Title
Imaging Trust: Information Technologies and the Negotiation of Radiological Expertise in the Hospital

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Publication Date
2012

Peer reviewed|Thesis/dissertation

Imaging Trust: Information Technologies and the Negotiation of Radiological Expertise in the Hospital

by

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DISSERTATION

Submitted in partial satisfaction of the requirements for the degree of

DOCTOR OF PHILOSOPHY

in

Medical Anthropology

in the

GRADUATE DIVISION

of the

UNIVERSITY OF CALIFORNIA, SAN FRANCISCO

AND

UNIVERSITY OF CALIFORNIA, BERKELEY

Acknowledgements

I would like to express my gratitude to the many people who provided me with support and guidance during this project. I am deeply grateful to Sharon Kaufman, the chair of my dissertation committee, for all the time and effort she spent helping me organize my thoughts and refine my arguments. In addition, Adele Clarke, Ian Whitmarsh, and Cori Hayden all contributed valuable feedback and advice, in addition to acting as outstanding role models for scholarship and teaching. Finally, I want to thank Kim Bissell, Kathy Jackson, Jana Toutolmin, and Catherine Norton for help navigating the murky waters of administrative paperwork.

I am also profoundly grateful to the doctors who welcomed me into their reading rooms, clinics, and offices and allowed me to observe and interview them as they worked. Special thanks go to a particular radiologist who supported my research from day one, and made entrance into my field site possible. In Addition, this research could not have been completed without the generous financial support of the University of California Humanities Institute Andrew and Florence White Graduate Student Research Grant, the Medical Scientist Training Program of the NIH at UCSF, the UCSF Department of Anthropology, History, and Social Medicine, and the American College of Radiology.

I wish to thank Elizabeth Fitzsimmons for her amazing editorial assistance, Seth Fitzsimmons for helping me retain my sense of humor during my training, and Marlow, Maggie, Aubergine, Navet, Chou, and Edward for reminding me of the important things in life. Finally, I want to thank my parents, Lynne and Tom, for all their love and unconditional and ongoing support.

ABSTRACT

This dissertation explores how the circulation of medical information into new places reshapes notions of expertise, trust, and medical authority among groups of clinical specialists. My case study is an examination of how the adoption of PACS (picture archiving and communication systems), an information technology which allows for the instant circulation and display of images on computer workstations throughout hospitals and beyond, has eroded radiologists' claims for authoritative knowledge over the interpretation of medical images. Through an ethnography of the daily practices of radiologists and non-radiology clinicians at a large tertiary-level academic hospital in the U.S., I show how the adoption of PACS enables medical images to become newly mobile and circulate beyond the control of radiologists, producing the following unintended consequences: 1) a newly intimate relationship between clinicians and medical images; 2) a marked reduction in clinician interactions with radiologists; and 3) the emergence of claims among clinicians for expertise in interpreting medical images.

I argue that changes in medical authority and knowledge produce opportunities for the renegotiation of claims for expertise among groups of physicians. This study increases our understanding of how boundaries of expertise and authority are socially negotiated. It reveals how these boundaries and their negotiations impact concepts of risk, responsibility, patient care, and professional identity in medicine.

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CHAPTER 1: Introduction

Dad's accident

About a year ago, a man I know (we'll call him "Dad" to maintain his anonymity) slipped on some ice while walking his dog, tried to break his fall with his right hand, and wound up in the emergency room of a large academic hospital due to a very painful and swollen right shoulder. Accompanied by his wife ("Mom"), Dad was seen by the ER[1] doctor, and promptly sent to have X-rays taken of the shoulder and arm. Once exposed, the X-ray plates were loaded into a machine and digitized by an X-ray tech. Dad, a physician, had already diagnosed himself with a broken humerus (upper arm bone), and asked the tech if he was correct. After looking at the digitized image on a computer monitor, the tech responded, "Yep, it's broken." Dad went back to the ER, where a different ER doctor confirmed what the tech had said, and ordered an orthopedic surgery consultation.

After waiting in the ER for several hours, a first-year orthopedic surgery resident appeared and informed Mom and Dad that the orthopedic surgery attending (Dr. Best[2]) had looked at the digital X-rays on a computer screen while in the OR[3], in the midst of operating on another patient. According to the resident, Dr. Best said that the location and type of fracture (an impact fracture where part of the humeral shaft [upper arm bone] is driven up into the humeral head that forms part of the shoulder joint) could not be operated on or cast. As long as Dad was careful to restrict use of the arm, the break

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[1] Emergency room
[2] All names used in this dissertation are pseudonyms
[3] Operating room

should heal fine on its own. Dad was sent home with his arm in a sling, some pain medication, and an appointment to see Dr. Best the next day.

At his appointment on the following day, Dr. Best brought up the X-rays of Dad's arm on a computer monitor, went over the images with him, and outlined the treatment plan, which included scheduling a CT of the injured area to assess healing after about 2 weeks. While at this appointment, Dad was able to see that the X-ray of his arm had also captured a large portion of his right lung on the film. Since he was treated for tuberculosis (TB) contracted as a medical resident about 20 years ago, he wondered aloud if the film could give any indication of whether the TB had remained latent. "I have no idea," Dr. Best responded. "I only do arms and legs."

This account of Dad's diagnosis and treatment may seem to be a fairly standard and unremarkable encounter with biomedicine. A man falls, goes to the hospital, gets an X-ray, is diagnosed with a broken arm, is treated, and sees a specialist who makes a plan for future care. Yet besides Dad, Mom, the X-ray tech, the ED doctors, and Dr. Best, there is another important actor in this scenario - the medical image. Both the diagnosis of a broken humerus and the approach to treating it rely on the information produced by the X-ray image of Dad's arm. Dad's story underlines the fact that medical imaging technologies currently have a privileged role in biomedicine. They have become potent symbols of scientific knowledge, authority, progress, and objectivity, and they are frequently considered superior to almost all other methods for gathering medical data, including the physical exam (Dumit 2004; Joyce 2006). The importance of medical visualization techniques is widely acknowledged by both biomedical practitioners and the general public and supported by studies documenting the number of imaging studies requested by physicians (see, for example Borgstede 2005, Krestin et al. 2007, Lehnert and Bree 2010). Imaging is a fundamental component of medical diagnosis, prognosis, and treatment, and has become one of the central ways to both envision and act on the bodies of patients.

However, Dad's story is noteworthy for an additional reason. While most people have heard of X-rays, CT, and MRI, and know that their invention has changed medicine in significant ways, this research focuses on the widespread adoption of another kind of imaging technology that, despite being virtually unknown to the general public, has profoundly changed the practice of medicine. We see that Dad's images are looked at on a computer screen by Dr. Best while in the OR, and later displayed on a computer monitor to discuss and plan Dad's treatment during his follow-up appointment with the surgeon. While this may seem unexceptional, it is in fact a major change in the way that physicians like Dr. Best are able to access and view medical images. In the past, radiologists have held a monopoly on imaging in biomedicine, acting as gatekeepers to imaging technologies and the images themselves as well as providing the vast majority of image interpretations (cf. Burri 2008). Only a few years ago, for a physician to see patient images, he or she would have had to go to the radiology "reading room," where a radiologist would find the appropriate film, put it up on a lighted viewbox[4], and interpret the scan for the physician (Saunders 2008). Generally, only a single copy of the image was available, and had to be shared by any number of physicians participating in a patient's care.

[4] A viewbox is a back-lit surface, usually located on a wall, used for viewing film-based medical images.

Yet with the widespread adoption beginning in the mid-2000s of an information technology called PACS (Picture Archiving and Communication System) by hospitals and clinics in the U.S., how, when, and where physicians view medical images has radically changed. PACS allows digital images to be stored, retrieved, and displayed in multiple locations simultaneously. Using a network of servers, computer workstations, and data storage devices, medical images produced by X-ray, CT, MRI, or ultrasound machines are acquired, stored, archived, and displayed by PACS throughout hospitals, and via the Internet wherever there is a secure broadband connection. PACS is one example of what are called health information technologies (HIT), which also include such technologies as electronic medical records (EMRs), large computerized patient databases used by health researchers or insurance companies, and telemedicine, in which health care is provided via various communication technologies.

Thus, I want to return to Dad's trip to the hospital a final time and highlight something that his narrative lacks: any reference to or mention of a radiologist. Where is the radiologist in this encounter? Will Dad's film ever be read by a radiologist? What if something did look unusual in the right lung field? Who was responsible for reading the whole image (not just the "arms and legs") and letting Dad know if there was a worrisome finding? Dad's diagnosis and treatment raise questions about the politics of risk and responsibility in medical care, and which groups of experts are held responsible and/or accountable for the knowledge that is produced. Who gets to "speak" for medical knowledge, and which narratives are valued and circulate in a diagnostic economy and which do not? How do shifting jurisdictions of expertise and authority change the production of medical knowledge and affect patient care?

Another series of questions springs to mind when considering Dad's hospital encounter. They revolve around what, exactly, is being circulated by these health information technologies like PACS. Is it medical knowledge, or is it medical information? Or Both? What is the difference? If, as Foucault (1980) argues, power and knowledge cannot be understood separately from one another, what happens when there are shifts in the circulation of knowledge? As hospitals and health care facilities in the U.S. and elsewhere are quickly adopting all kinds of HITs such as PACS and, perhaps especially, electronic medical records, it is important to investigate what forms or kinds of knowledge and/or information can be circulated by these systems, and which cannot. Critical also to these questions are notions of near and far, presence and absence, intimacy and distance that adhere to information technologies and influence the negotiation of trust and authority among medical practitioners.

These questions are the basis for this dissertation. I trace the unintended and unexpected consequences of the widespread adoption of a technology. Using the case of PACS, I show how new patterns in the production, circulation, and control of knowledge have transformed 1) the jurisdictions of expertise, authority, and responsibility among different groups of physicians; 2) the act and production of medical diagnosis; and 3) patient care. Ironically, it is the development of PACS, a technology originally developed to improve radiologists' efficiency, that has enabled medical images to travel to new places at new speeds and to diverge from their usual trajectories and "relevant and customary paths" of circulation (Appadurai 1986), creating an opportunity for the renegotiation of the relations of power and authority in medicine.

In the social sciences, explorations of epistemological production, expertise, and authority have largely been focused on contrasting the perspectives and practices of expert and non-expert communities (cf. Epstein 1996; Rapp 1999; Hogle 2002a). Within clinical medicine, the asymmetries of power, intersections of different kinds of knowledge and expertise and negotiation of diagnosis that can occur in the doctor-patient relationship has been particularly well studied. Tracking the transformations of the doctor-patient relationship as new technologies are introduced, new biological knowledge becomes available, and new ideas about kinship, subjectivity, or community are encountered has been a major task of medical anthropologists and others (cf. Rabinow 1996a; Rapp 1999; Taylor 2008). However, despite this intense focus, a relatively small amount work has been done on investigating the ways that the relationships among experts are also subject to power hierarchies and are influenced by the introduction of new technologies and/or new types of knowledge (cf. Rabinow 1996b; Sunder Rajan 2006). While there is a lively field of research focused on the sociology of professions, these studies are primarily interested in documenting the rise and fall of entire professional and/or expert groups (cf. Abbott 1988; Freidson 1970; Reid 1996; Light 2000).

In contrast, I am inspired by philosopher Ian Hacking to combine the work of Goffman and Foucault in order to study how people like radiologists and practices like medical image interpretation are "made up" through complex interactions among individuals, institutions, technologies, systems of classification, types of knowledge, mechanisms of power, and historical influences (2004). Goffman's methodology was characterized by a "bottom-up" approach, focusing on how individuals engaged in social exchanges and formed relationships in institutional settings, specifically a mental health asylum (Hacking 2004; Goffman 1959). However, as Hacking points out, Goffman paid particular attention to people's speech and also their silences as well as their actions, affects, and gestures; yet Goffman paid no notice to the historical shaping of the social practices or the institutions that he writes about (Hacking 2004). In contrast, in his early work Foucault used an "archaeological" method to study the "conditions of possibility" that allowed certain institutions like hospitals and prisons to emerge, and how these institutions then shaped human behavior (1971; 1973; 1995). Foucault's "archaeological" method, then, provides a "top-down" approach to understanding subjectivity, showing how institutions shaped individuals, while Goffman focused on the interactions of individuals and the ways that these interactions then shaped institutions. Similarly, like Goffman I investigate the ways that hierarchies of expertise and epistemological jurisdictions are constituted in face-to-face, daily interactions among physicians, while, like Foucault, I also want to explore how institutional structures and relations of power mold the conditions of possibility for the production of certain kinds of medical practice and medical knowledge.

In many ways, my examination of the changes in medical practice linked with the widespread adoption of PACS also fits into a larger body of work conducted by sociologists, STS scholars, and anthropologists focused on the relation between the introduction of new technologies and radiologists' claims for expertise in the interpretation of medical images. Much of this work is part of the sociological study of professions and professionalization, which focuses on the ways that occupational groups seek to monopolize and control certain skills, resources, or bodies of knowledge (Larkin

1978). Pioneered by such sociologists as Abbott (cf. 1988) and Freidson (cf. 1994), these scholars tend to view interactions among professional groups as a competitive struggle over various jurisdictions of expertise, where a variety of tactics are employed including appeals to public opinion, control over legislation and/or institutional administration, and arguments for the "scientific" status of various modes of knowledge production or work (Timmermans 2002).

While this focus on competition and control has yielded important insights about how power and expertise are negotiated in macro-level settings, including how entire professions/professional groups have expanded or declined, many of these studies neglect to recognize how these "macro-level" conflicts are supported or undermined through everyday practice. As Timmermans importantly points out in his study of boundary maintenance among medical examiners, "professionals in their respective workplaces…have to describe, maintain and defend the professional control over their work on a daily basis. Professional activities are not independently defined and determined by the professionals themselves but take place within clusters of interdependent relationships" (2002: 552). Therefore, I investigate the adoption of PACS at Central Hospital through multiple lenses, focusing on the broader field of boundary maintenance and conflicts over jurisdictions of expertise among radiologists and other types of physicians, as well as how these boundaries and jurisdictions are supported, challenged, and made blurry through the complexities of daily practice.

In addition, rather than viewing expertise as a fixed or stable body of knowledge, I follow such scholars as Hogle (2002a; 2002b), Carr (2010), and others in arguing that expertise is created, maintained, and disputed through social interactions and performances that are both relative and situational. I view expertise as something one does, not something one has. Being an expert means not only having an intimate knowledge of a certain subject or object; it is also performative, interactive, and embodied, and requires the recognition of others. There can be no single "expert"; instead, the expert is created through negotiations and interactions with others, and must be constantly maintained through these interactions. Thus, there is no "expert," only "becoming-expert" (Selinger and Crease 2002).

Using this approach, I explore how HITs like PACS have reshaped the geography of inter-physician performances of expertise and diagnosis, and how this respatialization has had profound effects on the daily practice of doctors in the hospital. The way that these technologies mediate and transform relations between people has largely been ignored in the rush to actualize their promised benefits. However, in a hospital environment that is moving increasingly toward the further sub-specialization of doctors, the need to process and evaluate large amounts of health information, and the burgeoning popularity of team-based care, understanding how hierarchies of expertise are negotiated and how they influence the production of medical knowledge is important for physicians, for social scientists, and for patient care.

<u>Approaches to medical technologies</u>

In order to characterize my approach to medical technologies in this dissertation, I begin with a quote from Annemarie Mol, from her book *The Logic of Care*. She writes:

> Technologies are instruments. This sounds tautological. Of course technologies are instruments. They are means to ends and the more effective these means are, the better. But what if technologies have unexpected effects? What if they go beyond, and indeed transform, the ends they are supposed to serve? Technologies are unruly. Once introduced into a world where they interfere in unexpected ways

> with lots of other erratic entities and configurations, they change much more than they were intended to, and are ultimately transformed themselves as well. Instead of being modest means, they are inventive mediators. [Mol 2008: 50]

Mol, with her typically lyric prose and overwhelming insight, goes straight to the center of the problems, potencies, and promises surrounding the use of technology in medicine and in life. Technologies, as Latour (1999) and others argue, are (often unruly) actors, and through interactions with other beings or things shape both themselves and "the other." In tracing the consequences of widespread PACS adoption for medicine in the U.S., it is therefore important to emphasize that the technical and the social are co-produced. Technological determinism - the view that technology develops independently of society according to an autonomous logic and then "impacts" society - is still dominant in many fields of study including medicine. Countering such assumptions, this study seeks to highlight the complex and intricate ways that institutional structures, individual action, and cultural values both shape technology, and in turn, are shaped by it. Technologies do not determine practices but instead create a space where new practices, subjectivities, populations, identities, and beliefs can develop (Lock 2003).

Thus, I define technology broadly, as not just a category of objects or manufactured things, but as a collection of forces, practices, beliefs, and relationships. I argue that technologies like PACS are complex, unstable, ambiguous, and malleable actors that join together people and things, bodies and tools, the self and other (Biehl and Moran-Thomas 2009; Haraway 1997). Further, I want to consider the ways that technologies such as PACS are simultaneously liberating and constraining; can lead to new intimacies as well as increased alienation; have transformative potential while capable of maintaining some aspects of the status quo; and, as they travel, are constantly changing both themselves as well as the other people and technologies that they contact along the way (Biehl and Moran-Thomas 2009).

The technology I focus on, PACS, can be characterized in some ways as a technology of *distance*, or what might be called a tele-technology. PACS, I argue, enables images to distance themselves from the reading room while simultaneously allowing clinicians to also distance themselves from the reading room, and for radiologists to distance themselves from the hospital. Yet as Ihde points out, technologies both amplify certain things while reducing others (2002). PACS also allows for the development of new *intimacies* among clinicians, both with PACS itself as well as with the medical images that PACS enables them to access in new ways.

Recent research in medical anthropology, science and technology studies, and medical sociology indicates that medical technologies are important tools for the production and redefinition of medical knowledge, with conflicts often arising over practices and agendas (e.g. Brodwin 2000; Lock, Young, and Cambrosio 2000; Ong and Collier 2005). Furthermore, social scientists have found that when engaging with new technologies, people enter into unfamiliar and uncertain terrain, producing concern over the possible destabilization of identities, professional futures, and control over resources (Brodwin 2000).

This project builds on this literature by examining the ways that an information technology can serve as a focal point for assertions of medical expertise and authority. The project offers valuable, specific, and detailed information about the impact of an information technology that is widely considered to have fundamentally reshaped the field of medical imaging. This re-shaping has implications for how certain kinds of knowledge circulate in the hospital, how medical diagnosis is negotiated among physicians, and for patient care, which I will explore and describe in the following pages. Further, this project illustrates the relevance and importance of the behavioral sciences in contributing to a broader understanding of how information technologies and the people that use them interact and impact patient care.

This project also provides a detailed ethnographic account of the social dynamics that exist within and shape the realms of the scientific, the technological, and the biomedical. While many anthropologists have explored the ways that medicine has become linked with politics, far fewer studies have analyzed the political and social relationships that exist within medicine. Following Berg and Mol (1998) and Haraway (1991), this project concentrates on the multiple languages, values, meanings, and identities that exist *within* what is called biomedicine, adding to our understanding of biomedicine as an assemblage of heterogeneous and diverse practices, institutions, and beliefs that have profoundly shaped modern life.

The medical gaze

The practice of "seeing" in medical anthropology has been largely guided by Foucault's notion of the medical gaze. He explores the logic and conditions of possibility that allow seeing to become knowing, and for seeing to become the primary way that physicians "know" their patients. Importantly, Foucault points out that this ability to see disease in the body and express this knowledge through rational language was not the result of a triumph of reason over imagination or a rediscovered skill in observation, but "that the relation between the visible and invisible… changed its structure, revealing through gaze and language what had previously been below and beyond their domain" (1973: xii).

In the clinic, Foucault writes, the gaze becomes linked with language and with knowing (1973: 108). The gaze is normalizing, yet observant of deviance, and calculating, projecting chances and risks (Foucault 1973: 89). The gaze organizes, decides, and governs, but also transforms; a sick person becomes an object of scientific study (Foucault 1973: 97). Thus, it is through the gaze that science becomes ocular and "the eye becomes the depositary and source of clarity" (Foucault 1973: xiii), while simultaneously man becomes the object of positive knowledge, and the science of the individual emerges. Yet the gaze also obscures its own origins, cloaking its historical development behind the discourse of objectivity and rationalism (Foucault 1973: xv).

Further, Foucault recognizes that the transformation, via the gaze, from individual body to the body as object of rational discourse and study involves both power and potential violence which are hidden through the depiction of the gaze as *a priori*, objective, and empirical. He writes, "To look in order to know, to show in order to teach, is not this a tacit form of violence, all the more abusive for its silence, upon a sick body that demands to be comforted, not displayed?" (Foucault 1973: 84). Further, he writes that "the gaze that sees is a gaze that dominates" (Foucault 1973: 39). For Foucault, the medical gaze exerts power over both the individual and society via surveillance. Thus, "medical space can coincide with social space, or rather, traverse it and wholly penetrate it. One began to conceive of a generalized presence of doctors whose intersecting gazes form a network and exercise at every point in space, and at every moment in time, a constant, mobile, differentiated supervision" (Foucault 1973: 31).

Since Foucault, the notion of the gaze has multiplied, expanded, penetrated further into the bodies of individuals and populations, and become a target for resistance. For example, Armstrong defines the medical gaze as “all techniques, languages, and assumptions of modern medicine” (1983: 2) This definition marks an important evolution from Foucault’s concept of the gaze, from a specific way of looking and privileging of the visual to a collection of techniques and practices all focused on knowing and disciplining the body. Further, Sharon Kaufman (1994) argues through an examination of geriatric medicine that the gaze has expanded to look beyond the individual body and include the environment of the individual. In geriatrics the entire social, economic, emotional, and familial milieu of the individual becomes the patient, and this broadened gaze thus serves to expand the notion of disease, diagnosis, and the role of the physician. Adele Clarke and her colleagues (2003) propose that the provenience of the gaze has expanded to include almost every aspect of life (a process they call ‘biomedicalization’), not just old age, sparking a series of articles and studies concentrating on this phenomenon.

Yet other authors attempt to show how the medical gaze is resisted even as it functions (Good and Good 1993; Davenport 2000; Hirschauer 1991). Importantly, the primary focus of these authors is not the patient, but the physician, making their work particularly relevant to my own project. Good and Good’s 1993 article investigates how the medical gaze is “taught” to medical students; they explore how the subjects (physicians) and objects (patients) of the medical gaze are constituted during the process of medical education. Unlike Foucault, they argue that biomedicine encompasses diverse, idiosyncratic, and contradictory practices, and cannot be reduced to a single set of beliefs or ideals (1993: 82). Instead, through an ethnographic study of a group of medical students at Harvard, they argue for the individual agency of physicians in determining clinical practice. In their study, they found that acquiring the medical gaze required students to redefine their personal boundaries and gain a new intimacy with the body, in the form of the cadaver. Therefore, the gaze according to Good and Good reconstitutes not only disease and patients, but physicians as well. Yet the gaze is also resisted by medical students through an emphasis on compassion, engaging with patients, and empathy. A "dual discourse" is produced that juxtaposes a suffering patient with a case or body produced by the medical gaze; at the same time the subject of the gaze is also doubled, contrasting a physician as objective scientist with a compassionate physician focused on the suffering of others (1993: 102). Thus, the objectifying, disciplining aspects of the gaze are tempered by an emphasis on caring and recognition of suffering.

All of these authors focus on individuals' experiences and perspectives to highlight that the medical gaze is not uni-directional, and that people (both physicians and patients) find ways to retain their subjectivity despite the objectifying tendencies of the gaze. The gaze shapes patients and it also shapes physicians and notions of disease, transforming both subjects and objects. I follow Mol (2002) in exploring the ways that multiple versions of the gaze interact with multiple individuals in multiple contexts.

I turn my own "anthropology-gaze" toward those doing a certain kind of gazing in medicine: physicians, specifically radiologists and other clinicians who rely heavily on medical imaging. For Foucault, the clinical gaze is anonymous; there is no perceiver of the gaze, only the gaze itself. In contrast, I concentrate on the figures of the perceivers. By introducing these characters, I introduce a plurality of knowledges that shape multiple gazes and thus a plurality of medical images that are constructed through these gazes. Through these non-anonymous gazers, the medical image cannot be imagined as a single image but instead as multiple versions of an image that has no original and that change with each gaze. Similarly, I also propose that as gazers of another sort, medical anthropologists must also not be thought of as anonymous but instead as situated observers (Haraway 1988), each perceiving a different "object" or field of study. I explore how these multiplications, refractions, and translations are productive and capable of generating insights into and new understandings of the medical gaze.

The image of desire

> Diagnostic radiology has become so central to the practice of medicine that it is difficult to conceive of any segment of medicine functioning without the assistance of imaging and radiologists. Conservatively, it is estimated that 40% of patient encounters result in the ordering, review, or use of imaging examinations. [Patti et al. 2008: 1042]

How can we better understand and characterize the fundamental role that imaging plays in biomedicine? One way might be to consider the rather extraordinary numbers associated with imaging use in the U.S. For example, a study examining Medicare data from 1992 to 2001 found that there were double-digit annual increases in the utilization of so-called "advanced imaging techniques," including CT, MRI, and nuclear medicine (Krestin et al. 2007). According to the study authors, this upswing in imaging represented a 25.1% increase in the workload for radiologists during this time. Similarly, another study, published in 2005, concluded that "diagnostic imaging is the fastest growing component of expenditures for physician services in the United States, with an annual growth rate of 9%. This rate is more than double the 4% growth rate of general medical procedures" (Borgstede 2005: 99). The numbers become even more extraordinary when they reflect the financial aspects of imaging. It is estimated that Medicare spent approximately $13.8 billion on imaging services in 2006, more than double that of the amount spent ($6.7 billion) in 2000. Imaging is an incredibly important source of income for hospitals; for example, outpatient imaging in 2007 yielded over $24 billion in hospital profits, which is almost triple the amount of the next most profitable hospital service, cardiology (Hillman and Goldsmith 2011: 100).

Thanks to its dramatic growth and high cost, medical imaging has become one of the most visible targets in the U.S. for government-led efforts to lower the price of health care. For example, the Deficit Reduction Act of 2005 included a cut in the technical payment for outpatient imaging.[5] Interestingly, the volume of advanced imaging studies (CT, MRI, and nuclear medicine) billed to Medicare actually decreased 14.8% in 2007, and the total Medicare spending on outpatient imaging fell 12.9% in 2007 to $12.1 billion (Levin, Rao, and Parker 2012). This gradual "flattening out" of the steep growth curve for imaging services is most likely due to a combination of factors (Rao et al. 2011). However, medical imaging remains one of the main targets of efforts to reduce health care spending. In fact, the reimbursement cuts introduced by the Deficit Reduction Act of 2005 will become even more profound and widespread with the Patient Protection and Affordable Care Act signed by President Obama in 2010.

Yet despite the overall recent decline in the use of medical imaging and the uncertainty surrounding the impact of health care reform on imaging, it remains a large

[5] In general, billing for a medical imaging study has a technical component, which is the amount of money that is reimbursed for actually acquiring the image, and a professional component, which reimburses the radiologist for interpreting the study.

and extremely lucrative business. In 2008, there were 687 million imaging procedures performed in the U.S., representing a business that has reached an estimated $170 billion dollars (Hillman and Goldsmith 2011). The U.S. continues to have higher utilization rates of imaging technologies than almost every other country in the world, and the highest payment rates for their use. Medical imaging is a more than $170 billion a year industry in America. Thus, the ability to control the production and interpretation of medical images remains an important source of economic and political power in health care, both for hospitals and for individual physicians, despite the looming (and likely) possibility of further reimbursement restrictions.

In the medical literature, explanations for the increasing use of these technologies include financial strategies, citing the large amounts of revenue that are generated by imaging, technological arguments that "the growth in imaging is simply the result of the modernization of U.S. health care" (Borgstede 2005: 100), and arguments that the public is demanding imaging at higher rates than before. However, none of these reasons address why medical images have emerged as an object of such intense desire for physicians and patients, who display a remarkable reliance on and trust of these images.

In is important to note that this trust is historically constituted and constantly shifting, as work by Daston and Galison (1992) and others has shown. Indeed, the content or information derived from medical images is not inherent to those images but is instead shaped by the practices of interpretation as well as the specific historical contexts of those practices. Images don't carry meaning that only has to be "decoded"; meaning must be constructed instead (Pasveer 1989). As Pasveer notes, for X-rays and other imaging techniques to be thought of as valuable diagnostic tools also involved the development of a certain " way of seeing, a language by which to communicate, and a technology" that would isolate some things while obscuring others (1989: 361). Thus, the production of X-rays as images that reflected the inner "truth" of the patient required shifts in knowledge and practice for physicians and for society more broadly (Pasveer 1989).

Several social scientists have explored the importance of medical imaging technologies in modern health care, making essential links between modern "visual cultures" and imaging techniques like X-ray, CT, and MRI (e.g. Clarke 2005, Joyce 2005 and 2006, Mirzoeff 1999, Sturken and Cartwright 2001). The 20th century has been characterized by an ever-increasing fascination with and use of mechanically-produced images, catalyzed by the development in the 1980s and 1990s of video cameras, digital cameras, and personal computers (Joyce 2006). In her investigation of the development of MRI, Joyce shows that medical imaging techniques are both supported by and help to further the centrality of images in the modern era. She writes that "the tendency toward visualization provided the technological support and cultural recognition needed to produce medical imaging as a desirable practice. The invention of new medical imaging technologies, in turn, aided visualization by producing more visual artefacts for consumption in scientific practice and popular culture" (Joyce 2006: 17).

In addition to both supporting and being supported by the current emphasis on vision and the visual in culture, medical images also emerge in public discourses as an important emblem of knowledge and scientific truth. When analyzing narratives of MRI in the popular media, Joyce found that medical images are portrayed as producing objective "facts" about patients and are often contrasted with "low-tech" tools for clinical diagnosis. These tools, like the physical exam and patient histories, tend to be represented in medical literature and by physicians themselves as subjective and inaccurate (Joyce 2005: 441). In addition, popular narratives of MRI "equate the image with the physical body, progress, and authoritative knowledge" (Joyce 2005: 437).

Similarly, in his examination of the uses of PET in courtrooms, Dumit found that both inside and outside the courtroom, images act as powerful persuaders, where the "image's apparent picture-like status and manufactured objectivity threatens to overwhelm its interpreted nature" (2004:112). He develops the idea of "expert images," or images that require expert interpretation even though they *seem* straightforward and intuitive. Dumit rightly points out that medical images are not photographs, yet their similarity to photographs lends them a familiarity and comfort that persuades both experts and laypeople into believing they are straightforward representations of the body that need no interpretation. He writes that "in many cases, ironically, this persuasiveness comes to exceed the authority and even ability of the image's authors: The very experts who made them can no longer delimit what they mean" (Dumit 2004: 113). He continues, "It is as if the picture, authorized by 'experts,' no longer needs them" (ibid: 115). With Dumit's work, we see the medical image as not just a symbol of scientific knowledge, progress, and objectivity, but a powerfully persuasive figure that hides its need for interpretation even as it depends on it.

Taking into account the findings of both Joyce and Dumit as well as the claims of the medical press, explanations for the remarkable popularity of the medical image both in medicine and in popular culture begin to emerge. The production and use of images provides an importance source of information for physicians and is also an essential generator of revenue for hospitals. More importantly, medical images are potent symbols of scientific knowledge, authority, progress, and objectivity that persuade both doctors and patients of their transparency and "truth," even as they obscure the work of interpretation required for their use. The current emphasis on vision and visualization in everyday life and the persuasive nature of the medical image work in tandem, mutually reinforcing one another as objects of consumption. Uniquely situated to feed off our obsession with visuality, the popularity of technology, our imperative for progress, and our yearning for positivism, the medical image cannot be resisted, even by those who (should) know better.

In the context of this intense popularity, control of the production and interpretation of medical imaging takes on considerable symbolic as well as political and economic significance. In the past, radiologists have held a monopoly on imaging in biomedicine, acting as gatekeepers to imaging technologies and the images themselves as well as providing the vast majority of image interpretations. As Joyce points out, "The cultural emphasis on images helped legitimize radiologists' work and secure this profession's status" (2006: 18). However, while radiologist have previously benefited from the increasing desire for and consumption of images, this desire for images is now threatening radiology's privileged status. Ironically, it is the development of PACS, a technology developed to improve radiologists' efficiency, that has caused radiologists to lose their control over the medical image and spurred them to anxiously question the future of their specialty.

