongside current channels of access, for the three distinct provider groups is described further below and summarized in **Table 3**.

Table 3. Summary of providers and their corresponding data and technical requirements and methods for accessing diagnostic imaging information.*

Professional Area	Data and Technical Requirements	Access to Local Images/Reports	Access to External Images/Reports
Radiology	• Access to (new/historical) images for diagnostic purposes to develop reports • Require high functionality/fidelity	• RIS/PACS/Dictation	• CD Imports • Cloud based solutions • DI-r Viewer • FEM to access images from DI-r on PACS • DICS
Specialty Care (secondary and tertiary care)	• Access to images and reports for diagnosis, treatment and/or procedural planning • Functionality/fidelity requirements depend on specialty	• PACS/Enterprise Viewer • EMR/HIS & Provincial Viewer • Specialty-specific viewer (e.g., radiation treatment software)	• CD Imports • Cloud based solutions • DI-r Viewer • FEM to access images from DI-r on PACS • DICS • ENITS • Fax (for reports)

Primary Care	• Often only require access to reports • Important to know patient's diagnostic history to prevent unnecessary duplicate imaging	• EMR • HRM	• CD Imports • Cloud based solutions • DICS • Fax (for reports) • Film-format transfer

*Note: this is based on interview data and may not represent all image sharing services that exist in Ontario such as third party cloud based solutions (e.g. PocketHealth).

4.6 RADIOLOGISTS' PERSPECTIVES

Interview participants expressed that radiologists were at the forefront of diagnostic imaging technologies given that their primary role is to interpret imaging tests and articulate their diagnosis in a report accessible to a referring healthcare provider. The perspectives of six radiologists (five general radiologists and one subspecialized in neuroradiology) are summarized below:

4.6.1 Radiologists: Current Methods of Accessing Images

Central to radiologists' workflow is their local PACS which offers the highest level of image fidelity and functionality to assure high-quality interpretation of diagnostic imaging results and subsequent reporting for patient care. All radiologists interviewed stated that access to images performed locally at their institution was facilitated through their local PACS. While the majority of images accessed are generated locally, radiologists did describe use cases for accessing images performed at external sites including healthcare provider consults, secondary reads to confirm a prior diagnosis, to treat patients transferred for urgent care, and for comparability studies to track disease progression.

Methods of access to externally performed images stated by radiology informants included:

- A patient bringing digitized copies of their imaging studies on CDs for import onto a local PACS, which was remains one of the most common method of access.
- Calling an imaging department to transfer an image.
- Access to their corresponding DI-r through local PACS or RIS whereby, in some facilities, images could be ingested temporarily or imported into their local PACS using foreign exam management (FEM) software.

- The introduction of a regional PACS consolidation permitting access to images within a catchment of facilities within southwestern Ontario.
- Access to DICS via ConnectingOntario or ClinicalConnect – which was usually accessible via their EMR or HIS.

> *"Traditionally patients bring CDs to upload, that still happens and actually it's still increasing even since the introduction of the Connecting Ontario viewer. The annual CD uploads in our department has increased from 25,000 to 50,000. This is still, with all the electronic and remote access in place, the most common way how we get remote images."*
> – Radiologist 1

In regards to functionality and ease of access to the platform, radiologists accessing DICS through ConnectingOntario described a hierarchal preference for accessing images: 1) local PACS central to workflow; 2) a DI-r wherein images could ideally be imported onto their local PACS or a separate viewer; and 3) DICS as a last resort due to the lack of tools and functionality offered. One radiologist accessing DICS via ClinicalConnect preferred DICS to the DI-r as ClinicalConnect is directly integrated into their EMR and did not require a separate login.

> *"One slight level up is the NEODIN OneView [DI-r viewer], which is only northeastern Ontario. It has the advantage of easier access. Instead of going through my hospital information system, it's a site I can access directly. The disadvantage is that, while it is a GE brand viewer, it's also, relative to a PACS, very slow."*
> – Radiologist 4

4.6.2 Radiologists: Experience with DICS

Unlike other healthcare providers, all interviewed radiologists had experience using DICS but were not given any explicit training or onboarding on the service. Due to the lack of features (e.g., inability to make side-by-side comparisons and import images into local PACS) and lower image fidelity offered, the majority of radiologists did not feel DICS was suitable to meet their professional requirements. Consequently, most interviewed radiologists stated they only use DICS as a last resort to access a required image. Only one radiologist, accessing DICS through ClinicalConnect, stated that DICS was fast and easily displayed previous patient imaging, and therefore felt it did not substantially impact their workflow. Another radiologist commented that an increasing number of referring healthcare providers request them to compare a study available on ConnectingOntario.

However, they cautioned heavily against this approach due to a perceived insufficient diagnostic quality of DICS. Radiologists identified issues with missing images or incomplete sequences or planes of view for some studies, and subpar resolution for particular images, such as X-rays.

Given that radiologists rely on their local PACS to access patient-level data, they all agreed that access to DICS via ClinicalConnect or ConnectingOntario on a separate browser or EMR was a disruption to their workflow. The ability to directly access and import images made the DI-rs a preferred channel of access over DICS among radiologists whose PACS had this capability. Among those who accessed DI-rs using a separate viewer, the consensus was that the DI-r viewer had more optimal functionality (e.g., side-by-side viewing) than DICS but was still suboptimal to their local systems. One radiologist discussed how they seldom used the measurement tools on the provincial viewers because they were cumbersome and not intuitive. Similar to feedback from other specialists, radiologists using ConnectingOntario found the viewer to be cumbersome to access, slow and often disrupted by system failures or upgrades resulting in downtime.

> *"We're being asked to look at these studies from outside and make comparisons with outside studies. Truthfully, it's extremely difficult to make comparisons from memory. Which means you look at one study in isolation, and then you go onto your system and look at another study in isolation. That makes it very, very difficult. On top of that, I haven't seen it really written anywhere, but these are discussions I had with a ConnectingOntario representative at the hospital saying that these are not for diagnostic purposes. You know, we should not be using these images for diagnosis, which is the case widely. And not only within radiology, but also within the clinical domain. People are looking at those scans and basing their decisions on those scans, that's for diagnostic purposes. So I think, from that perspective, we have been opened to significant medical-legal risk."*
>
> – Radiologist 3

4.6.3 Radiologists: Enablers to DICS Engagement

Radiologists identified several enablers to engagement that would incentivize adoption of DICS (**Appendix I**). Most importantly, for DICS to be optimized to support radiologists' workflows and clinical decision-making, participants stated that images should be ingestible onto their local PACS (analogous to importing images through FEM via DI-rs with this feature). This would allow radiologists to make comparisons with external priors and take advantage of the high functionality and fidelity offered on their native PACS. This would also evade the need to learn a completely new system. Ideally, many radiologists expressed that relevant outside images should be

downloadable onto their PACS server so that they could be available for secondary reads. While in some cases, radiologists relied on their PACS facilitator or imaging clerk to import images from one of the DI-rs through FEM (e.g., HDIRS East), many preferred for this process to be more automated to reduce the administrative burden. If integration with their local systems was not achievable, they recommended offering similar PACS tools such as side by side viewing capability. Further, similar to feedback from other providers, radiologists emphasized the need for a timely and efficient access to the viewer, implying it should be accessible via their PACS if image ingestion was not feasible. Alongside improving the technological features of DICS, radiologists discussed the importance of having a comprehensive data set of high-quality images from all IHFs, hospitals and private clinics to prevent unnecessary repeat imaging. One radiologist commented on switching to a commercial cloud-based imaging system to integrate IHFs and hospitals into one system. Two radiologists also discussed the need to expand the breadth of clinical images available on the DI-rs and DICS with an emphasis on cardiac imaging.

