

Facilitating image sharing for patients transferred to a tertiary care center through process assessment and identification of quality indicators in order to improve quality of patient care, reduce healthcare costs, and reduce reimaging.

by

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THESIS

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## Title and abstract

### Title

Facilitating image sharing for patients transferred to a tertiary care center through process assessment and identification of quality indicators in order to improve quality of patient care, reduce healthcare costs, and reduce reimaging.

### Abstract

#### BACKGROUND:

lifeIMAGE allows for images to be uploaded from a CD and permanently stored in PACS and also facilitates the transfer of images online via cloud-based sharing without the transfer of CDs. However, the current use of lifeIMAGE in imaging transfers remains poorly understood. Thus the aim of this study was to assess the current state of imaging transfers and ultimately to improve medical imaging handovers for patients transferred from outside hospitals to Clements University Hospital (CUH), which is UT Southwestern's tertiary care center, through the use of lifeIMAGE. Participants included radiology faculty, directors and managers of ambulatory imaging services at CUH, members of hospital administration involved in patient coordination, members of nursing administration, members of Information Resources and Analytics at UT Southwestern, and UT Southwestern residents and medical students.

#### METHODS:

The Plan Do Study Act method of quality improvement was used for this project. Based on our process mapping, we created a two-pronged intervention: the first focusing on increasing

online imaging transfers from outside facilities via Cloud Connection, and the second focusing on assessing and improving knowledge of uploading images from CDs. Baseline assessment included pulling data from lifeIMAGE analytics to assess the current use of lifeIMAGE, reviewing 9 months of transfer logs before the intervention, and conducting a resident survey before the intervention.

#### INTERVENTION:

The first component of the intervention involved improving the current transfer of images from outside hospitals via cloud-based image sharing, without the use of CDs. This involved reviewing transfer logs to identify which outside facilities to focus on, providing the facilities with a document explaining their options for transferring images via lifeIMAGE, and scheduling meetings with these outside facilities to work towards a collaborative effort for the online transfer of images. The second component of the intervention involved uploading images from CDs to lifeIMAGE. A survey of residents was conducted to determine healthcare providers' current practice related to medical imaging handover for patients transferred with a CD and to evaluate knowledge of uploading images. This was followed by presenting a brief PowerPoint tutorial on uploading images from CD to lifeIMAGE to Internal Medicine residents at noon conference and posting instructions on the IM Resident blog and website.

#### RESULTS:

Of the recorded transfers spanning 9 months (Dec 2015-Aug 2016) from 371 different outside facilities (after excluding hospitals within the UT Southwestern system), United Regional

Health Care System Wichita Falls and Dallas VA Medical Center were the facilities that transferred the most patients to CUH: 93 (3.63%) and 52 (3.32%), respectively.

68.2% of the surveyed residents expressed that at least half of transferred patients present with a CD containing images, and 72.7% of residents expressed that repeat imaging was required in at least half of the patients because they were transferred without imaging. Only 38.6% of resident respondents knew how to upload CD images to lifeIMAGE. 61.4% did not. Furthermore of the residents who knew how to upload CD images to lifeIMAGE, the majority of this group (82%) endorsed uploading images themselves. The data also indicated that the process for uploading imaging from CDs was highly variable among residents, supporting the need for an intervention to standardize practice. 34% of surveyed residents directly import images from the CDs into lifeIMAGE. 30% of residents send CDs to radiology to upload, 25% reported viewing the images on CDs without import them.

## CONCLUSIONS:

Creating a workflow diagram and assessing baseline data through lifeIMAGE Analytics and through the resident survey improved documentation and understanding of the current state of medical imaging transfers at Clements University Hospital. This study identified that cloud-based image sharing is an underutilized capability of lifeIMAGE. It further helped narrow the scope of the intervention by identifying the two sending hospitals with the highest volume of image transfers so that we could work to increase utilization of cloud-based transfers at these institutions. Based on the resident survey data exposing knowledge as a major barrier, we presented a short tutorial to the residents during noon conference detailing how to upload images to lifeIMAGE and push the images to PACS and created a brief instruction guide that was

emailed to the residents as well as posted to the IM Resident website and IM blog for future access. The survey data also supported the need to standardize imaging transfer practice by exposing large variability in the current process.

Although our interventions allowed us to establish baseline data and addressed important barriers to the transfer of medical imaging that were revealed by our process mapping and resident survey, additional work is needed in several key areas, specifically collecting data after our interventions to assess their impact. There is still work needed in coordinating with outside facilities to increase the amount of images transferred via cloud. Future PDSA cycles can be used to modify our approach based on this study to involve a greater number of outside facilities. In addition, resident knowledge regarding CD uploads will have to be reassessed to see if our educational intervention addressed the knowledge deficit exposed by the pre-intervention survey and if the resources we provided through our intervention had a lasting impact that modified resident behavior.