Research methods

In order to investigate the processes by which radiologists and other types of physicians negotiate claims for medical expertise and knowledge production after the adoption of PACS, I conducted 12 months of ethnographic fieldwork in 2010-2011 mostly at a large tertiary care academic hospital in the Western U.S. which I call "Central Hospital." Research tasks at this site included 1) six months of participant-observation of the daily routine practice of radiologists in reading rooms and at weekly multi-disciplinary conferences that bring together radiologists with other groups of clinicians; 2) six months of participant-observation of groups of non-radiology physicians (specifically surgeons, neurologists, pulmonologists, and practitioners from family medicine and emergency medicine) as they view, interpret, discuss, and use medical images during daily patient care; 3) semi-structured interviews with 15 radiologists and 15 non-radiology physicians, focusing on perceptions of the use and importance of medical imaging both before and after PACS, and the perceived impact of PACS on their own practices and behaviors. Interviews lasted from 20 minutes to over an hour and were audio recorded and later transcribed verbatim; 4) a literature review, focusing on attitudes of radiologists and non-radiology physicians toward medical imaging, the practice of radiology, and PACS. This literature was drawn from various sources, including medical and scientific journals, professional medical society web sites, and medical imaging-themed Internet chat rooms. This review enables my findings to be placed in the broader context of local, regional, and national health care issues, concerns, and trends.

Ethnographic data based on observations of radiologists and other clinicians' interactions and practices largely took the form of hand-written field notes and digital recordings of interviews. Both interviews and field notes were transcribed and then coded according to themes and patterns identified via iterative reading of the collected information. The analysis of these qualitative data consisted of identifying, organizing, categorizing, and ranking key themes in an ongoing process.

It is important to stress that my research focuses on a specific community of medical practitioners working in a specific environment – that of academic, inpatient medicine. The schedules, priorities, practices, and inter-physician patterns of communication are quite different in hospital-based academic health care than in other contexts, including private or community hospitals, non-academic hospitals and outpatient medicine. In addition, as I discuss further in Chapter 3, large academic hospitals providing tertiary care do have quite a few similarities, but in addition have their own particular intra-institutional cultures, including historically situated traditions, written and unwritten rules of behavior, power structures, and jurisdictional boundaries over "turf," including expertise, bodies of knowledge, patient populations, hospital space, and various procedures and interventions. Thus, while I use my observations at Central Hospital to address larger issues about technology and the circulation of knowledge within medicine, it is also important to recognize the local and specific nature of the complex interactions, claims for expertise, and patterns of communication my interlocutors engaged in.

Radiology at Central Hospital

Built in the early 2000s, Central Hospital is set in the midst of a sprawling health sciences campus that combines research as well as educational and clinical activities, and acts as a “hub” of medical care for the surrounding urban and rural areas. The hospital itself is divided into two towers or wings- one dedicated to outpatient services and routine care, and the other for inpatient services; it includes over 400 patient beds, the operating rooms, intensive care units, and patient wards. Combining inpatient and outpatient services, health care workers at this facility manage over 500,000 visits each year. Despite being less than 10 years old, Central Hospital quickly outgrew its original design, and a third tower (to house a new emergency department, more operating rooms, and more patient beds) was in the process of being added during my ethnographic work.

The medical imaging done at Central Hospital ranges from the routine to the highly specialized, and includes a mix of inpatient and outpatient care. The radiology department itself is divided into several anatomically specialized imaging units, each with its own reading room. These include abdominal imaging, breast imaging, musculoskeletal imaging, neuroradiology, thoracic (chest) imaging, and nuclear medicine. More than 260,000 imaging studies performed at Central Hospital in the year 2010 were interpreted by the approximately 30 full time radiologists, plus a few part-timers and three “emergency” radiologists, who read images from 10 p.m. to 6 a.m. These attending radiologists are aided in their work by 32 radiology residents and five fellows. Radiology residency requires an internship year in medicine or surgery, then 4 additional years of training in interpreting medical images. Fellows have completed radiology residency and have chosen to do an additional year or two years of training to become sub-specialized in a particular anatomic area. Almost all the attending radiologists at Central Hospital have completed at least one fellowship, which is common in academic medicine.

Production of medical images at this site is fully digital and integrated across the hospital and with Central Hospital associated clinics via PACS. Besides PACS, the hospital also has a limited electronic health record (EHR) system used primarily to record outpatient visits as well as some inpatient labs and pathology. The bulk of inpatient care records, however, remained paper-based at the time of my research. Another separate electronic system was used to track patients in the emergency department. However, during my observations, Central Hospital was beginning to install a hospital-wide, comprehensive EHR, which was scheduled to go on-line in the Summer of 2012.

Ethnographic stakes

In a project that examines the various gazes that interact with medical images and the forms of knowledge and authority that appear and disappear, I believe it is important to specify some of the ways in which my own ethnographic gaze has been shaped by my educational trajectory. As both an anthropologist-in-training and physician-in-training, I negotiate on a daily basis the challenges of being both an "insider" to the culture of medicine as well as an "outsider." I am what Gaufberg et al. (2010) call a "liminal operator," engaged in becoming-anthropologist and becoming-physician, yet fully neither. I can speak the language of medicine and navigate with relative ease the complex network of rules, expectations, and hierarchies that structure daily work in a hospital.

Although I generally introduced myself to the people I observed and interviewed as an anthropology student working on my Ph.D. and was always very clear about my research and its goals, my presence on rounds or in the reading room was often explained to curious newcomers by radiologists or other physicians as, "This is Allison. She's a medical student.” Once identified as such to doctors, residents, or hospital staff, my presence was almost immediately forgotten or taken for granted, even if I subsequently clarified that I was conducting research as an anthropologist. Given the ubiquity of medical students as hangers-on and observers in the hospital, my informants seemed much more comfortable placing me in an observational role that they understood, rather than having to adjust their perceptions to deal with an anthropologist in their midst.

My familiarity with academic medicine and my quasi-insider status as a medical student allowed me to gain unquestioned access to places that are traditionally off-limits to non-insiders (such as the OR). As a result, two things happened. People that might otherwise have been hesitant to speak with me did so. And, because medical students occupy the lowest rung of a very strict power hierarchy in the hospital, I, as researcher, was shifted by my interlocutors into the realm of “studying up” (Nader 1974). It is important to note, however, that my field site was not the hospital where I am a medical student – they are separate institutions located in different states. I felt this separation was necessary to place distance between my roles as anthropologist and medical student, although in the end, I found that each role informed the other and could not be so easily divided.

Chapter summaries

Chapter 2 examines how and why PACS emerged as the “right tool for the job” (Clarke and Fujimura 1992) in the early to mid 2000s, despite the development of the technology in the early 1980s. In Chapter 3, I investigate the concept of expertise, developing the notion of expertise as a process of engagement. I provide a brief historical overview of how radiologists established and maintained claims for expertise before PACS, focusing first on the specialty as a whole. I then focus on the daily engagements in the reading room that linked the "read" or interpretation produced by the radiologist, the performance of that "read" for the clinician, and the image itself, producing the core of radiologists' authority and power in the hospital. In Chapter 4, I look at how and why the ability of PACS to alter the accessibility and tempo of medical imaging has resulted in visits to the reading room being viewed now by non-radiology clinicians as a "waste of time" and by radiologists as an "interruption." Through an examination of the notions of efficiency and access, I show how radiologists' expertise has been challenged by other physician groups and by the very nature of PACS itself. Chapter 5 investigates how PACS has also re-spatialized the circulation of certain kinds of knowledge in the hospital, with a specific focus on the notion of "off the record" knowledge. In Chapters 6 and 7, through a focus on the practices of "reading" (Chapter 6) and "diagnosis" (Chapter 7), I examine how radiologists and clinicians are reshaping their claims for expertise and authority, and how radiologists are attempting to redefine how individual relationships of trust between clinicians are developed and maintained in the new, "all digital" radiology department. I conclude by discussing some of the broader implications of this research, as it is not only radiology that is being rebuilt from the inside out via the increasing "globalization" of medical information, but biomedicine itself.

CHAPTER 2: PACS and the "Digitization" of Medicine

> Four decades ago, radiologists were cave dwellers, living in the damp and dingy basements of hospitals amid yellowed linoleum flooring and flickering fluorescent lights. The primary job of these physician specialists was interpreting backlit anatomical images on film exposed to X-rays. Their work spaces stank of chemical developer and overflowed with dusty celluloid images archived in manila files… How remarkably things have changed! Radiology has become the archetypical medical specialty of the digital age. Thanks to ubiquitous broadband Internet and their embrace of digital technology, diagnostic radiologists can practice from anywhere they choose to be. [Hillman and Goldsmith 2011: x]

Introduction

In this chapter, I investigate the processes involved in the development and widespread adoption of PACS. I argue that PACS is both a symptom and a cause of the process of biomedicalization as defined by Clarke and colleagues (2010), and provides a case study for examining how computer and information technologies have become central not only to the practice of modern medicine, but to imaginings of biomedical futures. I show how changes in how medical work is done are not determined by the introduction of new technologies, but instead involve complex, highly contingent negotiations among technology developers and users that are influenced by broader trends in medicine, especially those encouraging greater standardization, rationalization, efficiency, and cost-effectiveness. Ultimately, I argue that PACS' success required reframing PACS from a tool made for and by radiologists to an "enterprise-wide image management system" that would enable physicians to deal with ever-increasing volumes of medical data. Yet I also show that HITs such as PACS both contribute to as well as pose an answer to the "problem" of information overload in biomedicine.

What is PACS?

PACS is defined as “a computer network dedicated to the storage, retrieval, and display of medical images” (Bransetter 2007: 84). Current PACS allow the processing and storage of a huge amount of data while still enabling the fast retrieval of individual studies from both inside and outside the hospital. While I call PACS a technology, it is actually an assemblage of technologies involving both hardware and software that is designed to perform several tasks that include: supporting image acquisition from a variety of different types of imaging machines; allowing both short and long term storage of images; displaying images on flexible workstations that enable interpretation and review as well as image manipulation and integrate imaging studies with patient information (Greenes and Brinkley 2006).

PACS has become the “heart” of modern radiology and is considered by many to be the primary tool of the radiologist (Chen, Bradshaw, and Nagy 2011). Without a PAC system in place, medical imaging departments would be unable to acquire, store, organize, and distribute the vast amount of data generated by today’s imaging machines, most of which is digital. However, while the first PACS were developed in the 1970s by radiologists and engineers working in academic medical centers, the widespread adoption of PACS occurred fairly recently. The report “Picture Archiving and Communication Systems: A 2000-2008 Study,” published by the Dorenfest Institute for Health Information,[6] gives some idea of the remarkable rate of adoption of PACS in U.S. hospitals. According to the report authors, in 2000 only 8.2% of the over 5000 registered hospitals in the U.S. had some form of PACS. In 2008, 76% of hospitals reported having

[6] Part of the Healthcare Information and Management Systems Society (HIMSS), a Chicago-based, non-profit research organization

a PAC system. The report also indicates that almost all (98.5%) of hospitals with over 500 beds had PACS by 2008, with fewer systems in small, rural healthcare facilities (Dorenfest Institute 2010).

The expansion of PACS from radiology departments to other areas of the hospital including the emergency room, intensive care units, and operating rooms also increased rapidly during this time. In 2004, 15.2% of hospitals with PACS reported that medical images could be viewed outside of the radiology department, while in 2008 this number had increased to 67.5% (Dorenfest Institute 2010). Additionally, in 2008, 70% of hospitals with PACS reported that medical images could be viewed outside of the hospital, via the Internet (Dorenfest Institute 2010). A more recent report from the Healthcare Information and Management Systems Society documenting trends in hospital information technology for 2010 states that, according to their records, the adoption of PACS by academic teaching hospitals is near 100% (HIMSS 2010). In comparison, around 20 to 25% of U.S. hospitals reported having an EMR system in 2005; according to a report issued by the Office of the National Coordinator for Health Information Technology, than number increased to about 35% in 2011 (www.healthit.gov).

In order to better understand these developmental transitions, PACS expert H. K. Huang identifies several different yet overlapping "modes" of PACS evolution, including PACS modules, also known as "mini-PACS", radiology PACS, hospital-integrated PACS, and enterprise PACS (Huang 2000). A PACS module or mini-PACS is usually an *ad hoc* assemblage of components put together to achieve a certain radiological or clinical application. Early mini-PACS were often capable of only dealing with the data from one particular imaging modality, such as CT or MRI, and were connected via point-to-point wires or cables rather than connected by a network. More advanced mini-PACS might be able to acquire, store, and distribute images from multiple modalities, but were generally fairly limited in their use. A radiology PACS indicates a system that is only used by and accessible to radiologists, without workstations that enable clinicians to view images independently of radiologists, whereas a hospital-integrated PACS has workstations located in clinical areas and the PACS is integrated into the hospital's information system. Finally, the last stage of PACS development is the enterprise PACS, which links together imaging from a variety of hospitals, clinics, and imaging centers and integrates this information into a patient's electronic medical record (EMR).

There is a tendency by some radiologists to characterize PACS evolution as progressing in a straightforward manner from simple "homegrown" systems to complex and advanced networks manufactured, installed, and maintained by a flourishing PACS industry. However, the actual development and use of PACS incorporates multiple trajectories, nonstop tinkering, and frequent "work arounds" (Knorr Cetina 1981). For example, while many large health care networks like the VA have had enterprise-level PACS systems since the 1990s, other major health care centers still rely on PACS that cannot be integrated with other data management and clinical monitoring systems. Because of their affordability, many smaller clinics may still rely on mini-PACS.

PACS: Symptom and cause of biomedicalization

Beginning in the 1960s computers have been continuously advocated as a way to "rescue" medicine from a variety of perceived ills (Kaplan 1995; Reiser 1993). Yet the "computerization" of medicine has largely been a slow and uneven affair, characterized more by suspicion and skepticism than by widespread adoption and enthusiasm. Until recently. While still unevenly distributed across the hospital, the computer and its associated capacity to store and analyze vast amounts of data have, since the mid- 1990s, been transformed in the eyes of hospital administrators, politicians, physicians, and patients from a relatively useful tool for some (especially administrative) aspects of medicine into the single most significant tool for all of medical practice, organization, and research now, and more importantly, in the future (Clarke et al. 2010; Jensen 2005). For researchers, hospitals, and physicians, being able to demonstrate a high degree of integration of computer-based systems (including but not limited to electronic medical records, physician decision support systems, resource tracking, automated billing, digital patient monitoring systems, and computerized diagnostic testing) is critical for receiving government funding, marketing to the public, and recruiting employees. The race for hospitals to become fully computerized, digitized, and "networked" is one which no one involved in health care can afford to lose.

Given the high stakes in this "digital revolution," understanding the development of computer-based technologies in medicine and the ways that they both shape and are shaped by broader trends in medicine, the computer industry, and society takes on crucial significance. As the excerpt from a radiologist-authored book on medical imaging at the beginning of this chapter indicates, radiologists in the U.S. see themselves as leading the way in the crusade to "digitize" medicine. As one of the first medical disciplines to become "fully digital," struggle with the problems and promises of computer technology, and develop forms of practice that depend upon computers, radiology with its adoption of PACS provides an important case study in which to examine the means and meanings of the digitization and computerization of medicine.

Yet despite the rosy picture of radiology's "embrace of digital technology" offered by Hillman and Goldsmith above, the computerization and digitization of radiology via PACS was in actuality an extremely rocky and uncertain path. Radiologists and engineers started to tinker with and develop precursors to PACS beginning in the 1960s. Yet it wasn't until the mid-2000s that PACS started to become a common feature in U.S. radiology departments and hospitals. Why did it take over 40 years for PACS to become "the right tool for the job" (Clarke and Fujimura 1992)? Investigating how PACS went from a patched-together assemblage of computers, monitors, and wires at a few academic medical schools to a $1.4 billion industry in the U.S. involves a focus not only on the technologies constituting the system itself, but also the conditions of possibility in bioscience, medicine, and society more broadly that help forge its technological trajectory.

I argue that the widespread adoption and "success" of PACS can be seen as both symptom and cause of a larger process that Clarke and colleagues call "biomedicalization" (2010). In developing this term, these authors show how, since the mid-1980s, American medicine has been and continues to be transformed from the inside out by the implementation of "biomedical, computer, and information sciences and technologies" that are restructuring how we approach health and disease, how medical care is organized, and how we live our lives (Clarke et al. 2010: 2). Clarke and her colleagues lay out five interactive processes that they argue are critical for understanding and characterizing how the practice of medicine has changed from the modern "medicalization" era to the postmodern or late modern biomedicalization era. These processes include: the increasing corporatization and privatization of medicine and medical research; an intense focus on heath, risk, and surveillance; the increasing “technoscientization” of biomedicine; new patterns in the production, distribution, and consumption of medical knowledge; and the transformation of bodies and identities (Clarke et al. 2010).

While all these processes help to shape the environments in which PACS was developed and eventually adopted, the trend toward “technoscientization” in biomedicine is perhaps most relevant here. For Clarke and colleagues (2010), this refers to the marked dominance of science and technology in medicine since the latter half of the 20th century. In addition to becoming constitutive of medicine, the authors follow Latour (1987) in arguing that science and technology must also be understood as co-constitutive, thus giving rise to the term “technoscience.” Yet the increasing importance of technoscience in the medical realm must not be seen as a result of an inevitable “march of progress,” but as a part of a major shift in how biomedical knowledge is produced, the goals and interventions that medical practice involves, and the organization of that practice on both individual and institutional levels including political economy (Clarke et al 2010: 65).

But what drives the desire for this techno-scientific transformation of medicine? Clarke and colleagues identify several key motivators of this “technological imperative,” including the overlapping notions of computerization, data banking, standardization, and digitization. At the heart of all these “-zations” is the view that medicine itself has become information (Webster 2002). If medicine has indeed become information-based, then what better way to manage and deliver that information than computers, which are designed to store and analyze large amounts of data? Computers seem to provide the answers to a number of “problems” in modern medicine, including the overwhelming amount of diagnostic evidence and research that physicians and patients are expected to master; the ever-increasing piles of paper forms and records that biomedicine generates; the fallible, error-prone, and subjective nature of humans; the increasing need to schedule, monitor, track, and bill an ever-increasing number of patients; and the need to assemble and analyze massive amounts of data in order to anticipate future health trends and crises (Kaplan 1995). Yet as a number of scholars from sociology, anthropology, and science and technology studies (STS) have shown, all of these “problems” are not inherent in the practice of medicine but have led to and are fed by the strong technological and informational imperatives that give rise to biomedicalization (cf. Berg 1997; Forsythe 1996; Pine 2011; Reiser 1978).

However, as Clarke and colleagues themselves point out, the different processes involved in biomedicalization are overlapping and co-constitutive. The transformation of medicine into information and the adoption and diffusion of specific technoscientific “advancements” to deal with this information has centrally motivated and been motivated by economic trends toward the centralization of healthcare services, facilities, and personnel. These trends, in turn, have been motivated by efforts to standardize, rationalize, and make more efficient the delivery of health care, often in the pursuit of greater profits (Clarke et al. 2010; Pine 2011; Timmermans and Berg 1997). Without computers and information scientists, the automatic monitoring and surveillance of individual and group practice and decision-making that are fundamental to efforts at rationalization and standardization would be impossible.

Thus, understanding the processes by which PACS was initially developed and became widely accepted throughout the U.S. medical community requires exploration of the broader economic, political, social, and medical trends that form the conditions of possibility for its emergence. Further, as Annemarie Mol points out, medical innovations must often make a new place for themselves in a world that already contains established techniques and procedures (Mol 1993). Emergent technologies, standards, or practices must be articulated in relation to what already exists, producing the need to negotiate among tensions that are created between the “old” or accepted and the new (Shostak 2005). In the case of PACS, understanding the ways that film-based radiology had to be transformed from the standard of practice into a “problem” to be solved is critical for comprehending this technological shift.

To investigate the tensions and trends that shape the emergence of PACS, I identify a series of temporal stages in PACS development. The use of these stages is primarily an organizing devise; I want to stress that there is much overlap and continuation from stage to stage. For each stage, I explore the ‘job’ of PACS (i.e., what ‘problem’ was PACS seen to answer) and investigate the broader concerns that made this job appear important. As Gibbons and colleagues (1994) and Shostak (2005) point out, aspirations for a technology have an important impact on the conditions of its materialization. I also consider for each period the relevant social groups or individuals that saw PACS as the right tool for these jobs, and what markets were being created and/or targeted for the technology. Both markets (either real or imagined) and highly visible “entrepreneurs” or “evangelists” have been identified as key motivators for the development and adoption of new technologies or new kinds of knowledge (Bucher 1962; Clarke 1998; Fujimura 1988; Shostak 2005). Yet as a large body of STS research shows, users of technologies shape their development and acceptance just as much as innovators (cf. Oudshoorn and Pinch 2003). Finally, I examine the perceived problems that, over time, were important for radiologists to overcome in adopting PACS. That is, what were the practical and theoretical barriers that had to be "solved" for the technology to develop and how did they change over time? To answer this question, I specifically address the tensions that emerge between traditional/existing and emergent standards and work practices (Timmermans and Berg 1997). Tracing how the answers to these questions shift and change over time underlines the highly contingent nature of PACS development and diffusion among U.S. radiologists and hospitals.

From ward to chart: making an image before PACS

In order to provide some context for understanding the changes in radiology and clinician and hospital practices that the adoption of PACS involved, I first characterize the work that producing a film-based medical image entails. In 1989 the Baltimore Veterans' Association (VA) Medical Center conducted a workflow study, in the hopes of making medical imaging at that institution more efficient. The study, summarized in a later (2003) article by radiologists Dr. Eliot Siegel and Dr. Bruce Reiner, identified 59 separate steps that were required to take place between a physician's order of a chest X-ray and the report (a formal, written interpretation of an imaging study by a radiologist) and placement in the patient's medical chart for review. These steps required the participation of no less than 11 different people located throughout the hospital (12 if you count the patient being imaged, which Siegel and Reiner did not). The summary below follows the movement of people, images, paperwork, and reports as they might have moved through the hospital in the late 1980s; it is drawn entirely from the workflow diagram developed for the 1989 Baltimore VA study (see Siegel and Reiner 2003: 103 for this diagram).

First the referring clinician located the patient's chart, wrote an order for a chest X-ray in the chart, and gave the chart to the ward clerk. In addition to writing the order, the clinician filled out a study request form, which specified why the study was needed. The ward clerk then flagged the order in the patient's chart and placed the chart in a "pending orders" bin, where a nurse retrieved it, documented the order, and asked the ward clerk to schedule the study. The ward clerk then contacted the radiology scheduler with the patient information, received an appointment for the patient, and informed the nurse of the scheduled time. The ward clerk also contacted hospital transportation aides, who came to the ward and brought the patient to the appropriate imaging area at the correct time.

In the radiology department, the radiology scheduling clerk used an index card catalogue to see if the patient had any prior imaging studies at the hospital. If old studies existed, the radiology clerk gave the index card to the film room, where the film room clerk located and pulled any old studies from the film library. If the films were older than six months, they would most likely need to have been retrieved from an off-site storage facility.

After locating any prior studies, the film room clerk then wrote the patient's name and medical record number on a new film jacket and placed the new jacket along with the request for the study in a "pending studies" bin. The radiology technologist retrieved the jacket and study request, tracked down the patient in the waiting area, brought the patient to the room with the X-ray machine, and took the image. The technologist then brought the exposed film to the dark room tech, who fed the film into a processor. After the film was processed, it was returned to the technologist, who checked the film for quality (i.e., making sure the entire lung field had been imaged), updated the patient's index card with the new study, returned the index card to the radiology clerk, and escorted the patient back to the waiting area. The radiology clerk then called the transportation aide, who took the patient back to the ward.

Meanwhile, the technologist brought the developed film to the film room, where the film clerk combined it with any old studies and brought everything to the radiology reading room. The radiologist then took the film jacket (containing the new chest X-ray as well as any old studies) from the "to-do" pile, hung the films on the viewbox, and began to review the films. After review was complete, the radiologist dictated the interpretation report, either using a telephone-based recording system or a Dictaphone. The radiologist then returned the films to the jacket and placed them in the "reviewed" pile, to be collected and re-filed by the film room clerk.

Some time later, the recording of the radiologist's dictation was received by the transcriptionist, who transcribed the report and printed out a hard copy. The transcriptionist then took the printed report to the file room, where it was placed in the patient's film jacket and brought back to the reading room. When not interpreting new imaging studies, the radiologist would review and proofread the report, and if no corrections were needed, would sign it. The signed report was brought by the transcriptionist to a clerk in the medical administration department, who sorted the reports and brought them to the correct ward. The ward clerk then placed the report in the correct patient chart, where it could be viewed by referring clinicians.

This process was slightly different for outpatient imaging – for example, the radiologist's report would be sent to the ordering physician's clinic rather than to a hospital ward, and the patient's appointment would be made by the clinic secretary or administrator rather than a ward clerk. Additionally, the time frame for inpatient and outpatient imaging could vary quite a bit, and the time between ordering and the production of the final report might range from a day or two (inpatient) to a week or longer (outpatient) (Siegel and Reiner 2003: 104).

Because each hospital or clinic is different, however, the circulation of people, films, and paperwork varied. Yet the workflow study conducted at the Baltimore VA gives a general idea of the significant effort and coordination involved in producing a medical image and image report, and the time frame for a report to reach a patient's chart. Although not discussed by the study's authors, the documentation of the work surrounding film-based imaging also highlights the multiple opportunities for mistakes to be made by numerous different actors. These mistakes could involve consequences ranging from a patient's late arrival to an imaging appointment to the misplacement of images or the wrong imaging study being performed.

For the purposes of this study, it is significant to note that in the inpatient setting, a referring physician wanting to read the radiologist's final report on an imaging study would most likely have to wait for at least a day, and often two or three days, before the report was placed in the patient's chart. While this delay might not have much of an impact for outpatient care, physicians working in the inpatient environment (where a patient's status can change dramatically in minutes or hours) were often unable to wait for a day, much less several days, to get imaging results. Instead, physicians would make regular and frequent trips and phone calls to the radiology reading room, in order to look at films and get the radiologist's interpretation as soon as possible. Thus, before PACS, the reading room served as an "obligatory passage point" (Callon 1986) for physicians needing diagnostic information about patients.

1960s: Precursors of PACS and the early development of teleradiology

PACS was certainly not the first application of computer technology in medicine. Yet while the term "PACS" was not coined until the early 1980s and development of these systems did not start in earnest until then, some important technological precursors helped to shape the medical-technical environment from which PACS eventually emerged.

Until the mid-1960s, computers had primarily been emphasized as a research tool to aid in the "scientization" of medicine. Computers were seen as a means of doing statistics and conducting quantitative analyses of medical data to derive "objective" diagnostic categories and assess outcomes (Kaplan 1995). As early as 1960, the NIH had established an Advisory Committee on Computers in Research, which was initially chaired by Dr. Lee B. Lusted, a radiologist. Indeed, Lusted was a major figure in the promotion of computer use in medicine from the 1950s through the 1990s, arguing that computers could "free" physicians from paperwork and allow them to concentrate on diagnosing and caring for patients (Kaplan 1995). With their association with technology (specifically, X-ray imaging devices) already firmly established, several radiologists, including Dr. Lusted, became high-profile advocates for the transformation of medicine via computers.

However, the 1960s were also marked by major changes in how medicine was organized and funded in the U.S. The 1965 establishment of Medicare and Medicaid meant that the government became the single largest provider and regulator of health care, and thereby came under pressure to provide care to previously underserved areas and populations. The cost of providing medical care to an expanded population also became an increasingly important issue, as did the need to perform administrative and bureaucratic tasks like billing, appointment and procedure scheduling, and gathering individual and group health statistics (Berg 1995). Thus, by the late 1960s, computers became viewed not only as a research tool, but also as an answer to the problems of communication of medical information across larger health institutions and government organizations (Kaplan 1995: 12).

With the efforts to provide care to so-called underserved areas ramping up via Medicare and Medicaid, it is perhaps not surprising that the precursors to PACS were developed to address the problems of distance. X-ray machines were much more widely distributed and common than radiologists who tended to practice in large, urban hospitals and made up a relatively small proportion of medical specialists. Yet by the 1960s, radiologists had solidified their monopoly on X-ray image interpretation. Therefore, getting the images themselves into the hands of radiologists was seen as important for providing good patient care. There was growing concern throughout medicine as how best to provide “modern” medical care to populations that remained primarily rural.

“Tele” is a Greek prefix that means distant, so telemedicine can be defined as “the delivery of health care services over a distance” (Thrall 2007: 613), or more specifically, as “the use of telecommunications technology to provide medical information and services” (Zundel 1996: 71). While telegraphs were used to relay medical information in the Civil War, the invention of the telephone and its subsequent widespread adoption is generally thought to mark the first time that telemedicine could be practiced on a large scale. The introduction of television was also a major moment in the history of telemedicine, enabling health practitioners to not only hear but also see other medical professionals and patients. In 1964, the Norfolk State Hospital was linked via closed-circuit video to the Nebraska Psychiatric Institute, over 100 miles away. Similarly, Massachusetts General Hospital used television to provide health care to travelers at Logan Airport in Boston beginning in 1967 (Zundel 1996).

Many of these early attempts at telemedicine were focused on providing health care to rural or geographically isolated areas. However, another crucial influence on the development of telemedicine was the growing interest in space exploration. NASA (National Aeronautics and Space Administration) used remote telemetry to monitor the effects of space flight on astronauts, and was responsible for the development and funding of many early attempts at using telecommunications technology to provide health care at a distance (Zundel 1996). One of the better-known outcomes of this research was STARPAHC (Space Technology Applied to Rural Papago Advanced Health Care), which in 1973 began developing a telemedicine network to address the health needs of the Papago community in Arizona.

Interestingly, the field of radiology had been exploring ways that X-ray images could be transmitted over long distances for more than 10 years. In 1950, the journal *Radiology* published an article by Gershon-Cohen and Cooley on the practice of “telognosis” (a combination of the terms tele, roentgen, and diagnosis), where facsimiles of X-ray images were transmitted over radio or telephone wires for examination by radiologists. In the case described by the authors, these images were transmitted between the rural Chester County Hospital in West Chester, Pennsylvania, which lacked a staff radiologist, and radiologists working in Philadelphia (Gershon-Cohen and Cooley 1950).

Most early attempts at teleradiology involved analog transmission of images over a variety of conduits, including standard telephone lines, coaxial cables, UHF radios, microwave links, and television (Kuduvalli, Rangayyan, and Desautels 1991). Because many rural and smaller health clinics did not have a radiologist on staff, being able to transmit X-ray images from outlying or underserved areas to larger medical institutions with a radiology department was seen as highly desirable. Additionally, many radiologists and non-radiology clinicians were interested in using these new picture transmission techniques to enable near-simultaneous viewing of images in two places within the same health care facility. For example, in 1972 radiologists at UCLA were using closed-circuit television to transmit scanned film radiographs to a screen in the ICU (Huang 2003). In this era, what would eventually be called PACS and teleradiology systems relied on the same technologies to achieve similar purposes – to link urban doctors with rural patients.

One of the largest perceived drawbacks of teleradiology and image display systems developed in the 1950s, ‘60s, and ‘70s was that they relied on analog transmission of images using slow-scan television (Kuduvalli, Rangayyan, and Desautels

1991). While the transmission of relatively low-resolution images could be accomplished in a reasonable amount of time, efforts to transmit high-resolution images met with little success (Kuduvalli, Rangayyan, and Desautels 1991). The spatial resolution and gray scale dynamic range of the transmitted images was inadequate for radiologists to interpret the images, and radiologists were frustrated by the inability to zoom in on certain areas or examine images next to one another. Despite these limitations, research on and development of teleradiology systems using television and analog image transmission continued through the 1970s at a few academic radiology departments in the U.S., including Massachusetts General Hospital, UCLA, and UCSF (Andrus et al. 1975).

By the end of the 1960s, computers were primarily used in radiology departments to schedule appointments, catalogue and track films, and to generate bills. However, nuclear medicine was one of the first divisions of radiology to use computers regularly for non-administrative tasks, although they were primarily used to quantify physiological functions rather than produce images (Bauman, Lodwick, and Taveras 1984). A few high-profile radiologists, often with Ph.D.'s in engineering, argued for the wider use of computers in imaging, but It was not until the introduction of CT in the early 1970s that computer use began to be contemplated in ways that would impact radiological practice significantly.

The beginning of radiology's "digital age": The 1970s and 1980s

According to Hillman and Goldsmith (2011: 35), the introduction of CT (computed tomography) in 1972 marked the arrival of the "digital age" in radiology. Traditional radiography involves passing X-rays through a patient's body and onto radiographic film, which turns darker or lighter depending on the intensity of the rays. Imaging modalities such as CT, and later MRI, ultrasound, and positron emission tomography (PET), all produce data that is inherently digital, and relies on complex computerized algorithms to transform the various signals captured by the imaging machines into digital pictures.