4.6.4 Value Propositions of DICS for Radiologists

Radiologists highlighted several advantages if DICS were integrated into their local PACS. The most prominent advantage is using DICS to improve follow-up processes on a previous or indeterminate diagnosis which involve comparing in-house images with external priors. Radiologists also acknowledged that services like DICS could improve consult processes for healthcare providers seeking secondary reads at external facilities. One provider discussed DICS as a potential opportunity to develop innovative models of radiological services. One radiologist commented that centralized access to images could incentivize more consistency in terms of producing high-quality images and reports as radiological services would become more transparent and comparable. All of these gains were cited to have downstream benefits in terms of reducing costs due to duplicate imaging or re-reads, culminating into improved patient care and efficiency for the health system.

> *"I think it [DICS] would hopefully not decrease but up the quality of the reports, because we would be expected to read at the same standard as teaching hospitals, potentially as the best hospital, whatever that might be, for that study. Also, the images would have to be at the same standard, because a clinician anywhere can look at it and go, well, why are your x-rays so ugly? What are you doing wrong? It would, I guess, encourage us to up our game."*
> – Radiologist 1

4.7 SPECIALISTS' PERSPECTIVES

We performed 21 interviews with specialists who practiced outside of radiology. This group included radiation oncologists (n=3), thoracic surgeons (n=3), medical oncologists (n=2), surgical oncologists (n=2), emergency medicine physicians (n=2), orthopedic surgeons (n=2), internists (n=2) and one respirologist, cardiologist, urologist, neurosurgeon and gastroenterologist each **(Appendix B)**. Nearly all specialists interviewed required access to both the radiology report and accompanying image for clinical decision making. Internal/general medicine may represent a grey area where some physicians rely solely on radiology reports for patient care while others have preference for the image; this was reflected in the mixed use cases for images and reports as described by two informants in internal medicine.

4.7.1 Specialists: Current Methods of Accessing Images

Nearly all specialists accessed images performed internally through their local PACS, which provides them with a full range of tools, including the ability to take measurements, make side-by-side comparisons, and image modification, in a quick and seamless manner. Another channel of access are in-house EMRs or specialty-specific viewers (e.g., radiation exposure viewers). Some specialists noted that external pathways for accessing images, such as the DI-rs and CD imports, have the ability to be integrated into local PACS at specific sites and therefore did not disrupt workflow.

Methods of access to externally performed images stated by specialists included:

- A patient bringing their imaging studies on CDs for import onto a local PACS;
- Calling an imaging department to transfer an image and/or fax a radiology report;
- Accessing their corresponding DI-r using a separate viewer or by importing the images onto their local PACS systems using FEM;
- Accessing DICS via ConnectingOntario or ClinicalConnect, which were accessible via EMR systems at most facilities;
- Accessing images temporarily through the Emergency Neuro-Imaging Transfer System (ENITS); and

- One specialist mentioned receiving a photo of the image through text message from another clinician in an emergency trauma situation.

> *"I think [the local PACS] has more functionality in terms of the ability to display multiple images from different dates on the same screen, and to synchronize the images so that I can make a direct comparison on one monitor between a current scan and a remote scan, like an older scan."*
> – Thoracic Surgeon 2

> "So, if we don't have those images, what we typically do is, we go back to either our admins or nurse coordinators in the transplant program and have to ask them to request the films from the centre. So, it's either the patient going to the medical imaging centre, picking up the CD, paying whatever fee there might be associated, and bringing them at the next appointment. Who knows when that might be? Or getting them couriered over. So, there's an expense there, there's time."
> – Respirologist 1

Specialists reported disrupted workflow in cases where another site needed to be contacted to obtain an image. Further, time from administrative staff was often required to track and retrieve a patient's imaging history and/or load DI-r images onto their PACS. Asking patients about previous imaging was also considered an unreliable method of identifying previous images as many patients are unaware of previous imaging performed or the details of their imaging (e.g. type of image, location, reason for image). Similar to radiologists, specialists reported better functionality with DI-rs than with DICS, but ultimately found the PACS functionality superior. In the absence of high-quality images, specialists would often repeat an image. Specialists described the same hierarchal preference for accessing images as radiologists: 1) local PACS central to workflow; 2) a DI-r whereby images could ideally be imported onto their local PACS; and 3) DICS as a last resort due to the lack of tools and functionality offered.

"Well, often some clerk who is checking the patient in just asks them. A lot of patients, you'd be surprised what they have no idea about. They remember going for some test, they don't remember what it was, they don't know what it was of."
– Orthopedic Surgeon 1

4.7.2 Specialists: Experience with DICS

While the majority of specialists had used DICS through ConnectingOntario, some were unaware that they were accessing the repository when retrieving images on the viewer. There was also variable frequency of use with some reporting using it once a week and others reporting using it only on a few rare occasions. Only one cardiologist and one internal medicine physician interviewed had no experience with DICS. Further, the same provider in internal medicine was the only specialist to state they only required accessed reports to provide patient care. DICS also received mixed reviews from specialists. Some specialists stated that the viewer was intuitive, had adequate imaging resolution, and improved their workflow by providing access to province-wide images.

"*Although I may bellyache about the Connecting Ontario viewer, the fact that I can do it is a huge advantage to the patients and to my ability to deliver care. Would I like to improve it? Of course I would but it's a huge step forward over even a year ago where it was like shooting blind unless people happened to remember to bring their CDs with them*."
– Urologist 1

Conversely, other specialists stated that the DICS viewer was not intuitive and had inadequate imaging resolution due to variation in imaging standards across sites or because they could not obtain the level of granularity required to make interpretations. The limited functionality was also a concern, especially among specialists involved in surgical and oncological planning who require robust measurement, annotation and image manipulation tools. Further, several specialists involved in surgical care complained that the viewer has a default timeout feature causing them to lose an image during critical periods during patient care. Many specialists also expressed frustrations with the inability to compare images from DICS and their local PACS. Specialists also experienced technical issues with ConnectingOntario, mentioning the site is slow to navigate and

often offline. The ability to directly access images made the DI-rs a preferred channel of access over DICS among specialists whose PACS had this capability. The consensus among specialists is that DICS is used as a last resort to access external images.

> *"Accessing Connecting Ontario, quite frankly, is still a little bit clunky. You have to go into the patient's chart, you have to go into another page, you have to pull it from a dropdown menu. You have to wait for it to all load up, and then you have to change the default date window. And you have to actually kind of know how to use it, and you have to be willing to invest the time to go through all those steps to then see if something is there, and then you make your decision. So, that's a lot to ask people to do for each patient, right?"*
> – Orthopedic Surgeon 1

4.7.3 Specialists: Enablers to DICS Engagement

Specialists identified several areas of improvement to expand the adoption of DICS **(Appendix J).** Similar to radiologists' feedback, desired technological features that would increase functionality include images that are importable onto their local PACS. For specialists who do not frequently use PACS, a separate viewer that is easy to access and navigate with side-by-side viewing, more robust measurement tools and a notification system in which providers would be notified of external images (on a DI-r or DICS) for a specific patient on their native system would improve workflow. This included the ability to directly send images to another provider, creating a section for comments to improve provider-to-provider communication and improving the image upload speed. However, specific technology and functionality features suggested varied by clinical specialty and sub-specialty. For instance, those in internal or general medicine had less need for sophisticated annotation and measurement tools, while those involved in surgical planning highlighted the need for PACS-level tools.

