



Does Officially Documenting Second Opinions of Outside CT Imaging Studies Reduce the Rate of Repeat Imaging in Pediatric ED Patients?

Citation

Magara, Emmanuel. 2016. Does Officially Documenting Second Opinions of Outside CT Imaging Studies Reduce the Rate of Repeat Imaging in Pediatric ED Patients?. Doctoral dissertation, Harvard Medical School.

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Scholarly Report submitted in partial fulfillment of the MD Degree at Harvard Medical School

Date: 1 February 2016

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Scholarly Report Title: Does Officially Documenting Second Opinions Of Outside CT Imaging Studies Reduce The Rate of Repeat Imaging In Pediatric ED Patients?

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ABSTRACT - Scholarly Report Title: *Does Officially Documenting Second Opinions Of Outside Imaging Studies Reduce The Rate of Repeat Imaging In Pediatric ED Patients?*

Emmanuel Magara, BA and Garry Choy, MD MBA

Purpose: There is wide institutional policy variation and continued debate on whether radiologists ought to provide second opinions on external images. In this study, we assess the value of second opinions in reducing imaging utilization by determining whether formal second opinion interpretations of outside CTs accompanying pediatric transfer patients lead to less subsequent radiology (CT and MRI) imaging in our emergency department (ED).

Methods: We performed a retrospective study of pediatric (ages 0-18) electronic medical records that contained external CTs uploaded during ED admissions between May 2011 and June 2012 at our institution. Each patient's medical record was reviewed to determine the indication and presenting complaints and if a repeat CT or additional MRI imaging was performed.

Results: 671 outside pediatric CT images were uploaded into our institution's image repository (PACS) and of these, 29% (196/671) met our inclusion criteria of being uploaded during an ED admission and within 48 hours of the patient's transfer. Patients may have lower odds of undergoing a repeat CT if they had a second opinion read (OR 0.8475, 95% CI 0.29 – 2.52) but greater odds of undergoing an additional MRI (OR 1.5, CI 0.73 – 3.08) when there was an official read than not. However, our results did not reach statistical significance ($p = 0.7658$ and 0.2685 respectively).

Conclusion: Although our results did not reach statistical significance, our study suggests that official documentation of second opinions of outside imaging studies may lead to less repeat CT imaging in pediatric ED patients.

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GLOSSARY OF ABBREVIATIONS

| | |
|--------|--|
| ED | emergency department |
| CT | computed tomography |
| PACS | picture archiving and communication system |
| CD-ROM | compact disc |
| MRI | magnetic resonance imaging |
| OR | odds ratio |
| CI | confidence interval |

SECTION 1: INTRODUCTION

Background

In the United States, approximately 2.2 million patients are transferred to larger, urban tertiary care centers for advanced care after being initially evaluated at regional medical centers and community hospitals.¹ Upon transfer to the larger medical centers for continuity of care, patients are either accompanied by their imaging results or get reimaged on arrival.²

When patients are referred with data from prior imaging studies, clinicians may often prefer formal second-opinion consultations of these studies by local radiologists for various reasons including the availability of subspecialty expertise or confirmation of diagnosis. Such consultations can be billed to the insurance and become part of the patient's medical record. However, these formal reports can consume significant professional services and have been shown to contribute up to 18% of radiologists' workload at some tertiary care centers.³ Their value needs to be assessed to determine if the time and expense are justified.

When a documented or "formal" second opinion read is present in the patient's medical record, this suggests that a radiologist has at least looked at the imaging study. When no such documentation exists, either a verbal/ "curbside" consult will have been made or no one may have looked at that study. The latter situation may lead to unnecessary repeated imaging of the patient.⁴

One way to evaluate the significance of documenting second opinion reads is to assess their effect on radiologic imaging utilization. In this study, we assess whether documentation of second opinion interpretations of outside CTs accompanying pediatric patients (0-18yrs) transferred to our ED lead to less subsequent radiology (CT and MRI) imaging utilization. This is important because reduction of radiation exposure is particularly important in pediatric patients as their lifetime risk of developing cancers from ionizing radiation is greater.⁵ The effect of second opinions on the rate of repeat imaging of pediatric patients transferred to an ED has not been studied in the literature to our knowledge.

Rationale

Our institution has a technology that imports radiographic images on CD-ROM into the picture archiving and communication system (PACS) at the point of patient transfer from an outside hospital. A benefit to this system is the concomitant incorporation of the images into the department's PACS and the ability to make second-opinion consultations available in the electronic patient record.

Prior to implementation of the electronic "cloud-based" PACS image platform, pediatric patients transferred to our ED from other institutions received no official second opinion interpretation of their radiology studies from our radiologists. In fact, radiologists often were not involved in the official evaluation of outside imaging studies for pediatric transfers. If they were involved, only "curbside" or "preliminary" reads were performed on the outside studies. Given the fact that an official report was often required for diagnosis and subsequent treatment, patients often received a local-based imaging study, which possibly could have been a repeat examination of the one(s) they received from their transferring institution.