The development of digital imaging techniques like CT sparked research into methods for digital image communication and display. In 1979, Professor Heinz U. Lemke at the Technical University of Berlin published an article that discussed a digital system for transmitting and displaying images titled "A Network of Medical Work Stations for Integrated Word and Picture Communication in Clinical Medicine." In 1981, the International Society for Optical Engineering (SPIE) held a conference on digital radiography at Stanford University Medical Center (Huang 2003: 94). At this conference University of Arizona faculty Paul Capp and Sol Nudelman introduced an idea for a "Photoelectric Radiology Department" and outlined a PAC-like system using digital technology that they had begun developing in the late 1970s. Already, a small group of radiologists and engineers were beginning to imagine an "all-digital" radiology department. The introduction of digital imaging technologies such as MRI, ultrasound, and PET in the 1980s made this goal seem even more doable (Fujimura 1987). As one article in the journal *Radiology* stated, "The concept of a fully digital department is intuitively attractive. After all, with 25% of our images already in digital form, how can one resist the world of computers?" (Bauman, Lodwick, and Taveras 1984: 74).

However, despite the fact that CT machines had a console to view the images that were generated, most CT images were printed on film. Early CT consoles could only retrieve a single image (or "slice") at a time, and did not allow the radiologist to zoom in on areas of interest, view slices concurrently, or rearrange them. Therefore, the image 'slices' produced by CT were printed onto film, with each film sheet displaying between 8 and 24 slices. The early consoles were used primarily to confirm proper positioning of patients in the CT apparatus (Greenes and Brinkley 2006). The digital output of the CT machines was usually stored by hospitals on large magnetic tape reels, which were usually kept for a few months and then erased, while the film print outs were kept in the image library Hillman and Goldsmith 2011).

It was with the introduction of digital imaging that film itself became the "problem" PACS was meant to solve. What had formerly been the standard medium for all imaging became (according to some PACS enthusiasts) a problematic material that was large, heavy, took up precious storage space, was expensive, required hazardous chemicals to develop, could be easily lost or taken, and could not be manipulated. PACS enthusiasts predicted that digitizing radiology would enable imaging departments to save large amounts of money spent on film as well as eliminating the expenses associated with storage and maintaining a staff of film librarians (Bauman, Lodwick, and Taveras 1984).

However, simply having methods to produce images in digital form did not automatically lead to PACS. In fact, the data produced by early digital imaging machines had a serious flaw for researchers interested in developing methods to transmit and view images without the use of film. None of the data was standardized. Data standards not only articulate a set of "rules" that dictate how digital information passes through networks and is stored in databases, but also enables different manufacturers' equipment to work together. In the early days of digital imaging and CT, each vendor had a different way of formatting their data, transmitting it, and storing it.

Dr. Stephen C. Horii, who worked on early PACS systems, notes that in the early days of CT the equipment manufacturers would encode the digital data to prevent display of the images on a monitor, restricting visualizations to film only. In a trade magazine interview, he recalled that "they [the manufacturers] didn't want the competition being able to read the [digital] tapes. Even the reconstructions were proprietary" (Wiley 2005). Being able to "read" digital tapes and then translate data into a common format was essential for even the most (seemingly) simple of tasks, like viewing images from more than one imaging device on the same workstation. Therefore, many PACS enthusiasts like Horii (then at the University of Pennsylvania) and Janice Honeyman-Buck, Ph.D. (at the University of Florida, Gainesville) spent countless hours decoding early digital tapes (Wiley 2005).

Establishing data standards became such an important goal for PACS researchers that in 1983 the American College of Radiology (ACR) formed a partnership with the National Electrical Manufacturers' Association (NEMA) to create technical standards for CT imaging. However, the CT manufacturers showed little interest in the project until the ACR convinced the FDA to "persuade" these vendors that voluntary collaboration would make the likelihood of mandated regulatory action less likely (Hillman and Goldsmith 2011: 115). The first set of ACR/NEMA standards were published in 1985; it concentrated on enabling the physical connection of different vendors' imaging equipment to the magnetic tape storage devices as well as providing a common organizing format for the data being stored (Hillman and Goldsmith 2011). Most manufacturers of imaging equipment at this time also had heavy financial stake in radiographic film and film processing chemicals. It is not surprising that these companies struggled to limit the development of systems that could potentially decrease radiologists' reliance on film or enable the output of one manufacturer's CT or MRI to be displayed on another manufacturer's monitors.

It is also significant to note that by the early 1980s, there were enough people interested in PACS development that the American College of Radiology was willing to pressure imaging companies to adopt a standard data format. The SPIE conference held in January of 1982 in Newport Beach, California, was named "First International Conference and Workshop on Picture Archiving and Communication Systems (PACS)." Over 400 researchers, radiologists, and vendors attended. Anecdotal evidence suggests that it was at this conference where the term "PACS" was first coined (Huang 2003). Several radiology departments in academic hospitals then began to develop single modality "mini-PACS," teleradiology systems, and patched-together multiple modality PACS networks that could process and display data from several different digital imaging sources.

Standardizing the digital output of the imaging machines was one problem that PACS developers needed to solve. Yet despite the burgeoning popularity of techniques like CT and MR, approximately 75 to 80% of diagnostic studies performed in the early 1980s were still X-rays (Lodwick and Taaffe 1988). If the "problem" of film was truly to be solved by PACS, researchers had to figure out a way to transform X-ray images into digital data. Two primary approaches were taken to address this problem. The first involved the development of techniques to transform film images into digital images using scanners and digitizers. The second technique was computed radiography (CR), a device that enables the digital acquisition of projection X-ray images. While various kinds of film scanners convert film-based radiographs into a digital form, CR uses a plate coated with a photostimulable phosphor, which is placed behind the patient and exposed to X-rays. Instead of developing the plate in a darkroom, it is placed in a laser scanner that detects and digitizes the image. Fuji introduced the first commercially available CR system in 1983 (Huang 2003: 98).

The introduction of scanners and CR generated another problem, however - dealing with the huge amount of data generated by these high-resolution images. Radiologists and engineers began experimenting with various methods to compress the data, based on research that had been done in the aerospace industry in the 1970s. In general, three types of compression techniques were used: lossless compression (or error-free compression), where the image can be recovered exactly, lossy compression, where selected data is filtered out and the original image cannot be exactly recovered (i.e. JPEG compression), and wavelet compression, which eliminates artifacts and other redundant information (Greenes and Brinkley 2006).

The University of Kansas may have been the site for one of the first multi-modality PAC systems, which was installed in 1982 and 1983. Samuel Dwyer III, who held a Ph.D. in engineering and began working in the radiology field in the late 1970s was one of the primary organizers of the first PACS conference in Newport Beach; he was instrumental in the development and implementation of the Kansas PACS. In a trade journal he described the system as having multiple workstations that were able to display images from CT and ultrasound, as well as plain films that were entered into the system via a film digitizer, all linked together via Ethernet (Wiley 2005). However, the clinical applicability of this early system was limited. Dwyer said, “it was more like putting together a demonstration. The workstations were slow and low-resolution. We had to talk the radiologists into reading on them, but we proved we could move the images around” (Wiley 2005). According to Dwyer, the system cost approximately $700,000 to install, and was in use for about five years.

Dwyer’s comments point to another problem for PACS developers. The entire culture of radiologists, including their practices and organization, was structured around film. Thus, a tension developed between a fairly small community of very vocal radiologists and engineers working in radiology who saw “going digital” as the future of radiology, and the majority of radiologists and hospital administrators for whom film was still faster, easier to work with, and cheaper. As one group of PACS supporters from Massachusetts General Hospital pointed out, “the fully digital department will not be possible unless digital interpretation stations can be improved so that radiologists elect to use them” (Bauman, Lodwick, and Taveras 1984: 75).

PACS installed in this era tended to be far slower and more cumbersome for radiologists than dealing with film. In addition, while CT and MR images were fairly low resolution and could be displayed on computer monitors without great loss of detail, plain films, especially chest X-rays and mammograms, required monitors with a higher level of resolution than was possible at the time. Many radiologists refused to interpret films on digital screens because they were worried that significant subtle details would not be visible.

In addition to Dr. Dwyer, Dr. Ronald Arenson was also hard at work designing a limited PACS to facilitate sharing of medical images in the ICU at the University of

Pennsylvania. In doing preliminary research for this project, I met with Dr. Arenson (now at UCSF) and asked about his early experiences with PACS:

> I was at Penn, and one of the projects I was working on was what later became digital subtraction angiography.[7] We had a large research computer, and we developed some very early fiber-optic connections between this research computer and our project, which was located in a different building. I saw that I could use this large computer to do some processing of the digitally subtracted images if I could get them from the angio [angiography] room where we digitized the images to this thing [the big computer]. So once I did that, I said, "Gee, we could store images this way, we could digitize and store images and do away with film." So I applied for a grant for that early on, which was not funded by the NIH. They said, "Oh, this is too commercial, you should get a company to fund you instead." But, so then I went on and got a grant, but it was to look at digitized images in the ICU. If you had them [digitized images] available and they could be immediately read in radiology as well as upstairs [in the ICU], could people actually get started on antibiotics faster? Or would decisions be made faster and therefore would it make a difference to care? And that was the grant. So that's how we got into PACS early on at Penn, it was a very focused application in the ICU.

It is interesting to note that during the early development of PACS, a primary goal was not making radiologists more efficient, but solving the problem of the "singular" nature of film – that is, that there was usually only one copy of an image that many people (both clinicians and radiologists) wanted to look at. Like Arenson at the University of Pennsylvania, Dr. H. K. "Bernie" Huang also developed an early, limited PACS system installed at UCLA in 1989. Funded by an NIH grant, Huang placed imaging monitors in the pediatric, ICU, and critical care wards, to see if speeding up access to images would translate into improved patient care at these sites.

One part of Arenson's experiment with putting a mini-PACS in the ICU was to examine how physician behavior changed when they had immediate access to patients' films. They found that when digital images were available to clinicians, the clinicians

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[7] Subtraction angiography refers to a fluoroscopy technique to visualize blood vessels, using an injected contrast medium

tended to stop visiting the radiology reading room as frequently and tended to view images themselves before a radiologist's report was available (De Simone et al. 1998; Arenson et al. 1998). I discuss this research further in Chapter 4. I want to stress that even during the earliest phases, radiologists involved with PACS development were aware of the technology's potential to "have a substantial impact on the logistics of clinical practice" (De Simone et al. 1988: 44). Yet the lure of the "all digital" radiology department seems to have swept aside concerns about the potential of PACS to decrease radiologists' involvement with clinicians and with patient care.

While PACS development at this stage certainly emphasized the image of radiology as a "high tech" specialty, the high price tag of such systems was coming under increased scrutiny by hospital administrators. By the end of the 1980s, cost had emerged as the primary concern of medical policy makers (Kaplan 1995). Interestingly, however, technology in medicine seems to have been both blamed for the ever-ballooning costs of care *and* considered the way that lower costs would be achieved.

For example, in 1979, the National Research Council's Committee on Technology and Health Care issued a report that condemned such technological developments as fetal monitoring and CT scanning for being overused and hospital information systems for not operating in a cost-effective manner (Kaplan 1995). Another major shift in hospital economics took place in 1983, when a series of amendments to the Social Security Act changed payment for medical services from retrospective (payment for services rendered) to prospective, via diagnostic related groups (DRGs). The DRG system paid hospitals the same amount for any patient treated under a certain diagnostic group, regardless of cost (Kaplan 1995). Computerized information systems, argued marketers and hospital administrators, could help implement business-like management techniques, in order to "analyze and optimize case mix loads and laboratory utilization, auditing patient care to reduce 'overutilized' procedures, and ensuring compliance with quality of care standards" (Kaplan 1995: 20).

In summary, by the end of the 1980s, the "proof" that a PAC system could be developed was demonstrated, but it was not yet seen as practical or cost-effective to install such networks on a large scale. Most PACS-related innovations took place within academic medical centers, resulting in "home-grown" networks patched together using components from a variety of manufacturers. These early projects were funded via a hodgepodge of sources including private vendors, government grants, and departmental funds. Yet despite increasingly tight hospital budgets, a growing community of radiologists seemed convinced that PACS was the future of medical imaging. In fact, the first issue of the *Journal of Digital Imaging* was published in 1988, marking the emergence of a venue specifically targeted towards promoting the digitization of radiology. As an article in this first issue boldly stated, "It is not so much whether society can afford information management systems, as whether society can afford not to have them" (Lodwick and Taaffe 1988: 11).

<u>The early 1990s: the filmless radiology department becomes reality</u>

By the early 1990s the initial excitement over developing functioning PAC systems had not translated into widespread acceptance of the technology. PACS remained largely pet projects at a few large academic medical centers, and film-based imaging continued to dominate radiological practice. Despite "proof" that PACS could work, concerns over the cost of the technology limited its perceived usefulness by most radiologists and hospital administrators. As radiologists Becker and Arenson point out, "In this environment of skyrocketing health care costs, the acquisition of new technology is under intense scrutiny. Until a few years ago, medical decision makers could pass on the costs of new technologies without much difficulty. Today, hospitals face diagnosis-related groups (DRGs) and other reimbursement schemes that force more careful analyses of new purchases" (1994: 361).

The concerns about rising health care costs that were prevalent in the 1970s and 1980s continued to dominate discussions of medical policy in the early 1990s. Concepts such as "efficiency" and "quality" became primary concerns; for example, the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) and the American Hospital Association (AHA) began requiring implementation of such business-inspired programs as "total quality management" (Zuiderent-Jerak and Berg 2010). Quantitative documentation of "quality" and cost-reduction became one of the primary goals of hospital administrations during this time (Wiener 2000).

Not surprisingly, supporters of PACS shifted their arguments for its adoption to frame them primarily in economic terms. Yet the handful of studies that had assessed the cost effectiveness of PACS in comparison to film-based imaging yielded conflicting results. While some studies concluded that PACS would pay for itself over several years, other studies found PACS installation to be more expensive in the long run than continuing with film (Becker and Arenson 1994). Some of the most vocal supporters of PACS, including Dr. Eliot Siegel and Dr. Bruce Reiner at the Baltimore VA and Dr. Ronald Arenson at UCSF, began arguing in radiology-themed journal articles, editorials, and speaking engagements that PACS was cost effective when so-called “indirect” or “hidden” costs associated with film-based imaging were factored into the equation. These indirect costs included calculation of time spent by physicians walking to and from the reading room, with the underlying assumption that physicians’ time can be directly translated into money, or shortening the length of patients’ hospital stays by making the images more accessible to physicians.

In addition, these PACS evangelists began targeting their arguments not only toward radiologists, but to the larger health care community. For example, one article co-authored by Arenson stated, “It is not only radiologists who need to be convinced of PACSs’ utility and cost-effectiveness, but also referring physicians, hospital administrators, and politicians” (Becker and Arenson 1994: 369). Often requiring an initial investment of over $1 million for a large PACS system, these advocates quickly realized that to fund such expenses required administrative and political support.

Despite these concerted efforts by PACS supporters, most radiologists still favored film-based imaging. While some improvements had been made to display monitors, it was still faster for radiologists to view films on an alternator than on a computer display. Additionally, while films could be easily and quickly placed side-by-side for comparison, PACS viewing stations could only show one image at a time. Despite being considered “cutting edge” technology, PACS did not yet make sense to the majority of radiologists, nor had the concerns and priorities of these users - primarily being able to read images quickly - been translated into PACS designs. This lack of support from rank and file radiologists affected PACS success in the larger technology market. As one journal article from 1992 states, “PACS is at present going through a crisis with a number of large systems either being stalled or having difficulty with funding and a number of major PACS manufacturers reappraising the marketing and support of PACS" (Crowe 1992: 181). Therefore, it is not surprising that a survey of 82 hospitals worldwide conducted in 1995 identified only 12 hospitals in the U.S. with what was called "large PACS" (PACS that acquired images from 3 or more modalities, was in daily clinical use, handled a minimum of 20,000 exams per year, and had workstation terminals located both inside and outside the radiology department) (Bauman, Gell, and Dwyer 1996).

Rather than finding support from technology manufacturers or hospital administrators, PACS development in the early 1990s was largely kept afloat thanks to the military. The Department of Defense (DOD) had become interested in PACS and digital imaging in the 1980s, in addition to its already well-established work on telemedicine and teleradiology, and had begun providing research support to PACS "tinkerers" like Dr. Huang at UCLA during this period. The DOD saw these technologies as a way to address the difficulty of providing health care to an increasingly mobile domestic military population as well as for a burgeoning number of small-scale military deployments such as Haiti and Somalia and for the first Gulf War (Mogel 2003).

Unlike academic medical departments, the DOD wanted to develop a single PAC system or, as they called it, a Medical Diagnostic Imaging Support System (MIDS in military lingo) to install in multiple locations. This was to be a "complete PACS" that included devices for the digital acquisition of images, short- and long-term storage for those images, a database management and radiology information system (RIS), and multiple types of workstations for image display (Mogel 2003). This first MIDS/PACS was manufactured and installed at three locations, via contract with the Loral Corporation which had been acquired by Siemens Medical Systems. These locations included Fort Lewis, Washington, Wright Patterson Air Force Base, Ohio, and Fort Sam Houston, Texas (Mogel 2003). Installation began in 1992 in Fort Lewis, and soon proceeded at the other sites as well. Additionally, in conjunction with the Georgetown University Imaging Sciences and Information Systems (ISIS) Research Center, the U.S. Army was also engaged in developing a teleradiology system called DEPRAD (short for "deployable radiology") specifically for U.S. troops stationed in Bosnia-Herzegovina (Mogel 2003). Because no radiologists were stationed in this area, DEPRAD enabled medical images including CT, ultrasound, and CR to be read instead by U.S. Army radiologists stationed in Hungary or Germany.

In addition to the DOD, the Department of Veterans Affairs (VA) was also very interested in the potential advantages of PACS. The Baltimore VA became one of the major centers for PACS development, lead by radiologist and PACS evangelist Dr. Eliot Siegel. After extensive research, the hospital decided to buy a PACS from Siemens; it cost $7.8 million, included 40 PACS workstations, and was installed in June 1993 (Siegel and Reiner 2003). Siegel states that the Baltimore VA's early interest in PACS was stimulated both by a broader move toward electronic medical records (EMRs) by the VA, and the goal of establishing the first "filmless" radiology department. This was achieved in 1994, with the only exception being mammography. Because of the extremely high resolution needed for detection of microcalcifications, digital mammography only became practical in the mid-2000s, when the resolution of digital images and viewing monitors began to approach the resolution of film-based mammography and the cost of such monitors became less prohibitive.

These projects by the military and the VA were important not only for funding of PACS research, but also moved PACS out of the radiology department and into the wider hospital environment. In part, this expansion was made possible by the release of the third version of the ACR/NEMA standards (now renamed DICOM, for Digital Information and Communications in Medicine) in 1993. These standards focused specifically on enabling image management across data networks, including the recognition of TCP/IP (the messaging protocol used by the Internet) as the means for organizing this cross-network communication (Hillman and Goldsmith 2011). Early PAC systems relied solely on local area networks (LANs) that restricted image transmission and viewing to the locations that the radiology group serviced, i.e. a hospital or a cluster of clinics. The new DICOM standards made it possible for PACS to use wide area networks (WANs) as well, enabling workstations to remotely access images stored on the PACS. Thus, the practice of teleradiology became more feasible with the use of these standards, yet was still perceived as limited by the low performance of computer systems, the high cost and slow speed of bandwidth and the continued reliance on film-based imaging.

<u>The computer revolution: PACS in the mid- to late 1990s and early 2000s</u>

By the mid-1990s, despite the best efforts of high-profile PACS evangelists within the radiology community, the promotion of PACS by the military and the VA and the (somewhat lukewarm) support of medical technology manufactures like Philips and Siemens, the PACS “revolution” was still largely theoretical. Why had PACS been so quickly adopted by a small group of "innovators," only to be ignored by "early and late majority users?" (Reiner, Siegel, and McKay 2000: 108). PACS supporters were stymied. As one article stated, "The large-scale implementation of picture archiving and communication systems (PACS) has occurred at a much slower rate than initially anticipated" (Reiner, Siegel, and McKay 2000: 108).

Ironically, it was to be clinicians, not radiologists, who ultimately transformed PACS from a technology only found in a few academic hospitals to the ubiquitous method for storing and viewing digital images that it is today. Supporters of PACS found that their arguments for PACS adoption that were based on its cost effectiveness lacked sufficient "proof" to sway hospital administrators. Instead, PACS evangelists began stressing the *clinical* benefits of the technology, in addition to arguing for increased efficiency by radiologists.

For example, a study conducted at the Baltimore VA that was published in 2003 listed the "benefits" of PACS: the almost complete elimination of lost or unread images; a decrease in the amount of time that radiologists took to complete their reports (from several hours to less than 30 minutes); and the ability of clinicians to see images without needing to go to the reading room (Siegel and Reiner 2003). All of these benefits – faster reports, no lost images, no time-intensive trips to the reading room – specifically addressed common and often-heard complaints that clinicians expressed about film-based radiology. In fact, Siegel and Reiner conducted a survey among clinicians after PACS had been installed for two years at the Baltimore VA, and found that 92% of non-radiology physicians strongly preferred PACS to film-based imaging, and that "the biggest benefit of PACS to their practice is the fact that it saves them time and makes them more productive" (2003: 104).

Both PACS manufacturers and radiologists who supported their adoption began to argue that rather than just helping radiologists save money and work faster, PACS could make *all* physicians more efficient and cost-effective. As one editorial in a radiology journal declared, "much of the benefit of PACS accrues from the provision of image results to clinicians in a timely fashion to facilitate clinical management" (Greenes and Brinkley 2006: 641). PACS had become, by the mid-2000s, not just a way for radiologists to overcome perceived shortcomings of film-based imaging, but more importantly touted as a revolution in both physician practice and patient care.

The significance of this shift in how PACS was conceptualized must be understood in the political and economic context of health care during this period. The Institute of Medicine released its highly influential report *To Err is Human* in 2000, advocating widespread computerization of patient monitoring and physician decision-making to reduce medical errors (Kohn et al. 2000). As Pine shows in her scathing assessment of Healthcare Information Technology (HIT) in U.S. hospitals, the HIT industry has received massive support from Congress and the Office of the President, including both George W. Bush and Barak Obama (2011). HIT has been characterized not only as the central means to reduce medical errors and make patient care "safer," but as the primary way that health care cost reduction will occur (Pine 2011). Hospitals face significant financial rewards for adopting HIT, as well as penalties for not installing such computerized monitoring systems. Thus, characterizing PACS as a healthcare information technology that has the ability to reshape *all* of medicine - not just radiology - is a crucial strategy to take advantage of the burgeoning symbolic and economic importance of HIT during this time.

Yet to be accepted and found useful by radiologists and clinicians alike, the clunky, slow, and awkward PACS terminals of the mid-1990s needed improvement. While radiology-specific innovations like CR and DICOM were important to the development of PACS during the 1990s, the most important changes that brought PACS from a homegrown technologic 'novelty' to the center of radiologic practice came from outside of health care. As radiologist James Thrall notes, "the rapid development of the components necessary to make PACS financially and operationally feasible was not principally driven by the medical marketplace but rather by the enormous demands of other commercial and consumer sectors for higher-performance, lower cost computing power and associated workstations, networks, and archives" (2005a: 383).

It wasn't until the late 1990s and early 2000s that the computing power, storage capacity, transmission speed, and network capabilities were sufficiently advanced, available, and inexpensive enough to make PACS seem like a reasonable replacement to film-based imaging. Specific innovations from the computer industry included expansion of disk storage capacity and decreases in data storage costs, new image compression methods to reduce storage requirements, and increases in RAM and video graphic board memory that facilitated workstation display improvements and cost-reduction (Greene and Brinkley 2006).

The expansion of the Internet from academic settings into the public sphere also had important ramifications for the success of PACS. Personal computers were now a common feature of U.S. homes, and most of society (radiologists and clinicians included) were becoming more comfortable and proficient in using computers in all aspects of daily life. PACS designers began to shift their focus toward improving the interface between PACS and other clinical data systems, linking PACS with the internet, and making the imaging data in PACS more easily available to clinicians, capitalizing on the innovations in the computer industry.

Interestingly, these technical developments didn't just improve PACS, but made the system itself more necessary. Concurrent advances in CT and MR scanners meant that new models could produce more "slices" and higher resolution images, which results in ever-increasing amounts of data to store, process, and interpret. For example, in 1980 a 20-slice CT of the head would have been about 6 mega bytes (MB). In 2000, the size of the average CT study had increased, so that around 1000 slices were produced for a CT of the body, which would have been about 500 MB of data. In 2009, the size of a typical whole-body CT had increased to around 4000 slices or 2000 MB.

Not only were the studies themselves getting bigger, more studies were being ordered. As I discuss in Chapter 1, the period between 1992 to 2007 was marked by significant increases in the number of medical images ordered per patient in the U.S. for all imaging modalities. Additionally, it seems that as clinicians became more familiar with PACS, they tended to increase both the number of imaging studies they ordered as well as the complexity of those studies. For example, a study by McCormick and colleagues found that physicians who had access to computerized imaging results were 40 to 70 percent more likely to order imaging tests than physicians without such access (2012: 488). I discuss the tendency for physicians using PACS to order more imaging studies in Chapter 4. The salient point here, however, is that PACS didn't just provide an answer to the "problem" of ever-increasing imaging data, but became an important contributor to this "problem" as well. This finding contrasts with the arguments by health policy makers that adopting health information technologies such as PACS would help control health costs by *reducing* test ordering (McCormick et al. 2012).

Further, while the technological advances during this period might have made PACS seem more attractive on paper, in practice radiologists tended to resist the shift from film to digital imaging. For example, the University of Pennsylvania went filmless in 1998 but Reuben Mezrich, one of the project architects, characterized the radiologists as "stubborn" and "unenthusiastic" about the switch. He said that "they [the radiologists] were used to looking at four over four film displays,[8] and they insisted that I give them a workstation with eight monitors. That was the chest guys, I refused, but they were yelling and screaming. The musculoskeletal doctors wanted at least four monitors. That we did, although some thought one monitor was just fine. It was interesting how different doctors tried to adapt to a new technology… Now our residents wouldn't know what to do with a piece of film. We've gone down to two monitors in every area" (Wiley 2005).

According to Mezrich, it only took 7 years (1998 to when the article was published in 2005) for radiologists to go from "unenthusiastic" about PACS to residents who can *only* read images with PACS. During this period, PACS was transformed into a critical component of the "modern," high-tech hospital. Despite years of campaigning by a community of highly visible and respected radiologists, PACS was not widely accepted until demands for its adoption were framed in the language of efficiency, cost-savings *and* benefit to clinicians and the broader health care enterprise. Once PACS supporters and manufactures were able to transform PACS from a "radiologist tool" into a

[8] That is, two rows of four images on a light box or film alternator

“enterprise-wide image management system” crucial for the practice (and management) of modern medicine, the concerns of “stubborn” radiologists were subordinated to the greater “need” of hospitals. Despite increasing evidence that PACS was causing widespread decline in clinicians’ rates of consultation with radiologists (cf. Reiner et al. 1999) and increases in the number of images ordered (McCormick et al. 2012), PACS had become something that radiologists could not exist without. As one article stated, “If we (radiologists) elect to ignore these inevitable changes in technology and its applications, we risk being marginalized by our peers and the community we serve” (Reiner et al. 2003: 329).

<u>The mid-2000s to now: widespread PACS adoption</u>

Current PACS systems must allow the processing and storage of a huge amount of data while still enabling rapid retrieval of individual studies from both inside and outside the hospital. In addition, with the passing of the Health Insurance Portability and Accountability Act (HIPAA) in 1996, imaging data must be protected and transmitted securely. Imaging studies, even using compression techniques, can range in size from 2 to 500 MB and require large amounts of bandwidth to move quickly from one location to another.

To handle the complexity and size of modern PACS, an entirely new occupational group has emerged in the hospital – the PACS informatics team, usually lead by a PACS administrator. In 2007, SIIM created the Imaging Informatics Professionals Certification Program, which trains and credentials individuals as “informatics experts” that oversee the day-to-day operation, maintenance, and updates of PACS.

PACS is now a part of every major hospital in the U.S. As one chapter in a PACS textbook states, "Printing CT and MRI exams for interpretation is like printing your e-mail in order to read it. Ten years ago this analogy would be lost on most radiologists because they didn't know what e-mail was, but now virtually all radiologists know what it is and use it on a regular basis. Digital cameras are ubiquitous, and millions of consumers, radiologists among them, are filling up hard drives instead of shoeboxes with their family photos" (Hirschorn 2010: 3). Yet in many ways, PACS has 'escaped' radiology and become a fundamental tool for all clinicians. One trade journal article, titled "PACS: It's Not Just for Radiology Anymore" stated, "While PACS grew out of radiology departments' need to manage, distribute, and store digital images in the 1980s and 1990s, it is no longer solely radiology's domain." (Orenstein 2008).

This general shift is perhaps best characterized by the decision of the primary professional society of PACS supporters, formerly called the Society for Computer Applications in Radiology (SCAR), to change their name in 2006 to the Society for Imaging Informatics in Medicine (SIIM).

Conclusion

Since the 1960s, the role of the computer in medicine has shifted from a tool for research and data analysis to the primary means by which medical reforms, including reducing errors, reducing costs, and improving patient care, will (supposedly) take place. Information technologies such as PACS are being touted by politicians, medical administrators, and computer manufacturers as the *sine qua non* of modern biomedicine, and have allocated a significant budget for the development and implementation of such electronic systems in medicine. However, as I have shown, there was a significant gap in time between the use of PACS by a few "early adopters" and more widespread agreement by the medical community that PACS was indeed the "right tool" for the job of medical image management (Clarke and Fujimura 1992). PACS' success depended not only on convincing radiologists that changing their well-established film-based practices was worthwhile, but framing the technology as a way for *all* physicians, not just radiologists, to deal with the "problem" of information overload in medicine. It is the consequences of widespread PACS adoption on medical practice that I examine in the rest of this dissertation.

CHAPTER 3: Engaging Expertise

Introduction

In his masterful exploration of the nature of scientific knowledge, philosopher/chemist Michael Polanyi writes:

> Think of a medical student attending a course in the X-ray diagnosis of pulmonary diseases. He watches in a darkened room shadowy traces on a fluorescent screen placed against a patient's chest, and hears the radiologist commenting to his assistants, in technical language, on the significant features of these shadows. At first the student is completely puzzled. For he can see in the X-ray picture of a chest only the shadows of the heart and the ribs, with a few spidery blotches between them. The experts seem to be romancing about figments of their imagination; he can see nothing that they are talking about. Then as he goes on listening for a few weeks, looking carefully at ever new pictures of different cases, a tentative understanding will dawn on him; he will gradually forget about the ribs and begin to see the lungs. And eventually, if he perseveres intelligently, a rich panorama of significant details will be revealed to him: of physiological variations and pathological changes, of scars, of chronic infections and signs of acute disease. He has entered a new world. He still sees only a fraction of what the experts can see, but the pictures are definitely making sense now and so do most of the comments made on them. He is about to grasp what he is being taught; it has clicked. Thus, at the very moment when he has learned the language of pulmonary radiology, the student will also have learned to understand pulmonary radiograms. The two can only happen together. [Polanyi 1958: 101]

What Polanyi is describing here is the process by which a medical student gains a new way of seeing and a new language to describe what he sees - in other words, a new kind of medical gaze. Yet this new way of seeing and saying is only partial, as the student, even with his newfound comprehension, "sees only a fraction of what the experts can see." How, then, do we understand the development and use of the expert gaze? What distinguishes the student from the expert, and how is this expertise established and maintained in medicine?

In this chapter, I begin by building on the insights of Benner (1984), Gordon (1988a), and Luhrmann (2000) to argue that expertise is a process of engagement among people, institutions, objects, different kinds of knowledge and ways of knowing, and hierarchies of power. According to the Oxford English Dictionary, "to engage" has several different yet related meanings, including to use, to activate, to entangle or involve, and to occupy the attention of. Yet "to engage" can also mean to pledge, promise, or obligate (as in marriage) as well as to enter into conflict (as in armies engaging with one another) (www.oed.com).

With these multiple overlapping meanings in mind, I show how expertise is produced through three different varieties of engagement. First, I draw on the notion of engagement as entanglement or activation to consider how experts become enmeshed with people, situations, types of knowledge, and things. Secondly, I explore how expertise involves the cultivation of certain modes of attention or ways of seeing. Finally, I argue that expertise as a process of engagement entails the evocation of promises, commitments, and obligations as well as conflicts. This framing enables me to characterize expertise as dynamic, evolving, and multi-faceted – an interactive process rather than an individual or static state. Thinking of expertise as a complex and multi-faceted process involving a number of different and shifting engagements allows me to move past models of expertise that are static or reductive, instead highlighting the situated interactions, commitments, entanglements, and relationships that enable claims of expertise to emerge and be recognized or disputed by others.