4.7.4 Value Propositions of DICS for Specialists

Similar to radiologists, if DICS were to be enhanced by integrating into PACS or offering easier channels of access with sophisticated image tools, specialists reported this would improve follow-up processes on a previous or indeterminate diagnosis which involve comparing in-house images with external priors. Given that many specialists stated they preferred to interpret an image themselves for patient safety and/or mistrust of radiologists' reports, timely access to high-quality images was seen as central to their clinical decision-making. Automated ingestion of images from DICS onto local servers could generate organizational efficiencies by freeing up administrative

staff time spent on uploading images and tracking down images from patients and/or outside radiological services. Specialists also described the potential for DICS to act as a platform for eConsults by efficiently transferring images and facilitating two-way provider-to-provider communication. All of these advantages would permit providers to have more time to focus on patient-centric care through streamlined workflow, resulting in increased patient satisfaction. Interviewees also identified specific high-value clinical areas for which DICS could be optimized. For instance, specialists reported that any provider involved in surgical procedures could benefit from DICS to plan the correct surgical approach and use outside imaging for follow-up to assess post-procedure outcomes. Similarly, oncologists were cited as a high-value group for DICS due to their need to frequently monitor tumor progression and plan radiation or surgical treatments.

4.8 PRIMARY CARE PROVIDERS' PERSPECTIVES

Seven primary care providers (PCPs) were also interviewed as well as one pharmacist working in an outpatient chronic disease management clinic. While there were less use cases for accessing images, viewing radiology reports and knowledge of a patient's complete imaging history were considered to be of high-value for these providers.

4.8.1 Primary Care Providers: Current Methods of Accessing Images

PCPs stated they usually access diagnostic imaging data through their EMR or HRM. However, not all primary care providers reported being connected to the HRM via their clinics, limiting the accessibility of imaging data to these users. In fewer instances, they obtain a report through fax or an image on CD. Most PCPs stated they only require access to reports, and many relied on DICS for access to external priors. Due to lack of training on how to read images, many felt the image was not necessary to their clinical workflow. On the other hand, some PCPs commented that they liked the option of being able to view an image to further investigate or confirm what was documented in the report. Some unique use cases for images were also described. For instance, one PCP stated they receive and independently read x-rays on plain film from a nearby radiology clinic.

> *"For the rest of the patients, I get all the reports through HRM, unless they go through an external imaging lab, an outpatient imaging lab that is not connected to HRM. In which case it's a hit or a miss, and those are the ones… where the patient will tell me, I've already had that test done."*
> – Primary Care *Provider* 2

4.8.2 Primary Care Providers: Experience with DICS

PCPs used ConnectingOntario or ClinicalConnect to access patient reports, although few were familiar with DICS. Similar to specialists, PCPs gave mixed reviews for accessing reports or imaging data using this channel with some stating that it improved workflow and others stating it was an inconvenience due to the requirement of a separate login. Majority of frustrations with DICS were due to technical issues of ConnectingOntario going offline. PCPs mainly relied on and prioritized access to the reports of an image and did not have any comments or recommendations on the DICS image viewer. Some stated that having access to the image is preferred to review with the patient when explaining their diagnosis or treatment. There may also be value in access to DICS for non-physician providers, such as pharmacists and other allied health professionals.

> *"Higher priority is on the reports. In terms of images, patients are usually curious about it, just to see what it is and what it looks like. A great example is two days ago, we just diagnosed a patient with lung cancer. They just wanted to see where it was in their body."*
> – Primary Care Provider 2

> *"I can't think of something that I would like better. I'm just so happy to have it [DICS] in the first place. I can't think of something that could be done better."*
> – Primary Care Provider 3

4.8.3 Primary Care Providers: Enablers to DICS Engagement

PCPs identified areas of improvements to expand the adoption of DICS **(Appendix K).** PCPs recommended integrating DICS into their local EMR to improve workflow. One PCP also suggested to co-design improvements with providers to better integrate DICS into clinical workflows. Improving communication between providers through DICS was also recommended to improve consults. PCPs and the pharmacist interviewed also said it was important to improve awareness of and training on DICS as it was likely many were unaware of this service and its potential benefits. PCPs were also concerned with ensuring the viewer had comprehensive access to a patient's imaging report history to ensure holistic access to their health information, which could avoid unnecessary referrals or repeat imaging. This implies that PCPs would value access to legacy data on DICS alongside complete access to reports from IHFs and private clinics. Of particular importance is expanding access to reports from clinical areas currently not captured on the viewer, especially for patients with multi-morbidities (e.g., cardiac and obstetrics/gynecology imaging data).

4.8.4 Value Propositions of DICS for Primary Care Providers

As the first point of contact and frequent referrer of diagnostic imaging tests, PCPs articulated that comprehensive access to a patient's imaging history can help ensure appropriate navigation of patients through the health system. Additionally, seamless integration within EMR would free up administrative staff time spent on accessing radiology reports or preparing referrals for unnecessary tests. Access to DICS could also enable PCPs to make point-of-care decisions by improving access to a patients' imaging history during clinic appointments, resulting in more efficient and high-quality patient care. One PCP and one pharmacist also described the value in using DICS to review images with patients, as this was perceived to improve patients' understanding of their health status and treatment options.

> *"In some cases, I might even show it [an image] to the patient to help give them not so much an understanding, but just an appreciation. Because often, a picture just … no, this is real, look. Because, for instance, what a heart-failure heart looks like, it just looks bigger. I can't describe it any other way, but a lot of patients I work with too, it's behavioural stuff, like motivation and change and that. And significant impact to a patient if they can see their information, as opposed to someone just telling them."*
> – Pharmacist 1

4.9 VALUE OF DICS FOR PATIENTS AND THE HEALTH SYSTEM

In addition to the specific value propositions for various healthcare providers as described, DICS could be optimized to create value at the patient and health systems levels **(Appendix L)**. Nearly all interviewees expressed that access to external imaging and reports reduces the risk of unnecessary repeat imaging. This would minimize wait-times and reduce costly expenditure on radiological services. Further, many providers described the value of using DICS to enable innovative models of radiological services that could generate efficiencies for the health system. Due to the lack of clinical expertise in some subspecialized areas, some specialists felt it would be more efficient to have referrals performed and interpreted by specialists trained to read images for specific anatomical regions and/or disease areas rather than relying on a general radiologists' report. This was associated with unnecessary repeat testing and preventing secondary reads. Beyond the cost savings and inherent benefit of having access to a centralized repository of patient images, the most pronounced value voiced is in patient care. Provider access to external images alleviates the patient burden of having to care for their copies of exams or CDs, and more importantly, minimizes the need to re-take radiology exams when moving between network

facilities. It can facilitate remote access to specialty care by easing transfer of images from rural and remote settings to subspecialized radiologists who tend to be centralized in urban centers. Not only does this save patients' and caregivers' time, but this also reduces the risk of unnecessary repeat exposure to radiation.