## Background Knowledge

Imaging studies play an integral role in diagnosing, documenting, and managing disease across specialties. Despite the growing importance of imaging in patient care, accessing, acquiring, and distributing these images continue to pose barriers to patient care, especially when patients are transferred from one facility to another.

Inability to access outside imaging can lead to delays in treatment and negatively impacting patient outcomes.<sup>1</sup> These challenges have largely been attributed to errors in systems and workflows.<sup>2</sup> One study found that transfer protocols and practices varied greatly by institution.<sup>3</sup> In a physician survey, 86.9% of physicians felt that patients arrived without

necessary transfer records, with the majority believing that lack of availability of records often posed a risk to transferred patients.<sup>4</sup> One study that aimed to describe inter-hospital handoffs among 335 patients transferred into ICUs from outside facilities found that complete imaging only arrived with 15% of patients and described an association with lack of information and mortality, adverse events and utilization. The study concluded that mandating complete documentation, including images, as a requirement for transfer was a reasonable first step in improving patient outcomes and to facilitate higher value care.<sup>5</sup>

Reimaging is an important consequence of inability to access images in a timely manner during patient transfers. Haley et al. found that more than 50% of transferred trauma patients undergo repeat CT imaging.<sup>6</sup> These findings were consistent with those of a study conducted at the University of Utah that found that 61% of transferred trauma patients received CT imaging at both the initial hospital as well as at the receiving hospital.<sup>7</sup>

In addition to impacting patient care, there is strong evidence that image exchange practices play a significant role in reducing healthcare costs associated with unnecessary redundancy. According to the American College of Radiology, diagnostic imaging accounts for about 10% of annual healthcare costs.<sup>8</sup> Furthermore about 9% of this cost has been found to be unnecessary or redundant.<sup>9</sup> A cohort study of 196,314 patients found that use of the New York Health Information Exchange, which facilitated provider access to prior images and reports, significantly reduced the odds of a repeat image by 25%.<sup>10</sup>

It is important to recognize the opportunity for improved operational workflow that can impact the quality and cost of patient care through electronic exchange of imaging. CDs have dramatically transformed the ability to facilitate image transfers, and picture archiving and communication systems (PACS) have allowed imaging exams to be stored digitally. Sung et al.



showed that importation of outside imaging from CDs into PACS in transferred emergency department patients decreased the rates of CT use in the subsequent 24-hour period by 29%.<sup>11</sup> Strategies for reducing duplication of CT imaging in non-trauma populations have shown that the importation of outside imaging into PACS is of paramount importance. Lu et al. showed that patients presenting for elective transarterial chemoembolization of the liver for hepatocellular carcinoma that did not have their outside imaging imported were 8 to 20 times more likely to undergo re-CT than those who had their CT images imported into PACS.

Yet despite this technology, image availability when patients travel from one provider to another remains a barrier of care. Patients may not receive the CD containing their imaging studies, the CDs may become damaged and unreadable, they may be misplaced or lost, CDs may be incompatible with the accepting hospital's PACS, and CDs often require manual effort on the receiving end to copy the images into the local PACS.<sup>12</sup>

The necessity for inter-hospital communication for transfer of images for both critical and non-emergent patients is becoming increasingly important. Standardization of practices may prevent or reduce errors. Cloud-based image sharing can provide an important opportunity to improve convenience and efficiency of patient care without compromising safety in the context of expanding healthcare networks. lifeIMAGE is a secure cloud-based medical image sharing software system that enables users to upload digital images and documents from a referring hospital system's PACS to a secure central repository for later review or download into the accepting hospital system's PACS. It also supports the importation of medical images from CDs into a hospital's PACS. A study implementing cloud-based technology (lifeIMAGE) across a regional trauma system resulted in significant reduction in re-CT imaging, with mean cost of repeat imaging per patient significantly decreasing from \$1,046 to \$589.<sup>13</sup> Sharing images via

such cloud-based technology is an opportunity to provide standard medical imaging services across different institutions while maintaining communication privacy.

Though many acknowledge the importance of adopting practices that will reduce medical errors through improved patient handoffs, interhospital patient transfers are a complex and understudied component of transitions of care.

### Local problem

UT Southwestern Medical Center's William P. Clements Jr. University Hospital (CUH) is a 12-floor, 460-bed teaching hospital in Dallas, Texas that opened in December 2014. It serves as UT Southwestern Medical Center's tertiary referral hospital, and is a major center for heart, lung, liver, kidney, and bone marrow transplantation as well as a site for cardiovascular interventional radiology procedures. As such, efficient and effective patient transfers are crucial in fulfilling the hospital's mission of providing patient-centered quality care. UT Southwestern has already adopted lifeIMAGE. Ideally, lifeIMAGE would facilitate image sharing such that a patient's imaging history would be available in the electronic medical record for immediate use upon a patient's arrival. Yet, we found widespread consensus among attendings, residents, and medical students that lifeIMAGE was not being used for cloud-based image sharing. This consensus was supported by the number of image transfers via cloud recorded on lifeIMAGE Analytics. Currently, there is no standardized process for acquiring imaging in a patient's medical record during inter-hospital transfers at UTSW.