Our institution recently implemented an electronic "cloud-based" image platform to allow effective importing of radiology images from outside institutions. This new system enables official over-read (second-opinion) interpretations of outside images by our radiologists at the time of patient transfer to our institution or at referring physician/patient's request.

The use of the electronic image import platform and second opinion re-reads of the imported images offers an opportunity to reduce repeat imaging of pediatric ED patients. However, it is still to be determined if this is indeed the case, which is the focus of this project.

Importance of the problem

The use of medical imaging for diagnostic purposes and to guide therapeutic interventions has increased significantly over the past two decades.⁶ For example it is reported that computed tomographic (CT) imaging in the USA increased from 26 million in 1998 to 70 million in 2008.⁶ Many imaging modalities deploy ionizing radiation, and, as a consequence the exposure of patients to radiation has significantly increased as medical imaging has expanded. The increased

exposure of patients to medical radiation has led some scientists and physicians to predict thousands of radiation-induced cancers and cancer deaths in the US in future years.⁷

We have chosen to focus primarily on pediatric patients as this population is considerably more sensitive to radiation exposure than adults. The reason is that children have a longer life expectancy resulting in a larger window of opportunity for expressing radiation damage.⁸ Moreover, most medical imaging devices such as CT scanners have been designed to suit the adult population. There is great variability in body size between adults and pediatric patients hence CT scanning parameters such as current, kilovoltage, collimation and pitch which regulate radiation dose have to be adjusted for pediatric patients.⁹ However, reports have shown that adjustment of these settings is not always followed and pediatric CTs are more often than not performed at adult settings which thereby exposes pediatric patients to unnecessarily high radiation doses during CT.⁹ The exposure of children to relatively high doses of radiation has been shown to have detrimental effects with some reports demonstrating an increased likelihood of thyroid cancer in children receiving multiple doses of radiation from an extended series of medical procedures.¹⁰

It is therefore important to reduce radiation exposure in the pediatric population and part of the solution is by avoiding unnecessary medical imaging. This study will determine whether documentation of second opinion re-reads of CTs accompanying pediatric patients transferred to the ED from outside institutions lead to a change in the rate of repeated or additional imaging.

Innovation:

Ever since the American Board of Radiology identified repeat imaging at the transfer of care between institutions as a key course of overutilization of radiation¹¹, efforts have been underway to try and reduce the rate of repeat imaging during patient transfer from one institution to another.

Although this area of research is new significant results have emerged over the past years unveiling ways of how this can be achieved. Two studies have shown that patients transferred with outside images on CD underwent less repeat imaging compared to those transferred without outside images.^{12 13} However, in neither of these studies did the investigators upload

these outside images into PACS. In 2011 a study by Sodickson et al¹⁴ took a step further and showed that patients whose images were imported from a CD-ROM onto the PACS system of the receiving institution had significantly fewer subsequent diagnostic imaging than those whose CDs were not imported hence highlighting the importance of importing the images to the PACS system. Reasons highlighted for this observation is that the PACS system eliminates the risk of losing the CD as the patient transitions through multiple clinical handoffs and it also allows the radiologists to more carefully view the images on diagnostic quality monitors. Moreover, PACS also streamlines multi-disciplinary care by allowing enterprise distribution and simultaneous viewing by multiple members caring for the patient.¹⁴

Although the benefits of importing outside images into the local PACS system have thus been well documented in the literature, there is institutional variability regarding what to do with those uploaded images. There are concerns that as tertiary hospitals receive more outside images there will experience a negative impact overall. For instance, DiPiro et al³ noted that second-opinion consultations at one tertiary care center caused an 18% increase in radiologists' workload. 20% of the workday ended up being spent reviewing outside exams. The daily workflow was disturbed and interpretations of local primary studies were interrupted. Moreover, a majority of the consultations were not financially compensated.

Consequently, whether or not radiologists should render and document second opinions on uploaded outside studies continues to be an issue of debate.⁴ Neither the American College of Radiology Practice Guidelines nor any court ruling directly addresses this issue.⁴ Some radiologists argue that interpreting outside images that present with no accompanying original documentation is unethical and they [radiologists] should not be legally required to do so. Others question if radiologists have to read *every* outside imaging study that is uploaded into PACS.⁴ These among other arguments highlight the resistance towards documenting second opinion reads.

It is therefore important to assess the value of second opinions as institutional policies and reimbursements depend on their proven worth. No studies to our knowledge have looked at their effect on imaging utilization in pediatric ED patients. In this study, we hypothesize that second opinion reads will lead to less subsequent CT and MR imaging utilization.

SECTION 2: STUDENT'S ROLE

Emmanuel Magara (student) was responsible for study data extraction from the patients' electronic medical records. He also compiled, performed statistical analysis on the data and prepared this manuscript.