5. Summary of Findings

The qualitative findings of this evaluation echo pre-existing literature presenting evidence that diagnostic image sharing technologies, such as DICS, can decrease the likelihood of duplicate imaging, and therefore, reduce costs and improve provider workflows and efficiency.[1–6] At the patient-level this translates into reduced patient burden to retrieve and transfer images, reduced wait-times for imaging, timelier access to treatment, and reduced risk of unnecessary radiation exposure.[1,5,7] At the systems-level, two studies found that this could reduce redundant health resource utilization, and thus, lower costs.[6,8]

However, as currently constructed, DICS does not fully align with provider workflows, and therefore, does not optimize provider experience and the quality of patient care across the healthcare system. Nearly all interviewees described the need to ensure DICS captures a comprehensive data set of all potential sources of patient images and reports. **However, several challenges to image centralization were identified:**

- Interoperability challenges
- Data contribution gaps from IHFs and specific clinical specialties
- Data quality issues

Vendor choice and platform architecture vary across organizations due to differences in size, scope, geographic distribution, funding and breadth of specialities practiced within a network. In order to overcome challenges with interoperability, many suggested implementing provincial standards or regulation that would impose vendor compliance with the requirements for contribution to the DI-rs and DICS. The financial burden of contributing for IHFs remains an ongoing concern with some suggesting that provincial funding may be required to support this. However, some interviewees believe that provincial investments in

IHF contribution would be offset by the reduced likelihood of unnecessary repeat imaging and minimizing the current administrative burden of transferring data.

This evaluation determined that provider method of access and DICS utilization varied based on clinical specialty. **Enablers to DICS engagement included a number of key technological features:**

- **Radiologists and specialists who read images** – automated integration with local PACS, ability to download images into their local system, side-by-side viewing, prompts/flags in local system for outside images
- **Specialists and primary care providers** – creation of provider-to-provider communication tools, receiving image uploads in a timely manner
- **All providers** – creation of industry standard for imaging, reports and storage

Given the heterogeneity of clinical use cases for DICS, identifying high value users for whom to prioritize access and features for is required to improve the technology. Potential areas of benefit, as gleaned from the interviews, include surgical planning and follow-up with an emphasis on orthopedics, oncology and radiology. Within the literature, valuable clinical areas for diagnostic image sharing technologies include trauma/emergency care,[4,7,8,13,14] oncology,[1,5,15] wound/burn management,[15] outpatient and after-hours care.[15] However, most interviewees stated that any provider involved in clinical decision-making could benefit from access – even primary care providers and allied health professionals who reported some use cases for viewing images.

More broadly, image sharing technologies can lead to the redistribution of radiological services to establish local, regional, national and even international networks to achieve different levels of consultation, care coordination and resource sharing.[16,17] Several providers commented on the potential of DICS to generate innovative models of radiological services that would create more efficiency for the health system. For instance, to promote high-quality interpretations of images, several providers suggested that specialists trained to read images pertaining to specific diseases or anatomical regions could be more heavily engaged to interpret images for referring providers rather than relying on a general radiologist's report.

6. Recommendations for Phase II

In order to improve DICS to generate the highest impact for patients, providers and the health system further infrastructure and implementation changes to the service need to be explored. **Results from this evaluation indicate that the following high-level recommendations would facilitate DICS optimization, which can then be evaluated for value in scale and spread. We would ask that you review and determine priorities moving forward so that we can map out a project plan for a Phase II evaluation.**

1. **Optimize the functionality of DICS for high priority clinical areas:**

   Taking into consideration current usage, the heterogeneity of clinical roles and needs for diagnostic imaging access, DICS may not be suitable as a "one-size fits all" approach. The current evaluation has identified preliminary priority areas as gleaned from interviews including oncology, surgery, and orthopedics. A Phase II evaluation would choose one or more of the specialist areas and involve further stakeholder consultation and engagement with them. Interviews, focus groups and more robust workflow mapping of these specialist areas would be performed to identify which providers could create the most value-add for the health system and how this value would be realized through DICS.

2. **Make changes to the current tool to improve workflow:**

   Provider interviewees described technical changes to the viewer that could improve workflow. For most specialists outside of radiology, this includes enabling side-by-side viewing, increasing the speed of image download and expanding the default timeframe on the clinical viewers. Providers believed this would to reduce treatment time and improve clinical coordination. For radiologists and more subspecialized clinicians who use a local PACS, this would mean enabling an image request that can be integrated into their PACS. For generalists, ensuring efficient and comprehensive access to patient reports should be prioritized. A Phase II evaluation would include the evaluation of provider satisfaction and engagement with DICS after changes to the current tool are implemented targeting both radiologists and specialists. As part of the deploying enhanced services via change management activities, a communication and education plan should be developed that follows suggested workflows for better use of the tools based on care setting.

3. **Early stage optimization within the Ontario Health Teams (OHTs):**

Given that the Ontario healthcare system is moving to models of integrated care through the OHTs, there is value in ensuring the functionality and purpose of DICS and the larger diagnostic imaging strategy fit into the needs of the OHTs; for example, in facilitating communication between providers caring for the same patient, supporting clinical decision-making, and promoting efficient transfer of imaging data through their pre-existing IT systems. A Phase II evaluation would engage an upcoming OHT as a use case for DICS in an integrated care model. We would work with high-value clinical teams through focus groups to determine their specific workflows and diagnostic imaging needs. The model could then be developed to meet the needs of high-priority clinical areas in OHTs and the evaluation would include how to better leverage existing data/resources, markers of patient and provider satisfaction, cost-effectiveness, and patient outcomes. The findings of the evaluation would be used to guide further development and scale-up of DICS for OHTs by assisting in its implementation in future OHTs.

4. **Develop a strategy to create a comprehensive data set:**

The image contribution gap from IHFs and specific clinical specialties was reported as a significant barrier of DICS utilization, indicating a need for a provincial strategy to address this policy challenge by increasing the comprehensiveness and consistency of available imaging. A Phase II evaluation could include a symposium of multiple stakeholders to explore methods and develop policies around onboarding IHFs and private clinics. This would increase the breadth and comprehensiveness of images. There is particular need to consider incentives for IHFs to negotiate contracts with vendors who can integrate with DI-rs and DICS. This could potentially through accreditation by the Ministry or another regulatory body, or through the creation of a single cloud-based network for all IHFs.

5. **Develop and implement a provincial strategy for centralized imaging data sharing:**

The multitude of channels of access to outside diagnostic imaging data (e.g., DI-rs via their independent viewer or integration through PACS, DICS through ConnectingOntario, ClinicalConnect or ONE Portal and emerging regional PACS networks, etc. [See **Figure 1**]) can lead to user confusion, image duplication and fragmented data sets. A Phase II evaluation would bring together a large group of diverse stakeholders through a symposium (e.g. healthcare providers, hospital and DI-r administrators, IT stewards, the Ministry of Health) to identify the key challenges within the diagnostic imaging landscape. We would explore how local and aggregator/external systems work together in a value-chain to promote data sharing and identify regulatory standards (e.g., patient identifiers, rules for pulling foreign exams,

Image Object Change Management) that could improve data availability, interoperability with local systems to develop and support a provincial strategy. Provincial terminology standards could support uniform ordering and health system reporting, and allow faster retrieval of relevant priors.

Developing a Provincial Strategy

"I would approach it two different ways, and the first would be we need to stop looking at the PACS system, which is the local system, the imaging repository, which is the aggregator, and DI Common Services. The challenge I think that we have, and why we so often miss the mark in delivering these images back down to the appropriate clinical population, is we treat them as three different systems, and we design functionality complexly independently of the three and we need to stop doing that. We keep looking at, okay, how do we evolve DI Common Services, or how do we evolve the DI-rs? But it's the PACS system, it's the DI-rs, and it's DICS, and they're three parts of a value chain and they need to be looked at collectively as opposed to in silos, and we've only ever looked at them in siloes, and I think until we change that mindset, we're going to be challenges."
– Administrative Stakeholder

7. References

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8. Appendices

A. INTERVIEW GUIDES

1. Guide for Clinical Users

General background:

- What is your medical specialty?
- Where are your practice locations?
- What are your specific roles at these locations?
- What kinds of patients do you see at these locations?
- How long have you been practicing?
- Which clinical viewer do you use to access patient-level data (Clinical Connect, Connecting Ontario, ONE Portal)?