## Intended improvement

The aim of this study is to reduce reimaging for patients transferred to CUH from outside facilities by 25% within 12 months.

## Methods

### Context

The team used a variety of methods to help identify the barriers to image sharing.

#### Mapping the possibilities for imaging transfer via lifeIMAGE

Members of Information Resources and Analytics at UT Southwestern were consulted to better understand the options for transferring patient images via lifeIMAGE (Supplemental Figure 1). LISA, lifeIMAGE Sending App, is an application that can be installed on a network for the purposes of accessing images on a DICOM device such as a modality or PACS. LILA, the lifeIMAGE Local App, enables all authorized personnel on a hospital's network to quickly access and review outside exams on CD, share them with colleagues, and import them into the patient's local permanent EMR. There are two image-sharing options for non-lifeIMAGE senders. The first option via Cloud Connection is free of charge with the only requirement being Internet connection; however it requires manual upload of images and sending by a user, and is thus more ideal for a low volume of image sharing. The second option via lifeIMAGE Sending App (LISA) enables users to send from a workstation and directly share with UT Southwestern and is thus more ideal for a high volume of image transfers, however it has a monthly fee of \$100. Sending facilities that are already lifeIMAGE members or Nuance PowerShare members can directly share images via lifeIMAGE cloud for no additional cost.

#### Process Mapping

Process mapping was a crucial piece of this study and was a necessary first step to examine the communication events during transitions of care. The process map was used to

assess the current state of patient transfers, to identify the players involved in the process, and to understand how these could be aligned with the capabilities offered by lifeIMAGE. Our process map identified two major barriers in the image transfer process. The first barrier involved the ability to share exams electronically without CD transfer via cloud-based services, which relied on communication between CUH and outside facilities. The second barrier involved uploading images from CDs to lifeIMAGE, which relied on healthcare providers.

### Stakeholders

Attending physicians, residents, medical students, nursing staff, and administrators were identified as major stakeholders. These stakeholders play an integral role in shifting the culture of image transfers. Furthermore, this intervention directly impacts them by allowing more efficient use of their time, promoting more informed and effective patient care, and reducing healthcare costs. Patients were also identified as stakeholders and were impacted by this study because the intervention works towards decreasing delay in care, decreasing repeat imaging and associated health risks, providing safer and more efficient quality care, and decreasing adverse outcomes.

### Planning the Interventions

Our team consisted of faculty members of the radiology department including the head of diagnostic radiology, directors and managers of ambulatory imaging services at CUH, members of hospital administration involved in patient coordination, members of nursing administration, members of Information Resources and Analytics at UT Southwestern, and UT Southwestern medical students.

Based on our process mapping and the data we extracted from lifeIMAGE, we created a multi-faceted strategy to understand two major capabilities of lifeIMAGE: the ability to upload images from CDs to lifeIMAGE and the ability to transfer exams electronically without CD transfer via cloud-based services.

#### Part 1: Electronic image sharing intervention to promote cloud-based transfers

We conducted a retrospective study of patients transferred to the Clements University Hospital ED from outside hospitals. 4,256 de-identified transfer logs that spanned 9 months (12/01/2015 through 08/31/2016) were sorted by sending facility. 3,826 logs that had sending facility recorded were reviewed and grouped by frequency. The group chose to focus on the two outside facilities responsible for the largest volume of patient transfers to CUH, excluding hospitals in the UT Southwestern system (Parkland Memorial Hospital, Children's Medical Center, and Zale Lipshy University Hospital). We decided to focus our intervention on these two highest-volume referring facilities with the rationale that this would allow us to narrow the scope of our project such that our intervention would be feasible while still impacting the greatest number of transferred patients. We hoped that doing so would help the team identify barriers and limitations of the intervention, which could be assessed before applying our intervention on a broader scale to more facilities. We sent the two facilities a brief one-page invitation to connect with CUH that explained the options that were available to share images electronically through lifeIMAGE. The first option via Cloud Connection is free of charge with the only requirement being Internet connection; however it requires manual upload of images and sending by a user, and is thus more ideal for a low volume of image sharing. The second option via lifeIMAGE Sending App (LISA) enables users to send from a workstation and directly share with UT Southwestern and is thus more ideal for a high volume of image transfers, however it has a

monthly fee of \$100. We felt these two options would accommodate the different needs of different sending facilities, making them more likely to collaborate with us.