After examining expertise more broadly, in the second half of this chapter I investigate the ways in which, before PACS, radiologists were able to claim and preserve their control over the production and interpretation of medical images. While medical specialties such as orthopedic surgery, obstetrics, and cardiology have had some success in appropriating certain imaging tools and techniques, radiology in the U.S. has historically been able to control the majority of medical image production and interpretation, even with the introduction of new imaging techniques such as CT and MRI (Burri 2008). The establishment and maintenance of radiologists' status as medical specialists focusing on image interpretation and their authority as visual experts has required a great deal of work. Given that new technologies provide an opportunity for the renegotiation of identities and jurisdictions of expertise (Barley 1988; Brodwin 2000), it is perhaps not surprising that a discipline like radiology, which has been tied closely to a range of ever-changing technologies, has had to constantly reinvent itself and renegotiate its position in medicine. In addition, the continued struggle of radiologists to assert authority over the production and analysis of medical images has been characterized by a long history of engagements involving both cooperation and conflict within medicine, as well as with the political, legal, and commercial fields.

Thus, I explore how the figure of the expert radiologist has emerged through a series of engagements and interactions with people, technologies, and institutions. First, I give a brief historical overview of the emergence of radiologists as imaging experts in the U.S. and follow the subsequent efforts of this profession to maintain and expand their boundaries of expertise. As most accounts of the history of medical imaging and radiology adopt a sociology of professions-based approach that focuses on large-scale boundary shifts and changes in the specialty as a whole (cf. Blume 1992; Burri 2008; Howell 1995; Kevles 1988; Reiser 1978), this section primarily focuses on the engagements between the field of radiology with other medical and non-medical occupational groups as well as with the state and the judicial system.

After exploring these broader engagements, I then use a variety of primary and secondary sources to focus on negotiations of boundaries of expertise through the daily practice of medicine. Specifically, I examine the ways that the expertise of radiologists in interpreting visual images and their ability to speak for and act as the "authorized voice" of those images was constituted (before PACS) through individual, daily engagements between radiologists, clinicians, and images that took place in reading rooms. It is through the everyday production and performance of image interpretations in front of the viewbox that relationships of individual and professional trust are built and maintained between radiologists and physicians, allowing radiologists to emerge as authoritative experts. Therefore, the "read" or interpretation produced by the radiologist, the performance of this interpretation for clinicians in the reading room, and the image itself become bound together in the reading room, forming the situated core of radiologists' authority and power in the hospital.

Clinical expertise: Benner and Gordon

In her study of how nurses become clinical experts, Benner uses a specific model of skill acquisition developed by Dreyfus and Dreyfus (Benner 1984). This model sees the attainment of expertise as involving movement through five "levels" or categories of proficiency, from novice to expert. Moving through the various stages marks a transition from reliance on "rules" and abstract principles to an intuitive understanding of complex situations based on experience (Dreyfus 1979). For example, in Benner's study novice nurses relied on general descriptions of what to do and when that involved incremental steps or rule-based procedures (Benner 1984: 21). In contrast, expert nurses did not rely on rules or guidelines when acting. Instead they had an intuitive grasp of each situation, based on a large amount of experience. This is not to say that experts never use analytic tools, yet by and large they are able to quickly hone in on the essential aspects of a problem or situation and ignore that which they deem irrelevant or unimportant. Frequently, the expert cannot completely describe how he or she makes a judgment or decides to act; instead, the Dreyfuses and Benner draw on the insight of Polanyi that "the expert always knows more than he or she can tell" (Benner 1984: 43).

While not an anthropologist herself, Benner's approach to studying nursing expertise was influential in recognizing that the attainment of clinical "connoisseurship" (Polanyi 1958) involved engagement with and mastery of multiple forms of knowledge. The Dreyfuses developed their model by studying pilots and chess players as they gained new knowledge and new skills, through both processes of formal education (didactic teaching, reading textbooks, and experience. For Benner and the Dreyfuses (building on the insights of Polanyi), expertise is as much a matter of "knowing that" as "knowing how," as much an understanding of formal, explicit knowledge as development of practical, personal knowledge. Benner emphasizes that the process of becoming an expert is not simply dependent on longevity, or doing something for a certain amount of time, but instead is an active process where preconceived notions and theories are refined via engagement with practical situations (Benner 1984). Thus, with Polanyi's example of the medical student I quoted above, the process of developing an expert radiologist gaze involves not just learning the language of radiology and reading textbooks, but "looking carefully" at new cases and actively engaging with what is going on around him.[9]

[9] Or her, although Polanyi's medical student is male

Benner also recognizes that not all types of expertise are equally valued in medicine and in society more broadly. Part of her project is to argue for experienced nurses' "knowing how" as a legitimate form of expertise that should be nurtured rather than restricted by training technique, yet she realizes that in the hospital it is doctors rather than nurses who are most commonly thought of as possessing clinical expertise. A hierarchy of expertise exists within the hospital that corresponds to the amount of power certain individuals or groups may have in determining their own or others' actions and practices. Thus Benner shows how expertise cannot be understood as separate from the broader institutional and epistemological context in which experts practice.

Using Benner's research as a starting point, anthropologist Deborah Gordon expands on the tension between "knowing that," or theoretical knowledge and "knowing how," or practical knowledge (1988a). She shows how the growing requirement in modern biomedicine for clinical decision-making to be more "scientific" and "rational" directly challenges the largely intuitive, tacit, experience-based expertise of veteran clinicians (Gordon 1988a). Gordon links the rise in demand for a science of clinical judgment based on quantitative, explicit, formal knowledge with an increasing preoccupation about notions of uncertainty and risk and the shift from a causal, mechanistic model of medicine to one based primarily on probability (1988a: 261). Additionally, she argues that the shift in autonomy from doctors to patients the rise in demands for doctors' accountability and the increasing visibility of medical decision-making processes has resulted in widespread emphasis on medical practice as a data-based science rather than an "art" (1988a).

The medicine-as-science paradigm, Gordon points out, relies on the notion that there is a universal, autonomous "truth" about reality and that reasoning is a process of calculation (1988a: 268). Rather than seeing clinical expertise as practical knowledge acquired through experience, this paradigm considers it to be reasoning that is cognitive, mental, intellectual, and analytical. Yet drawing on the research by Benner, Polanyi, and Dreyfus and Dreyfus, Gordon argues that, in fact, the knowledge of expert clinicians is frequently gathered with the entire body rather than just the mind, involving a gestalt-like perception of a situation as a whole rather than analysis of its parts or elements. To the expert, then, "things appear salient not according to some objective *a priori* criteria but depending upon the particular situation and concerns of the actor" (1988a: 270). Gordon calls this context-specific, embodied, and often intuitive grasp of what is salient "situational understanding," and argues that it is a key quality of the clinical expert. She also challenges the notion that knowledge can be gathered or deployed in a neutral or "objective" manner; rather she points to Polanyi's notion of "personal knowledge" to highlight that the known is always co-constructed with and through the knower, and that decisions are never neutral. Thinking of expertise as a process of engagement highlights the ways that known and knower become entangled.

Thus, Gordon questions the dominant view in western science and medicine that explicit, quantitative, formal knowledge expressed as "rules" or guidelines is more objective, rational, and value-free (and therefore more valuable) than knowledge that is implicit or tacit. By associating themselves with the "clinical science" approach to medical practice, physicians also draw upon this highly valued "scientific" knowledge as a source and symbol of legitimacy and power. Yet this alignment creates its own tension, as formal, quantitative, "rational" approaches to medical decision making and practice also reduces physicians' individual autonomy and makes them subject to the same statistically-based audit techniques of surveillance and monitoring that were once primarily targeted toward patient populations (Gordon 1988a). In the process of acquiring a "scientific" medical gaze, physicians become both the subject and object of that same gaze. A certain democratization of expertise takes place under the clinical science episteme, where formal, explicit, quantifiable notions of physician behavior open them up to examination and questioning by patients, hospitals, insurance agencies, and other physicians (Armstrong 1977).

Gordon draws upon her own ethnographic observations as well as published research to show that rather than act according to the "clinical science" or "clinical expertise" epistemes exclusively, in practice physicians tend to tack back and forth, strategically engaging each notion of medical knowledge and practice depending on the situation. Although formal models and theories of medical practice might downplay or make invisible the importance of intuition, situational understanding, and experience by clinical experts as they make decisions about patient care, in reality these tacit, personal knowledges cannot be so easily discarded. Gordon shows how, in western medicine, expertise must be understood as both a political as well as epistemological claim.

Benner and Gordon highlight several different yet overlapping forms of engagement that are involved in producing expertise. First of all, these authors show that expertise is an embodied skill that involves certain situational, personal, implicit entanglements and involvement with events, processes, and contexts. This kind of embodied engagmement must be learned; it is not simply a function of having a body, but of using that body to engage with people, objects, and different types of knowledge and knowing in very specific ways. Yet this embodied engagement is dynamic rather than static, as experts must learn how to see, feel, hear, act, and speak in situations that are always evolving and changing. Further, Benner and Gordon show how "becoming expert" also requires engaging with the structures, norms, and demands of the hospital and the health care system, as well as hierarchies of value that rank some forms of knowledge and expertise more highly than others. However, as I noted above, engagement not only encompasses notions of entanglement and involvement but also of conflict. The nurses that Gordon and Benner study, as well as the authors themselves seek to push back against and oppose the dominant view in western medicine that "knowing that" is more valuable than "knowing how." For Benner and Gordon, clinical expertise entails engaging with different situations in order to develop experience, becoming engaged and entangled with different ways of knowing and types of knowledge as well as a variety of institutional norms, values, requirements, and power structures.

However, I want to push Benner and Gordon's work further by questioning the fixed and static nature of the category of "expert." Instead, I adopt a view of expert engagement as a process that is ongoing and involves constant negotiation. I want to push even more on the idea that expertise is always entangled in historical and cultural trends that determine which kinds and areas of knowledge are valued, thus shaping the very conditions of possibility for the ways that certain kinds of experts can think and act. Even further, the bodies that acquire skill and are engaged in becoming-expert are themselves also culturally embedded, with relevant biographies, genders, races and/or ethnicities, and ages (Selinger and Crease 2002: 260). Finally, and perhaps most importantly for my own research, I want to consider expertise not as something a single person achieves or learns, but as something that is produced through engagement with other actors, both human and non-human. To be an expert, one must not only enact that expertise for others, but also have that enactment recognized *as* expert by others. Expert engagement, therefore, is mutual and co-productive. In order to explore these notions further, I engage with the work of anthropologist Tanya Luhrmann.

<u>Expertise: Luhrmann</u>

In her book *Of Two Minds* (2000), Luhrmann explores how psychiatrists in the U.S. learn how to see *as* psychiatrists. Like Gordon and Benner, Luhrmann views clinical expertise an entanglement of knowing and doing, involving constant negotiation between formal rules and explicit knowledge (in the case of psychiatrists, embodied in the DSM) as well as experience and instinct. Also like Gordon and Benner, Lurhmann is attentive to the ways that expertise is shaped by broader structural forces and trends. Specifically, she traces how psychiatrists emerged in the U.S. as widely accepted experts trained to diagnose and treat mental illness through complex processes of professionalization and institutionalization, involving the careful construction of boundaries separating medically-trained psychiatrists from non-medically trained psychologists and others. Adoption of the rhetoric of biomedicine and evidence-based scientific research was also a strategy used by psychiatrists to improve their place in the hospital power hierarchy.

Yet Luhrmann goes beyond Benner and Gordon by viewing expertise as not only embodied but also as a kind of affect or a "way of seeing." This affect, for Luhrmann, is based on experience that both guides and shapes how psychiatrists think and act. In

Luhrmann's work, we see the emergence of another aspect of expertise as a process of engagement that I alluded to above: the cultivation of a certain mode of attention. For example, Lurhmann writes, "Psychiatrists are taught to listen to people in particular ways: they listen for signals most of us cannot hear, and they look for patterns most of us cannot see" (2000: 23). Thus, thinking of expertise as a process of engagement enables me to highlight the ways that experts develop a specific form of attentiveness, of looking and listening in certain ways for certain patterns and signals.

Yet for the psychologists Luhrmann studies, becoming an expert involves not a single way of seeing but the cultivation of multiple modes of attention. She found that psychiatric residents are trained in two different approaches to psychiatric expertise, which she identifies as the pharmacologic model and psychotherapeutic model, which teach students of psychiatry "to listen and look in different ways," (Luhrmann 2000: 2). Luhrmann shows how a single psychiatrist can employ multiple forms of expertise, and demonstrates that these modes can both challenge each other as well as form "uneasy alliances" (2000: 7). Expertise in psychiatry, then, involves multiple modes of attention, producing experts that can "see" in more than one way. But these different ways of seeing also involve different ways of acting; further, each approach "changes the way doctors perceive patients, the way society perceives patients, and the way patients perceive themselves" (2000: 23). Thus, these expert ways of seeing or modes of attention also entangle both the subjects and objects of that attention, blurring the boundaries between both.

By engaging multiple lenses, psychiatrists are able to shift and combine multiple ways of being expert. The difficult task for these clinicians is then how to negotiate between these multiple ways of seeing, given the variety of possibilities for thinking and acting that these lenses make available. Here, Luhrmann opens up a space for doubt and uncertainty within the category of "expert." In fact, she argues that quite often expertise is defined by both certainty as well as uncertainty. She quotes one psychiatric resident as saying, "The more I know my patients, the less I diagnose them. The closer you get, the less helpful it is to classify and the more you doubt the classifications" (Luhrmann 2000: 56). Similarly, she writes that "different senior psychiatric experts have widely diverging ideas about what they are treating and how to treat it" (2000: 53).

Doubt, here, is produced simultaneously with expertise at both the individual as well as at the "expert community" levels. Thus, the affect/engagement/mode of attention of the expert is marked both by intuition and certainty as well as doubt and uncertainty. Yet the boundaries between "knowing" and "not knowing" are largely determined by the expert lens that is being engaged, and these boundaries shift and become blurry as these different lenses are used and combined. For example, in the psychotherapeutic episteme diagnostic categories are considered fluid, unreliable, and even irrelevant, while in the pharmacologic model of mental illness, specifying a diagnosis is central to how psychiatrists think about and treat patients (Luhrmann 2000).

Yet socioeconomic conditions also frequently shape which kinds of expert gaze are used. At a community hospital that provides care to disadvantaged patients, Lurhmann found that the volume of people needing care is so large and the rate of patient turnover so great that psychiatrists have little time to do anything else except administer medication. The pharmacologic expert lens dominates in this context, not due to psychiatrist preference, but because of larger institutional and structural demands.

Luhrmann emphasizes that there are important consequences to engaging different expert modes of attention, writing that "it matters a great deal how a psychiatrist is taught to look…because the 'how' cannot be clearly separated from the 'what' of the disease" (2000: 10). Thus, expert ways of seeing are shaped by the structural situations in which both psychiatrist and patient are located.

Identification as an expert depends on both individual and collective acts of judgment. For example, Lurhmann notes that "when I was spending time with psychiatrists, there were some whose inferences I'd have trusted absolutely and others who I though were selling snake oil" (2000: 52). Being an expert, then, involves more than gaining mastery of valued knowledge or developing a specific mode (or modes) of attention; it involves convincing others of one's status as expert at both group and individual levels, and engaging in relationships of trust. Despite the fact that all the psychiatrists Luhrmann interacted with had undergone similar processes of institutional and professional education and licensing that confer the label 'expert' on the profession of psychiatry, on an individual level she trusted some psychiatrists and not others.

Clinical expertise emerges from Luhrmann's analysis as a complex and multifaceted way of seeing that involves certainty as well as doubt, and is shaped by specific socioeconomic conditions and institutional structures. She also shows that these interactions and relationships are constantly in flux, helping to trouble the notion of "clinical expert" as a homogenous or stable category. However, despite mentioning that trust plays a role in her own evaluation of experts, Luhrmann does not elaborate on or analyze the importance of trust in shaping notions of expertise.

I will examine the role of trust in the process of negotiating jurisdictions of expertise at both the individual and group levels in more depth in Chapter 7. Here, however, I highlight that, unlike Benner or Gordon's notion of expertise as embodied or Luhrmann's characterization of expertise as a way of seeing, my notion of expertise as a process of engagement argues for trust as an important component of establishing and maintaining claims for expertise.

In addition to meaning to entangle or involve, to enter into conflict, or to occupy the attention of, "to engage" can also mean to pledge, promise, or obligate. As a process of engagement, becoming an expert also involves engaging in relationships of obligation and responsibility with others. David Mechanic, in his article on the role of trust in medicine, writes, "To say we trust is to say we believe that individuals and institutions will act appropriately and perform competently, responsibly, and in a manner considerate of our interests" (1996: 173). Trust involves an expectation of behavior in the future and so involves states of risk and dependency (Luhmann 1979). As a process of engagement, expertise involves a pledge or obligation to act appropriately on behalf of a specific person or group of people. As STS scholar Barry Barnes points out, "Experts are trusted specialists who carry a differentiated body of knowledge and competence on behalf of those who trust them and accord them the standard of experts by way of signifying that trust" (Barnes 1999: 52). Thus, claims for expertise are underpinned by relationships of trust that are both interpersonal as well as institutional, and involve complex negotiations of risk, dependency, obligation, and responsibility.

Yet relationships involving trust, risk, dependency, obligation, and responsibility dwell in institutional and other situations rife with hierarchies and asymmetries of power.

Assertions of expertise, then, are as much about power as they are about knowledge and skill. Consequently, "the *claim* to expertise itself involves a social demand; it is not merely a neutral identification label but a declaration that others should defer to the expert's judgments…an expert is not only 'in' a field but 'for' an audience" (Selinger and Crease 2002: 264).

In expert engagement, the subjects and objects of expertise are entangled in complicated, ever-fluctuating networks of power. This is especially true in biomedicine, as Gordon and Luhrmann acknowledge. The ability of medical practitioners to classify behaviors and bodies into categories of "normal" and "abnormal," to assign diagnostic labels, to define and describe states of "health" and "disease" at both the individual and the population level represents a potent source of power in western society (Foucault 1971, 1973, 1995). As Foucault argues, "There is no power relation without the correlative constitution of a field of knowledge, nor any knowledge that does not presuppose and constitute at the same time power relations" (1995: 27). Engaging with and making claims over a field of knowledge, then, points toward the inseparability and mutual production of politics and epistemology in biomedical expertise, and indeed throughout society.

Thinking of expertise as a process of engagement enables me to move away from and trouble discourses that portray expertise as purely cognitive as opposed to embodied, as a quality of individuals rather than as co-produced by networks of interactive entanglements among people, objects, and institutions, and as static rather than being constantly negotiated through both conflict and cooperation. Expertise as engagement involves developing certain modes of attention that shape both the objects and subjects of that attention, and also requires the ongoing negotiation of trust and responsibility, obligation and power. Equally importantly, expert engagement both produces and is produced by and through interaction. Luhrmann concludes that “people are never ‘in themselves’ to other people. Who they are is mediated by the person *to whom* they are, by the way they are understood, responded to, engaged with” (2000: 275).

Becoming experts: Radiology from 1895 to the Early 2000s

Almost as soon as X-rays were discovered 1895, struggles about jurisdiction over the interpretation of X-ray images were underway (Pasveer 1989; Larkin 1978; Reiser 1978; Golan 2004). Not only did early proto-radiologists need to convince physician colleagues of their superior skills at interpreting images, they also needed to establish X-ray images as important diagnostic tools that *required* interpretation (Blume 1992). These disputes were not only about controlling a new technology, they were about who could ultimately claim expertise over the process of diagnosis itself. X-rays were a diagnostic technology that directly challenged what had formerly been the primary means of diagnosis – the physical exam (Reiser 1978: 63). In addition, X-ray images also challenged other sense-based approaches to diagnosis, such as auscultation via the stethoscope or percussion of the lungs (Reiser 1978: 65). Thus, physicians were both drawn to and threatened by this new technology. However, the stakes for physicians and others involved in this struggle should not be underestimated, given the central importance of and power associated with diagnosis throughout biomedical history (Rosenberg 2002). From the very beginning, the power of medical images and the power of radiologists shaped one another.

The acceptance of X-ray imaging as an authorized and trusted diagnostic tool was aided in large part by the increasing instrumentalization of medicine during the turn of the 20th century, as well as the increasing centrality of vision to medicine and to the sciences more broadly (cf. Cartwright 1995; Fyfe and Law 1988; Latour 1986; Lynch 1985, 1998; Lynch and Woolgar 1990;). Blume argues that the introduction of such implements as the thermometer, the ophthalmoscope, and the sphygmomanometer enabled the practical and intellectual components of diagnosis to be separated and delegated. With these instruments, a non-physician assistant could gather measurements, "leaving the physician to apply diagnostic skills to the interpretation of the data generated" (Blume 1992: 15). Thus, in the late 1800s and early 1900s physicians were becoming increasingly familiar with technologies designed to measure and produce data, and were crucial in the campaign to portray medicine as a science. In addition, visual evidence and vision were becoming increasingly recognized by physicians as the primary means of evaluating patients (Foucault 1973; Reiser 1978; Golan 2004; Daston and Galison 1992).

However, the X-ray image quickly emerged as the site of an important tension that has persisted throughout the history of U.S. biomedicine, between medical images as photograph-like reflections of the inner "reality" of the body and the recognition of these images as being technologically-mediated representations needing expert interpretation (cf. Reiser 1978; Golan 2004; Dumit 2004; Joyce 2008). Interestingly, it was in the courtrooms that X-ray images emerged as something that required expert interpretation and where the authority of radiologists to be the authorized interpreters of X-ray imaging was advocated and solidified. Yet as Golan (2004) points out, the eventual determination by the courts that X-rays required interpretation by a radiologist was anything but straightforward. Initially, X-rays were considered to be a type of photographic evidence that jurors could view for themselves. However, as physicians interested in radiology began to organize into groups and argue that the interpretation of X-rays required a certain kind of expertise, court opinion began to shift.

The formation of such professional groups as the American Roentgen Ray Society in 1900 were crucial in resolving these boundary issues. It was around this time that medically associated professional societies argued that only doctors with special training in X-ray imaging should be allowed to interpret X-ray images (Golan 2004: 485). A line was drawn early on between the production and the interpretation of these images (Larkin 1978). Simply mastering the technique to produce the images was not sufficient; rather, one not only needed to know the details of anatomy and pathology, but also how what was considered the normal and the pathological appeared when imaged by X-rays (Golan 2004). Importantly, as Canguilhem (1989), Durkheim (1982), and Foucault (1973) have shown, what defines pathology and separates it from the normal is never given, but instead shifts according to the values, behaviors, and structures of certain people at particular times and places. In the case of the X-ray, radiologists argued that they should be the ones to distinguish the abnormal from the normal. Thus, the newly formed profession of radiologists argued that the X-ray image "has no intrinsic value. It is worthless, even dangerous, unless in the hand of one able to correctly interpret it" (Lange 1907: 79, as quoted in Golan 2004: 485).

Radiologists also struggled to become recognized as experts within the hospital. Largely invisible to patients, a radiologist's status as "an integral member of the health care team" was therefore not recognized at the same level (if at all) as a surgeon or physician (Howell 1995: 126). In response to these concerns, radiologists began generating imaging request forms to document the number of X-ray studies being ordered by physicians, and used these numbers to persuade hospital administrators of the importance of radiologists' work (Howell 1995). To further avoid being thought of as "photographers" rather than medical consultants, radiologists decided to charge for their interpretation of X-ray images, but not for the images themselves (Howell 1995). The radiologist's written report became not only a way to document and record radiologists' expertise, but also linked that expertise with payment (Yakel 2001). In fact, these two strategies for ensuring the status and identity of radiology within the hospital remain important in modern practice, and have become important "centers of accountability" (Yakel 2001: 236) for radiologists.

By 1920 radiologists had largely achieved control over X-ray imaging in the hospital, aided by the establishment of professional standards for education and training (Golan 2004). As Pasveer notes, "The institutionalisation and professionalisation of radiology was an important aspect of the convincing power of the images" (1989: 364). While the specialization of medicine began in the U.S. around the 1850s with the establishment of surgery and obstetrics as distinct fields of practice, it was the era from 1890 to the 1950s when specialization became the dominant form of medical practice (Weisz 2006). Radiologists both benefited from and contributed to this trend.

The profession of radiology continued to solidify and grow into the 1960s. During this time, imaging technology was characterized by gradual improvements to existing X-ray machines and imaging techniques, facilitating radiologists continued control over most medical imaging (Barley 1988). Like all other physicians, radiologists from 1920 to 1960 enjoyed a large degree of autonomy and authority in American society and benefited from the dominance of professional medical associations, which determined licensing and governed physician behavior (Mendel and Scott 2010).

However, the technological advances that occurred in the late 1960s, 1970s and 1980s, including the introduction of US, CT, PET, and MRI, represented critical disjunctures in radiological practice and knowledge (Barley 1988). Radiologists showed considerable enthusiasm for and interest in CT as soon as it was developed. According to Blume (1992), it was this early interest that enabled radiologist to quickly gain control of CT and guide how the technology was developed and used in the hospital. Radiologists also used their experience with radiation to argue that they were the most qualified specialists to oversee the use of CT, an argument afforded considerable weight after the 1950s and 60s when the dangers of radiation exposure were well documented (Kevles 1997).

Yet although based on similar principles as X-rays, the introduction of CT scanners heralded a series of major shifts in radiological practice and in how radiologists engaged with radiology technologists. Instead of looking at images of the body along the coronal and sagittal planes, radiologists had to learn how to deal with "slices" of the body (Saunders 2008; Burri 2008; Barley 1986). Additionally, unlike X-ray imaging, CT required computers for the images to be constructed. Barley shows how radiologists' inexperience with the new scanners and cross sectional imaging forced them to become more dependent on the radiology technologists, and how the technologists developed a degree of autonomy in their work (Barley 1986).

In contrast with CT which, despite being unfamiliar with tomographic processing and cross-sectional imaging, radiologists quickly adopted and successfully controlled, claims over the creation and interpretation of ultrasound images have been and continue to be multiple and overlapping. In fact, the development of medical ultrasound occurred simultaneously within a variety of specialties including obstetrics, neurology, cardiology, and radiology (Blume 1992). Several of these specialties, especially obstetrics, saw the adoption of ultrasound as an opportunity to become less reliant on radiologists in their work (Blume 1992). Rather than concentrating solely on radiologists, the manufacturers of ultrasound machines marketed them to a range of professional groups, and their relatively low cost (in contrast to CT and MR scanners) made the technology fairly accessible. Additionally, non-radiology physicians argued that because ultrasound did not rely on radiation, its use did not require supervision by radiologists.

Radiologists, however, were not willing to give up control of ultrasonography without a struggle. Against their colleagues in obstetrics, neurology, and cardiology, radiologists argued that they had more experience with imaging technologies, a better knowledge of anatomical structures and the appearance of pathology on imaging, and considerable expertise converting the two-dimensional images produced by ultrasound into three-dimensional understanding of bodily structures (Burri 2008). Interestingly, turf battles over who is able to perform and interpret ultrasound exams have still not been resolved, and are largely determined on an institution-by-institution basis.

Like ultrasound, the introduction of MRI scanners in U.S. hospitals also involved struggles over who would control the technology and interpret the scans. While radiologists were "early adopters" of NMR/MR, nuclear medicine physicians, internists, and pathologists were also competing for control (Joyce 2008). Interestingly, data generated by early MR scanners was primarily numbers, but radiologists successfully argued that the machines should produce black and white images instead, which they were used to from CT and X-ray (Joyce 2008; Burri 2008). Political lobbying by radiology professional societies, especially the American College of Radiology and the Radiological Society of North America were powerful influences in securing radiologists as the primary "controllers" of MRI (Joyce 2008: 37).

In addition, due to the weight and size of MRI scanners in the 1980s and 1990s and the need for magnetic shielding in the walls and floors, many hospitals chose install the equipment in the basement. Many radiology departments were already located in hospital basements due to the requirements of developing film, further facilitating arguments by radiologists that they should control the technology (Burri 2008). Radiologists also argued that they had extensive knowledge of anatomy as well as a large amount of experience with digitized cross sectional images gained from work with CT, and thus were the most appropriate medical professionals to interpret MRI (Burri 2008).

Using all these strategies, radiologists were able to establish professional jurisdiction over the production and interpretation of MR images. However, after several years of use in the hospital, further technical developments enabled some degree of 'black boxing' of MRI, which enabled the technology to separate from academic medicine and become available for purchase by other kinds of medical specialist groups, like cardiology, neurology, and orthopedic surgery (Burri 2008). This expansion was partially driven by the desire of equipment manufacturers to enter into "new" markets and partially by specialist groups who wanted their own scanners, so they could become more independent from radiologists and increase their income. Radiologists responded to this “diffusion” of MR (and CT) technology by adding an economic aspect to their claims for expertise, positioning themselves not only as visual experts, but also as financial experts who were dedicated to reducing the overuse of medical imaging and thereby reducing the cost of health care (Burri 2008: 44).

This strategy is not surprising considering that radiologists, like other physicians, had to adjust to the profound shifts in how medical practice was organized, regulated, and paid for. From the mid 1960s (when Medicare and Medicaid legislation was passed) until the early 1980s there was an enormous increase in the power of the federal government in health care regulation and funding, which supplanted the control formerly enjoyed by private groups and professional medical societies (Mendel and Scott 2010). The cost of health care became a primary concern, culminating in the introduction of managed care in the late 1980s and early 1990s. Radiologists, like other groups of medical practitioners, struggled to maintain their autonomy as health care shifted to an institutional system focused on efficiency and cost reduction.

In summary, radiologists as a group have relied on several kinds of engagments to establish and maintain their jurisdictions of expertise over medical imaging. The ability to control the imaging technology itself and determine who has the ability to engage with and use this technology has been a key source of both symbolic and economic capital for radiologists (Blume 1992; Burri 2008). Engagements with equipment developers and manufacturers have been key to sustaining this control, often enabling radiologists to dictate the nature and form of the images produced by new technologies. Equally important have been radiologists' engagements with hospital administrators to ensure the placement of imaging machines within radiology departments.

Yet successfully engaging new imaging technologies involves more than the ability to direct their placement and shape their output. It also requires that radiologists engage with images themselves in new ways and develop new modes of attention and ways of seeing (Dumit 2004; Burri 2008; Prasad 2005). These new forms of visual expertise are built on older claims for knowledge of anatomy, pathology, physics, and radiation. The courts have provided important and ongoing support of radiologists as expert witnesses who are authorized to interpret medical images to juries. In addition, through the development and strengthening of their professional groups, radiologists have also been successful in lobbying state and federal government agencies to support and protect their role as experts in medical imaging.

But what of the everday engagements that support, challenge, and make blurry these jurisdictions and boundaries of radiological expertise? As I argue above, expertise requires engagement not only among professional groups, institutions, governments, and economies writ large, but is negotiated through daily, embodied entanglements of people, practices, and technologies. In the following section, I explore how the daily engagement and interaction among images, radiologists, and clinicians produced expertise before PACS.

Characterizing radiological expertise pre-PACS

By the time I began looking for possible field sites in which to conduct my own research in 2010 and 2011, the only medical facilities I could identify in the western U.S.

without PACS were limited to a few isolated rural clinics, and most of these were in the process of installing such systems. This dramatic expansion of PACS from a handful of academic hospitals in the mid-1990s to almost complete adoption across the U.S. by 2010 is noteworthy and further examined in Chapter 2. For the purposes of this chapter, however, it explains why in order to characterize the practice of radiology before PACS, I draw on a variety of sources, both primary and secondary. These sources include the reminiscences of my informants, descriptions in articles and books, and perhaps most importantly, the detailed ethnography of pre-PACS radiologic practice written by anthropologist-physician Barry Saunders, *CT Suite* (2008).

In many ways, the study Saunders produced might be considered (retrospectively) a kind of 'salvage ethnography,' documenting a series of objects, practices, and interactions that no longer exist. Based on research in the late 1990s at "University Hospital," a large, urban, tertiary-care academic medical center, *CT Suite* (2008) explores how CT scanners shaped medical practice. Saunders is especially interested in the various activities united under the label of "reading"- that is, how medical images become knowledge or evidence through certain rituals and 'suites' of practices centered in the CT reading room.

However, by the time of the book's publication in 2008, Saunders was aware that much of what he observed in the CT reading room had changed radically with the introduction of PACS. Hints of this impending transformation are to be found throughout Saunders' text, primarily through the occasional appearance of the "MagicView" system, which allows radiology technologists and radiologists to view CT images on a computer monitor before they are printed to film. Acting as an occasional supplement to film-based

CT, "MagicView" can best be described as a PACS module or mini-PACS (See Chapter 2 for a discussion of PACS types) that was used primarily to confirm that a study was complete and of sufficient quality before the patient was allowed to leave the scanner area. Yet despite the presence of "MagicView," the medical imaging done at University Hospital in 1996-97 remained almost entirely film based (Saunders 2008: 175).

Saunders' book has served as an important starting point and interlocutor for my own project. For the purposes of this chapter, it is significant that we both conducted most of our research in U.S. academic hospitals with large, sub-specialized radiology departments with a wide variety of imaging modalities and imaging-based practices. In addition, each of these hospitals has reading rooms in different parts of the hospital dedicated to different types of imaging.