SECTION 3: METHODS

Study Population and Eligibility Criteria

Our institutional review board approved the retrospective review of patient data for this HIPAA-compliant study and waived the need for individual informed consent. The study period was from May 2011 to June 2012. Only records of pediatric patients (aged 0-18yrs) with outside, imported, CT images were analyzed. Each imported image's assigned medical record was reviewed to determine if the imaging study was associated with an emergency department (ED) admission note within 48hrs of that study. The 48hr benchmark was established since it is not uncommon for patients to stay in the ED up to 48hrs before an inpatient bed is available.¹⁵ The reason/indication for the study (when available), patient's age and gender were also extracted from the electronic medical record. We classified the CT scans according to the examination codes that were entered at the time when the images were uploaded. The codes corresponded to the following body parts: abdomen (CT-Abdomen), brain (CT-Brain), chest (CT-Chest), neck (CT-Neck), spine (CT-Spine), lower and upper extremity (CT-Lextremity and CT-Uextremity respectively).

Acquisition of Images

When a patient presented with CD-ROMs containing imaging studies performed at other institutions, their studies were imported into our institutional PACS. Import of outside imaging from CDs to PACS was performed at our institution's "film library" using commercial software (OpenLiteBox, Etiam).¹⁷ The film library operates 24hrs a day. Each uploaded study was assigned a unique accession number and labeled according to its modality and body part. The patient's age and electronic medical record number were also recorded.

Requests for Formal Second Opinion reads

At the time of image import, the patient's treating physician could request a formal second opinion read from our radiologists. If no request was made, the study was labeled with a disclaimer stating that it had been performed from an outside institution and had been imported for comparison purposes. No outside radiologists interpretations of the studies were stored on our PACS. Per our institutional policy, only studies imported into PACS could receive a formal second opinion read. In this study, a case was classified to have had an 'official' second opinion interpretation when a radiologist at our institution interpreted the outside CT accompanying the patient and a formal report was added to the patient's medical record during that ED admission. A case was classified to have had 'no official' read when the outside study was uploaded into the PACS during the ED visit but no electronic record of our radiologists' interpretation of the outside study was found.

Indications for imaging

The main presenting or chief complaint of each patient included in our study was determined from the ED admission note.

Definitions of Repeat and Additional Imaging

Each emergency department (ED) transfer pediatric patient's medical record was reviewed to determine if a repeat CT or additional MRI imaging was performed. 'Repeat CT' imaging was defined as exactly the same type of CT examination performed in our ED within 48 hours of the patient's initial external CT study. For example, in the case of CT, if a patient received a head CT scan from an outside hospital and received another head CT scan at our institution, be it special coronal, sagittal, 3D, or thin axial slice imaging, this was considered re-imaging. A head CT followed by an abdominal CT or a CT followed by X-Ray was not considered re-imaging because they were imaging on different body parts and modalities, respectively. 'Additional MRI' was classified as subsequent MR imaging of the exact body type as the CT also performed within 48 hours of each other.

Statistical Analysis

The relationship between second-opinion status and repeat CT or additional MRI was assessed using the chi-square test for independence. Statistical data analysis was conducted using Microsoft Excel 2016 with the Analysis – Tk Add-in.

SECTION 4: RESULTS

Study Demographics

There were 196 CT studies that met our inclusion criteria of being uploaded during an ED admission. These corresponded to 166 unique patients ranging from 0-18yrs, mean 11.4yrs. There were three times as many boys than girls. Table 1 provides a summary of the demographics and clinical characteristics of the patients in our study.

Table 1. Study demographics

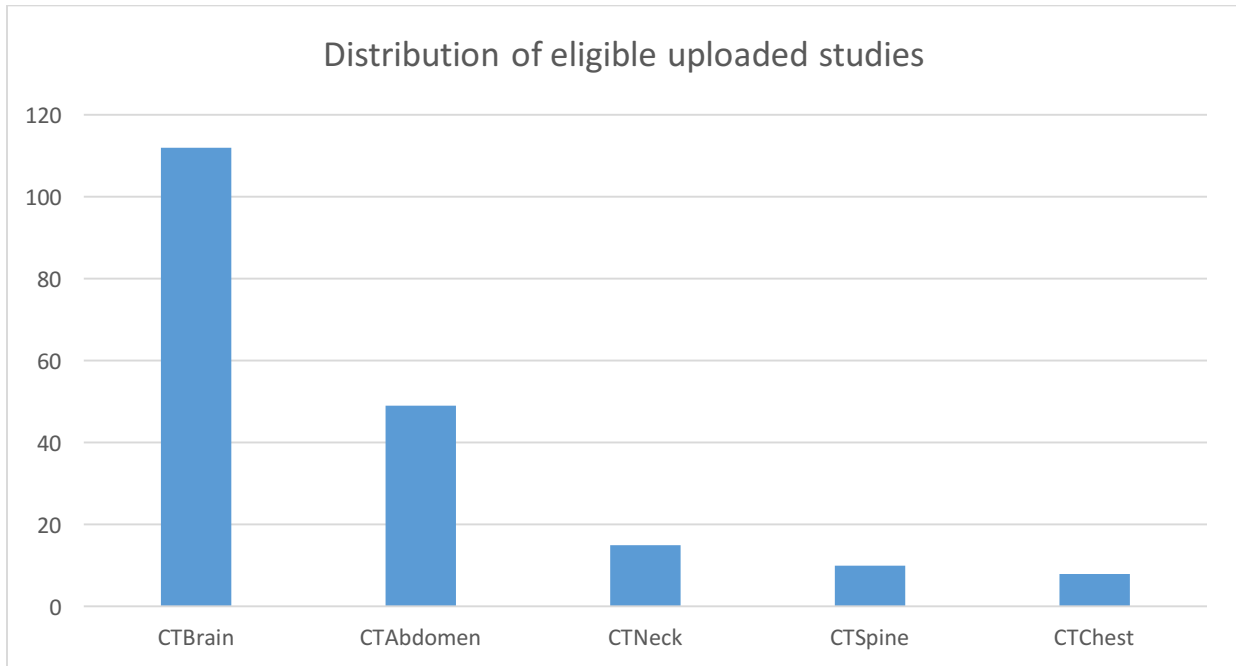
| Demographics | Number |
|---------------------|---------------|
| Age range (years) | 0-18 |
| Mean age | 11.4 |
| No. of patients | 166 |
| No. of studies | 196 |
| Male | 67% |
| Female | 33% |