1. Do you access digital medical images or only the reports?
   - Can you describe common use cases for which you require access to medical images and radiology reports? (e.g., diagnoses, providing consults, monitoring disease progression, research purposes, etc.)
   - What is the value of imaging access compared to/ in addition to report access?
   - What type of imaging modality do you need to access most often?

2. Please describe how you currently access imaging reports and/or medical images for your patients.
   i. **Prompt:** What are the advantages and disadvantages of your current process for accessing digital images/radiology reports? (*If not addressed already*)
   ii. **Prompt:** How does your current process of accessing digital imaging/radiology reports impact your workflow, clinical decision-making and patient outcomes?
   - How do you identify whether an imaging test you are interested in has already been completed?
   - How often do you re-order an imaging test that has already been done? Why?
   - To what extent does your ability to access images impact on the timeliness with which you can provide care? How?

3. Are you aware of the Diagnostic Imaging Common Service (DICS)?
   - Do you have authorized access to DICS?
     i. If yes, can you describe how you gained access and your experience with onboarding/training?
   - Have you ever accessed DICS?
     i. If not, why not?
     ii. If not, what is your current process of accessing images outside your organization/region?

For people who use DICS:

- How often do you use DICS? For what purpose?
- How satisfied are you with the process of accessing reports and imaging via DICS?
  i. **Prompt:** Do you experience any delays/challenges/frustrations when it comes to DICS? Please describe.
- How does using DICS fit into your current clinical workflow?
- Can you describe a situation in which the DICS had value for you?

4. What would be the potential value of having the ability to view imaging for all of your patients? **OR**
   - Would this impact your decision-making? Your workflow?
   - What type of imaging would you want available?
   - Does your current process enable you to accomplish this? If not, what would need to change to enable it?

5. What technology features do you require in your viewing software
   i. **Prompt:** (e.g. image resolution/ image quality, speed, ability to query, ability to integrate into an electronic patient record, ability to access from home)?

6. Which settings/clinical areas/stage in the patient journey do you think the DICS would be most appropriate for?
   i. **Prompt:** Are there certain professional groups who would benefit more from access to DICS?
   ii. **Prompt:** Does everyone need access to DICS?

7. Aside from the current clinical viewer you use to access DICS, what would be the ideal scenario to access DICS imaging?

2. Guide for Administrative Stakeholders

<u>General background:</u>
- Describe your role and involvement in diagnostic image sharing?
  i. **Prompt**: type of organization they operate in (e.g., hospital, independent health facility, regional DI-rs, etc.)
- What geographical area do you operate in?

<u>Diagnostic image contribution:</u>

1. **For DI-rs**:
   - Describe how sites (IHFs/hospitals) contribute to what is uploaded on the DI-r viewer.
   - What information is contributed on the DICS viewer?

   For IHFs/hospital sites:
   - Describe current methods of external image transfer and sharing at your organization.
     i. Probe: do they contribute to DI-rs, DICS or use other technologies (e.g., cloud-based servers, FEM, etc.)
   - **(If they contribute to a regional repository):**
     i. Describe why you decided to contribute to a regional repository (probe for if there were any incentives – e.g., financial incentives).
     ii. Describe the procedures/steps you took to contribute to the regional repository.
   - Describe your level of knowledge of the Diagnostic Image Common Service (if any)?

2. What are the major administrative challenges with diagnostic image sharing?
   i. **Probe**: What are the major barriers for contributing to a regional imaging repository (e.g., DICS vs. DI-rs)

3. What are the major technical challenges with diagnostic image sharing?

4. What percentage of imaging is performed at independent health facilities?

- **For DI-rs**: What percentage of independent health facilities are on boarded onto the DI-rs? Has this changed over time?

5. Are there any images that are blocked (not shared with regional diagnostic image repositories)? If so, which ones?

Image requirements/standards:

6. **For DI-rs**: are there institutional/ IHF requirements or standards for imaging sharing with the regional diagnostic image repository?

   For hospitals/IHFs: what standards for image sharing do you currently adhere to?
   i. **Prompt:** Adherence to DICOM, HL7, etc.
   ii. **Prompt:** Completeness of all planes of view

7. Are there any incentives in place to ensure these requirements are maintained?

8. Describe the typical workflow/process to consolidate diagnostic images from multiple sites.

Future directions:

9. How can image sharing processes be improved?
   i. **Probe**: What are the regulatory or governance requirements needed to improve image sharing between diagnostic image data systems?

10. **(If familiar with DICS**): How do you feel the diagnostic image common service (DICS) fits in with the regional diagnostic imaging repositories?
    i. **Prompt**: Do you think it is complimentary?
    ii. **Prompt**: How can DICS be optimized so it is not duplicative?
    iii. **Prompt**: What clinical users groups benefit more from DICS vs. the DI-rs?
    iv. **Probe**: What is the value of DICS?

B. CHARACTERISTICS OF HEALTHCARE PROVIDERS INTERVIEWED (n=35)

Characteristics	Details	n (%)
Region	HDIRS*	**29 (83%)**
	SWODIN catchment	**3 (8.5%)**
	NEODIN catchment	**3 (8.5%)**
Professional background and specialty	Physicians	
	Oncology**	**7 (20%)**
	Primary Care	**7 (20%)**
	Radiology***	**6 (17%)**
	Thoracic Surgery	**3 (8.5%)**
	Emergency Medicine	**2 (5.5%)**
	Orthopedic Surgery	**2 (5.5%)**
	Internist/General Medicine	**2 (5.5%)**
	Respirology	**1 (3%)**
	Cardiology	**1 (3%)**
	Urology	**1 (3%)**
	Gastroenterology	**1 (3%)**
	Neurosurgery	**1 (3%)**
	Pharmacist	**1 (3%)**
Setting	Hospital	**30 (86%)**
	Community	**5 (14%)**
Organization	Academically affiliated sites	
	SMH	**5 (14.5%)**
	Sunnybrook	**5 (14.5%)**
	UHN	**8 (22.5%)**
	Other****	**12 (34%)**
	Non-academically affiliated sites	**5 (14.5%)**
Provincial viewer used	ConnectingOntario	**29 (83%)**
	ClinicalConnect	**3 (8.5%)**
	None	**3 (8.5%)**
Years of practice	0 to 5	**7 (20 %)**
	6 to 10	**7 (20%)**
	11+	**18 (51.5%)**
	Unavailable	**3 (8.5%)**

* Includes HDIRS and GTA West (now referred to as HDIRS East and West respectively)

** Includes 3 radiation oncologists, 2 medical oncologists and 2 surgical oncologists

*** Includes 1 specialist subspecialized in neuroradiology

**** Other: Trillium Health Partners, Montfort Hospital, McMaster University Medical Centre, St. Joseph's Hospital, Lakeridge Health, Kingston General Hospital, Michael Garron Hospital, Baycrest Hospital, Health Sciences North, Bruyere Family Medicine Centre, Stratford General Hospital