However, despite these similarities, it is important to stress the individual, specific, and local nature of different hospital "cultures" in the U.S. and that struggles over hospital "turf," - whether physical, conceptual, or practice-based - are negotiated differently in each hospital. For example, the radiology departments at University Hospital (where Saunders' study was set), Central Hospital (where my research was conducted), and the hospital where I attend medical school all divide up responsibility over image interpretation and image-based procedures in different ways. At City Hospital, imaging of the spine is sent to either the Musculoskeletal Radiology Group or the Neuroimaging Group, depending on which service (Orthopedics or Neurosurgery) referred the patient for imaging. Radiologists in different specialty groups are not asked to read images outside of their specialty area, so a musculoskeletal radiologist, for example, would never be asked to read body studies or chest studies. The only exception to this rule is for weekend shifts, when a single radiology attending supervises a handful of residents and is responsible for reading any studies performed during this time.

In contrast, Saunders writes that at University Hospital, all head and spine films are reviewed by the radiologists in the Neuroimaging reading room, but that sometimes the radiologists in the Body CT reading room are asked to supervise residents and interpret films in other areas. Jurisdictions over medical procedures also tend to be worked out on a hospital-by-hospital basis, where lung biopsies might be done by chest radiologists at one institution and by pulmonologists at another. These arrangements tend to be based on specific and constantly shifting alliances, contingencies, and histories among physicians, departments, and administrators.

Yet despite these differences, it is possible to draw on the observations and analysis of Saunders and others to more generally characterize the practice of radiology and interactions in the reading room before the widespread adoption of PACS. With this in mind, I turn to Saunders' ethnography and the recollections of my own informants to more fully characterize the daily practices and interactions that defined radiologists' expertise before PACS.

<u>The reading room: flows of people and images</u>

Saunders' ethnographic observations are primarily set in the Body CT reading room at University Hospital. This particular reading room is located across the hall from the CT scanner itself and the control room attached to the scanner (see Saunders 2008: 189 for a map of the CT suite). This is a common arrangement found in many hospitals. As Saunders states, "The major reason for keeping the reading room close to the scanner room is the possibility of allergic reactions to intravenous contrast…Also, some patients brought to the scanner are quite ill. Sudden emergencies are uncommon, but they occur – and when they do, the closest physicians are often the CT reading room team" (2008: 64-5). Another reason to place the reading room and scanner close to each other is to facilitate "timely film flow" from one place to another and back again (Saunders 2008: 55). Yet the location of reading rooms next to the imaging machines themselves can also be explained by both practical and political concerns. Burri points out that locating imaging technologies like MRI within departments of radiology enabled radiologists to claim the technology when it was first introduced, as well as enable them to monitor and control access to the machines (2008: 43). Often the sheer weight and size of the scanners (both CT and MRI) required that they be located in hospital basements where, more often than not, reading rooms were placed as well.

Reading rooms themselves tended to be quite dark, with the overhead lights usually turned off to facilitate better viewing of films. Rows of viewboxes on the walls provided ambient light (Saunders 2008: 13). While the walls of a reading room might be covered with departmental memos, lists of phone numbers, or whiteboards for teaching, most were dominated by viewboxes. Saunders describes the viewboxes in the CT reading room at University Hospital as offering "four panels (14" x 17") of backlighting, with a motorized mechanism to allow rapid scrolling through many films" (2008: 153). These motorized viewboxes, also known as film alternators, enabled radiologists to quickly examine multiple associated sheets of film, such those produced by CT scanners. On of my radiologist informants that I'd never seen an alternator and tried to describe it to me, saying:

> So in the reading room, you'd either have a room full of viewboxes, and you would just try to put up all the images around you and then walk from viewbox to viewbox, trying to remember what you'd seen. Or, you'd have a couple of alternators - they were these huge machines that had four to eight actual light boxes that you could load like 50 or so films in. So a panel would come up and you would see eight images and you have more films than that, so you push a button and that goes down and another comes up. It was fine when you were just reading chest X-rays, you have a PA and a lateral[10] and you had another PA and lateral from the old exam so you could make your comparison and you they were hung that way so you had the two laterals, the old one and the new one, and two frontal views, old and new, and they were side by side. But when you are dealing with CT and you have lots of images, or an angiogram, then you need a way to be able to see lots of films without having to constantly take down and re-hang them.

A sheet of film is generally the size of a standard viewbox window. For CT or MRI, which produce many "slices" of the body instead of just one image, there can be anywhere from 8 to 24 slices arranged in a grid pattern on a single piece of film (Hillman and Goldsmith 2011: 113). Unlike a sheet of paper or a photographic print, films are surprisingly heavy and can be awkward to manipulate. At the time of Saunders' ethnography, an average CT study consisted of 6 film sheets displaying 12 slices per film (72 total) and weighed approximately one pound. A patient who has had multiple imaging studies may have a film jacket (the folder where each patient's films are stored) that weighs over five pounds (Saunders 2008: 329, note 11).

In the CT reading room at University Hospital, individual radiologists tended to sit in chairs when interpreting images, or in clusters if an attending radiologist and radiology residents are engaged in teaching/learning (18). Postures and minute

[10] PA and lateral are notations indicating the placement of the film relative to the patient when the image was taken. PA stands for posterio-anterior and indicates that the X-rays enter through the posterior/back of the patient, and exit out the front, where the film is located (the patient stands with her back to the X-ray source and her front pressed against the film). In a lateral view, the patient would stand with her left side pressed against the film, with both arms raised.

movements are important to the enactment of expertise, where “sitting is a posture of method – and of being at home at the viewbox. Legs tucked under the writing surface, feet on the floor” (Saunders 2008: 18). Where one sits in the reading room is equally important as how one sits: senior radiologists tend to sit further back from the images, emphasizing an expertise in “seeing,” while trainees tend to sit closer (Saunders 2008: 16).

In contrast, visitors to the reading room usually stood when reviewing films (Saunders 2008: 18). Visitors were primarily referring clinicians. While radiology technologists frequently came in and out of the reading room to deliver films or ask questions, they were not considered “visitors.” As Saunders illustrates, the presence and comments of technologists were often ignored by radiologists as they worked (2008: 55). Also absent from the reading room were patients, who encountered their images in other settings, if at all. Yet despite being somewhat isolated in hospital basements, reading rooms were visited frequently by both individual referring physicians and physician teams. During an interview an older radiologist who had been practicing since the 1970s told me “Before PACS, all the clinicians had to come to radiology to see films, and our days were spent in face-to-face contact with clinicians.” Similarly, a neurologist who was about the same age said, “We [the neurology team] used to, at the end of rounds, go downstairs [to the reading room], and the last thing we’d do on rounds was to review all the films of the day with the radiologist.” My informants’ memories of the reading room as a busy place punctuated by frequent visits from clinician colleagues is also reflected in Saunders’ ethnography. He writes:

> A CT reading room is a watering hole in the savanna: different beasts come and drink, perhaps mingle, look warily at competitors, move on. Clinician visitors

> come to look at films and "pick the brains" of radiologists. These clinicians represent various sections and services of the hospital: Renal Consult, Pulmonary, Medical ICU, the Liver Transplant Team, and so on. All these formations, and more – constituted around clinical disciplines and service regimes – send emissaries to CT viewboxes. For some services the pilgrimage to the viewbox is routine. On Pulmonary Consult service it is a rare day with no chest CT to review; Neurology likewise travels to the Neuroimaging reading room at least daily. Some services give greater weight to collegial interaction, some to direct viewing of images. [2008: 54]

As Saunders emphasizes, going to the reading room to review images was an important part of daily practice for clinicians.

Many scholars in STS have pointed out the central place occupied in science and medicine by practices of "seeing for oneself" or witnessing (cf. Shapin and Schaffer 1985; Haraway 1997; Dumit 2004; Daston and Galison 2007). In fact, Foucault himself interrogated how, in the clinic, seeing became the primary way to 'know' about patients and disease through the development of the medical gaze (Foucault (1973). While I discuss this link between seeing and knowing in more depth in Chapter 1, I want to highlight Saunders' point in the quotation above because, for many clinicians, engaging with medical images firsthand was an important reason to visit the reading room. Film images were precious commodities in the hospital because there was often only one copy. In general, radiologists had first "dibs" on images, and so clinicians who wanted to take films elsewhere in the hospital often had to negotiate with the radiologists. For example, an Emergency Medicine doctor I interviewed recalled:

> When I was a medical student during my surgery rotation, one of the things that they would do is send the medical student out to get the imaging for the case. They would say, "we want the CT," and at that time it was hard copy film. So I was sent out on a mission to find the study and bring it back to hang up in the room. This was 2 o'clock in the morning or something and I found a radiology resident who was dictating studies and she wouldn't let me have it, she hadn't dictated it yet so she said, "you can't take that, I haven't dictated it yet!" So we looked at it, she put it up [on the viewbox] and we kind of looked at it together,

> but I guess it's true it required some face-to-face interaction, because you had to physically go and get the studies.

Saunders calls this practice of seeing for oneself "autopsis," but he also stresses that this practice involves not just of seeing but of testifying and saying what one has seen or acting as an eyewitness (2008: 16). Saunders underlines that the "ocular witnessing" that occurs in the reading room is not just an individual engagement with images but is a social event. Thus, "If autopsis connotes self-possessed direct observation, it also connotes a problematic of persuasion and reception, a performative milieu in which the veracity of the viewer is not so much presumed as it is at stake" (Saunders 2008: 17). Therefore, even clinicians who visit the reading room "just" to look at images (as opposed to engaging radiologists in direct consultation) are involved in a broader network of engagements involving witnessing, testifying, and persuading.

Upon entering the reading room, a visiting clinician was "usually greeted by one of its occupants. There may be a delay – depending on the time of day and engagement of radiologists. If a visiting clinician knows what she wants – goes to the unattended viewbox, finds a particular study, inspects it, and leaves quickly – she might elude greeting. But on most occasions, a visitor will be offered assistance" (Saunders 2008: 53).

Residents tended to handle more routine and basic tasks while attendings generally greeted visitors. Saunders comments, "Radiologists' host manners reflect departmental ownership of the reading room and traditions of consultative service: theirs is a 'shopkeeper' habitus, one which acknowledges that professional strangers are key clients. Some clients become familiar, and guest-host relations can be genuinely warm. Yet radiologists' manners are not necessarily deferential: they are inflected with the power of the shopkeeper as well" (2008: 54). Ownership and control of images lends power to radiologists as they interact with other physicians.

Assuming that the visiting clinician or clinical team would like a particular imaging study reviewed for them by a radiologist, the radiologist's display of expertise could begin almost immediately, with the way he or she handled and hung the films - radiologists' embodied engagements with films. The ability to competently and smoothly handle and hang films emerged as a fundamental skill in the reading room and not just for the sake of efficiency and moving things along. Saunders shows how the adept handling of film was also a way for radiologists and radiology trainees to assert expertise. He writes that "handling film is (in the 1990s) part of radiological craft – an aspect of expertise as valuable as card handling to a poker player. Dexterity serves work flow – and displays competence" (Saunders 2008: 65). There were unwritten rules about how films were to be organized on the viewbox; knowing these rules, which may differ from hospital to hospital or even between reading rooms in the same hospital, signaled "insider" status in the realm of imaging.

In his typically lyric prose, Saunders describes the skills involved with film handling:

> Knowing where to look on the film for patient-identifying data; knowing how to correlate the last slice on one panel with the first slice of another; swiftly recognizing left and right, forward and backward; knowing guild conventions for "mounting" – old study left of new, non-contrast before contrast, soft tissues windows separate from bone. But it also involves gestural knowledge – how to push a floppy film through the air with the fingers and slip it beneath the monofilament retainer on the board – or how to slip in a small stack and spread it out with one sweep of the hands. [Saunders 2009: 153-4]

As one of my radiologist informants pointed out, keeping films organized was a difficult and time-consuming but essential task in the reading room, especially given the busy traffic of physicians wanting to see certain imaging studies:

> So, you are putting up a CT scan and you are comparing it to an old CT scan and they [the films] are all mixed up- it's like they were almost shuffled. Every film is out of order and upside down, and then someone has mixed two studies together, and you are trying to figure out if that film actually goes with this other film, and you are sitting here doing this on a view box. It was really difficult, but it was the way we were all used to doing it. Then, somebody comes in and wants to see an exam, and there's no other way for them to see it but come to the reading room. So you would be reading the exams and trying to get through the day and clinicians rightfully would come over, and we'd have to stop and find the study they want to look at, and go through the whole thing again.

Once the films are properly organized and hung on the alternator, the radiologist could then proceed with "reading" or interpreting the images. For radiologists the proves of "reading" involves many activities in addition to gazing at images. In the reading room seeing is linked to saying, writing, and gesturing. The gaze of the radiologist is fully embodied and always moving, always "scanning" among the various components of the reading room and the image itself. As Saunders writes, "Radiologists look back and forth between films and folders, films and texts" (2008: 21).

Yet Saunders reminds us that "it would be a mistake to apprehend the viewbox "gaze" as a simple, coherent, or merely visual experience. Looking comprises a multiplicity of gestures, especially pointing. Even without a patient's body at hand, the visual/visible is intertwined with the speakable/audible and the tactile/touchable" (2008: 18). Rather than simply the act of one specialist interpreting an imaging study for another specialist, engagement in front of the viewbox is rich with wide-ranging "social features" (Saunders 2008: 52), including host/guest relations, interspecialty relations, the logistics of patient care, and academic hierarchies. Friendly greetings, exchange of jokes, "small talk," and gossip can help to set the stage for the exchanges of clinical and imaging information and expertise.

Radiological expertise, then, involves a specific mode of attention in which a certain way of seeing is engaged with a certain way of saying and a certain way of acting. Saunders also shows how regimes of writing and marking are just as significant in constituting the expert radiologist gaze. For example, he shows the importance of radiologists' marking of films with a wax pencil while reading, arguing that the circles, numbers, and lines drawn on the film by the radiologist were a kind of territorial marking, a staking out of professional space (2008: 76). The marks directed the gaze of those who viewed the film after the radiologist, thereby differentiating between the significant and the unremarkable. Thus, something as simple as a circle drawn around a suspect lesion served to link the medical image itself with the interpretation provided by the radiologist in the reading room. Since images traveled widely in the hospital, these markings helped suture together radiologists' claims for expertise in interpreting medical images with the images themselves in ways that extended beyond the reading room.

Yet like patients, films were "clothed" when not being examined or moved around the hospital. The film "jacket" or folder - a large tan envelope - was used to organize films and protected them from unauthorized gazes. Saunders writes that "the film folder is like skin: a visible tangible outer layer, upon which superficial signs are inscribed: color, number, sometimes a procedure date and a brief 'reading' – enabling quick, summary grasping, more rapid channeling through the sociotechnical spaces of the hospital" (2008: 172). While seemingly trivial, a hastily scribbled synopsis of the radiologist's "reading" or interpretation on the film jacket serves a rather non-trivial purpose; to stake a visual claim over the image's interpretation that could be seen not just by other physicians but by couriers, administrative assistants or anyone involved in circulating imaging studies in the hospital.

Finally, there was the radiology report. This report was the tangible and legible product of the radiology gaze. The radiologist's report, both before PACS and today, follows a standard format that includes patient information, technique, findings, and impression. Creating a report that balances brevity with clinical relevance takes skill and experience. Saunders argues that "the typed report is the ultimate product of the radiological work regime. It is reviewed by a range of overseers: the clinician who ordered the study; consultants who peruse the chart; the CT attending… (Rarely by patients)" (2008: 75). The complexities and uncertainties of a case are often smoothed away in the report, retroactively bringing certainty and assurance to reading room engagements that are far "messier" in practice, as clinical data are correlated with radiological data. Although I focus more on radiologic reports in Chapter 6, I want to emphasize that the radiology report, as a "formal" document produced in the reading room, can simultaneously support the radiologist as the authorized interpreter or "voice" of the image while also serving to obscure or render invisible the complex work that interpreting images involves.

Conclusion

Through the above ethnographic observations and insights, we see how "reading" an image at the viewbox is not only a performance of a radiologist's expertise in interpreting medical images but an engagement among a variety of people and objects that together *constitute* that expertise. What emerges from Saunders' careful ethnographic analysis is the recognition that the expertise of radiologists in interpreting visual images and their ability to speak for and act as the "authorized voice" of those images is constituted (before PACS) through interactions among radiologists, clinicians, and images that take place in the reading room. It is through the production and performance of such "diagnostic intrigue" in front of the viewbox that relationships of individual and professional trust are built and maintained between radiologists and physicians, allowing radiologists to emerge as the authorized, trusted spokespersons of images. Therefore, the "read" or interpretation produced by the radiologist, the performance of this interpretation for clinicians in the reading room, and the image itself become bound together in the reading room, forming the core of radiologists' authority and power in the hospital.

This process that links radiologist, interpretation, image, and clinician is especially important considering Burri's (2008) research on radiologists' strategies to maintain professional authority when new imaging modalities are introduced. She found that "once the images leave the radiology department… they are out of the radiologists' control and no longer serve as a power resource unless they have already been transformed into reputation. This transformation is achieved when other actors acknowledge the skill a radiologist has demonstrated in interpreting a specific image" (Burri 2008: 49). Thus, it is through reading room interactions that the clinician's acknowledgement of the radiologist's expertise in "reading" images takes place, allowing radiologists to maintain images as a "power resource" even as they circulate beyond the reading room.

Mastery over a body of knowledge is not sufficient to maintain claims for expertise. Instead, these claims are embodied and produced through relations among schedules, rituals, dialogues, unspoken rules and hierarchies, postures, and gestures. Yet it is also important not to forget that these claims are always enmeshed in hierarchies of value and power relations, in which certain ways of thinking, speaking, and/or doing are viewed as "better" than others (Gordon 1988a). In the reading room attendings speak and residents listen, surgeons take priority over those deemed less "important," and certain radiologists are sought out for an opinion while others are avoided. Patients are excluded entirely.

When examining how radiologists established their control over medical imaging before PACS, a certain characterization of the medical image itself emerges. Unlike the popular narratives of imaging discussed by Joyce (2008), for radiologists the image is not transparent; rather, it requires a certain set of practices, performances, and encounters before it can be translated into clinical knowledge. Yet the image is also a symbol of the radiologist's power and expertise; by speaking for the image in front of an audience of clinicians, the authority of the radiologist and radiologists' control over medical images is established and maintained. Before PACS, the medical image was firmly tethered to the reading room, where it was created, spoken for, disciplined, and controlled by radiologists.

CHAPTER 4: Efficiency and Access: The Crisis of Relevance

The numbers

As soon as the first PACS stations were installed in clinical areas like the ICU, radiologists began to notice a marked change in physician behavior almost overnight. Concurrent with the ability to see images via PACS, clinicians drastically reduced their trips to the reading room and altered their patterns of communication with radiologists. For example, one study conducted by Kundel and colleagues (1991) tracked the methods and frequency of communication among radiologists and ICU physicians before and after a PACS station was placed in the ICU at the University of Pennsylvania Hospital. They found that before PACS was installed, physicians communicated with radiologists for 49% of ICU patients' films. After placing a PACS station on this ward, ICU physicians only spoke with radiologists directly, either face-to-face or by telephone, for 5% of films. Perhaps more significantly, Kundel and colleagues found that while clinicians in the ICU before PACS only acted on 5% of films without talking to a radiologist, after the PACS station was in place, 40% of film-based clinical decisions were made without consulting a radiologist (1991). In a different journal article based on the same University of Pennsylvania study, the authors concluded, "It is unlikely that display consoles scattered throughout patient care floors in a hospital will have a benign effect on the way medicine is practiced. More likely, the fruition of this technology will have a substantial impact on the logics of clinical practice" (De Simone et al. 1988: 44).

A series of studies conducted at the Baltimore Veterans Affairs Medical Center also looked at patterns of communication as well as the number of imaging exams ordered by physicians before and after PACS stations were placed in clinical areas

(Reiner et al. 1999; Reiner et al. 2000). The studies found that after installing an "enterprise-wide" PACS, the number of radiological studies ordered per inpatient per day increased by 82%, compared with a 11% increase nationally for the same year (Reiner et al. 2000). However, despite this increase, they also found that after PACS was installed there was an 82% reduction in the rate of face-to-face consultations with radiologists by physicians (Reiner et al. 1999). In other words, before PACS Reiner and colleagues recorded that there was a consultation by clinicians with a radiologist for every 7.5 medical imaging studies produced, while after PACS was installed, this number fell to one consultation for every 42.1 imaging exams performed (1999). The study authors conclude that both changes can be primarily explained by "the convenient access to current and prior images provided by the PACS" (Reiner et al. 1999: 1169). Similarly, a study conducted by Pare and colleagues that examined referring providers' opinions about the adoption of a hospital-wide PACS found that for clinicians, "the ability to have instant access to images from any point in the hospital is the greatest perceived advantage, *avoiding time wasting trips* to the radiology department" (2005: 477, emphasis added).

How did trips to the reading room, once a standard part of daily rounds and patient care, become viewed as a "waste of time" by clinicians? Why, with the adoption of PACS, did visits to the reading room and interactions with radiologists become the exception rather than the norm for clinicians, who now are increasingly making care decisions based on their own interpretations of images? What is the impact of these changes in behavior on radiologists' claims for expertise, for the process of diagnosis, and for patient care?

As I showed in Chapter 3, the primary place for physicians to view medical images before PACS was in the radiology reading room. There were, of course, ancillary locations where films could be examined by non-radiology clinicians, including the film library and multidisciplinary conferences. However, for looking at relatively recent films, the radiological reading room was the “obligatory point of passage” for health care providers wanting to look at images. Visiting the reading room also meant, more often than not, interacting with radiologists and, through these interactions, negotiating and maintaining jurisdictions of expertise, producing and exchanging different kinds of medical knowledge, and participating in the process of diagnosis.

In talking with my informants about how PACS had changed medical imaging and clinical practice, many of our conversations tended to focus on two perceived results of PACS adoption: increased access to images by clinicians and increased efficiency of both radiologists and clinicians. I discuss the importance of these two “results” for my informants below and show how changes in the location and speed of the circulation of images helps to shape the practices and patterns of communication between referring providers and radiologists. To explore this change in the status of the reading room, I begin by briefly “following” a PACS-based image from physician order to radiologist’s report, highlighting the ways that this process differs from the film-based system described by Saunders (2008) and others in the last chapter.

From ward to electronic medical record: making a PACS image

In Chapter 2 I referred to a study conducted in 1989 at the Baltimore VA Medical Center that documented the 59 separate steps needed to go from a physician’s order of a chest X-ray for a hospitalized patient to the placement of the radiologist's final report in the patient's medical chart. After installing PACS at this institution, a similar workflow study showed that the number of steps had decreased to 10, and the number of people involved decreased from 12 to 5 (Siegel and Reiner 2003).

At Central Hospital, for example, a physician wanting a chest X-ray for a hospitalized patient would enter the order into the computerized hospital information system (HIS), which is integrated with the radiology information system (RIS) (see Appendix 1). The RIS automatically schedules the patient for the imaging exam, notifies a transportation aide that the patient needs to be taken to the imaging department, notifies the radiology technologist of the pending exam, searches the PACS for any prior radiological exams and relevant information electronically from remote data storage to short-term storage to facilitate rapid accessibility of those past scans by the radiologist. Once the patient arrives in the imaging area of the hospital, the technologist identifies the patient from a computer-generated work list of studies that have been ordered, takes the images, checks them for quality using a PACS workstation, and electronically signals the radiologist that the images are ready for interpretation.

The study then appears in the radiologist's electronic queue or work list, which displays all the studies waiting for interpretation. Each reading room at Central Hospital has isr own specialized work list, which, theoretically, displays only the studies that that particular radiology group is responsible for reading. For example, if a patient is brought to the emergency room after a car crash and gets a head and neck CT and X-ray of her knee, the CT would be sent to the neuroradiology imaging group's work list, while the knee X-ray would be added to the musculoskeletal radiologists' queue. It is not uncommon, however, for studies to be added to the wrong reading room work list, especially since the rules for who reads what can be ambiguous. For instance, imaging of the spine (CT, MR or X-ray) could be read either by the MSK radiologist or the neuroradiologists, depending on whether the physician ordering the study was a neurosurgeon, in which case images would go to the neuro group, or an orthopedic surgeon, in which case they would go to the MSK group.

If a study ends up on the wrong list, radiologists have to ask of the radiology technologists to re-assign the image to the correct list. Depending on how many studies are already on the radiology work list, the number of radiologists interpreting studies, and the clinical urgency of the imaging request, the radiologist might be able to interpret the study immediately or might have to finish going through other studies first. While my emphasis on the work list -- many radiologists simply call it "The List"[11] -- may seem excessive here, I will show later in this chapter that it plays a crucial part in organizing radiologists' practices in the PACS era.

Returning to the ways that a digital image moves through PACS at Central Hospital, the radiologist then selects the study needed from the The List. When interpreting the study, the radiologist calls up any prior imaging studies on his or her PACS station monitors and compares then with the current image. In general, PACS stations at Central Hospital have three monitors. Two are very high definition black and white monitors, and the other is a lower resolution color monitor. Radiologists usually use the black and white monitors to display the medical images themselves, and the third color monitor is used to display The List; they also use the color monitor to check email,

[11] I capitalize "The List" to emphasize its importance and status as agent in shaping radiologists' practices

look up things on the Internet, access the HIS, or occasionally to display 3-D color renderings of imaging studies. A wireless mouse and keyboard are used to navigate from one screen to another or within any one of the screens.

The digital nature of the images and the image processing software on PACS lets radiologists manipulate images in many ways that were impossible with film. These ways include adjusting the contrast and brightness of images (called “window” and “level”); magnifying specific regions of interest (ROIs in PACS slang); highlighting various anatomical structures that have different types of tissue contrast (e.g., optimizing the display to look closely at lung tissue, bone, or soft tissue); subtracting certain features of the image to better view other structures (e.g., subtracting the ribs on a chest X-ray to look at the lungs); and measuring various aspects of the image (e.g., giving the dimensions of a tumor or lymph node). All of these features are made possible through complex mathematical transformations and equations done invisibly by PACS.

After reviewing the images, the radiologist then dictates the formal report using a computerized voice recognition system, reads over the report and corrects any errors, and signs it electronically. Once the report is signed, it appears in the patient’s electronic medical record for review by the referring physician or any other authorized health care provider who wants to read it. The images themselves are stored in the PACS and can be retrieved by physicians at a PACS station or at any computer with a broadband VPN connection.

According to the Baltimore VA report, the installation of PACS, with RIS and digital dictation system, reduced the amount of time between performing a study and having the radiologist’s interpretation appearing in the patient chart up to 24 hours to less than two hours and often within 30 minutes during a normal workday (Siegel and Reiner 2003). However, it should be noted that at the Baltimore VA and Central Hospital the images themselves would be available in the PACS system for physicians to view as soon as they were acquired. Therefore, there was usually a lag of about 30 minutes to two hours between the availability of the images for viewing on PACS and the radiologist's report. In addition, the images themselves are stored in a different PACS domain than the radiologists' reports. Thus, at Central Hospital imaging studies and the radiologists' report do not appear on the computer screen together. Instead, if a physician was looking at an image and wanted to read the radiologist's report, he or she would have to navigate to another area of the PACS where the reports are digitally stored.

Unlike film-based imaging, clinicians can view medical images through the Internet from almost any computer terminal in the hospital -- at Central Hospital computers are fairly abundant -- including those on patient care wards and in physicians' offices or at home. Viewing images does not require talking to a radiologist or a film librarian; instead, all that is needed is a PACS access code. Furthermore, imaging studies are loaded onto PACS as soon as they are acquired. A clinician wanting to see an image need not wait the 30 minutes to two hours it generally takes a radiologist to interpret it.

A clinical interlude

[Begin field notes] One morning, while I'm rounding on patients with the Central Hospital ICU team, we are interrupted by the sound of multiple alarms going off in a room a few doors down from where we are standing. The team rushes into the room; this patient's condition has been deteriorating rapidly over the past few days, and the ICU doctors have been struggling to keep her alive. A quick glance at the monitor displaying the patient's oxygen saturation shows that she's not getting enough oxygen, despite being on a mechanical ventilator. The team begins to assess the possible reasons for the patient's hypoxia, including using a bedside ultrasound to look at the lungs and heart (to check for pneumothorax or a cardiac effusion).

With nothing worrisome showing up on the ultrasound, the attending decides to order a stat chest X-ray to further assess the cardiopulmonary system. We all wait nervously for the on-call X-ray technologist to bring the portable digital X-ray machine and take the images. Once the X-ray tech has obtained the images, Kris, the critical care fellow, wheels the COW[12] we've been rounding with over to us, leaving it just outside the patient's room. We all gather around, anxiously waiting for the image to appear in PACS. One of the residents hits "refresh" every 10 seconds or so, and Kris says to me, "This must be great for your study- a bunch of doctors standing around waiting for the image to come up." But I'm just as absorbed as the rest of the group by the blank screen, waiting on tenterhooks for what the image will tell us.

After about 5 minutes, the image finally loads – the bright white of ribs and sternum contrasting with the duller outline of the heart and the shadowy outlines of the lungs. The attending, who has been adjusting the settings on patient's mechanical ventilator while we wait for the image appears, is called over to the COW. After examining the image intently for about 5 seconds, he says, "Nope, nothing going on there!" and returns to the patient's bedside. In the meantime, the patient's oxygen levels have returned to normal. We loiter by the bed for a few more minutes to confirm that the patient has stabilized. Then we all slowly walk back to where we were before, speculating on what caused the event in the first place. I look at my watch, and realize that this entire episode, from the patient crashing[13] to the attending determining that there's nothing on the X-ray, took less than 10 minutes.

In the days before PACS, clinicians' trips to the reading room had to be scheduled around the requirements of patient care. For example, if a patient was crashing, the medical team had to be with the patient, not down in the reading room where the image was being developed and read by the radiologists. The above excerpt from my field notes shows, however, that with PACS physicians at Central Hospital are able to incorporate viewing medical images with patient care, often without having to leave the patient's side. It is also interesting to note, however, that during this episode nobody talks to a radiologist. In fact, while I stayed with the ICU team for the entire day, I never saw anyone read the radiologist's interpretation of the chest X-ray, which would have been available in the computer after about 30 minutes. The crisis had passed and the situation

[12] Computer on wheels: a mobile computing station that we often took with us on rounds, to look at patient's medical images, review charts, or enter orders

[13] Medical slang for an acute, life-threatening deterioration of condition

had been resolved in 10 minutes, so what did the radiologist's report have to offer these busy clinicians? From their perspective, very little.

<u>Circulation of images: Access</u>

When I asked non-radiology physicians how PACS had changed medical imaging, many of them focused on how PACS made accessing medical images easier, and spared them from having to visit the reading room. For example, Dr. Singh, a neurology attending in her late 30's told me:

> Because PACS is so easy to use, physicians outside of radiology are much more likely to look at the films because they are easy to find. Before, we had to go to the reading room or the file room and it took a long time. You had to have a good reason to go look at films, so a lot of times you would just call downstairs [to the reading room] and take the radiologist's word for it. I think it is improving the educational mission and it helps also to detect things that radiologists, rarely, but some radiologists miss, so it improves the diagnostic accuracy.

Similarly, Dr. Roth, one of the pulmonologists I rounded with, confirmed that for him a big advantage of PACS was the increased access to images. He told me, "I still call radiologists if there's something difficult, but on a daily basis, images are much more involved in our daily management of patients, just because of their accessibility now with PACS." Another neurologist, Dr. Chen, agreed, saying "Because PACS is so easy to use, physicians outside of radiology are much more likely to look at the films, because they are easy to find…and because PACS is out of sight of the neuroradiology suite, a person can read scans and not have to sit next to the radiologists who they're taking business away from."

For all these clinicians, there is a straightforward relationship between the ease of being able to access images and the use of images in daily patient care. Dr. Singh says that PACS saves her from having to spend the effort and time to go to the reading room, and enables her to see images for herself rather than rely only on a radiologist's finding. It is also interesting to note that Dr. Roth says he only communicates with radiologists now "if there's something difficult" while Dr. Chen specifically links looking at images outside the reading room with bypassing radiologists' expertise. In fact, she viewed the ability to look at images without radiologists' assistance as a positive rather than negative outcome of PACS adoption.

For the clinicians at Central Hospital, the ability to look at images from home was also considered a major benefit of PACS. For example, one neurologist stated:

> In the acute setting when someone has a stroke and is in the emergency department, we have our residents look at the images on PACS and then a senior person, a stroke attending like myself or one of the fellows, views the image as well, and then makes a decision about emergent treatment. We make a lot of decisions from home… we have our web-based PACS that we can look at from home, so I wake up at 1 AM and stagger down to the computer and look at the thing, and then tell folks what we're going to do.

The opportunity to look at images outside the reading room, in this case at the clinician's home, is again linked with bypassing the advice of a radiologist. Instead, in the scenario this neurologist describes, the senior stroke attending, not the radiologist, is the one to look at the images and decide what clinical actions, if any, will occur. The pulmonologists I spoke with also highly valued the ability to look at images from home on PACS. As one of them told me, "One of the main advantage of PACS that I am sure you have heard from other people is the fact that images can be remotely interpreted, which is important when you are supervising the care of the patient that is in the hospital. So for me, I am more likely to look at a scan at 2 AM, now that they are remote, than before."