### *Study of the intervention*

The 9-month transfer log data was cross-referenced to a list of outside orderables, resulting in a sample set of 203 transfers with CD imports. The time between a transfer being accepted to CD import and the time between patient arrival to CD import was calculated for the sample set. This provided baseline data that allowed assessment of wait time associated with CD imaging transfer as compared to images that are immediately available when transferred via cloud.

For the two facilities we identified as having transferred the most patients to CUH, we were given the transfer data for patients who were transferred to CUH after having outside imaging for the 3-month span of June through August. After excluding patients with incomplete information, we were left with a sample set of 50 patients. We conducted a chart review of these patients and determined 1) If the outside imaging was uploaded, 2) If the interpretation of the outside imaging was uploaded, 3) If the patient was re-imaged, 4) If the diagnosis was changed for patients who were re-imaged, and 5) the time that the re-imaging was completed. We defined re-imaging as having an imaging study done with the same modality performed at the sending hospital study within 3 days of transfer due to not having access to the sending hospital study. Not only will this information provide baseline data, but it can also be used as a reference point to assess the impact of our intervention at these two outside facilities. Furthermore, lifeIMAGE Analytics records the number of images sent to and from CUH by sending facility via Cloud Connection or via CD upload. Comparing the data before and after our intervention allows us to

assess the impact of our intervention at the two outside facilities we chose to focus on for streamlining the process of image transfers via lifeIMAGE.

## Part 2: CD imaging upload intervention

### *Rational and Study of the Intervention*

The second major capability of lifeIMAGE besides cloud-based image sharing is physically uploading CDs to lifeIMAGE. The Internal Medicine residents are involved in patient care at CUH during wards, ICUs, clinics, consults, and electives, and thus have a great deal of exposure to patients at CUH. Based on the rationale that patients generally spend a great deal of time interacting with the medicine team, as well as the data collected from lifeIMAGE Analytics showing that Internal Medicine was the specialty that most used lifeIMAGE's LILA (lifeIMAGE Local App), we decided to survey the Internal Medicine residents. Furthermore, the data collected from the pre-intervention survey helped us design our intervention and allowed for a baseline assessment of knowledge that could be used to measure the influence of our intervention.

### Survey Process

We sent out a survey via e-mail to the first, second, and third year residents in the UT Southwestern Internal Medicine residency program that remained open from January 31, 2017 to February 5, 2017. The survey was designed to shed light on the current state of image transfers, to assess baseline knowledge of uploading CD images to lifeIMAGE, to assess the frequency of patients arriving with CDs upon transfer, and to identify barriers to imaging transfer.



## Survey Content

Data assessed how frequently patients transferred from outside hospital arrived with a CD containing imaging and/or an imaging report and how often repeat imaging is required based on the aforementioned scenarios. Data also included transfer process upon receiving a CD containing images, with survey choices of: importing the CD to lifeIMAGE, sending the CD radiology, viewing but not importing, and an option of free text. The survey asked whether or not residents knew how to upload images to lifeIMAGE and how to import exams into PACS, and it included a free response section for survey participants to comment on the biggest barrier to uploading images from CD to lifeIMAGE (See Supplemental Figure 2).

## *Post-Survey Resident Intervention*

After administering the survey, the team determined that knowledge was a major barrier that prevented residents from uploading images from CDs to lifeIMAGE for patients transferred to CUH. Thus, we created a multi-pronged strategy to teach residents how to upload images to lifeIMAGE, and we also provided instructions that were easily accessible. Noon conference is held daily for all Internal Medicine residents, as well as for medical students, and has a high attendance rate; thus, we felt this would be the best opportunity to reach the greatest number of interns. We were given the first ten minutes of noon conference (presented at CUH, and broadcasted to Parkland Memorial Hospital) and presented a short tutorial that walked the audience through the steps to upload images from CDs to lifeIMAGE and push the images to PACS. A brief instruction guide was then emailed to the residents and also posted to the Internal Medicine Resident website and the Internal Medicine Resident blog for future access.

## Measures

Measures were chosen to assess the baseline state of image transfers as well as to capture the impact of our intervention on the process of clinical care, the outcomes of care, and clinical safety. The following measures were used:

1. *Reimaging rate after transfer*: This measure was defined as the % of patients transferred to CUH that have a repeat imaging study within 3 days of transfer with the same modality performed at the sending hospital due to not having access to the prior study. The source of this information was the chart review conducted for United Regional Wichita Falls and VA Dallas transfers. This measure was chosen to better understand the current state of reimaging and serve as a baseline comparison point to evaluate whether the intervention reduced the rate of reimaging. Reimaging is an important consequence of inadequately transferred images and impacts quality, cost, and outcomes of care.
2. *Ratio of Cloud to CD Image Sharing via lifeIMAGE*: This was defined as % of Images Shared via Cloud vs. % of Images Uploaded via CD on lifeIMAGE. The source of this measure was lifeIMAGE Analytics. This measure was chosen as a means to evaluate the current methods of transfers and provide a baseline to evaluate whether our intervention affected the % of cloud based transfers.
3. *% of residents who know how to import images from CD to PACS*: This measure was defined as the % Internal Medicine residents who know how to successfully upload images from CD to lifeIMAGE and push to PACS. The source of this measure was the Resident Survey. This was important given that the resident survey we administered identified that knowledge was a large barrier to successfully importing images from a CD to PACS. Furthermore, lack of knowledge led to barriers of care by introducing

additional sources of error in uploading, as well as other consequences such as lost CDs and images that were not imported into a patient's chart.

4. *% of residents who import CDs and push to PACS themselves when they receive a CD containing transferred images.* This measure was based off the survey administered to Internal Medicine residents. This was important to assess whether increasing resident knowledge regarding the transfer process translated to action in a clinical setting.

## Results

### Outcomes

Our process mapping helped us identify the two important components of our intervention: the sharing of images online via lifeIMAGE Cloud Connection and the upload of patient images from physically transferred CDs.

#### *Baseline Data*

9-month transfer log data was cross-referenced to a list of outside orderables, resulting in a sample set of 203 transfers with CD imports. The average time for transfer accepted to CD import was 120 hours, and average time for patient arrival to CD import was 133 hours; however the data was very diverse (interquartile range median of 8 hours and 3 hours, respectively).

lifeIMAGE analytics for the past year showed that 96% of the exams that were received were from CDs, and only 4% were from cloud.

#### *Part 1: Electronic Imaging Sharing Outcomes*

4,256 transfer log entries were sorted by sending facility. Hospitals in the UT Southwestern system (Parkland Memorial Hospital, Children's Medical Center, and Zale Lipshy University Hospital) and those entries with incomplete data were excluded. Of the remaining 2,552 recorded transfers from 371 different outside facilities, United Regional Health Care System Wichita Falls and Dallas VA Medical Center were the outside facilities that transferred the most patients to CUH: 93 (3.63%) and 52 (3.32%) patients within the 9 month time frame, respectively. The facilities expressed interest in connecting with CUH through lifeIMAGE, and telephone conferences were scheduled to help facilitate this process.

Chart review of the transfer log data for United Regional Wichita Falls and for the Dallas VA showed that only 38.8% of patients had outside imaging uploaded and pushed into PACS via lifeIMAGE after transfer; 61.2% had outside imaging that was not uploaded. 81.6% of transferred patients had an interpretation uploaded; 18.4% did not have interpretation uploaded. 40% of patients had re-imaging done at CUH after transfer, and diagnosis was changed for 2% of the patients after reimaging. The length of time from the date and time the transfer was requested to the time the repeated image after transfer was performed was calculated for each patient. The median of the resulting time intervals was 14.7 hours, and the mean was 24.6 hours. Of the transferred patients with images uploaded, 10% were reimaged, in contrast to the 56.7% of patients transferred without images uploaded who were reimaged. This difference in reimaging was statistically significant.

### *Part 2: CD Imaging Upload Outcomes*

44 of the Internal Medicine residents responded to the survey, with a good distribution across all levels of training (36.4% PGY-1, 36.4% PGY-2, and 27.2 PGY-3). Based on the data collected, the process for uploading imaging from CDs was highly variable among residents: 34% of surveyed residents directly import images from the CDs into lifeIMAGE. 30% of residents send CDs to radiology to upload, 25% view the images on CDs but do not import them, and 11% opted to respond with free text. Responses from those who selected free text included handing the CD to the charge nurse to upload, sending the CD to radiology after viewing the image, and walking the CD down to medical records. Only 38.6% of resident respondents knew how to upload CD images to lifeIMAGE, in contrast to the 61.4% who did not. Furthermore of the residents who responded that they knew how to upload CD images to lifeIMAGE, the majority of this group (82%) endorsed uploading images.

68.2% of the surveyed residents expressed that at least half of transferred patients present with a CD containing images, and 72.7% of residents expressed that they felt that repeat imaging was required in at least half of the patients because they were transferred without imaging. When asked to identify the biggest barrier to uploading images from CDs to lifeIMAGE, 74% of residents felt that knowledge was the biggest barrier (not knowing how to upload, not being taught how to upload, not knowing that uploading was an option, and not knowing where to find instructions). 17% identified time as the largest barrier (an additional time-consuming task while busy admitting a patient, time to find someone who knows how to upload, time it takes to transport the CD to medical records or radiology). The remainder of responders expressed that they did not know what order to place, they did not know where the drop-off location for CDs was, and that images were never uploaded in a timely manner.