Overview

671 outside pediatric CT images were uploaded into our institution's image repository (PACS) between May 2011 and June 2012. Of these, 71% (475/671) cases were non-ED admission images (the majority of these being images uploaded during follow-up outpatient appointments) and did not meet our inclusion criteria for study of the ED setting. 29% (196/671) cases met our inclusion criteria of being uploaded during an ED admission and within 48 hours of the patient's transfer.

Of the cases meeting our inclusion criteria, 33% (64/196) received official second-opinion reads and 67% (132/196) did not receive a formal second opinion. Neuroimaging CT (brain, neck and spine) was the most common uploaded ED study and made up to 70% (137/196) of all studies.

Figure 1. Types and frequencies of imaging studies that met our inclusion criteria



Indications for Imaging

Among all uploaded outside CTs that met our inclusion criteria for this study, “trauma” was the most common presenting complaint and constituted 46% (90/196) of the cases. Other common indications included “appendicitis” and “abdominal pain” for abdominal CTs (31% and 24%, respectively) and seizures for brain CTs (20%). Similarly, trauma, seizures, appendicitis and abdominal pain (in descending order) were the top four indications for studies to receive official second opinion reads.

Figure 2.1 – Common presenting chief complains of patients with abdominal CTs

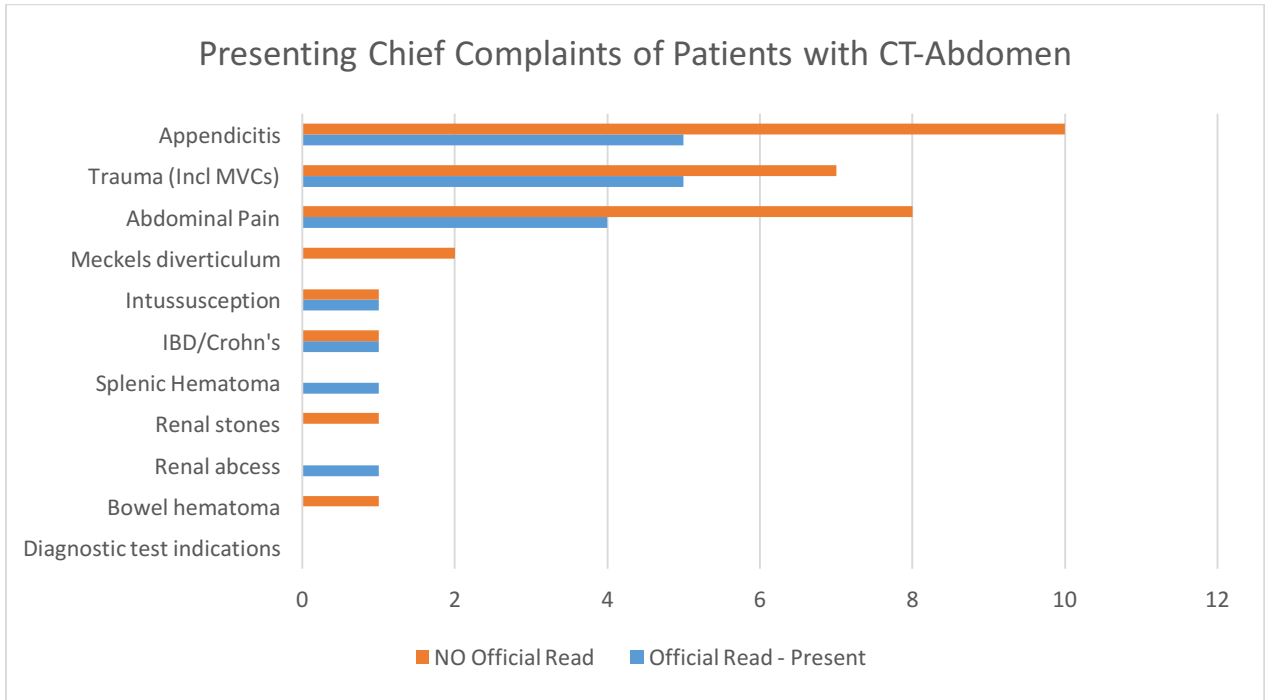
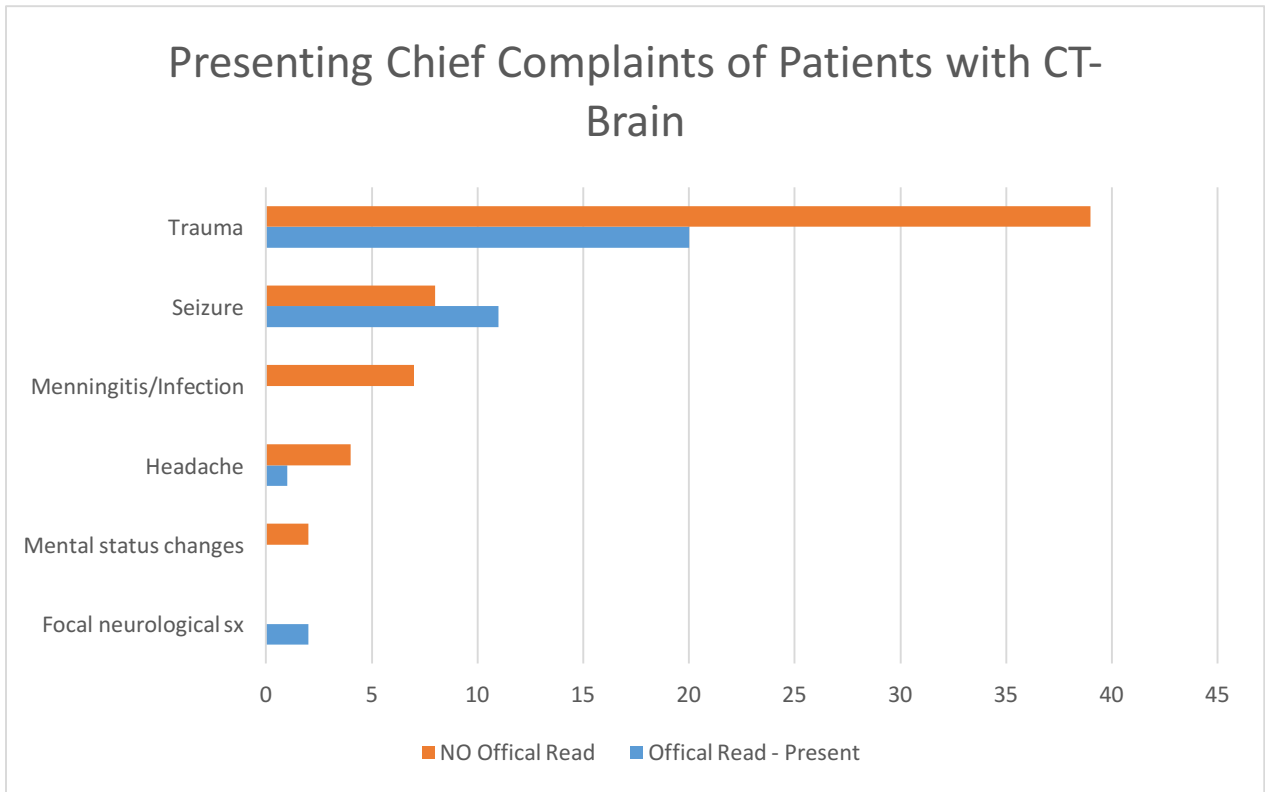


Figure 2.2 – Common presenting chief complains of patients with brain CTs



Repeat CT Imaging

Out of the 196 studies in our study, there were a total of 17 repeat CT scans. 29% (5/17) were associated with an official second opinion read and 71% (12/17) were associated with no official read. There was a lower rate of repeat CTs when there was an official second opinion read compared to when no official read was present (7.8% vs 9.1% respectively). Patients had lower odds of undergoing a repeat CT when they had a second opinion read than not (OR 0.8475, 95% CI 0.29 – 2.52). However, this outcome did not reach statistical significance ($p = 0.7658$).

Among the cases that had official second-opinion reads, CT-brain studies accounted for more than half 58% (37/64) of the second opinion interpretations and were associated with 80%(4/5) of the repeat CTs. 20% (1/5) were repeated after a CT of an upper extremity. CTs of the abdomen, chest, spine and neck were not associated with any repeat imaging.

Of the cases that did not receive a formal second opinion interpretation, CT-brain studies also accounted for three-quarters (9/12), of the repeat CT scans. Only 1 repeat CT scan was performed each for CT-Abdomen, CT-Neck, CT-Extremity with no official read. There were no repeat CT-Chest or CT-Spine.