Another important aspect of PAC systems is that they allow images to be viewed almost immediately after the imaging study has been completed, without having to wait for a radiologist to first interpret the image. As I noted above, the interpretation of each image does not appear with that image since they are found in different locations in the Central Hospital computerized patient data system. Therefore, it is possible for a physician to look at an image without ever reading the radiologist's impressions. Of the neurologists and pulmonologists I spoke with, most said that they only looked at the radiologist's report if they thought the image was particularly difficult or had unanswered questions. As one neurology fellow said, "If I think the image is really complicated, then I'll look [at the radiology report], but mostly I just look at the images myself." Clearly this is another important way in which PACS has challenged radiologists' monopoly on medical imaging, sundering the link between an image and the radiologists' "read" of that image.

Switching from a film-based to an all-digital computerized imaging system seems to have not only changed where and when physicians could view their patients' images, but also whether clinicians thought it was important to continue visiting the reading room (in general, they didn't), how they chose to interact with radiologists (usually by phone rather than face-to-face), and why they communicated with radiologists (to answer specific questions about specific images rather than to review all films). Radiologist tended to view this shift with concern. For example, Dr. Vanberg, a chest radiologist, stated that with the installation of PACS:

> Almost overnight we saw a dramatic decrease in the number of visits from clinicians. And that decrease in visits continued to decline as clinicians got more adapted looking at images in their own venue. So over the course of weeks to months to a few years they got much more adapted at looking at them. So overnight there was a dramatic drop in visits, and there was some decline in phone calls. The other thing that changed is that we had a fair number of film

> review rounds with the clinicians because that was the best way for them to see them. But the film rounds where the medicine teams in particular would come and look at films stopped once they had access.

Dr. Vanberg not only links increased access to images with a sudden drop-off in clinician visits to the reading room, he also states that over time, referring providers got "more adapted" to looking at medical images themselves. Another attending radiologist, a musculoskeletal specialist, articulated why this is considered problematic by radiologists, saying, "The clinicians don't have to come to us anymore, as we have talked about. So they can read them [images] anywhere, in their office too, they can look at them and they think they can read them, and maybe they can in some cases as well as we can." Similarly, an older radiology attending named Dr. Gifford, reflected:

> It's certainly true that when things were on film, in general there was one copy. Well, sometimes in some crazy environments, you know, we'd burn two sets of studies off the CT scanner or something so that one could go out to the clinician or whatever. But one of the advantages of PACS is that the images can exist in multiple locations and be viewed in multiple locations simultaneously. So, that's a huge cultural change and that's a big concern for radiologists.

When I asked him why increased access to images was a "big concern," he responded, "I believe that there are fewer radiology-clinician interactions now because of PACS, and that worries me. Specialists can look at the images without talking to us now, and I think they can be lured into a sense of comfort and miss critical issues that might be outside of their own specialist knowledge."

Dr. Gifford indicates that PACS allows a multiplication of images in both space and time. He, like the other radiologists I have quoted, links the ability of PACS to multiply what was once a single film with a decrease in interactions between radiologist and clinicians. He also worries that without these interactions, specialists might be "lured" into feeling that they can interpret images by themselves. While I investigate the ways that PACS opens up medical images to multiple gazes and allows multiple, sometimes conflicting "reads" of images in Chapter 6, in this section I want to focus on the notion of access, exploring why increased access to images is perceived as a "huge cultural change" for medicine.

In practical terms, access implies gaining entry to or obtaining a resource. However, the notion of access, I argue, also involves a dynamic of power, a negotiation of who has the "right" to view images. As scholars from Foucault to Haraway have shown, gazing is never a neutral activity but instead is a practice fraught with relations of power, of seeing and being seen. Furthermore, medical images are themselves powerful objects in science and medicine. Never neutral or transparent representations of medical "fact," in this drama they are lively actors who seem to contain their own expert knowledge (Dumit 2004). Western science and medicine, as Don Idhe and many others have argued, relies on visualism, the overwhelming tendency to "produce, display, and reiterate what counts for evidence in visual form" (Ihde 2002: 37). Taking into account the power of gazing combined with the potency of visual images, it is no wonder that expanded access to CTs, MRIs, and X-rays carries with it a profound change in the organization of medical practice and claims for expertise. Suddenly, with PACS, the "right" to see is no longer mediated by radiologists, as it was in the reading room. PACS allows images to circulate along electronic pathways that bypass this "obligatory passage point." The power radiologists derived from being able to control the flow of images in the hospital has vanished.

It is not only the radiologist' loss of control that poses a problem for notions of radiological expertise; it is also clinicians' gain of control. Increased access to medical images by clinicians also concerns the ability to develop an in-depth relationship with and familiarity with medical images. As I showed in Chapter 3, radiologists' expertise in the hospital involves intimate engagements with images and the ability to "speak" for those images. This definition suddenly becomes problematic when other kinds of clinicians in ever increasing numbers are able to directly engage with images via PACS. As one attending neurologist commented to me, "Angiography, looking at images of blood vessels, I am probably better than most general radiologists. In terms of neuroradiologists I am probably as good as them at vascular imaging just because I have done it for 15 years, and I've seen a lot of images." The intimate relationship that radiologists enjoyed with medical images in the reading room is suddenly available to everyone with a PACS code.

The ability to easily access images outside the reading room, therefore, poses a serious threat to the ways that radiologists have established and maintained their expertise in the past. Although access does involve dimensions of time, such as the ability to view an image the moment it has finished being acquired, in the next section I explore more closely the relationship between PACS and time through the notion of efficiency.

Time, efficiency, and the circulation of images

- "*Great case. Next case*."
–Teleradiologist saying

As Kaufman shows in her ethnographic study of death and dying in American hospitals, one of the primary functions of the modern health care institution is to "move things along" (2005: 96). This phrase points towards the requirements within the structures of managed care to move patients through the medical system as quickly -- and cheaply -- as possible. Kaufman observes that doctors are often caught between the institutional imperative for efficiency from all employees and the desire to provide appropriate care to patients (2005). Time is money, as the saying goes. Time, then, becomes something to be carefully managed by physicians and other care providers, who, according to insurance companies and hospital administrators, should constantly strive toward making their practices as *efficient* as possible.

I highlight efficiency as one of the key institutional logics of health care. This notion, emerging out of Taylorism and Fordism, was characterized as a "scientific" way to evaluate workers' efforts and was quickly adopted by hospitals (Howell 1995). Efficiency has had remarkable staying power in medicine, continuing to be of central importance in the managed care era of the 1980s and 1990s; it has also persisted in dominating the rhetoric of health care administration to the present day (Mendel and Scott 2011). The notion of efficiency has also been more recently linked to widespread calls for the increased adoption of information technologies in medicine, primarily through government-led efforts to address escalating cost of health care (Pine 2011). Efficiency is also tightly associated with the evidence based medicine (EBM) movement. Epidemiologist Archie Cochrane, one of the 'founding fathers' of EBM, published a lecture in 1972 titled "Effectiveness and Efficiency" that argued for the evaluation of medical interventions through double blind randomized controlled trials (RCTs). In his argument, Cochrane advocated EBM as an important mechanism for making health care more cost efficient (Pope 2003).

When discussing issues of efficiency in radiology, it is also important to remember that the development and widespread adoption of PACS has both led to and been fed by recent trends in medical imaging in the U.S. and the increasing technological sophistication of medical imaging machines. As I discussed in Chapters 1 and 2, not only are there now more images per study for radiologists to look at since CT and MR were first introduced, the number of studies ordered has also been increasing sharply until very recently. The installation of a hospital-wide PACS has also been associated with increases in the number of images ordered per hospitalized patient, as indicated by the Reiner et al. (2000) study I mentioned at the beginning of this chapter.

Thus, the notion of *efficiency* in U.S. health care is intertwined with techniques of industrial management, efforts to limit costs but still make a profit, the EBM movement, adoption of information technologies, and by the production of what seems to be an ever increasing amount of medical information. With this in mind, it is perhaps not surprising that, almost universally, my ethnographic informants expressed that making radiology and clinical medicine more efficient was one the most important benefits of. Yet as I show below, efficiency takes on a variety of meanings among the people I talked to and observed and elicits a variety of responses. I found that in the reading room, more often than not, the notion of efficiency is fundamentally tied to the idea of speed as well as the feeling that because of PACS radiologists have become factory workers rather than clinical consultants. The time it takes to produce a radiology report, even using speech-recognition software, has been considered the “rate limiting step” in producing a medical imaging study since the late 1990s (Robinson 1997). It now takes longer for radiologists to interpret medical images than it does to acquire them. While there was always pressure for radiologists to read images quickly (cf. Barley 1988), radiologists have found that with PACS, the expectation to read more studies in less time has been magnified. For example, as Dr. Geshram, one of the more senior radiologists at Central Hospital, reminisced:

> The old work flow model was that there was film library staff, and they took the films from the new study and they had pulled jackets from old studies, and hung them up on film alternators- you know, these huge 50 panel film rollers- and then they'd make a little list of what the patient names were and who is on ward 3 or ward 7 and so on, and you'd sit down between your coffee breaks and you'd dash them [the interpretations] out, but you wouldn't be continuously doing that. You'd have to be waiting for the films to be printed, and you'd have to be waiting for them to be combined with the patient's jacket. Well, that all happens invisibly and electronically in the background now, with PACS. The point is that you can still take a coffee break, but we look very carefully at interpretation time now. We are expecting people to do more: do more images per study, more studies, which is more stuff to look at.

Instead of waiting for films to be acquired, printed, sorted, and hung, radiologists now are always playing catch up, looking at more "stuff" in less time. Furthermore, the ability to view one "slice" at a time for CT and MR and easily magnify areas of interest with PACS means that each image can be scrutinized at a far more detailed level than with plain film. As Dr. Perlmann, an attending who specializes in abdominal imaging, noted:

> Well the biggest change, I think, was ultimately - and it is not just PACS it is the evolution of the imaging equipment - the increase in the number of images. So we used to… when we read CT it was very standard to print 12 images on one large sheet of film. Now we read CT on a full monitor one image at a time a lot of the time… But it is interesting, because I think that we see a lot more smaller findings on the big field of view and the question is too whether or not those are significant.

More images that can be explored in greater detail means more findings that need to be noted in the report and communicated to referring physicians. For radiologists, PACS is what enables them to deal with the increase in information generated by burgeoning numbers of studies made up of increasing numbers and detail of images. Dr.

Ling, for example, told me that "with the rapid increase in imaging in general, especially CT and MR…if it weren't for PACS, radiology would have been pulled apart at the seams, because we could not have possibly met the challenge of reading all those cases. We had to find a way to read a lot more images a lot faster, and PACS was there." Jonathan, a third year radiology resident agreed, saying, "I think we have become more efficient with PACS. I think the amount of data that we see has just exploded, and the productivity is the net balance between the overload of data and the increased efficiency that computerized images has caused."

What work does the concept of efficiency do for these radiologists? For Dr. Geshram it seems to mean eliminating the "waiting" associated with film production and organization, while for Dr. Perlmann, Dr. Ling, and Jonathan, efficiency means the ability to deal with more information via computers while still being productive (although it is somewhat ironic that it is computers that have enabled the production of more information in the first place). Dr. Ferguson, a chest radiologist, seemed to combine all these notions of efficiency when he told me:

> I think its [PACS] greatly improved our efficiency. I remember as a fellow just before they changed to PACS, a huge part of my time was spent hanging up the images, the actual hard copy CT images, and nowadays we can have several hundred images coming out of the study, you couldn't conceivably hang those anymore, it would be ridiculous. Having all the electronic images pretty much immediately available to you also makes it much easier to do serial comparisons. If I see a little lung nodule and it hasn't changed since the last study, I can now very quickly go back to the earliest available study and see if it has been stable for five years, I can see if it's benign versus maybe it is slowly progressive, or actually it is new from five years ago. I think you get access to more information faster, and similarly if I see something funny on a CT, and the patient had an ultrasound a year ago, whereas before you might have said you couldn't be bothered to look for it, it would take too long. But right there on PACS you can do that and it makes it much easier to interpret comparisons.

Yet even with this trend towards more information and the increasing complexity of imaging studies, the pressure to work faster remains. In addition to making it easier and faster to view old studies, PACS also enables radiologists to deal with the increased volume of images needing interpretation by distributing the workload over multiple reading rooms instead of just one. One of the body radiologists clarified this for me, saying, "PACS has eliminated the need for radiologists to be at the source of the image to read it, so larger departments can clearly spread the work out and make radiologists more efficient in their time. So if you have an imaging center somewhere and their volume of work isn't very high, you can shift cases for that individual to read, and make their time more useful and level the work load of various radiologists, if you will."

For example, Central Hospital has a sports medicine center located on the other side of the city from the hospital. This center has both CT and MRI machines, and the images are normally interpreted by a musculoskeletal radiologist working at the center. However, if the volume of studies waiting for interpretation gets to be too large, the studies start appearing on the work list of the musculoskeletal radiologists at Central Hospital. The reverse situation also applies: if the sports medicine radiologist isn't busy, he or she can start reading studies from the musculoskeletal list at Central Hospital. In this case efficiency means distributing work more evenly and taking advantage of the ability of images to circulate more widely not just in the hospital but among radiologists as well.

At other times, however, the ability to share responsibility for The List is not available. At night a lone radiologist is responsible for interpreting all of Central Hospital's urgent imaging studies. The List can go from "easy" (two or three studies needing to be interpreted) to “out of control” (six or more studies waiting) in the blink of an eye. The excerpt from my field notes, below, characterizes how efficiency becomes even more vital to the radiologist working at night:

> I arrive at Central Hospital around 10 pm, and walk to the reading station where the night radiologists work. During the day, it’s where the chest and nuclear medicine radiologists read; it’s also the closest reading room to the ED[14], where the majority of the night read requests come from. I glance into the various cubicles in the reading room (empty) until I find Dr. Morgan, one of the three radiologists at Central Hospital that cover the night shift, from approximately 10 at night until 8 the following morning. Interestingly, Dr. Morgan was the only night radiologist willing to let me observe him- the other two declined, saying they were afraid I might “slow them down.”
>
> I locate Dr. Morgan, who is sitting in a cubicle about halfway down the hall, with the sliding door mostly closed. I introduce myself and remind him of my project. He’s relatively young, perhaps in his late 30s, with an athletic build. He has a shaved head and is wearing scrubs and crocs, and trendy eyeglasses. He has an informal manner and is very friendly. He’s hooked up his iPod to the computer speakers, and music plays softly.
>
> After I explain my project, he says to me, “Well, you’re wasting your time, but you’re welcome to sit. I never call anyone, and no one calls me. “ He explains that so far, it’s been a pretty slow night- he’s been able to keep on top of The List fairly easily. He says that it’s usually much busier, and that if things pick up he “won’t be able to talk much or answer questions.” I assure him this is fine, and that I’ll try not to disturb his work too much. He’s in the middle of reading a chest X-ray, and tells me, “They [the radiology department] just started doing this rib subtraction view,[15] so we supposedly can see nodules[16] better, but all it is is another image to look at. Instead of two or three views you get with a normal chest X-ray, now there are four or five that I have to look at.” As with almost all the radiologists I observed at Central Hospital, Dr. Morgan keeps The List visible at all times on one of his monitor screens. I notice that he seems to check this screen every 30 seconds or so, even when he’s in the middle of interpreting a study.
>
> He begins dictating the study using PowerVoice, and I immediately notice how different his dictation style is than the day radiologists I’ve observed. He speaks much more quickly and tersely and has very few pauses, but most significantly he uses the PowerVoice abbreviation function almost constantly. This feature allows the radiologist to preset various frequently used phrases and assign them a name. For example, when Dr. Morgan says “PowerVoice perinephric” into the microphone, the phrase “perinephric inflammatory changes are present” appears in the report, indicating that the image shows changes consistent with inflammation in the tissue surrounding the kidneys. Each radiologist tends to customize their PowerVoice abbreviations, frequently using them to indicate normal findings or to indicate when a standard imaging protocol is used. While the day radiologists seem to only occasionally use these short cuts, Dr. Morgan’s

[14] Emergency department
[15] Where the ribs are digitally subtracted from the image
[16] Small round abnormalities in the chest that can indicate a lesion or tumor

dictations are almost entirely made up of these abbreviations. The only time he actually dictates a finding without using these templates is when there is something unexpected, or a pathology that is not typical in its presentation.

I ask Dr. Morgan why his style is so different from that of the day radiologists, and he replies, "Well, I worked for NightHawk[17] for one year, so I had to be really fast and efficient. Not like the day people here- they're academics. They have more time to go through the studies, and they have to teach the residents. A day radiologist here might read 30 studies a day, but I probably read around 80 to 125 studies every night. But that's nothing compared to the private practice guys- they can read like 125 to 150 studies in the same time that an academic radiologist reads 30. Some of the guys at NightHawk, they were really fast. They could do like 30 to 50 cross-sectionals [CT or MRI, as opposed to X-ray] an hour! And their miss rate [the rate of missed findings] is only like 0.5%, which is pretty much the same as radiology more generally."

I ask how Dr. Morgan liked working for NightHawk and working so fast, and he answers, "Well, you never get interrupted [by referring providers], so that's great, and it pays really well. But the schedule can be really tough." I ask if he missed having contact with other physicians or patients, and he says, "Oh yeah, big time. It can get really lonely in here [the reading room]. That's why I'm going back to do a fellowship in IR[18] in a few months. I've gotten really burnt out on just reading films all day."

Like many of the other radiologists I spoke with, Dr. Morgan associated efficiency with speed, but he also correlated it with avoiding certain "interruptions" like instructing residents or talking to referring providers (or anthropologists). According to him, academic radiologists are the least efficient, whereas "private" (i.e. non-academic) radiologists and those working for NightHawk were able to work more efficiently. Yet Dr. Morgan also indicates that there is a price to pay for this kind of radiological efficiency: loneliness, isolation from patients and colleagues, and burnout.

Dr. Morgan is not the only radiologist I spoke with who associated PACS not only with increased efficiency and speed, but with transforming radiology from a dynamic consult service into factory or assembly line work. Dr. Ziegler, another radiologist I interviewed at Central Hospital, expressed his frustration to me:

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[17] A private, for-profit teleradiology company that offers "off hours" (i.e., nights and weekends) coverage for radiology groups

[18] Interventional radiology

> With PACS, work is busier now. We have 70% more cases to read than 10 years ago. So now I get home at the end of the day and I want to take a nap - I don't want to exercise or coach my kid's soccer team. I'm fried. PACS has enabled this kind of factory assembly line approach to radiology. And everyone knows they are seeing more cases, but the question is: how are they reading them? Are they looking less, or doing a worse job? Every so often, someone publishes the number of cases that a radiologist reads in a year, and it is inevitably higher each time. And then radiology groups see that number and they want to match it, because that means more money.

Medical imaging in the U.S. is reimbursed on a per study basis. Until recently, performing and interpreting more studies equaled more money for the hospital and for radiologists. However, with recent budget cuts and government efforts to curb health care spending, the reimbursement rate for both performing and interpreting an imaging study has been steadily decreasing. Thus, to keep profits at the same level, radiologist must read more images. Maria, a second year radiology resident, told me, "If you look at the numbers of scans radiologists are reading… one could argue that it's been driven up in large part by profitability. Radiologist are told to read more and more if they can so they can continue to have their same lifestyle." Efficiency for radiologists, as in all branches of medicine, is also about money. Fewer distractions mean faster interpretations, and faster interpretations mean more money. For Dr. Zeigler, however, working faster for better pay has both personal and professional drawbacks. In this light, efficiency comes to have certain negative meanings for radiologists. Personally, Dr. Zeigler finds that he is drained after a day of work and less likely to interact with his family. Professionally, he worries about the impact of the increasing tempo of interpretation on patient care.

These worries permeate the field of radiology in the U.S. For example, while perusing a radiology website chat room one day in the spring of 2011, I was struck by the following post from an anonymous radiologist titled "Crisis of Conscience":

> As a private practice rad [radiologist] out about 5 years, I think:
> A) Working hard for great pay is fine. Working fast for great pay makes me ill. I'm getting more ill each day as volumes go up, pay stays flat or diminishes. This especially hits me hard when
> B) I have a miss. I know to some degree they are inevitable, But when I see one of my own misses all I can think is "I wonder if I was going too fast to keep up with 'The List'[19] when this case came up?"…Of course I try to slow myself down when I feel myself "going too fast." But, in the end, I always feel a little rushed almost all day. Pulled in 3 directions at once. Nature of the gig? Perhaps. One that I can live with forever? Not sure.
> C) I turn on the TV and see the slumping economy and feel very fortunate to have a high paying, overall secure job. No doubt…being able to "provide" for my wife and kids brings me great joy outside the hospital. However, it doesn't change that during the 8-10 hours I am at the hospital…
> D) This job is slowly killing me. I can truly say that if I do radiology as it is now for 20-25-30 years, I will feel like I have wasted my life

Responses to this post by fellow radiologists ranged from commiseration to accusations of "whining," as well as recommendations for everything from "refine your visual skills" to "get a hobby" or "go part-time." The fact that no one seemed to have a good answer for this young radiologist reflects wider anxieties and concerns about the sustainability of the current way radiology is practiced as well as a general disenchantment with a career that is increasingly being seen as "factory work." Quantity, not quality, has emerged as the driving force of modern radiology, much to the concern of most radiologists. However, few are willing to accept the drop in revenue associated with "slowing down."

The changing nature of radiologic practice is not only about the money. As an opinion piece in a radiology journal pointed out, PACS is also seen by radiologists as narrowing their opportunities to engage in "diagnostic intrigue" and chances for professional fulfillment. The author of this article writes, "These technologic

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[19] Capitalization original- the author of this post also felt "The List" significant enough to warrant extra emphasis

advancements [PACS] have eliminated so much of the collaborative problem solving that has always been an important part of the medical process. Frankly, I think our profession has lost a lot. We no longer have the opportunity to engage in the medical detective, problem-solving situations that we came to enjoy" (Forman et al. 2010: 1017).

In addition to anxiety about decreasing reimbursements and fewer chances for acting as a "medical detective," radiologists also feel that efficiency and keeping up with The List are critical for maintaining relevance in patient care. Having lost their ability to control access to images and in the face of ever-dwindling numbers of clinician consults, radiologists recognize that referring providers are becoming more and more comfortable looking at and interpreting images, as I discussed above. As another radiologist told me, "What PACS did, amongst many other things, is it put a high premium or requirement on radiologists to read quickly and contemporaneously. Because, if you don't do that, your value added as a radiologist is compromised."

I want to flag the phrase "value added" but set it aside until Chapter 6, in which I discuss the ways that claims and counter-claims for visual expertise are now being negotiated among radiologists and clinicians in the PACS-equipped hospital. For now I want to point out that for radiologists, simply interpreting images is no longer "of value" with PACS; instead, one of the ways that value emerges is through the speed with which the interpretation is generated and made available to clinicians. As Dr. Michaels, a neuroradiology attending, explained, "Now that PACS lets referring providers see an X-ray or CT or whatever as soon as it's acquired, there's more pressure to get our reads out faster. Because surgeons or ER docs or whatever won't stand around and wait for us, they'll just go ahead and act. So we have to be more efficient, we need to get our interpretations out there fast if we're going to keep being relevant to patient care."

For Dr. Michaels, efficiency is crucial for remaining "relevant" to both referring providers and patients. Indeed, as the Kundel and colleagues (1991) study I cited above and the field notes of my experiences in the ICU indicate, with PACS it is fairly common for clinicians to view images and act on them without first reading the radiologist's report or talking to a radiologist.[20] The notion of efficiency, then, isn't just relevant to radiologists. Clinicians working in the hospital setting must also act efficiently, using available information such as that provided by medical imaging to guide patient care. Yet acting in a timely, efficient manner and "moving things along" also represents a risk for both clinicians and patients if some clinicians are acting on images without reading the radiology report. On a daily basis physicians working in the hospital setting must negotiate between waiting for the radiologist's report or immediately acting on the information the image provides. Waiting may give the care provider more information and guide his or her actions, but waiting, especially if the patient is clinically unstable, may also mean greater harm to the patient.

While the schedules of clinicians in the hospital are largely shaped by routines of patient care, The List primarily dictates the timing of radiologists' work. Although there has always been pressure for radiologists to complete interpretations in a timely manner, PACS has placed additional demands on radiologists to focus on producing reports as fast as possible. Radiologists tend to view any interference with their abilities to interpret images as "an interruption," including phone calls and (increasingly uncommon) visits

[20] However, I observed that clinicians' comfort with interpreting images and acting on those interpretations varied widely according to their clinical specialty and the type of image, as I discuss further in Chapter 6.

from clinicians. Yet, as the chat-room post from the disillusioned radiologist highlights, the emphasis on speed, efficiency, and keeping up with The List is always haunted by the specter of "The Miss." Radiologists must constantly negotiate between reading images quickly and reading them too quickly; speed can be dangerous and have profound consequences for patients.

In an article examining how the introduction of CT altered the work practices of both radiologists and radiology technologists, Stephen Barley uses the notion of "socio-temporal order" to examine how the organization of time is perceived for occupational groups in the hospital. He writes that "the temporal order of the workplace… serves simultaneously as a template for organizing behavior as well as an interpretive framework for rendering action in the setting meaningful" (1988: 125). He further argues that interactions between people who do not share similar temporal orders may lead to conflict and that for complex organizations like hospitals to function, different temporal orders must be made to "mesh" (Barley 1988: 128).

Having observed in depth the daily schedules, interruptions, and timing of events that take place in the reading room, the operating room, the emergency room, and on the wards, I noticed how different temporal orders are made to 'mesh' at Central Hospital. In Chapter 3, I argued that before PACS the reading room acted as a site of exchange for a number of different kinds of knowledge as well as an important space for the performance of radiologic expertise. In addition, I argue here that the pre-PACS reading room functioned as a space in which various temporal orders in the hospital were made to "mesh."

On daily team rounds in the reading room or while talking to radiologists about a particular film, clinicians' frequent visits brought what I call "clinical time" into the reading room. Clinical time, as I described above, primarily revolves around daily patient care. Events on the wards follow a general schedule when everything is happening "normally," including pre-rounds to check on patients, team rounds to plan out the daily treatment plan for each patient, individual work time to write notes, place orders, and talk to consultants, time spent in an afternoon clinic seeing outpatients, and evening sign-out[21] of patients to the overnight team. Yet there is rarely a "normal" day on the wards since events are constantly rearranged to deal with the variable and unpredictable course of sickness and treatment in the hospital. Urgent and unplanned occurrences constantly intrude upon and fragment hospital schedules.

Clinical time can be contrasted with radiological time, which before PACS was largely structured by reading images and producing reports, but was fraught with delays, waiting, the busy work of organizing and hanging films, and constant traffic into and out of the reading room by a wide variety of clinicians. In the reading room, clinical time and radiological time were brought together; the urgencies of patient care and the practicalities of medical imaging were negotiated as referring providers and radiologists exchanged information and constructed diagnoses.

With PACS, however, the reading room no longer serves this purpose. Instead, The List increasingly dictates radiological time, and radiologists become more isolated from clinical time, engaging in clinical problem solving, and participating in patient care. Ironically, it is PACS that has both made radiology more "efficient," and by doing so,

[21] A meeting where the on-call team responsible for caring for patients overnight is given a brief summary of other teams' patients, with special attention to unstable patients that might need care during the night

jeopardized radiologists' claims for expertise and involvement in patient care. Isolated in reading rooms, radiologists are rarely aware of shifts in the clinical status of patients. Beyond seeing an image marked 'stat' or 'urgent' on The List or getting a phone call from an agitated physician, radiologists have little way of knowing the clinical situations of most patients. In the next chapter, I explore how the circulation of certain kinds of knowledge about patients has changed with PACS and consider the broader implications of this shift.

CHAPTER 5: PACS and the Circulation of Knowledge

Introduction

As I have shown, PACS has facilitated the ability of images to circulate in new places and at new speeds in the hospital and beyond. In turn, this newly mobile medical image has had an important impact on another kind of circulation -- that of physicians. Referring providers at Central Hospital prefer to use PACS stations and the Internet to access images rather than seek them out in the reading room. While they still occasionally occur at Central Hospital, scenes of inter-specialty dialogue and interaction set in the reading room are becoming more and more rare. Instead, communication between radiologists and clinicians is more frequently accomplished through methods such as the radiologists' written reports or imaging study order forms.

What is the significance of these shifts in patterns of communication? In this chapter, I use the case of PACS adoption at Central Hospital to explore the differences between information and knowledge and argue for the central importance of what I call "off the record" knowledge in daily medical practice. Using Foucault's notion of subjugated knowledge (1980) and Douglas's concept of dirt (1966), I show how "off the record" knowledge has an important role in health care and is valued by medical practitioners along side of lab values, patient histories, or other kind of "formal" information recorded in clinical records. However, I demonstrate that health information technologies such as PACS have altered the circulation of this "informal" or "off the record" knowledge in the hospital, with important consequences for radiologists, for clinicians, and for patient care.

Information and knowledge in the hospital

According to Tsoukas in his important article examining the role of knowledge production in late modernity, communication is increasingly viewed through a "conduit metaphor" (1997: 830). In this metaphor the form of communication is irrelevant and serves only as a channel for ideas and information to move from one person to another (Tsoukas 1997). Further, information is conceived as neutral, objective, unchanging, and able to be separated from its creator. According to this notion, the means radiologists and clinicians use to communicate does not matter, as long as some form of communication occurs.

In contrast, Central Hospital radiologists felt strongly that the lack of face-to-face conversation with clinicians has a negative impact on radiological practice. As Dr. Ziegler, an abdominal radiologist, told me:

> We (radiologists) knew all the clinicians intimately before. And then with PACS, this intimacy disappeared. Before, I knew the face, name, wife's name, and kids' names of all the clinicians, but now I don't know who you are if you joined the medical staff after we got PACS. Now we're operating in a void, because there's no history of the patient on the written image requests. Before, when a clinician showed up, I could ask them and find out *what's really going on* with the patient. [emphasis added]

In this short statement, Dr. Ziegler says that with clinicians no longer visiting the reading room because of PACS, he has trouble forming personal and professional relationships with them. These relationships were significant, he says, because when clinicians visited the reading room, he could find out "what's really going on." Dr. Ziegler points to the way that information and knowledge are produced through interactions and collaborations. Unlike the notion of communication proposed by the conduit model where information is thought of as objective and neutral, Dr. Ziegler argues that personal relationships and knowledge of people shape the information or knowledge that is communicated between people.

Now, instead of talking with the medical staff, information about the patient is primarily communicated at Central Hospital in an image order form which is filled out by the physician ordering the imaging exam and scanned into the RIS. However as Dr. Ziegler points out, more often than not the clinical history is either completely absent from these forms, or as I observed in many cases, too general to be of use. For example, an order for an abdominal CT might be accompanied by a patient history of "abdominal pain." Such details as the type, location, duration, or timing of the pain, or the fact that the patient had been stabbed in the stomach, were left out. Thus, radiologists would often have to interpret images without any knowledge of the patient.[22] Radiologists at Central Hospital feel they are increasingly "operating in a void," separated from the details of patient care.

Similarly, while observing one day in the chest reading room, Dr. Wyatt told me that it has become harder for him to read portable chest X-rays. He said, "It used to be easier when we'd talk with the ICU people and they could tell us, 'Yeah, he's got a fever and an increased white count' and we could say, 'Ok, that's fluid or that's pneumonia.' But without that information, it's really hard to tell the two apart on a portable film, and we're just not getting the relevant clinical information anymore." Dr. Ling, a neuroradiologist, voiced a similar opinion, saying, "The bad thing [with PACS] is there

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[22] There is a longstanding tension in radiology between the perceived advantages of not knowing too much about the patient, enabling radiologists to interpret images "objectively" and being able to use in-depth knowledge of individual patients to tailor each interpretation to the specific clinical situation. I discuss this tension further in Chapter 6.

are always the nuances from speaking with the clinicians that you just don't get anymore. One thing I really do miss is a targeted evaluation. The only thing we have to go on now is a clinical history which is often poor, so when the team would come it would make you look two, three, and four times at a specific area and make sure you don't miss something."

According to Dr. Ling, clinician visits to the reading room were important not just for exchanging "nuances" of clinical care but also for helping to constitute her radiologic gaze and influencing her interpretations, which forced her to look more carefully at an area she might have otherwise ignored. As second year radiology resident Maria stated, it is often the more subtle details of a patient's case that turn out to be important in interpreting images:

> A lot of the radiologist-referring physician discussion is very beneficial to patient care, at least we think so. There are subtle things about the patient that are brought up [during these discussions] that were never on the requisition, there's no history that's adequate, and vice-versa. Radiologists would say, "Well, I saw this thing and I didn't think much of it, but maybe we should do something."