## Discussion / Interpretation

Process mapping identified key players and barriers and helped us establish baseline data. Based on our process map, we were able to create a two-pronged approach to work towards 1) increasing the number of cloud-based image transfers and 2) improving image handovers in the inevitable scenario when a resident is presented with a physical CD.

Our data shows that online image sharing via cloud is an underused component of lifeIMAGE, with only 4% of lifeIMAGE image sharing occurring via cloud (versus 96% via CD upload). Our study identified Wichita Falls and VA Dallas as the two sending facilities with the highest volume of patient transfers to CUH. We reached out to the facilities to work with them to increase the number of cloud-based transfers. We will need to assess the impact of our

intervention and determine if it affected reimaging. We can then modify our approach based on this study to involve a greater number of outside facilities

Though ideally, transfers would happen via cloud and would thus eliminate the need for CDs, the reality is that patients will still present with CDs considering cloud-based transfer requires participation from both the receiving facility (CUH) and all sending facilities. While we hope our interventions increase the number of cloud-based transfers, it is important that images are still transferred effectively and efficiently when they arrive on a CD.

The resident survey data that demonstrated the variability in methods for uploading CD images among residents supported the premise of this study that there is no standardized process for imaging handover when patients are transferred to CUH. This variability affects the quality of patient care because it introduces inefficiency during patient transfer and consequences associated with failure to upload a patient's imaging in a reliable and timely fashion.

The survey data also exposed lack of knowledge as an important barrier to standardizing the process of image transfers and supported our hypothesis that teaching residents how to upload images would affect their behavior during patient transfers. Additionally, the actions taken by residents who did not know how to upload images introduce consequences that may affect the quality of patient care. Relying on another source to upload images adds another physical handoff in the process of image transfers, and thus introduces an opportunity for the CD to be misplaced or damaged, is an inefficient use of the provider's time, and could lead to delay in patient care. Furthermore, when images are viewed and not uploaded, this poses a barrier in communication between specialties involved in patients care, and it impacts patient care in the long term as that image is not available in permanent storage for future reference, for example when monitoring disease progression. Consistent findings of this survey included the lack of a

standardized method to upload images from CDs to lifeIMAGE and the lack of knowledge to upload images among internal medicine residents.

## Limitations

Our intervention was largely based on the premise that increased knowledge will translate to changes in behavior; however this is not necessarily the case. Evaluation of the effectiveness of our intervention in addressing behavior will require further investigation. Furthermore, increasing effective image transfers may not necessarily translate to decreased reimaging. This project was also limited in that we were unable to get a baseline assessment of monetary cost associated with reimaging.

An appealing capability of lifeIMAGE is that it allows not only referring hospitals, but also patients themselves to upload images to lifeIMAGE themselves for free even if they are not lifeIMAGE members. However, there are many hurdles to this process, including educating referring facilities and patients of this capability.

An imaging cloud-based repository helps providers compare images over time in a readily accessible platform and works towards decreasing repeat imaging and health care costs by making images available among a patient's different providers. Interoperability measures are a rising component of the Medicare Access and CHIP Reauthorization Act (MACRA) programs and value based care, and cloud-based image sharing helps facilitate such value based care. However, cloud-based sharing is also limited by potential security concerns. With cloud-based image storage, there is increased likelihood of data breaches associated with information sharing and the greater potential of health information access and disclosure points that might allow cybercriminals the potential to steal greater amounts of data by attacking one large enterprise.



There were also limitations to the intervention to standardize CD uploading among residents. A major limitation of the resident training session regarding CD uploads to lifeIMAGE was the setting. Though noon conference has a high attendance rate, residents are often distracted during this time, and it is hard to have the audience's full attention. Teaching the residents in a different setting, such as during intern orientation, and having the residents actively walk through the imaging upload steps may be more effective.

## Conclusions

The process map that we developed improved documentation and understanding of the current state of medical imaging transfers. Variability in methods for uploading CD images among residents supported the premise that there is currently no standardized process for imaging handover. Knowledge was a significant barrier to uploading images among residents. Resident knowledge regarding CD uploads will have to be reassessed to see if our educational intervention addressed the knowledge deficit exposed by the pre-intervention survey, and if the resources we provided through our intervention had a lasting impact that modified resident behavior in the long run. Modifications for a future PDSA cycle include integrating resident training on image transfers into intern training, having the residents actively walk through the steps as they are being taught, and emphasizing that opening an image in lifeIMAGE is not sufficient as it must also be nominated and processed to store into PACS. Further improvements include administering a post-survey immediately after training and looking for other opportunities to establish a culture where uploading is the norm when an image is received.