Additional MR Imaging

40 additional MRI scans were performed in our study. 40%(16/40) were associated with an official read and 60% (24/40) were associated with no official read. There was a greater rate of undergoing an additional MRI when there was an official second opinion read than when there was no official read (25% vs 18% respectively). Unlike for repeat CTs, patients had greater odds of undergoing an additional MRI when there was an official read than when there was no official read (OR 1.5, CI 0.73 – 3.08). However, this association did not reach statistical significance ($p = 0.2685$).

Brain MRs accounted for most of the additional MRIs performed among patients with both official and no official reads (69% and 92% respectively). MRs of the spine and neck collectively made 24% (4/17) of the additional MR performed when an official read was present and 9% (2/22) when there was no official read.

SECTION 5: DISCUSSION

Pediatric patients transferred to tertiary care centers for further evaluation and treatment options beyond the scope of the referring institution often present with radiologic imaging already been performed at that institution.¹⁶ Our study results suggest that when the recipient institution's radiologists perform official second opinion reads of outside images accompanying ED transfer patients, they may lead to less repeat CT imaging of those patients (OR 0.8475). Although our results did not reach statistical significance ($P = 0.7658$) most likely due to our small sample size ($n = 196$), they are still important because they are corroborated by the findings of another larger study also from our institution by Lu et al (2013). Lu et al¹⁷ looked at the effect on the rate of subsequent imaging of formal second-opinion reports for 10,330 patients with outside abdominal CT imaging studies uploaded into our PACS and found a 32% reduction in repeat CTs performed when official reads were present ($p < 0.001$).

Why official second opinion reads may lead to less repeat imaging

There are several reasons why official reads may lead to less repeat imaging. Official second opinion reads serve as documentation that a board-certified radiologist was consulted and made recommendations. Such recommendations may or may not have been factored into the ED physicians' decision making process but are more likely to have influenced care. When there is no formal read documented in the medical record, it is not reliably possible to determine if the uploaded images were at all reviewed. Not reviewing outside studies may lead to patients undergoing repeat imaging.⁴

In addition, close to two-thirds of uploaded ED studies did not receive an official read. It is not an uncommon institutional practice for admitting ED physicians to seek "curbside" or verbal consultations from local radiologists. Such verbal consultations can be documented in the patient's medical record. However, there is anecdotal evidence that verbal or "curbside" consultations of outside images often result in referred patients undergoing repeat imaging by trauma surgeons and other critical care physicians who need prompt official reads.¹⁸ Since close

to half of our studies were associated with trauma, this could also have contributed to why cases with no official reads had more repeat imaging.

Increased additional MRIs with official reads

Our study results suggest that patients were more likely to undergo an additional MRI if their outside images had an official second opinion read (OR 1.5). Moreover, there were more than twice as many additional MRI studies performed than repeat CTs (40 vs 17 respectively). The increase in the rate of MRI studies in general could be due to treating physicians requiring complementary information for the clinical management of the patient. Admitting physicians may have requested an official read prior to therapeutic intervention and the additional MRIs could be secondary to the need to monitor the progression of such patients before and after therapeutic intervention. It is also likely that since MRI scans result in no ionizing radiation exposure, physicians may be more comfortable requesting these especially in our pediatric population.

There is a need for uniform institutional policies around second opinions

There is wide institutional variation in both practice and policy regarding re-interpretations of outside studies for patients transferred to larger academic tertiary care centers.¹⁹ During our study period (May 2011 – June 2012), only a third of ED-uploaded outside pediatric CTs received an official second opinion read. This low rate could be explained by work from several authors who have described challenges when providing official reads such as logistical issues and increased local radiologists' workload.^{20,21} One institution reported a 1400% increase in the number of outside imaging studies uploaded into their PACS over a year.²² Such volume increases in the setting of limited professional resources can pose significant disruptions in the workflow of a radiology department. Thus, a balance needs to be achieved regarding which uploaded outside studies can realistically be officially re-read.

Our study suggests that neuroimaging of trauma patients is the most common reason for treating physicians to seek an official second opinion read and should probably be a focus when institutional policies are being considered. Neuroimaging comprised 70% of the studies that

received official reads and 58% of these were in the setting of trauma. Trauma transfers, in particular, have been shown in other studies to have a high predilection for repeat imaging. Gupta et al²³ found that 58% of transferred trauma patients received duplicative CT studies, with head CT primarily repeated for their trauma indication. Haley et al²⁴ studied 410 patient transfers and found that 53% of patients received repeat imaging with the injury severity score as an independent predictor of study duplication. Given our overall finding that suggests official reads of outside studies reduce the odds of undergoing repeat imaging, policies that encourage official reads of neuro-images, particularly in the setting of trauma may be beneficial to patients and reduce unnecessary imaging utilization.