As Maria notes, these "subtle things" tend not to appear on the imaging requisition form, yet they can still alter the way a radiologist interprets imaging findings. Dr. Michaels, an attending neuroradiologist agreed, saying:

> I think with less clinical information and less interaction we have less impact on patient care… Often we are reading the films without all the clinical history so our differential diagnoses may be different had we had the history. I also think there is less trust [between radiologists and clinicians] because you don't know what their processes are, you don't know if things are well thought out or not, you're depending upon the few lines that they put on a request, it is really hard to judge.

Dr. Michaels links a decrease in interactions with clinicians and information from them with a decrease in trust. Without being able to witness or take part in clinicians' processes of clinical reasoning, radiologists have no way of knowing whether the patient's diagnosis or presumed diagnosis, the decision to order imaging, or approaches to treatment are "well thought out." Dr. Michaels points out an evaluative aspect of communication, in which engaging in conversation and sharing information can enable analysis of reasoning and thinking and can form the basis for establishing trust or distrust.

In turn, radiologists also said to me that they felt that often they couldn't communicate the subtleties or importance of their imaging interpretations solely through formal documents like the radiology report. Dr. Wyatt, a chest radiologist, told me:

> I think that the current method of communicating clinical information to radiologists is not very good. So I think the number one danger is we don't get all the useful information that we need to interpret studies appropriately. Now more often than not when I do communicate with them, it's after the fact. I think that's a huge problem. We will see if electronic medical records allow us to do that better, but right now that's a big danger. I also think that, in at least complicated or difficult cases the reverse holds where once we know the clinical information we can provide the clinician more insight that will allow them to figure out what is going on for the duration. I think, I guess it's saying the same thing but it goes in both directions. They have to provide us with more information and then I think sometimes there is nuance that comes across in a personal communication that you don't get in a report.

Besides adding to the other radiologists' calls for more information from clinicians, Dr. Wyatt also acknowledges that the flow of information "goes in both directions." Besides not knowing "what's really going on" with patients because referring providers are not visiting the reading room much anymore, radiologists also feel that their own interpretations are restricted by the current forms of communication.

Interestingly, Dr. Wyatt also suggests that the ways that PACS has disturbed the flow of information between radiologists and clinicians might be fixed through the use of another HIT, the electronic medical record. Radiologists at Central Hospital were eagerly awaiting the installation of a new hospital-wide computerized information system that promised to replace paper charts with electronic records. While at the time of my field work they had limited access to some patient records such as labs, pathology reports, and outpatient clinic visit summaries, radiologists could not view the majority of patient records without either going to the wards or the medical record office to hunt down the paper-based charts. While I never observed a radiologist attempt to obtain patient information in this way, they would occasionally call the referring provider to try and get more information. This was a time-consuming activity, however, as clinicians caring for hospitalized patients are notoriously hard to get on the phone. The most common way for getting information about patients was to call the imaging technologists. Despite the fact that these technologists generally had very restricted contact with patients, they frequently possessed more information about patients than the radiologists.

I want to focus on two problems that Central Hospital radiologists are concerned with. The first is that without regular and frequent visits by clinicians to the reading room, radiologists feel they are not getting the information they need to tailor their interpretations to individual patients. This, they believe, has a negative impact on patient care. As part of this argument radiologists are pointing to the inadequacies of the current system of radiologist-referring provider communication at Central Hospital. They seem to be blaming both the clinicians themselves for not filling out the patient history section of the image request form as well as the broader form-based system of communication that does not allow the nuances of patient care to emerge. However, the radiologists I spoke with and observed also indicated a second and deeper issue that the adoption of PACS has raised -- concerning different types of knowledge and the various ways that these knowledges circulate in the hospital.

In his analysis of the work of hematologists, Atkinson shows how communication among medical specialists involves "complex and delicate expressions and codings of knowledge and opinion" (1995: 117). Rather than treating medical uncertainty as a binary division separating the known from the unknown, Atkinson shows how degrees of context-specific certainty and uncertainty are woven into medical discourse. The case history narrative, Atkinson argues, is in fact an assessment by the physician delivering the narrative of the relative plausibility of a variety of information sources, including other physicians, the patient, lab results, events, and others. Atkinson concludes that for physicians "not all knowledge is treated as having equal value. It has different sources, has different weight attached to it, and may be regarded as more or less warranted" (1995: 127). Atkinson's insights echo Dr. Michaels' acknowledgement that interacting directly with clinicians is an important means to assess both the physician communicating information as well as the information itself. Atkinson also stresses that in medicine, all knowledge is not equivalent. Instead, physicians value some types of knowledge more than others, and even quantitative information like lab values is open to questioning and doubt.

It is also interesting to note that while some kinds of communication can help individuals evaluate one another's thinking processes, approaches to problem solving, or mastery of certain bodies of knowledge and may lead to relationships of trust or distrust, personal relationships can also shape the conditions of possibility for certain kinds of communication to occur in the first place. For example, as Dr. Solano, a radiologist who had just become an attending, commented:

> As a resident- I went to medical school and was a resident here [at Central Hospital]- several of my classmates from medical school were ER residents. So

> when I was working [in the reading room], I could call up the chief ER resident who was one of my former classmates, which was nice because I got the official story of "they had this symptom" or whatever from the patient record, and then we would talk on the phone behind the scenes, and I could get the "off the record"[23] information.

It was Dr. Solano's personal relationship with the ER residents that gave him access to information that was left out of patient records. I want to argue that this "off the record" information plays a large part in various aspects of health care. In fact, I want to argue that this "off the record" or "behind the scenes" information is not information at all but a kind of knowledge. While up until this point I have not distinguished between the two, I now want to adopt Tsoukas's definition of information and contrast it with his notion of knowledge. For Tsoukas, information "consists of objectified, decontextualized, time-less, impersonal, value-free representations" whereas knowledge is "context-dependent, personalized, time-bound, and infused with values" (1997: 839). Of course, according to Tsoukas's argument, information itself can never exist, because information always comes from somewhere and is created by some body/somebody. However, the concept of information as something objective, valueless, and neutral is what is important and powerful for Tsoukas, and it is this concept, this mis-recognition of the true nature of information, that does so much work in radiology, medicine, and late modernity in general.

Simply by pointing towards information in medicine that is "off the record," Dr. Solano reveals the importance of both information and knowledge in the hospital. While the idea of objective, value-free information is critical to the depiction of medicine as a science, it is the value-laden, personal, highly contingent knowledge that characterizes

[23] Informant supplied 'finger quotes' to set off this phrase, which I've represented as actual quote marks

"what's really going on" with the patient and in the hospital. Yet while both are crucial for the process of diagnosis and the care and treatment of patients in the hospital, and both turn out to be equally important to the practice of radiology as well, information and knowledge do not have equal status in the hospital.

That different kinds of information and knowledge have different values in western science and biomedicine has been observed by many different scholars (cf. Adams 2010; Freidson 1975; Gordon 1988a; Pine 2011; Polanyi 1966; Pope 2003). In general, these authors distinguish between formal and informal knowledge, or explicit versus tacit knowledge, or "knowing what" and "knowing how." In biomedicine Gordon differentiates between two forms of knowledge that she terms clinical science and clinical judgment, where clinical science describes knowledge that is seen as universal, abstract, explicit, and quantitative (similar to Tsoukas's notion of information), and clinical judgment involves knowledge that is personal, tacit, and implicit (1988a). She argues that through the "scientization" and "rationalization" of medicine, clinical judgment has become an example of Foucault's subjugated knowledge.

Foucault defined subjugated knowledges as "a whole set of knowledges that have been disqualified as inadequate to their task or insufficiently elaborated: naïve knowledges, located low down on the hierarchy, beneath the required level of cognition or scientificity…unqualified, even directly disqualified knowledges…a popular knowledge…a particular, local, regional knowledge" (1980: 81-2). Like Gordon's (1988a) characterization of clinical judgment, I argue that "off the record" knowledge is subjugated knowledge. Yet it is subjugated not by individual clinicians or radiologists who need to know "what's really going on" but by the medico-legal restrictions and requirements of medical records, as I shall show.

As an example of what I am calling "off the record" knowledge, consider my field notes of an interaction I witnessed while sitting with an abdominal radiologist named Dr. Horn one afternoon:

> Two people, a woman and a man, both in their late 30s (clinicians, judging from their long white coats and stethoscopes) enter the reading room. They all great each other by first name (Dr. Horn calls them "Sarah" and "Rob") and clearly know one another well, because Sarah and Rob immediately sit on the counter on the side of the reading station, and let their legs dangle off the end. They mock Dr. Horn's rather fantastic, 70s era sideburns in a friendly manner- apparently this is a new addition to his "look." "My wife thinks they're cool!" Dr. Horn protests in his own defense. Rob is the first one to get down to business, telling Dr. Horn, "We're trying to make your life easier. The patient's name is Smith, and Dr. Barnes (another radiologist) read the study and mentions rectal wall thickening in his report. We wanted to determine in conversation with you guys how significant that is, because the husband is a dick and we have to go talk to him. She (the patient) has constipation, but we don't want to mention this finding to him if it's no big deal."
>
> Dr. Horn laughs, and brings up the patient's most recent imaging study and begins to scroll through it. He looks carefully at the rectum, and says, "Well, I think she might have colitis, which you don't really see with constipation. I don't know what Ted [Dr. Barnes] was talking about, I don't see anything in the rectum. There's plenty going on in the sigmoid and transverse colon, though." Rob responds, "Well, she did just have antibiotics, so she could have C. dif. [*Clostridium difficile*] colitis…" Sarah asks, "Would a barium enema be helpful to clean her out and have a look?" Dr. Horn responds, "Well, she doesn't have all that much fecal material, so I think a CT with contrast would be best. But, I'm mostly worried about pathology in the sigmoid and transverse colon." Rob asks, "Do you see anything else?" To which Dr. Horn replies, "Well, just this liver cyst here" (gesturing with the computer pointer). "Aw, who cares about a liver cyst?" exclaims Rob.
>
> Dr. Horn continues, "I wonder about true colitis, because she doesn't really have traumatic constipation. My hunch is that she has colitis, but she doesn't look like that clinically, right?" Sarah responds, "Yeah, she has fecal incontinence, she's had a CVA [cerebrovascular accident, aka stroke] with right sided weakness, and her husband is being a dick. She has cellulitis that's getting better, but he [the husband] has told us he wants us to fix 'everything.'" Everyone rolls their eyes and expresses frustration that the husband is being so demanding (especially since the patient's clinical problems aren't ones that lend themselves to "fixing" easily, if at all). Dr. Horn says, "Well, IV contrast might help us figure some of her problems out, and if the husband wants all stones looked under, than that would probably be the best approach." Sarah and Rob agree to this plan, and leave the reading room after teasing Dr. Horn about his sideburns a bit more.

There were relatively few of these kinds of interactions when I was observing in the body reading room. Visits from referring providers were rare enough, perhaps occurring once a day or every few days, but visits from clinicians on a first name basis with one of the radiologists were even rarer. In fact, this was the only time I witnessed such a visit while observing body radiologists. From what I gathered from Dr. Horn, he had gotten to know these particular clinicians through his involvement with an administrative committee that they all served on about a year ago.[24] This interaction is also interesting, however, for a number of additional reasons. First of all, the imaging study that Sarah and Rob are asking about has already been formally interpreted by another radiologist. However, they are hesitant to mention one of the findings in this report ("rectal wall thickening") to the patient's husband if it doesn't have clinical significance. All three physicians then engage in a complex negotiation to determine what actions (if any) to take next; this negotiation includes the suggestion of various hypotheses and "hunches," the evaluation of clinical and radiologic data (and radiologists themselves) against one another, focusing on some findings while discounting others, and suggestions for further tests. Different types of information and knowledge are compared, valued, judged, and adjusted during this process of diagnosis. All of this discussion is contextualized, however, by the "off the record" recognition that, according to Rob and Sarah, the patient's husband is being unreasonable (a.k.a. "a dick") and is pushing them to investigate and "fix" all of his wife's problems. Dr. Horn ends up suggesting an imaging study that will help Rob and Sarah figure out why the patient is constipated while also reassuring the patient's husband that her clinical problems are being

[24] After PACS adoption, participation in such committees, tumor boards, or other multi-disciplinary conferences has become an increasingly important way for radiologists to get to know other physicians –see Chapter 7

adequately investigated.

Hunches, hypotheses, frustrations with patients or their families, second-guessing, judging of colleagues, and similar activities that mark how uncertainty is negotiated on a daily basis in medical practice are rarely reflected in the medical records. "Off the record" knowledge, like Gordon's clinical judgment involves personal judgments made in specific contexts; it is subjective rather than objective. Yet this "off the record" knowledge is not tacit, but explicit; it can be articulated and communicated among health care providers. However, this knowledge can only circulate in private or semi-private contexts; by its very definition, this knowledge cannot be made a matter of public record. These types of "off the record" knowledge are also potentially risky to communicate, as they involve personal assessments of people, information, or things that can be controversial, construed as unprofessional, or even harmful if they became recorded or common knowledge. For example, if the husband of Rob and Sarah's patient were to find out that they thought he was "a dick," they could risk censure by the hospital administration. Similarly, Dr. Horn's feeling that a fellow radiologist incorrectly interpreted a study could, if communicated to him, be very awkward professionally as well as personally. Hunches can be embarrassing if they prove to be wrong, and questioning of information is always fraught with the risk of upsetting whoever produced that information in the first place. Thus, communicating "what's really going on" involves relationships of trust; trust that the person conveying this knowledge is reliable, and trust that the receiver of this knowledge won't circulate it inappropriately.

The significance of "off the record" knowledge in the hospital also has to do with the status of medical records as objects of accountability. These documents, whether paper or digital, act not just as records of patient care but as modes of institutional, financial and legal accounting of the actions of both patients and health care workers. Thus, there is a need for all types of health care workers to mediate between the "fixed" nature of the medical record and the flexibility, contingency, and uncertainty involved with caring for patients. In her study of scripting and nurse call centers, Pine uses the work of Tambiah, who writes, "The technology of writing fixes and freezes…in a manner different from oral dogma which is inevitably flexible and adaptive" (Tambiah 1968: 181, in Pine 2011: 269). Thus, there are certain things that a radiologist or clinician might say in the "flexible and adaptive" space of dialogue that they would never write, and in writing become accountable for, in the formal, fixed and frozen report.

Therefore, medical records are places for the recording of information and not knowledge. As Holmes and Ponte observe in their study of medical students learning to present patients to their superiors, medical records, including radiologists' reports, transform "complex, situated, individual human experience into decontextualized cases of universalized, standardized diseases" and work to manage uncertainty in clinical decision making (2011: 178). However, communicating *too much* certainty in medical records can also be problematic. For radiologists, qualifying their image interpretations with hedging or statements of uncertainty affords a certain amount of protection against malpractice lawsuits. For example, a fellow in chest radiology commented to me:

> One thing that's really annoying is that we're really vague and ambiguous in our reports. We're kind of like lawyers dancing around issues, and we have to be really careful what we say from a medico-legal standpoint. But we see a lot and we know a lot, so if you actually come talk to us, you could learn a lot, as opposed to what we have to say in the report. If you come ask me what I think, I'll say that this patient or whoever has a 95% chance of a particular diagnosis, but I can't say that in the report, because there's a 5% chance I'm wrong, and I could get sued.

In some cases, then, “off the record” knowledge is a way to navigate between uncertainty, certainty, and the risk associated with both.

With PACS, an important opportunity to find out “what’s really going on” has been diminished for both radiologists and clinicians at Central Hospital. Without daily face-to-face meetings in the reading room, the relationships of familiarity and trust between clinicians and radiologists that enabled the exchange of “off the record” knowledge seem to have declined. By communicating with clinicians primarily through their reports, radiologists can be hesitant to express diagnostic certainty in this formal, legal document. In turn, radiologists also believe that they are not getting sufficient information *and* knowledge about patients to interpret images to the best of their abilities. After the implementation of PACS, radiologists are still reading images and producing interpretations, but the opportunity to translate those interpretations into authority and trust has all but vanished. Instead, radiologists see themselves as “operating in a void,” becoming increasingly physically and practically separated from physicians and patients. As one radiologist expressed in a journal editorial:

> Technology has served a lot of purposes, both good and bad. While it has had a positive impact on many areas of our profession, it has meant that we have fewer opportunities to interact with our colleagues. In the past, the radiology department often served as the central information clearinghouse for what was going on in a hospital. Now, however, technology has meant that so much of this has changed, especially when it comes to the perception of the importance of radiology. Our importance in the health care environment has increased, yet the perception of our importance has changed significantly among our peers. [Forman et al. 2010: 1015]

This situation has implications beyond the personal and professional status of radiologists, specifically for patient care and how medicine is practiced. Despite the increasing isolation of radiologists, medical imaging continues to be central to the process of diagnosis, including prognosis, strategies for treatment, and assessment of treatment. Radiologists argue compellingly that the best patient care is based on the ability of radiologists and clinicians to exchange both information and knowledge.

In her excellent ethnography of life in a psychiatric ward, Lorna Rhodes (1991) describes a “topography” of medical practice, which includes a hard, high ground where theory and formal information reign supreme, and a swampy lowland where the daily ambiguities, complexities, and contradictions of caring for patients are negotiated by physicians. While “off the record” knowledge might be considered a kind of subjugated knowledge from the formal perspective of the heights, this knowledge is powerful in the swamp of the hospital diagnostic economy. I propose to use Mary Douglas’s notion of dirt (1966) as a way to understand this subversive power of “off the record” knowledge in the hospital. For Douglas dirt is understood as matter out of place; it is the by-product of classification systems -- those inappropriate elements that don’t fit neatly into our conceptual categories. Douglas recognizes that while the purity and cleanliness of systems of classification have power, so, too, do the things that lie in the margins and the inarticulate areas between boundaries and borders. Notions of dirt and pollution are a way to control behavior and give order to disorder, yet the division between clean and dirty is never fixed and is always context-dependent, i.e., what is polluting in one situation is pure the next, and vice versa. Further, dirt can be both destructive and creative, according to Douglas.

Thus, if we consider “off the record” knowledge as a kind of dirt- that knowledge that falls between the cracks and margins of formal documents and medical categories- it can be understood as powerful in some circumstances and discounted in others. Reading rooms are no longer places where this kind of dirt circulates. PACS has made radiologists and reading rooms pure, and by doing so, has made radiologists less powerful, largely excluding them from the daily "swamp" of patient care.

Thinking of PACS as a technology of purification raises important questions about what will happen to medical knowledge (as opposed to medical information) with the increasing adoption of electronic medical records and other kinds of health information technology. These technologies are supposed to allow physicians to access complete and comprehensive information about patients, facilitating better coordination of care, increased efficiency (i.e., lower cost), and better outcomes for patients. With access to EMRs, physicians can (in theory) look up every test, every exam, every point of communication with "the system" that a patient has had. The key assumption of this model is that more information is always better and will lead to better care.

According to this argument, it does not matter that radiologists are not meeting face-to-face with clinicians anymore or even talking on the phone as much; any information that a radiologist might have obtained from talking to a physician will be in the EMR; and vice versa, anything important the radiologist might have to say will also be found in the computer data base. Communication will be more efficient -- instead of talking to five clinicians, the radiologist can just write one report -- and time and money will be saved. Yet these arguments conflict with the realities of medical practice in the "swamps," where knowledge and information are equally important to patient care. But how do we digitize dirt?

CHAPTER 6: Reading as Expert Engagement

Engaging with images

Reading medical images, for radiologists and for clinicians, entails different engagements with images, patients, other types of physicians, and with PACS itself; thus, it involves the cultivation of different gazes which generate different responsibilities and obligations. Rather than enabling the simple "diffusion" of radiological expertise to other groups of medical specialists, PACS has created a space for new kinds of expertise to emerge, which, while heavily influenced by and based on the practices of radiologists, also differ in significant ways. The emergence of these multiple claims for expertise in interpreting medical images and the multiplication of "reads" of these images have important implications for the personal and professional identities of radiologists and clinicians, the negotiation of responsibility within health care, and also for patient care.

I begin with a brief discussion of practice and the medical gaze. I then examine how the practice of reading images differs among clinicians and radiologists. I explore three related questions: first, what do radiologists and clinicians focus on when they read medical images, and what types of engagements shape this focus?; second, what obligations and responsibilities does reading entail for these physicians; and third, what is produced by these different practices of reading?

I use these questions to highlight two key tensions that dominate the practice of reading for radiologists and clinicians. I show that radiologists believe that with PACS, they have been reduced to the text of their reports. Facilitated by PACS, this reduction of radiologist to report emphasizes a slippage between the report as a crucial mode to communicate radiologists' expertise to clinicians and the report as a primarily medico-legal document that renders the work of radiologists invisible. Further, concentrating on the practice of reading reveals a second important tension surrounding the radiologist's report, this time among clinicians. While clinicians say that providing good patient care is their primary responsibility and acknowledge that part of "good care" involves reading radiology reports, in actual practice reports are often ignored. As I show below, by preferring to rely primarily on their own 'reads' of medical images instead of correlating those interpretations with those of radiologists, clinicians are placing patient care in jeopardy.

Practice

What do I mean by practice? On the one hand, practice can refer to the specific tasks, routines, and behaviors of medical professionals (the practice of medicine) or to the place that a doctor works (a medical practice). On the other hand, practice is also used in the sense of repeating a behavior to refine or hone a skill, e.g., an attending telling a medical student to practice her patient history presentations or physical exam. In anthropology, however, the notion of practice refers to action or 'doing' in a more general sense and has become a major focus of anthropological inquiry. For example, in her 1984 article titled "Theory in Anthropology Since the Sixties," Sherry Ortner argues that since around 1980, "there has been growing interest in analysis focused through one or another of a bundle of interrelated terms: practice, praxis, action, interaction, activity, experience, performance" (1984: 144). Similarly, many in the field of STS also began in the 1980s to prioritize looking at how science is "done," including key studies by Hacking (1983), Latour (1987), and Pickering (1992). Mol's 2002 work may be seen as the culmination of this "turn" to practice, moving beyond the early STS studies by arguing that what appear to be "facts" are, in fact, never black-boxed, "finished," or closed. Instead, for Mol everything must be continually brought into being and defined through practice (2002).

Indeed, Mol's argument that objects do not exist *a priori* but emerge through action (2002) is foundational to my own research. Thus, the *practice* of reading does not involve merely the generation of a series of interpretations of a single, "real" image, but instead generates multiple versions of what is real about the image. Yet Mol argues that "doing" must be analyzed separately from thinking, or that epistemology[25] can and should be considered apart from ontology. However, like other scholars, I observed during my research that principles, perspectives, theories, and practices co-constitute one another. Thus, in my analysis of the practice of reading, I concentrate not only on the activities, objects, and procedures that are involved in "doing" but also the self-reflexive musings and considerations of medical practitioners about what it is that they do. Further, I highlight the significance not only of doing, but of *not* doing. Clinicians' decisions not to act in certain ways shapes how radiologists engage in reading images and vice versa. Similarly, I show that practice must also be understood in a context of both past and future action.

[25] In her article exploring the tacit understandings and worldviews that underlie biomedicine, Gordon helpfully defines epistemology as "assumptions about knowledge and truth" and ontology as "assumptions about reality and being" (1988b: 19).

Gazing

Foucault showed how the gaze is the clinical practice of modern medicine, writing, "The medical gaze embraces more than is said by the word 'gaze' alone. It contains within a single structure different sensorial fields…The medical gaze is now endowed with a plurisensorial structure. A gaze that touches, hears, and, moreover, not by essence or necessity, sees" (Foucault 1973: 164). The power of the gaze comes from the slippage between gaze-as-perspective and gaze-as-practice. As Hacking reminds us, one cannot be separated from the other because "seeing is intervening" (1983). I view the notion of "gaze" as a verb rather than a noun, where "the gaze *does*, acts, moves; it is a gesture, not a thing" (Rhodes 1993: 136). This plurisensorial gaze is also a performative, enacting gaze, as seeing is always linked to saying in the space of the clinic (Foucault 1973). Thus, gazing is itself a process of engagement, of seeing and being seen.

The notion of gazing as practice also allows me to explore the particular arrangements of power that gazing, as a certain kind of medical expertise, can involve. As Haraway reminds us, "vision is *always* a question of the power to see," and thus "struggles over what will count as rational accounts of the world are struggles over *how* to see" (Haraway 1988: 179-80). Therefore, the stakes over who claims expertise in reading images, which "reads" count as authoritative, and which responsibilities become linked with reading are important both for the physicians involved and for medical practice. It might be said, therefore, that reading is a process of expert *engazement*.

In exploring the reading of medical images, however, I also highlight an important slippage that takes place between "reading" and "read" in the hospital. I argue that for both radiologists and clinicians, reading involves a broad range of engagements with other people, objects, and technologies as well as various sub-practices and perspectives that includes but is not limited to the interpretation of the medical image. However, in hospital jargon, a "read" generally refers only to a one- or two-line summary of the major image findings. Thus, I maintain a distinction between reading as a process of expert engagement and the "read" or summary of findings that is produced as part of this engazement.

Question 1: What do radiologists and clinicians focus on when they read medical images, and what types of engagements shape this focus?

<u>Radiologists</u>

At Central Hospital images are what radiologists engage with most frequently, and the production and interpretation of images are the activities that structure the practice of reading for radiologists. One radiologist told me,

> Reading, what we (radiologists) do, involves four integrated parts. The first thing we have to do is assess whether the image needs to be done, whether the study is appropriate. Then we make sure that the study is good, so we look at the quality of the images. Then we interpret the image, and then we will communicate that result to the clinician, and finally we have to be able to consult with that clinician on the significance of the findings and what it means for the patient's care.

While reading for this radiologist involves a comprehensive suite of activities that includes assessing appropriateness, quality control, interpretation, and communication, the radiologist's primary focus during all of these tasks remains centered on the image. However, this focus is shaped in specific ways through radiologists' engagements with a series of 'others,' both real and imagined.

I found that radiologists' gazes were largely shaped by their beliefs about the practice of reading among non-radiologists (and vice versa, as I discuss below). In the musculoskeletal reading room, I overheard an exchange between the MSK fellow, James, and one of the first year radiology residents, Avi. Avi was "staffing out" his studies with James, and they had just started reviewing a post-operative spine X-ray. Avi suggested his preliminary interpretation, and Mark agreed with his "read," saying, "Yeah, I agree, I think all the hardware looks fine. But the one thing we don't want to miss is lung cancer. The ortho[26] surgeon, the ortho PA, lots of other people will look at the spine hardware, but we need to make sure the lungs are clear. These films always catch a lot of lung, and I don't care that the lung volumes are crappy, I just don't want to miss the cancer. You have to look at everything, not just the obvious stuff."

Similarly, Dr. Haley, an abdominal radiologist, told me:

> Well, PACS has made it easier for us to do our jobs, but it has also made it easier for other people to try to get our work because they say, "Sure, I can look at that (images) too," but the reality is that we're not looking at the same things. We look at the whole image. So, one example is if you have a urologist looking at his own IVPs[27], if he practiced he might be pretty good at reading the IVP portion. Unfortunately there is a lot more information on the image – you can see the liver, adrenal tumors, you name it. So you need someone looking at the whole study, not just the urologist who is only interested in a little part.

James and Dr. Haley both emphasize that radiologists must look at the entire image or study and contrast their own "global" focus with the "partial" gaze of clinicians. Thus, the way that radiologists believe that clinicians look at images becomes included in and guides the way that radiologists conceive of and enact their own engazement. In a related way, what radiologists *don't* focus on -- patients, specifically -- contributes to their characterization of their gaze as "global." As one radiologist told me, "I feel like

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[26] Short for 'orthopedic'

[27] IVP stands for intravenous pyleogram, an X-ray study of the kidneys, ureters, and bladder

I'm much more objective than clinicians when I look at images, because I'm not distracted by the patient like they are."

Yet there is controversy about this issue among radiologists. While some radiologists argue that knowledge about patients is critical in providing accurate interpretations, others, like the radiologist above, feel that patients are more of a "distraction" that biases a radiologist's otherwise "objective" focus. However, with fewer and fewer clinicians choosing to visit the reading room, it is proving more difficult for radiologists to learn "what's really going on" with patients. At Central Hospital most radiologists were too busy keeping up with The List to either call clinicians to gain additional patient information or sift through the partial health records made available via computer. Even when such information was available, however, radiologists' focus remained concentrated on the image rather than the patient.

In addition to characterizing their focus as more comprehensive, objective, and "less distracted" than that of clinicians, radiologists I spoke with also believed that they are better able to distinguish what is "real," i.e., actual pathology, from what is "not real," i.e., findings that are not pathology but are artifacts generated by the imaging machines themselves or normal anatomical variants. As Dr. Wyatt, a radiology resident in his third year of training commented to me,

> MR is so complex, and I have a background in electrical engineering and I still find MR imaging complex. There are just so many different sequences that you can use and so many ways you could alter that particular sequence to answer a particular clinical question, and an equal number of ways that you can be fooled into thinking that something is real when it isn't. And every machine is different, they generate slightly different artifacts, so you have to watch out for that. So that is a part of our expertise too, knowing about the technology. I think referring providers are often tricked into thinking something is real when it isn't just because they don't know as much about the technology.

Yet I also found that the boundary between what was determined to be "real" versus "not real" could be quite fluid and differ significantly from one radiologist to another. For example, in the musculoskeletal reading room, I observed an interaction between Dr. Geshram, a more senior attending, and Avi, the first year radiology resident. When reviewing a knee MRI together, Avi used the mouse cursor to point out an area where he believed there might be a small meniscal tear. Dr. Geshram replied, "Yeah, that doesn't really meet my threshold for calling something. If Dr. Solano (another radiologist) was looking at this study, he'd probably call that, but not me. You put that in the report, and then the ortho folks feel like they need to do something about it, when it might not even be real. I want to save the patient from an unnecessary operation."

As Dr. Geshram points out, he and Dr. Solano have differing opinions about what is "real." Yet he also calls attention to the fact that deciding if something is "real" isn't just about seeing or not seeing but is about levels of significance and opening up something or someone to the possibility of (perhaps unnecessary) action or intervention. Thus, Dr. Geshram's gaze is shaped by the inclusion of other radiologists' practices as well as concern for the patient.

Marking something as "real" is also a matter of politics and strategy in the musculoskeletal reading room. When Dr. Geshram leaves the reading room to go get a cup of coffee, James, the fellow, leans over to Avi and says, "Dr. Geshram is totally right. Dr. Solano always calls things that aren't there, just to put something in the report to impress the ortho guys. I'm the opposite- I'm not going to put anything in (the report) that isn't real." According to James, putting something in the report, even if it isn't "real," is a strategy used by Dr. Solano to impress the orthopedic surgeons.

I would not want to give the impression, however, that radiologists at Central Hospital are deliberately "making things up." The radiologists I observed worked very hard to correlate what they saw in images with what was "real." For example, in the musculoskeletal reading room, every month or so the radiologists would compare their interpretations of imaging studies with the orthopedic surgeons' operating reports to see how often their interpretations turned out to be "correct" when surgeons took the patients to the operating room. Based on this method, the radiologists were able to provide "evidence" that for roughly 95% of patients who had imaging and then went to surgery, radiologists accurately determined the "reality" of the patients' injuries. In a profession where inter-observer variability is notoriously high, these correlation studies were an important way that radiologists assured themselves and others that what they were seeing was, in fact, "real." Thus, at Central Hospital radiologists' gazes were also shaped by the inclusion of surgeon's practices and audit techniques.

Anxiety about the future also seemed to shape radiologists' focus when reading. In fact, almost all the radiologists I talked with expressed anxiety about the future of the specialty and used this anxiety to argue for the practice of reading to involve more than just image interpretation. As one of the chest radiologists told me,

> We can train monkeys to just sit there and describe what they see, so we have to use our intelligence and our knowledge to spit out a diagnosis and say what we think. But we are also a service specialty, so we can't just hide in a dark room, we have to be responsive to referring physicians, not just put out reports. If you don't add value, then clinicians don't come and ask your opinion, and that means they don't value you and you are not providing a service, and if you are not providing a service then the specialty is not going to survive.

With PACS, it seems that "seeing and saying" has changed from the activity of an expert to something a monkey can do. Rather than simply offering interpretations, radiologist must "add value" by giving diagnoses instead of descriptions and being responsive to clinicians. Interpretation itself, it seems, no longer has "value" to clinicians, according to radiologists. For this chest radiologist, value is also linked to the notion of service, and providing a service is linked to the survival of the specialty.

The radiologists I talked with also stressed the importance of having a "specialized" focus for "adding value" to the practice of reading medical images. As Dr. Ling, a neuroradiologist told me one day, "I think PACS has really reinforced the notion of sub-specialization in radiology. Because the generalist (radiologist) -- and there are still a lot of generalists in practice -- their ability to actually add value when neurologists or neurosurgeons can have their own images and look at them themselves is pretty limited. And sub-specialized radiologists definitely add value."