C. CHARACTERISTICS OF ADMINISTRATIVE STAKEHOLDERS INTERVIEWED (n=7)

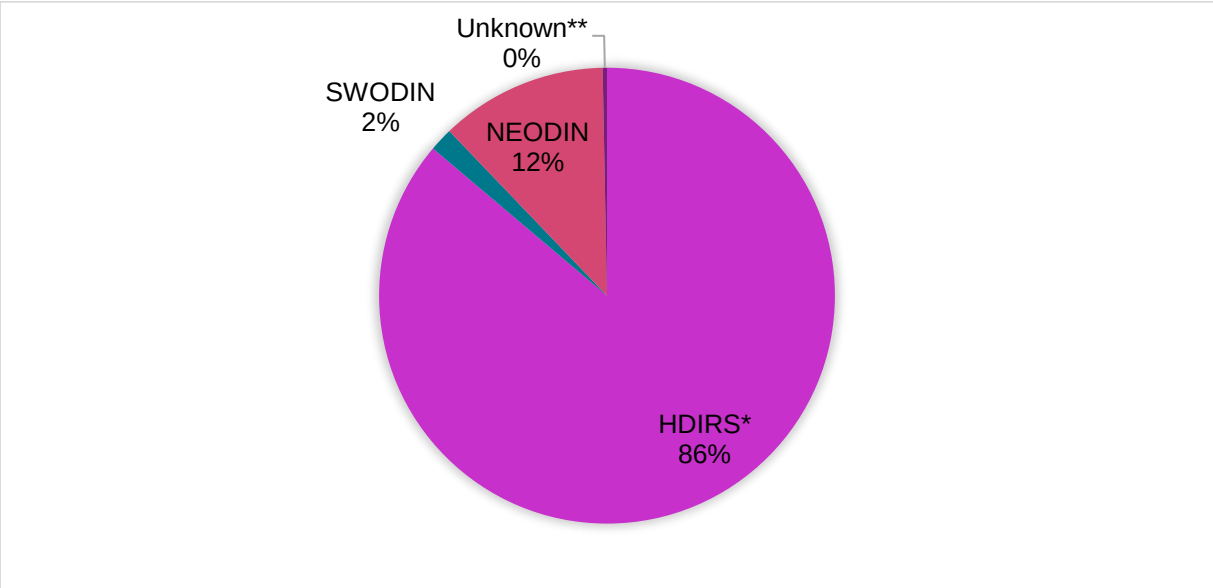
Characteristics	Details	n (%)
Region	HDIRS* NEODIN catchment SWODIN catchment	**3 (43%)** **3 (43%)** **1 (14%)**
Role	Administrator for DI-rs PACS administrator Imaging director of IHF	**5 (72%)** **1 (14%)** **1 (14%)**

* Includes HDIRS and GTA West (now referred to as HDIRS East and West respectively)

D. DICS VIEWING STATISTICS FROM SEPTEMBER 2018 TO APRIL 2019

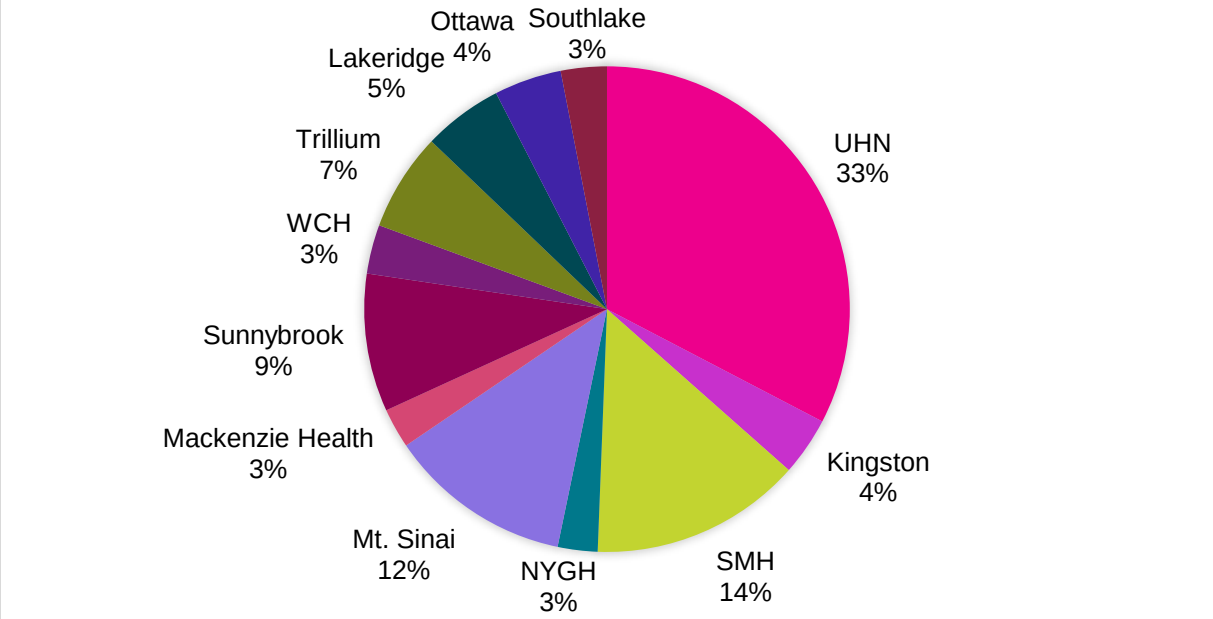
	Clinical Connect		Connecting Ontario		ONE Portal	
	# report views	# image views	# report views	# image views	# report views	# image views
September	836	186	47,560	9,027	1,283	540
October	1,021	309	57,978	11,607	1,667	628
November	1,276	340	63,872	14,369	1,557	458
December	1,063	249	54,496	13,422	1,224	334
January	1,887	495	88,279	21,714	1,690	576
February	1,545	781	73,305	18,177	1,594	513
March	1,750	450	79,438	19,975	1,433	470
April	2,045	451	81,797	21,864	1,536	532
TOTAL	**11,423**	**3,261**	**546,725**	**130,155**	**11,984**	**4,051**

E. HIGH-END USERS OF DICS IN FEBRUARY 2019 BY REGION (n=658)



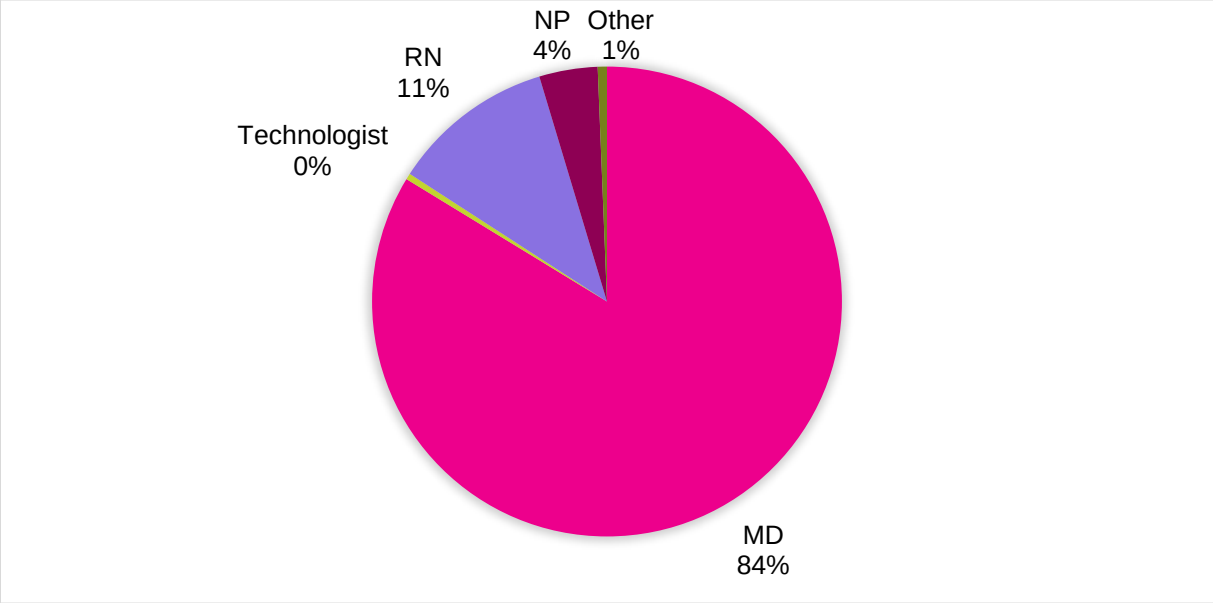
* HDIRS includes HDIRS East and HDRIS West (formerly GTA West)
** Unknown (n=2)