Other important considerations

There are other benefits to having institutional policies supporting second opinion reads. Sometimes admitting physician make treatment decisions based on outside radiologists' reports. However, Eakins et al¹⁶ showed that at one tertiary care pediatric institution there were substantial discrepancies between the outside hospitals' reads' and the local radiologists' second opinions. There were major discrepancies in 12.6% and 32.6% of neuroimaging and body imaging studies respectively, and the second opinions were significantly correlated with final pathology-confirmed diagnoses. This finding highlights an importance and the need for local physicians to have access to second opinions by sub-specialized in-house radiologists rather than simply basing treatment plans on external reports.

Lack of official formal second opinion interpretations was associated with a higher absolute number of repeat CT imaging compared to when a formal second opinion was performed by a local radiologist. This finding suggests that patients may be at a high risk of radiation exposure when a formal second opinion interpretation is not performed, a significant clinical issue especially in a pediatric population. The exposure of children to relatively high doses of radiation has been shown to have detrimental effects with some reports demonstrating an increased likelihood of thyroid cancer in children receiving multiple does of radiation from an extended series of medical procedures.¹⁰

There are financial implications: official reads are financially reimbursable and can be cost effective.²⁵ The new proposed payment models such as bundled payments and a shift away from fee-for-service models, re-reads of outside hospitals may become important in reducing the costs associated with diagnosing patients and help the institutions' financial bottom line. Repeat imaging adds to the cost of care and also exposes patients to additional radiation doses.

Limitations

There are several limitations to our study. First, we had a small sample size (n = 196) and this may have contributed to our not achieving enough statistical power to see significant results. Second, we analyzed data over one year at a single tertiary care center and it may not be applicable to other institutional settings or time periods. Third, our study does not distinguish what may have been necessary repeat imaging from unnecessary and inappropriate re-imaging. Fourth, undocumented but important communication may have occurred between the treating physicians and our radiologists via verbal or "curbside" consultations. Such consultations may have influenced the decisions of the treating physicians regarding repeat imaging to the same extent as official consultations. Fifth, our study only looked at outside images that had been successfully imported into our PACS using our cloud-based platform that may not be representative of other import tools.

CONCLUSION

Official documentation of second opinions of outside imaging studies may lead to less repeat CT imaging in pediatric ED patients.

Suggestions for Future Work

When a second opinion re-read is given by a local radiologist either the interpretation reached will be in agreement with the initial interpretation that was made at the outside institution (concordance) or it will be in disagreement (discordance). In the event that a concordance interpretation was reached we expect that the patient is less likely to be subjected to the same imaging study that was performed at the transferring institution. However, if a

discordant interpretation was made, the patient may be more likely to undergo additional imaging studies. We would like to quantify concordance and discordance between outside radiologists' reports and our local radiologists' reads and determine the rate of repeat/additional imaging for both concordant and discordant interpretations. Such information will help us evaluate discordance between studies is a reason for additional imaging of pediatric patients transferred to our ED from other institutions.

ACKNOWLEDGEMENTS

Garry Choy – for unwavering support in making this project a reality.

Harvard Medical School Scholar In Medicine Office – for the financial support and guidance in crafting research proposals

REFERENCES

- ¹ Pitts SR, Niska RW, Xu J, Burt CW. National Hospital Ambulatory Medical Care Survey: 2006 emergency department summary. *Natl Health Stat Rep* 2008;(7):1–38. Medline2. Broder J, Warshauer DM. Increasing utilization of computed tomography in the adult emergency department, 2000-2005. *Emerg Radiol* 2006;13(1):25–30. CrossRef, Medline
- ² Lu MT, Tellis WM, Fidelman N, Qayyum A, Avrin DE. Reducing the rate of repeat imaging: import of outside images to PACS. *AJR Am J Roentgenol*. 2012;198(3):628-34. doi: 10.2214/AJR.11.6890 10.2214/AJR.11.8316. PubMed PMID: 22358003.
- ³ DiPiro PJ, vanSonnenberg E, Tumeh SS, Ros PR. Volume and impact of second-opinion consultations by radiologists at a tertiary care cancer center: data. *Acad Radiol*. 2002;9(12):1430-3. PubMed PMID: 12553355.
- ⁴ Berlin L. Interpretation of outside radiologic studies. *AJR Am J Roentgenol*. 2011;197(6):W1155. doi: 10.2214/AJR.10.5534. PubMed PMID: 22109334.
- ⁵ Miglioretti DL, Smith-Bindman R. Overuse of computed tomography and associated risks. *Am Fam Physician*. 2011;83(11):1252-4. PubMed PMID: 21661705.
- ⁶ Hendee WR, O'Connor MK. Radiation risks of medical imaging: separating fact from fantasy. *Radiology*. 2012;264(2):312-21. doi: 10.1148/radiol.12112678. PubMed PMID: 22821690.
- ⁷ Berrington de Gonzalez A, Mahesh M, Kim KP, Bhargavan M, Lewis R, Mettler F, et al. Projected cancer risks from computed tomographic scans performed in the United States in 2007. *Arch Intern Med*. 2009;169(22):2071-7. doi: 10.1001/archinternmed.2009.440. PubMed PMID: 20008689.
- ⁸ Kleinerman RA. Cancer risks following diagnostic and therapeutic radiation exposure in children. *Pediatr Radiol*. 2006;36 Suppl 2:121-5. doi: 10.1007/s00247-006-0191-5. PubMed PMID: 16862418; PubMed Central PMCID: PMC663653.
- ⁹ Paterson A, Frush DP, Donnelly LF. Helical CT of the body: are settings adjusted for pediatric patients? *AJR Am J Roentgenol*. 2001;176(2):297-301. doi: 10.2214/ajr.176.2.1760297. PubMed PMID: 11159060.
- ¹⁰ Ron E, Lubin JH, Shore RE, Mabuchi K, Modan B, Pottern LM, et al. Thyroid cancer after exposure to external radiation: a pooled analysis of seven studies. 1995. *Radiat Res*. 2012;178(2):AV43-60. PubMed PMID: 22870979.