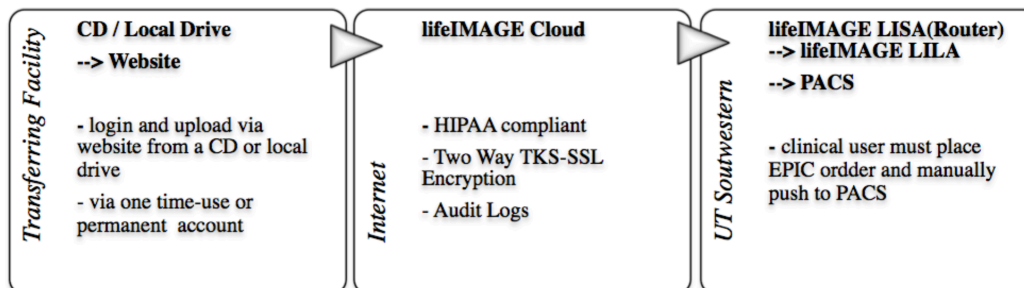
This study also showed that transferring images online via cloud is an underused capability of lifeIMAGE. There is still work to be done in coordinating with outside facilities to

increase the amount of images transferred via cloud. A subsequent PDSA cycle can be used to modify our approach based on this study to involve a greater number of outside facilities.

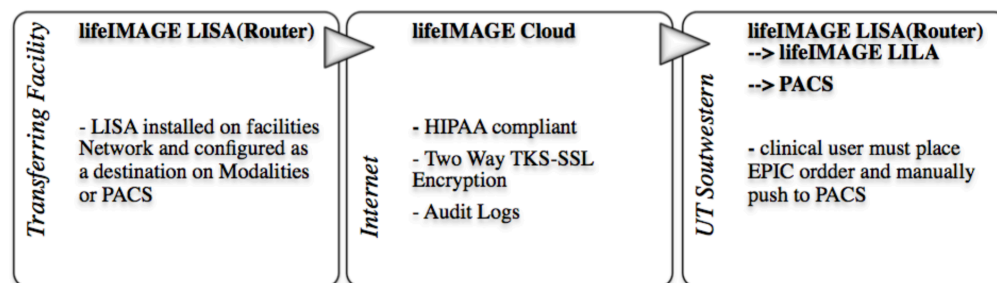
## Supplemental Figures

Figure 1: Options to send images via lifeIMAGE

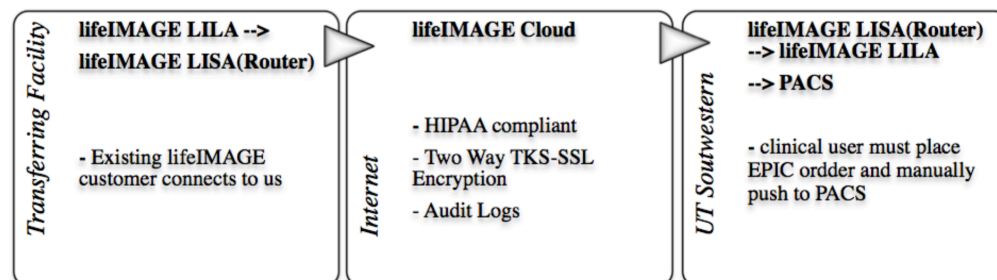
1) **Login and upload from a CD:** Non-lifeIMAGE sender – cost: *free*



2) **Install LISA:** Non-lifeIMAGE sender – cost: *\$100 a month*



3) **Sharing with existing lifeIMAGE customer** – cost: *no additional cost for connecting existing lifeIMAGE customers*