F. HIGH-END USERS OF DICS IN FEBRUARY 2019 BY INSTITUTION (n=490)*



* Including only centres with > 10 high end users
Abbreviations: UHN: University Health Network; SMH: St. Michael's Hospital; NYGH: North York General Hospital; WCH: Women's College Hospital

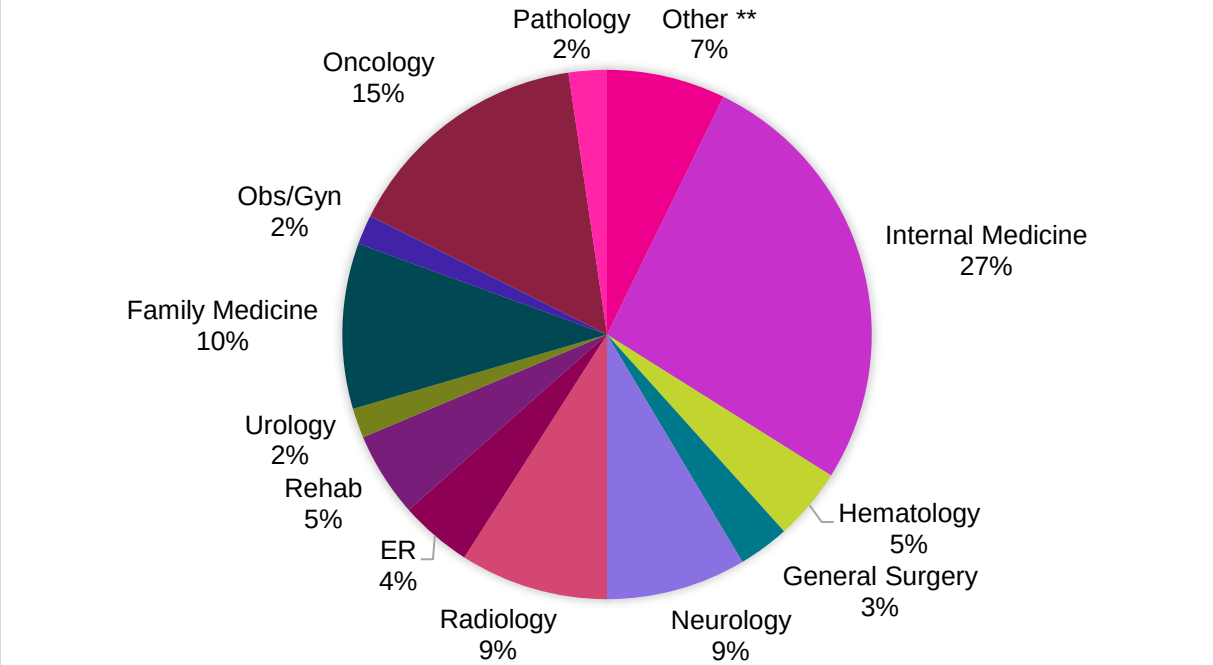
G. HIGH-END USERS OF DICS IN FEBRUARY 2019 BY PROFESSIONAL BACKGROUND (n=473)*



***** Only 473 professional backgrounds were provided in the usage data

Abbreviations: MD: medical doctor; RN: registered nurse; NP: nurse practitioner

H. HIGH-END USERS OF DICS BY PHYSICIAN SPECIALITY (n=393)*



* Not all specialties listed

** Other (rheumatology, respirology, cardiology, dermatology, thoracic surgery, head and neck surgery, critical care, nephrology, paediatrics, ophthalmology, orthopaedic surgery, neurosurgery)

Abbreviations: ER: emergency medicine; rehab: rehabilitation medicine

I. ENABLERS TO DICS ENGAGEMENT FOR RADIOLOGISTS

Enablers to Engagement	Supporting Quotations
Technological Features	
Automated integration with local PACS	"*I guess what I would need is that my PACS facilitator, the informatics team at my hospital, ideally, automatically, without having to do any work, would automatically be able to import those images in DICOM format from this larger system into our system, and be matched with the patient's name so that when I open the study, I can see all the prior imaging*." – Radiologist 2
Ability to download images onto their local system	"*Let's assume I read a case and yes somebody told me that the images are available on Connecting Ontario. I look at the images and I compare, three days later I have to present the case at rounds and I have to do the same thing again. So the images are not downloaded into our system and every single time we have to go through the extra steps. It is relatively slow for scrolling for larger data files and a side-by-side view is not possible*." – Radiologist 1
Side-by-side viewing	"*The only way that imaging can be used for diagnostic purposes is if it's directly comparable to other studies*." – Radiologist 3
Prompts or flags in local system of outside images available on DICS	"*Well it is still the case that I don't know whether a patient had outside images. When I read x-rays it's several hundred cases per day, when I read conceptual imaging it's 20, 30, 40 cases per day. I don't know whether there was outside imaging done. If there would be a prompt that would be very helpful, that is one. It's just not practical. I cannot log in to Connecting Ontario and check for every single patient was there any outside imaging done*." – Radiologist 1
Viewer that is easy to access and navigate	"*For us to use the ConnectingOntario clinical viewer involves at least six, seven different steps. We have to go into our RIS. The, from the RIS, we have to look at the patient. Then, we have to pull up the imaging. Then, we have to go to a tab called eHealth Ontario. Then, we get it onto the clinical viewer. Then, we have to find specifically the imaging. Finally, we open it up in a web-based, clunky kind of viewer, where it's slow. Relative to a PACS. Admittedly, a PACS is fast, but that's what it's meant to do. To pull up images, particularly large cases. To scroll through them. So, that's by far the biggest disadvantage*." – Radiologist 4
Standardized imaging, reporting and storage practices	*"Going forward, if standards were set, you know, that would mandate to do things in a certain way, and, in the future, would make it easier for systems. The initial pull together of data is pretty difficult."* – Radiologist 3
Unified data set	*"All the data should reside in the one place. You really have infrastructure which is redundant infrastructure with data centres in two or three geographical locations where the data is being stored. These data sets have been mined from IHS, from Public Hospitals, from everywhere, basically, and is sitting in these repositories."* – Radiologist 3
INCLUSION OF OTHER IMAGES	**"***It's logical, it's obvious, to be able to look at an echo and an ECG with a cardiac MRI makes complete sense, and it would be used widely. But, currently, the systems are fire-walled, you can't view ECHOs on our system, you can't view nuclear medicine heart testing on our system, which is, again, absurd*." – Radiologist 3