-
- ¹¹ Hendee WR, Becker GJ, Borgstede JP, Bosma J, Casarella WJ, Erickson BA, et al. Addressing overutilization in medical imaging. *Radiology*. 2010;257(1):240-5. doi: 10.1148/radiol.10100063. PubMed PMID: 20736333.
- ¹² Sung, J. C., Sodickson, A. & Ledbetter, S. Outside CT imaging among emergency department transfer patients. *J Am Coll Radiol* 6, 626-632, doi:S1546-1440(09)00191-4 [pii] 10.1016/j.jacr.2009.04.010 (2009)
- ¹³ Cook, S. H., Fielding, J. R. & Phillips, J. D. Repeat abdominal computed tomography scans after pediatric blunt abdominal trauma: missed injuries, extra costs, and unnecessary radiation exposure. *J Pediatr Surg* 45, 2019-2024, doi:S0022-3468(10)00473-2 [pii] 10.1016/j.jpedsurg.2010.06.007
- ¹⁴ Sodickson, A., Opraseuth, J. & Ledbetter, S. Outside imaging in emergency department transfer patients: CD import reduces rates of subsequent imaging utilization. *Radiology* 260, 408-413, doi:radiol.11101956 [pii] 10.1148/radiol.11101956
- ¹⁵ Barish RA, McGauly PL, Arnold TC. Emergency room crowding: a marker of hospital health. *Trans Am Clin Climatol Assoc*. 2012;123:304-10; discussion 10-1. PubMed PMID: 23303998; PubMed Central PMCID: PMC3540619.
- ¹⁶ Eakins C, Ellis WD, Pruthi S, Johnson DP, Hernanz-Schulman M, Yu C, et al. Second opinion interpretations by specialty radiologists at a pediatric hospital: rate of disagreement and clinical implications. *AJR Am J Roentgenol*. 2012;199(4):916-20. doi: 10.2214/AJR.11.7662. PubMed PMID: 22997387.
- ¹⁷ Lu MT, Tellis WM, Avrin DE. Providing formal reports for outside imaging and the rate of repeat imaging. *AJR Am J Roentgenol*. 2014;203(1):107-10. doi: 10.2214/AJR.13.10617. PubMed PMID: 24951202.
- ¹⁸ Clark O, Second opinion readings on outside studies: Should we bother?. *Appl Radiol*. July 10, 2012
- ¹⁹ Swenson DW, Ellermeier A, Dibble EH, Movson JS, Egglin TK, Mainiero MB. Review of outside studies by radiology residents: national survey of chief residents. *Emerg Radiol*. 2014;21(5):479-84. doi: 10.1007/s10140-014-1228-y. PubMed PMID: 24777574.
- ²⁰ J.C. Sung, A. Sodickson, S. Ledbetter. Outside CT imaging among emergency department transfer patients. *J Am Coll Radiol*, 6 (2009), pp. 626–632
- ²¹ S.A. Bagg, S.D. Steenburg, J.G. Ravenel. Handling of outside trauma studies: a survey of program directors. *J Am Coll Radiol*, 5 (2008), pp. 657–663

²² Reis SP, Lefkovitz Z, Kaur S, Seiler M. Interpretation of outside imaging studies: solutions from a tertiary care trauma center. *J Am Coll Radiol.* 2012;9(8):591-4 e1. doi: 10.1016/j.jacr.2012.01.008. PubMed PMID: 22863471.

²³ Gupta R, Greer SE, Martin ED. Inefficiencies in a rural trauma system: the burden of repeat imaging in interfacility transfers. *J Trauma.* 2010;69(2):253-5. doi: 10.1097/TA.0b013e3181e4d579. PubMed PMID: 20699732.

²⁴ Haley T, Ghaemmaghami V, Loftus T, Gerkin RD, Sterrett R, Ferrara JJ. Trauma: the impact of repeat imaging. *Am J Surg.* 2009;198(6):858-62. doi: 10.1016/j.amjsurg.2009.05.030. PubMed PMID: 19969142.

²⁵ Zan E, Yousem DM, Carone M, Lewin JS. Second-opinion consultations in neuroradiology. *Radiology.* 2010;255(1):135-41. doi: 10.1148/radiol.09090831. PubMed PMID: 20308451.