4) **Sharing with Nuance PowerShare Customer** – cost: *free*

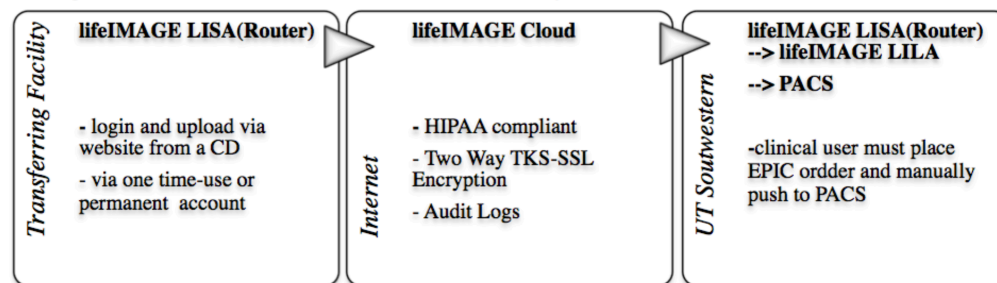


Figure 2: Process Map for images transferred to CUH

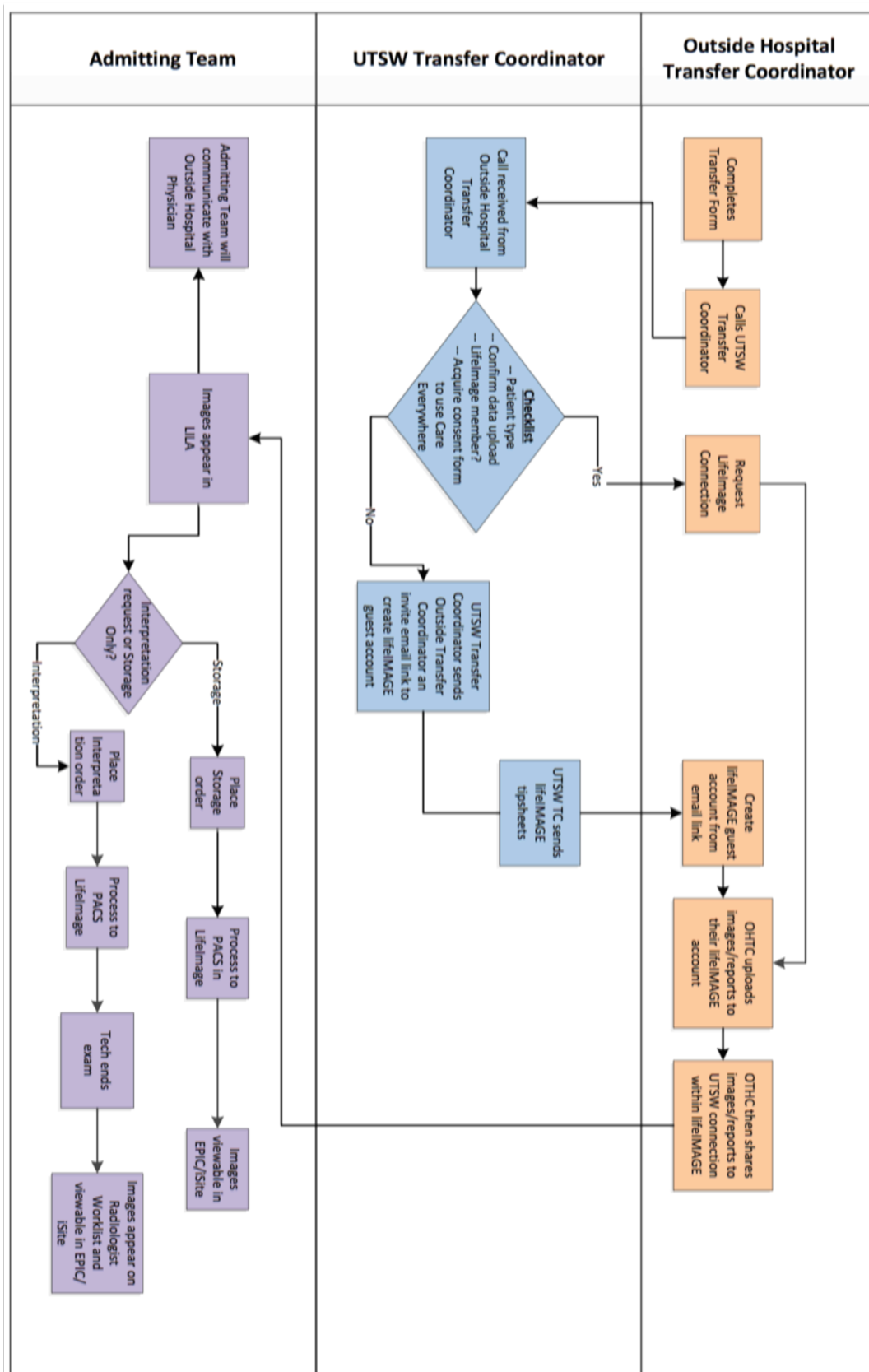


Figure 3: Survey administered to Internal Medicine Residents

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                          |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|
| What is your year in residency                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | R1<br>R2<br>R3                                                                                                           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                          |
| <p>Rate the frequency of the following situations 1 to 5, with 1 being rarely, and 5 being almost always.</p> <ul style="list-style-type: none"> <li>• A CD with imaging is sent with the patient</li> <li>• An imaging report is sent with the patient</li> <li>• No images or reports are sent, but the patient provides enough information about previous imaging so that repeat imaging is not required</li> <li>• No images or reports are sent, so repeat imaging at our hospital is required</li> <li>• Even though images or reports are sent, repeat imaging at our hospital is obtained</li> </ul> | 1 - 5                                                                                                                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                          |
| What do you do when you receive a CD containing images?                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | <p>Send the CD to Radiology View but do not import</p> <p>Import the CD into lifeIMAGE</p> <p>Other (please specify)</p> |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                          |
| Do you know how to import exams from a CD into PACS / upload images to lifeIMAGE ?                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Yes<br>No                                                                                                                |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                          |
| What is the biggest barrier to uploading images from CDs into the PACS via lifeIMAGE ?                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Open-Ended Response                                                                                                      |

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