J. ENABLERS TO DICS ENGAGEMENT FOR SPECIALISTS

Enablers to Engagement	Supporting Quotations
Technological Features	
Automated integration with local PACS	*"The final downside of the Connecting Ontario viewer is that I can't transfer the images to my own PACS system. That's always handy because then I can have access to them when I'm on the network and if there is network down times but then also it would allow me to use that internal viewer to do all that stuff more expeditiously."* – Urologist 1
Ability to download images onto their local system	*"I think the other feature that would be very nice, when we're looking at outside images, is having the capacity to upload images onto our system, or vice versa, to allow that side by side viewing."* – Respirologist 1
Side-by-side viewing (for local and outside images or for historical comparisons)	*"So what I can't do is can't put stuff side-by-side and directly compare them on the screen at the same time, for example, a CT scan now with one performed three months ago or six months ago or a year ago. I have to kind of go by memory. I imprint it in my memory and then I go look at the other one but that's not as good as having them side-by-side."* – Urologist 1
Prompts or flags in local system of outside images available on DICS	*"I can think of a recent case, maybe a year ago, where a patient came to me with symptoms that required a CAT scan of their head, and so I ordered a CAT scan of their head and then the report from radiology said, similar to the CAT scan done two days ago, and I was like, what? And the patient purposely withheld that information from me because they wanted a second opinion from me and they weren't honest about it. And so, until I have a reason to go looking and see if they have old images, I'm not going to look. Yeah, there's no flag currently to suggest that."* – Emergency Physician 1
Receiving image uploads in a timely manner	*"For a routine brain tumour, if I put an order in it takes three months which is really just unacceptable and then doing functional imaging on brain tumours is not ministry-funded and it's a standard of care. And so, if we don't have ministry funding for it, the radiology department would feel that they would have to cut into their main capital budget in order to provide what apparently really would be standard care in all of North America for doing functional imaging of the brain. It's not really even just brain tumours. It's for a lot of other pathologies, epilepsy and movement disorder."* – Oncologist 7
Creating provider-provider communication tools	*"For instance if you could put preliminary comments, if you could have sort of ask a question, if you could flag something that went somewhere. In a certain sense we're still all viewing stuff and we're not really communicating. The truth is one of the limitations of all these services is the inability to communicate effectively back through these portals."* – Emergency Physician 2
Co-design DICS with clinicians	*"I'm not saying it's a panacea for everything but the engineers were told not to design a system to load imagining, it was design something. Watch the clinicians work and then design around that so I think that's important."* – Oncologist 2
Creating industry standards for imaging and reporting	*"But as we automate some of the reports, it may be an opportunity to automate things like feedback and say, you know what, this was not present in your report, to allow quality improvement in general. The second thing is whether there are opportunities, moving forward, to*

	centralize some of these image reporting. So that if images are uploaded, is there an opportunity to centralize some of this, so that less than standard reports can be weaned out, so that when we are getting reports from somewhere, that we know we can trust that data." – Internist 1
Including IHFs and private clinics on DICS	*"Putting the private clinics on there would be icing on the cake. Then a lot of the family doctors who might invest in getting access to the system if they can get the ultrasounds they ordered down the street, sort of thing, on there. Eventually that might come. Ideally, your model is Alberta's Net Care because everybody is on Alberta's Net Care but it has been around for almost 10 years."* – Oncologist 8

K. ENABLERS TO DICS ENGAGEMENT FOR PRIMARY CARE PROVIDERS

Enablers to Engagement	Supporting Quotations
Co-design DICS with clinicians	*"I am a tech person, I work in the tech industry as well, and so my viewpoints are biased. But at the same time, I also do user designs or experience with a lot of the tools I do, and I find that these tools should have come out initially with user experience in mind, and they weren't. As well as practicality, I think having a physician on board, who actually understands how user experience works, is really important."* – Primary Care Provider 2
Improving clinician-clinician communication	*"It would be helpful to improve communication when you are trying to find a missing report, if you could flag that, hey, this person got this a week ago, I still don't see the report, and I need it clinically. I've noticed, sometimes, it's just sitting in their queue and they just haven't uploaded it. If you end up calling and talking to the right person, they will just bump it to the top of the radiologist's queue and it ends up getting done within an hour or two. You actually end up having the report, but it takes a lot of work to find the right person. If that process … there is always someone connected to the imaging so you can follow-up with it; that would be really helpful."* – Primary Care Provider 5
Improve awareness of DICS	*"I think the big thing is … and it's an awareness, maybe not just pharmacists, but I know for sure pharmacists. And this is, again, a problem with the name, it isn't just imaging. It's the reports, which are actually more important for most. It says 'diagnostic imaging', and people think it's just a picture, so it's kind of misleading. People may not think to access it or even want to get it because they don't realize this is where all the reports are."* – Pharmacist 1
Inclusion of all hospitals/ clinics onto one system	*"The other part is, it's useless to have a tool that only taps into half the diagnostic imaging. I think that a mandatory aspect should be all community or outpatient or private imaging labs have to be on HRM. Because it's pointless to have some people on paper, where the rest of the world is going digital."* – Primary Care Provider 2
Automated integration into EMR	*"I would just say anything that can come directly to the patient chart is a thousand times easier than having to log in, even, to the Connecting Ontario, because I find by the time you find the website again, and then you always have to change your password because you can't remember your password, and then you look for your password … anyway, it's a 10-minute process, minimum."* – Primary Care Provider 4

	"I think just, again, the integration into our workflow is really important. Primary care has a very busy, very, very chaotic workflow. If things don't fit into that, they often get left behind, even if they are potentially a helpful resource. I think just really thinking about how to access this in a very easy way, where I don't have to re-type in the patient's date of birth, MRN, name. Ideally, it's from the EMR, it's connected in. I think that is really important." – Primary Care Provider 5

L. VALUE PROPOSITIONS OF DICS FOR PATIENTS AND THE HEALTHCARE SYSTEM

Patient Value Propositions	Supporting Quotations
Imaging done closer to home, reducing travel costs and time	*"We used to say, well, if you're getting a CT, you have to come to Toronto General to get the CT. But now we can say, get it done in your home centre and at least we can look at the pictures. And it saves people hours of travel and costs and things associated with that. We find that really helpful."* – Respirologist 1
Reducing radiation exposure	*"If that's, then, available on Connecting Ontario, I don't need to send them for more x-rays, reduces radiation exposure to them, reduces cost to the system. It's more efficient, I don't need to send them away to come back another day so it's their inconvenience."* – Orthopedic Surgeon 1
Reinforcing patient trust in the system	*"I think its patient peace of mind in terms of being able to see that their records have not been lost, that they can see them. If we do want a report or an image from whatever location, we can access it. Whether they were up on Manitoulin Island getting an x-ray done, or whether they're down here, they know that their image has not been lost, and they don't have to go back and do it all over again."* – Primary Care Provider 2

System Value Propositions	Supporting Quotations
Reducing system costs by reducing repeat imaging	*"I found that used to be like, 'we're never going to get a copy of this test'. We would just be better off repeating this test. There was a lot of repeating of tests, for sure. That has been minimized."* – Primary Care Provider 1 *"You know, I didn't look into this really definitively, but anecdotally at least, it has cut back on the amount of repeat images that we are doing."* – Respirologist 1