Similarly, Dr. Ferguson, a chest radiologist, said, "Now with PACS, you really need to have some specialist experience in order to really add value to the interpretation. It probably takes a few years post-residency to get really good in one particular area where you can truly add useful analysis or interpretation to patients who are being taken care of by doctors who are specialized in that area." As Dr. Ferguson indicates, "sub-specialization" refers to radiologists who have completed a year or two of fellowship training in one or more particular areas (such as breast imaging, abdominal imaging, neuroradiology, etc.) after completing the four year radiology residency.

Interestingly, both Dr. Ferguson and Dr. Ling agree that with PACS it is not just interpretation of images that has no value, it is interpretation by a radiologist without specialist training. In this situation we see that radiologists' gazes at Central Hospital also engage with and include a group of radiologists outside of Central Hospital, which Dr.

Ling identifies as "generalists." Likewise, they indicate not all clinicians believe that radiologists' interpretations don't "add value," just clinical specialists like neurologists or neurosurgeons. Thus, "adding value" is context-specific and shifts with the types of engagement that are involved; generalist radiologists do not "add value" when they read images for clinical specialists, but a sub-specialized radiologist can.

The focus of radiologists is also shaped in important (but often unacknowledged) ways by fatigue. Dr. Geshram informed me:

> With PACS, there are more images per study and we have more studies to read, so the question is how do we keep being accurate and efficient but not fatigued, how do we look at these very large data sets without missing something, it's a tough problem. There's research coming out that our ability to detect pathology goes way down after staring at a computer screen for 5 or 6 hours, but I'm not sure that anyone has a solution for what to do.

In fact, issues of eye strain and cognitive fatigue have emerged as key topics in the recent radiological literature. A study by Krupinsi et al. published in 2010 showed that radiologists were significantly more likely to have lower rates of fracture detection at the end of a work day than at the beginning. While clinician visits to the reading room enabled radiologists to actively alter their gaze, in the setting of PACS radiologists are more likely to stare at the computer screen for hours at a time.

The issue of fatigue also highlights that radiologists' focus is strongly shaped by engagements that have become less intimate or less frequent, specifically, clinician visits to the reading room. As Dr. Atkinson, an attending abdominal radiologist with many years of experience, remarked:

> With PACS, since clinicians don't have to come see us anymore, we can get away with just interpreting exams. So some people, all they want to do is interpret exams, forget about whether it (the exam) needed to be done, forget about the quality piece and forget about the consultation piece, because interpretation, that's

> where the money is[28]. And that's what turns us into a commodity, because now all we do is interpret. We've been reduced to our reports.

For Dr. Atkinson, reading should entail more than just interpreting images. Yet he claims that because of PACS, the lack of clinician visits to the reading room, and radiologists' own desire to make money, reading has been reduced to interpretation, and radiologists have been reduced to their reports. We see how PACS works as a technology of amplification and reduction (Ihde 2002), amplifying the desire to make money while reducing physician visits, reducing radiologists to their reports, and reducing the practice of reading to involve just interpretation. However, we also see how clinicians' decisions of what *not* to do, e.g., visit the reading room, shapes the focus of radiologist engazement.

Notions of business, service, and "adding value," anxiety about the future, and perceptions of how other types of radiologists and clinicians are practicing shape radiologists' focus when reading at Central Hospital. For radiologists, then, reading (as opposed to interpretation) is a political act that is seen as being crucial to the survival of the specialty.

Clinicians

The practice of reading images has become an integral part of physician activity. For clinicians, looking at images on the computer via PACS has become as central to patient care as examining and talking to the patient herself, and even the smallest decisions, such as whether to advance a feeding tube an inch or two, require imaging. For

[28] As I mentioned in Chapter 1, imaging is billed on a fee-for-service basis, with the 'service' in this case referring only to the production of the radiology report

example, the teams of pulmonologists and medicine residents I rounded with in the ICU and the neurologists and neurology residents on the stroke team held daily "PACS rounds" to look at, interpret, and discuss any new images from their patients. Yet in stark contrast to radiologists, I observed that with PACS, the physician gaze has widened to include medical images but remains firmly focused on patients. Thus, the gaze of clinicians as they look at images is focused by their knowledge of the patient, and shapes both what is and isn't seen. For example, Dr. Singh, a neurologist, told me:

> Neurologists, we want to think about the patient, we want to think about the differential diagnosis and then we do imaging to help us narrow down the possibilities. We are not supposed to start with a scan and then say, "Gee, what are your symptoms?" and I continue to follow that rule when I see patients in my clinic. They come into my office, they hand me the CD with their CT on it and ask, "Do you want to look at these?" I say, "Sure, but let me talk to you first," and I always do that. Based on the history and exam, I say to them, "These are the certain things I am thinking about" before I look at the image. I do that for my own mental state – to keep me honest. Then if I see something on the scan that I completely didn't expect it is educational to me and it helps me realize the thing that I am seeing on a scan is incidental and really didn't have anything to do with the patient's complaints.

While many clinicians I spoke with felt less strongly than Dr. Singh about the need to come up with a differential diagnosis before looking at any imaging, they all echoed his insistence that without correlating imaging findings with knowledge about the patient, the image itself was fairly useless. Instead, for clinicians, the meaning of images emerges through the act of correlation, of bringing together knowledge about the patient with images of the patient. Thus, the practice of reading for clinicians involves focusing on individual patients, with a gaze that is constantly comparing and correlating what is known about the patient with image findings. It is also interesting to note that Dr. Singh identifies an ethical component to his gaze. Correlating patient symptoms with images keeps him "honest" and from being led astray by the image. The image emerges here as a tricky, perhaps even dishonest actor in this engagement and is secondary in importance to patient symptoms.

Similarly, in the excerpt from my field notes below, Dr. Daniels, a pulmonologist, pushes a resident to not just interpret images, but to interpret them based on what he knows about the patient:

> Dr. Daniels pulls up Mr. Flanders' latest chest X-ray on one of the PACS station monitors, and a chest X-ray taken two days ago on the adjacent monitor. He asks Mark, the second year resident in charge of his care, to interpret the exam. Mark looks closely at the screen for a few seconds, then states, "Well, his lines are unchanged, and the lungs continue to be hypoinflated, and there's still patchy infiltrate that could indicate vascular crowding. I think some of what looks to be improvement is because we've shot the film from a different angle."
>
> While talking, he leans over Dr. Daniels' shoulder and points out these findings with the mouse cursor. Dr. Daniels seems to agree with Mark's assessment, saying, "Ok, so not significantly changed. But, he's got a little retrocardiac opacity there, do you see?" [He gestures towards the screen with a finger]. Mark leans in more closely to the screen, and acknowledges what Dr. Daniels is pointing out. "So, in Mr. Flanders, what are you worried about with that finding?" Dr. Daniels continues. "Um, pulmonary effusion, or maybe infection" Mark answers, fairly confidently. "Yeah," Dr. Daniels agrees, "But which one? So, let's listen to his lungs when we round on him, but his nurse told me that he was febrile overnight, so let's check his white count and think about starting him on antibiotics.

It is not enough for second year resident Mark to say that a finding on a chest X-ray could indicate infection *or* lung fluid; instead Dr. Daniels requires that Mark's read of the image take into account the patient's fever and suggest a plan of action that involves both more correlation (listening to the patient's lungs, checking the white blood cell count) but also a decision (whether to prescribe antibiotics).

Further, the focus of clinicians while reading is also influenced by the way radiologists talk as well as radiological notions of how images show pathology. I frequently observed that both clinical residents and clinical attendings would use words and phrases that, before PACS, were primarily heard only in the reading room. When

Mark interprets the chest X-ray for Dr. Daniels, he uses descriptions like "hypoinflation," "patchy infiltrate," and "vascular crowding," while Dr. Daniels himself describes some "retrocardiac opacity." Yet this radiology-speak is combined with observations about a "febrile" patient, white blood cells, and lung sounds, topics firmly tethered to medical practice in the clinic. The ability to read images has become a major part of learning to act and engage others as a clinical expert. Thus, at Central Hospital, clinical engazement is not only productive, generating information and decisions, but also reproductive, shaping the engazement of medical trainees.

Yet if the practice of reading for clinicians involves a specific focus or way of seeing and saying, it also involves a way of *not* seeing, in which certain things remain out of focus. For example, during the stroke team PACS rounds I observed the following interaction between Matt, a neurology resident, and Dr. Cohen, the neurology attending:

> The team is discussing a patient that was originally admitted to the hospital for stroke, but developed severe diarrhea after about a week that has been resistant to treatment. On the recommendation of the infectious disease consult service, the team ordered an abdominal CT that was performed yesterday. Matt turns to Dr. Cohen and asks, "I presume you don't want to look at the CT of the abdomen/pelvis?" Dr. Cohen answers, "No, let's look at the radiology read on that one, I'd be lucky to identify the spleen!" Everyone laughs, and we leave the conference room to begin walking rounds.

Here, Dr. Cohen admits that he lacks the expertise to read a CT scan of the abdomen and pelvis, saying he'd be lucky to identify the spleen. While his comment can be taken somewhat tongue-in-cheek (he would most likely be able to identify the spleen), I took the opportunity to ask him later in the day why he felt comfortable reading head CTs and MRIs, but not imaging of other areas of the body. He replied:

> I think I'm just very focused on a particular part of the puzzle. I've been looking at head CTs and MRI and angiography for years, and so I have a lot of experience at reading those scans, and I feel really comfortable. And I really haven't thought

> about abdominal anatomy since medical school, so I'm not the one who should be reading those scans. But I will say, because I deal with the brain and the vascular supply, I don't look closely for things within the face or neck, like in the sinuses or maxillary bone or whatever. It's just not what I'm focused on.

Dr. Cohen raises an important point that speaks to the larger issue of the increasing specialization of physicians in biomedicine, especially within the inpatient setting. Someone hospitalized with heart trouble will most likely be cared for by a team of cardiologists, while stroke patients are seen by the stroke team. Fewer and fewer physicians take responsibility for the "whole" patient, instead delegating various organs or biologic systems to various experts. Even radiologists, who claim to have a "global" gaze when it comes to reading images, are divided up into anatomical specialty groups at Central Hospital.[29] Thus, both radiologists' and clinicians' gazes when reading are importantly shaped by their specialty.

Like radiologists, clinicians I spoke with frequently characterized how they engage in reading through comparison with how they believe others (specifically, radiologists) read. For example, one ER attending commented to me, "Sometimes we might see something on the scan that the radiologist didn't see. It's actually not that uncommon, because we know much more about the patient history. We know what to look for." This clinician's gaze is shaped not only by what she sees (the image and the patient) but what radiologists *don't* see (the patient) and what they missed (a finding).

According to another clinician, this time a thoracic surgeon, the focus of both radiologists and non-radiology physicians is influenced by relevance and efficiency, but in different ways:

[29] This is the standard way that academic radiology departments are organized

> Radiologists usually don't know much about the patient when they look at images, and the vast number of studies that the radiologists have to read doesn't allow them to get that deep into each one of them. In a way, it's a good thing that they are not too biased when they first see a scan, and they teach themselves to look at the whole scan. So they are very unlikely to miss less relevant things, we are more likely to see what we want to see and miss the extraneous details. So those two together I think balance each other. Since we looked at it they've looked it, we very rarely miss anything.

The surgeon characterizes radiologists' focus as being relatively objective and complete, scanning surfaces rather than depths, limited by time, and good at identifying "extraneous" or "less relevant" details. In contrast, his own gaze is perhaps more biased but fixed on what is relevant. Extraneous but objective and biased but relevant – in theory, each is necessary for the other to form a balanced gaze.

The technologies of PACS, and most centrally PACS stations, were another important influence shaping clinicians' focus during reading. Yet while the radiologists I observed could navigate the PACS system fairly effortlessly and were rarely plagued by technical problems or glitches, clinicians' engagements with PACS were more often characterized by frustration than comfort. For clinicians, frozen screens and broken mice were quite common, and the system seemed to be having "a slow day" more often than not. On numerous occasions, walking rounds would be suspended due to COW[30] breakdown, and the team would fan out to search the wards for a functioning replacement. In all kinds of ways, the related technologies of PACS (monitors, computers, COWs, the hospital LAN) frequently "pushed back" against clinicians as they engaged in reading. Further, the clinicians I observed almost never used some of the more advanced image processing tools that radiologists use regularly. In fact, even accessing

[30] Short for "computer on wheels"

the more basic features for manipulating images such as adjusting the contrast and brightness were beyond the PACS skills of many clinicians I observed.

In addition, at Central Hospital radiologists' monitors and computers are of the highest quality available on the market, while most of the PACS stations on the wards are of much lower quality. This, too, shapes clinicians' focus when reading as well as what they see. One day during PACS rounds with the stroke team, for example, I commented that the computer seemed particularly slow that morning. Dr. Cohen, the neurology attending, agreed, adding, "Yeah, the computers up here are really slow compared to the ones in the reading room, and the monitors are crappy. Sometimes, I look at the image and then look at the radiologist's report, and I'm like, 'Huh? What?' because I can't even see what they're talking about. Then, if I go down to the reading room and look at it [the study] on one of the good monitors, I'm like, 'Oh. Now I see it.' Central Hospital does not have the money to continually upgrade all the computers in the hospital, nor do the PACS stations in clinical areas seem to get replaced very often. Unless they want to go to the reading room to view each image, clinicians must make do with the available equipment. For clinicians, therefore, reading is further shaped by pressure to "move things along" (Kaufman 2005) as well as by the financial constraints of the hospital.

Finally, I want to discuss the ways that clinicians' engagements with radiologists, through the radiologist's report, shape the focus of clinician engazement. I observed that, despite developing their own claims for expertise in reading images, clinicians would still occasionally read the reports generated by radiologists[31]. Although the decision to

[31] It is difficult to gage how significantly clinicians' focus when reading is shaped by the radiology report, if they do indeed decide to read the report. I explore this issue more in

consult the report varied from clinician to clinician, I was able to detect some patterns regarding when clinicians sought radiologists' reports. In general, the most common reason for clinicians to look at a radiologist's report was when the images were of a part of the body outside of that clinicians' area of specialization. For example, as I indicated above, Dr. Cohen, a neurologist, says he will look at the radiologist's report for a patient's abdominal CT. As a brain specialist, he admits to being uncomfortable with interpreting images from other parts of the body. On other occasions I saw clinicians decide to look at the radiology report when they perceived that the imaging study was particularly complex or if a specific question arose that the clinicians couldn't answer. Interestingly, clinicians' decisions to look at the report were frequently based on which radiologist wrote the report, especially if the image lay within the clinician's own realm of specialization – a trend that I discuss in the next chapter. Rarely was the radiologist's report consulted if a disagreement arose among clinicians as to the "correct" interpretation of a study.

Perhaps of more significance were the circumstances in which clinicians tended to *not* look at the radiology report. For images that were designated "routine," such as a chest X-ray to check line placement, the report was seldom consulted by clinicians. In addition, if a clinician felt particularly pressed for time, either during a clinical emergency or when there were simply too many patients to see and too many notes to write, the images were examined but the reports tended to remain unread. Several clinicians also indicated to me that they did not regularly read radiologists' reports because the reports simply confirmed what the clinician already knew by reading the

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the next chapter, in which I examine how different "reads" are negotiated among by the patient care team during diagnosis.

images. As one more senior surgery resident expressed, “Why would I waste my time reading the reports, when I’ve already looked at the images and gotten the information I need? Nine times out of ten, by the time the report is ready, I’ve already read the study and done what I needed to do. They [the reports] just aren’t helpful.” During rounds and while teaching residents, I never observed clinicians or residents consult the radiology report. Rather, if reports were looked at, it tended to be a solo activity conducted away from the team.

Question 2: What obligations and responsibilities do radiologists and clinicians engage when reading?

Radiologists

In exploring this question, I found that most radiologists at Central Hospital felt they had to negotiate among multiple responsibilities of different types, including obligations to patients, referring physicians, and the hospital itself. However, the responsibility that radiologists engaged with most frequently was the obligation to directly notify the clinician who ordered the imaging study if there were unexpected or clinically urgent findings (referred to as a “critical result” by radiologists). While these findings are also documented in the radiology report, in situations where the findings may require immediate or urgent intervention (such as a pneumothorax or internal bleeding) or if the finding is not urgent but still may significantly impact the health of the patient and is unexpected by the physician (such as a lung nodule on a chest X-ray ordered to look for pneumonia), radiologists are legally responsible for informing the physician who is in charge of the patient’s care.

As one radiology resident told me, "It is our responsibility to communicate the urgent or unexpected to the clinicians, you don't expect them to just read the report and actually get that out of it, if it is unexpected or something important then you really need to get in touch with them." Similarly, another radiology attending told me, "We are the ones responsible for communicating to the physician if it is a critical result or a significant result. If it doesn't get communicated, we don't have a leg to stand on if we just say, 'Well, we sent the report they just didn't read it.' Then we get sued." As these quotes indicate, there is both an ethical as well as a legal side to this responsibility. On the one hand, the radiology resident recognizes that clinicians do not always read the radiology report, and that the radiologist should convey important information. On the other hand, the radiology attending notes that there are legal repercussions (i.e., getting sued) for not communicating critical results.

Most radiologists I spoke with expressed mixed feelings about this responsibility. In an interview, one of the abdominal radiologists told me:

> I would argue that I shouldn't have to call a Central Hospital physician to tell him that his patient has appendicitis when he ordered a CT for appendicitis, the images show appendicitis, and the final report is on the computer in front of him that says appendicitis, and he is looking at the images. I shouldn't have to interrupt him to call him to tell him what he already knows, and it takes up my time to track the physician down. On the other hand that is one of the requirements that we've ended up being responsible for, and I guess it's better for patient care than having something important slip through the cracks.

I often witnessed radiologists spending five or ten minutes on hold, waiting for a physician to come to the phone, or calling all over the hospital trying to track someone down. I also witnessed physicians getting interrupted during the middle of procedures or while talking to patients in order to take a phone call from a radiologist relaying critical results. To try and make this notification system more efficient, Central Hospital had recently installed a critical test result management (CTRM) system called Witness (see Appendix 1 for further discussion of CTRMs). When a radiologist needed to communicate a critical result, he or she could use the Witness system to record a voice message relaying the result. The physician who ordered the imaging study would then get a page, notifying him or her of the need to log in to the Witness system to retrieve the message. Witness enabled the radiology department to track each message and confirm that it was listened to by the physician. However, if the physician did not log into the system, he or she would be paged repeatedly. Eventually, after multiple pages, the physician's section or department head would be notified.

It is perhaps not surprising that most physicians I talked to detested the Witness system. Radiologists, however, had more mixed reactions. Some felt that it was an important time saving device that enabled them to be more efficient and obtain some degree of legal protection, while others saw it as a poor substitute for communicating with physicians. As Dr. Gifford, a musculoskeletal radiologist, expressed:

> The problem with calling a referring provider is, I can guarantee you, there will be clinicians who will say, "No, I didn't get a phone call" when they did. So with Witness, we have a way to document that, so that we have to have something that we can confirm. The clinicians are right that a lot of the reason we use Witness is because of the medical/legal issues, but on the other hand it's the right thing to do to notify a doc about a significant finding on a patient. Now in the ideal world, they would be calling us, they would take care of that. But, unfortunately the courts, getting back to legal side of things, the courts don't view the responsibility as equal between us and the clinician. If Mrs. Smith had a cancer on her mammogram, and nobody acts on that, then the courts tend to view that if we didn't grab Dr. Jones' face and rub it in the report, it's our fault that he didn't act on the report, even though we may be able to prove that we interpreted it accurately, we sent it to him, it was received by his office. But if it was a significant finding and we didn't get in his face, we're at fault. And that is what Witness does.

The responsibility to notify clinicians about clinical results emerges as a complex negotiation between legal accountability, time management, and doing what is "right" for the patient. Again, we see how radiologists' notions of responsibility are shaped through an engagement with their beliefs about how clinicians practice – specifically, that clinicians tend not to read reports and "forget" that they've spoken to a radiologist about critical results. Radiologists' perception of their own responsibility is also influenced by their "global" gaze as well as their beliefs about what responsibilities clinicians *don't want.*

As an example, one of the attending radiologists said, "We teach our residents that they are responsible for the whole image. But clinicians don't view themselves as responsible. They want to brag about their quality of their interpretations and all that, until there is some sort of misadventure and then they say, 'Well, I wasn't responsible for that part of the film.'" Dr. Ferguson, a chest radiologist, agreed, saying:

> Pulmonologists are good at looking at lungs, but they don't really look at all the other things. It's really easy for them to miss something, like they miss an effusion in a rib and the patient ends up five years down the road having uncontrolled cancer. That's a big problem for them when they thought they could read that CT and couldn't. I think that maybe the liability issues will keep radiology safe, because people are always scared of missing something that is not in their domain.

By accepting responsibility for "the whole image," radiologists see themselves as protecting the patient as well as protecting their own practice. In addition to the communication of critical results, radiologists at Central Hospital also feel an obligation to protect patients and the hospital from what they view as inappropriate use or overuse of imaging by clinicians. As one of the radiology residents stated:

> We've gotten to the point where our clinical colleagues will order imaging studies to protect themselves from malpractice, especially in the ER. Like when a patient

> comes in with a headache, but the physician orders a head CT just to rule out the tiny possibility that it's a brain tumor. Not only does the patient get a big dose of radiation that isn't necessary, but it increases the cost of care. It's up to us to work with the physicians, and convince them that maybe they don't need that CT, or maybe there's a better study that might answer the question they have.

However, a more senior radiologist I spoke with, while recognizing the responsibility radiologists have to minimize patients' radiation exposure, had a more jaded view of radiologists' ability to control the imaging patterns of physicians:

> Our job as radiologists is to protect our patients and do the right thing for them, sure. But I think for years and years and years we talked about controlling utilization, but we didn't actually put our money where our mouth is, because in the end there are financial incentives to do more imaging. And, if you try to control utilization, you just piss somebody off and they end up doing it anyway. Ultimately, we're dependent on physicians for referrals, so we're not going to tell them what they can and can't do.

Dr. Michaels, another radiologist, seemed to agree with this viewpoint, saying, "We are not making any decisions about whether things get done or not except under extreme circumstances when an MR is absolutely contraindicated or a contrast is absolutely contraindicated, but short of that we are not saying 'no' to anybody." When I asked him why not, he responded, "Because of the power of structure of the hospital. You know the clinician will rant and rave, and the bottom line is it is easier to cave and do what they want."

Yet other Central Hospital radiologists emphasized the importance of being an advocate for the patient and helping to keep the costs of health care contained. James, the musculoskeletal radiology fellow, argued, "The days are over where we can just sit and read images and not evaluate whether the study is appropriate or not. If radiology is going to survive as a specialty, we have to show that we're dedicated to keeping patients safe and improving the bottom line. It's going to be a challenge, but it's part of our job." For James, the future of radiology depends on taking on the responsibility for educating clinicians about ‘appropriate’ imaging, while also becoming increasingly responsible to patients and to the hospital.

<u>Clinicians</u>

In contrast to radiologists, who felt conflicting responsibilities to clinicians, other radiologists, the patient, and the hospital, the non-radiology physicians I spoke with and observed tended to see themselves as primarily responsible for and obligated to their patients and their families. While they acknowledged that they had certain responsibilities to the hospital as well, such as trying to get patients out of the hospital as quickly as possible and using hospital resources sparingly, most clinician I spoke with believed that these obligations were a much lower priority than providing good care to their patients.

In fact, several clinicians I interacted with used their responsibility to patients as a way to distinguish themselves from radiologists. For example, one emergency medicine resident told me, “Radiologists tend to be people that don’t like patients, don’t like seeing patients. Radiology lets them earn lots of money without getting coughed on or dealing with patient problems. They’ve never held the hand of someone that is dying… they just sit in their dark room and hide from patients.”

While they spoke highly of individual radiologists, the clinicians I spoke with tended to view radiologists as a group somewhat negatively, characterizing them as being more concerned with money than with patient care. As Dr. Daniels, a pulmonologist, expressed to me, “Our health system is really broken. The person that spends a long time figuring out the issues of a complex patient is compensated much less than someone taking 20 seconds to read a chest X-ray.” Yet rather than wanting to take over the jobs of radiologists, Dr. Daniels explained, "I wouldn't want to bill for reading images, even if I could, because I don't want to have to describe stuff that isn't clinically relevant. I want to help people get better." Most clinicians agreed with the sentiments expressed by Dr. Daniels. They viewed reading images as a part of their own obligation to provide good care to their patients rather than a political move against radiologists. In fact, most clinicians readily acknowledged that the radiologists might have more skill at finding subtle lesions or interpreting very complex images but felt that for "day-to-day" imaging their own skills were more than adequate.

However, I want to highlight a central tension I identified among clinicians at Central Hospital between their daily practices, which included reading images, and their acknowledgement that reading images without input from radiologists could have negative consequences for patients. For example, when I interviewed Dr. Roth, one of the MICU attendings, he readily admitted that not looking at radiologists' reports was dangerous for patient care:

> That we have a PACS station in the ICU does affect how we round, and did disconnect us from the verbal discussion with the radiologist. And, it has led to some medical errors. Specifically we look at a scan, and say it looks negative – the wet read[32] either isn't there or we didn't look at it, or the wet read was done and the nighttime radiologist missed something. The formal read happens and we never go back and look at the actual formal interpretation and realize that the discussion we had on rounds was wrong. And that has rarely led to anything significant but it's a frightening side effect to PACS. We need to change our culture. I want people to look at scans and I want them to come down on one side or the other saying, "This is what it [the image] shows." Is it normal or abnormal, and if it's abnormal what the pathology is. But, the culture has to be, "Okay, now that we've looked at the images, what is the formal interpretation?" And if that culture piece is missing people may not be self-policing themselves, and I have made that mistake myself. That is why I feel a bit passionate about it.

[32] Preliminary interpretation provided by the night radiologist

Dr. Roth raises a major patient care issue surrounding the decision by clinicians to not look at radiology reports (i.e., that important findings are missed) and argues that the culture on the wards needs to change. Similarly, Dr. Chen, one of the neurologists, reflected:

> One of the hats I wear is that I chair our M&M[33] committee in neurology. And actually one of our biggest sources of error was folks not going back and looking at the final radiology report. In fact, for the last three or four years that was a common source of error. So we try to educate our residents and attendings and everyone that they really need to do that. It's amazing how many other things are picked up. And, it's not automatic that that triggers a phone call, especially if its something relatively subtle, like, "Oh, yeah, and there's a thyroid nodule." You know, that's usually not communicated, no one picks up the phone for that, but we've really started being sure that we're looking at final reads. The other group where this happens a lot is in ICU rounds. At the end of rounds, they get in front of the PACS and look at all the chest X-rays of the day, with essentially no… I mean, there's a pulmonologist on the team, but with essentially no input from radiology. And I've seen on a number of occasions errors occur where an assumption was made about what a chest X-ray showed, and then nobody looked at the report which showed a very subtle finding that only a radiologist would pick up.

In general, when I asked clinicians why they didn't choose to read radiology reports, they often answered that it took too much time, or that the reports seldom told them things they didn't already know. Clearly, however, as the previous two quotes from Dr. Roth and Dr. Chen indicate, the reports do contain important information that clinicians may miss. These "misses" can include subtle lesions or unexpected findings in areas of the image that lie outside the clinician's interest area. However, they can also arise from the complex and technically advanced nature of current imaging procedures.

For example, one day during PACS rounds, the stroke team spent about 20 minutes trying to trace the arterial vessels in a patient's head and neck on a MR with contrast. Both the attending neurologist and the residents were confused because some of

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[33] Morbidity and mortality

the smaller arterial vessels seemed to look very abnormal. They decided that the patient's hemorrhagic stroke was most likely due to a ruptured aneurysm located among these smaller abnormal vessels. However, several days later at the multidisciplinary stroke conference, the neuroradiologist who was reviewing the image pointed out that the contrast was injected later than normal, so what was captured on the image was not only the arterial circulation but also vessels carrying venous blood back to the heart. The "abnormal" arterial circulation was, in fact, a normal combination of arterial and venous vessels that looked different because of when the image was taken. No one on the team had looked at the neuroradiologist's report and did not realize their mistake until it was pointed out at the conference. Luckily there were no consequences for this patient's care, but such errors could easily impact how patients are evaluated or treated in other circumstances.

"Best practice" clearly involves looking at the radiology reports for every imaging study a physician orders. Yet despite stressing that providing good patient care is the most important responsibility of clinicians, these same clinicians, in actual practice, tended to read the report only sporadically.

Question 3: What is produced by and through the practice of reading for radiologists and clinicians?

<u>Radiologists</u>

The practice of reading among radiologists produces many things. For some radiologists, anxiety about the future is produced, as they struggle to reconcile their responsibilities to the patient, referring clinicians, their radiological colleagues, and the hospital itself. Both doubt and certainty are produced; certainty that radiologists need to "add value," but doubt about what exactly this "value" is, and how to add it.

Another source of doubt and uncertainty has also arisen among radiologists with PACS. As one radiologist told me, "I feel like I'm a doc in a box. I have no idea how much difference I'm making with patients, I'm just generating these reports and they fly out into the ether. Now that clinicians don't come down to the reading room, I never find out if my interpretations are right, or helpful. It's frustrating." Becoming separated from the day-to-day practicalities of medicine has challenged some radiologists' sense of worth and led them to doubt their contributions to patient care.

Yet despite the changes in reading that have occurred with PACS, the radiology report remains the most visible and recognized product generated by radiologists during reading. The report is a complex document: at once a representation of radiologists' skill in reading images, an administrative tool that enables hospitals to bill for imaging services, a medico-legal record, a way to communicate with clinicians and with other radiologists, and a method for disciplining the excess contained in the image itself. Yet the report generates both uncertainty and certainty, as radiologists try to navigate between including too much or too little information.

For radiologists the production of the report is also fundamentally tied to the network of responsibilities and obligations that radiologists engage when reading. In a fascinating study of the construction of accountability among radiologists, archivist Elizabeth Yakel (2001) shows that the many uses of the radiology report often conflict with one another. For example, she found that the radiologists she studied often wrote their reports with other radiologists in mind, as the practice of looking back at old reports when interpreting subsequent studies on the same patient was common. Yet she also found that this tendency made the reports more difficult for clinicians to understand, which was further exacerbated by the need for the report to also act as a legal document. The radiologists she studied also preferred to convey results using the passive rather than active voice; for example, “an abnormality was seen in the liver” versus “I saw an abnormality in the liver.” Yakel argues that this strategy was used by radiologists to mitigate responsibility in the reporting of image findings but had the added effect of increasing the ambiguity of report findings for clinicians (2001: 241).

Yakel also investigated the use of what she terms “hedging” or language that indicates uncertainty in radiologists’ reports. She argues that radiologists used hedging both unconsciously and consciously and that this language of uncertainty was a “response to administrative accountability and pressures to be cautious and avoid lawsuits” (Yakel 2001: 242). Thus, Yakel concludes that radiologists’ reports must embody multiple accountabilities, including, helping clinicians care for patients, educating residents and medical students, communicating with other radiologists, and providing the basis for billing (2001: 243). Often these accountabilities conflicted with one another, resulting in “ambiguous, conservatively written reports with no clues as to the radiological reasoning or the strength of a radiologist’s ambivalence” (Yakel 2001: 243).

My observations of radiologists at Central Hospital generally confirmed Yakel’s findings, although I found a great deal of variability among different radiologists. For example, on multiple occasions I observed radiologist Dr. Solano urge residents to shape their reports in response to what other radiologists had reported on prior studies. When staffing out studies with one of the first year radiology residents, he remarked, "We need to check the old report on this one. Why? Because if we say it's [the image] normal, and our other colleague says it wasn't, or vice versa, we have to make the reports match for our clinician colleagues- sometimes we have to finesse these things, you know?" On another day he told a different resident, “Don’t forget to see what your colleague said before [i.e., be sure to look at the old report]. That way, if he made a mistake or we made a mistake, we can cover for each other.”

For Dr. Solano the report is clearly not just about conveying information, but about the political and strategic tasks of “covering” for one another’s mistakes and presenting clinicians with reports that confirm rather than contradict each other. However, in other situations, I observed radiologists who would diligently look at older studies for a patient, but would not read the report. When I asked one radiologist about this behavior, he told me, “Yeah, I don’t look at the old reports because I don’t want to be biased by them. I want my observations to be objective.” One radiologist “finesses” his reports to match his colleagues, while another tries to avoid “bias” by looking at others’ reports. The tension between the report as a medico-legal document, a representation of radiologists’ skills, and an “objective” record of image findings is well illustrated by these quotes. There is a lot more going on in the construction of reports than just “seeing and saying;” the report is an important site for the enacting of politics at many levels.

In addition, the use of hedging language in the report was something that radiologists at Central Hospital acknowledged and viewed negatively yet continued to use. Radiologist Dr. Horn joked with me:

> Do you know what the radiologist’s crest is? It’s a weasel, sitting on a fence, eating a waffle, surrounded by hedges! But seriously, I really try to avoid hedging in my reports. I know it drives the referring providers crazy, but there’s a lot of

uncertainty in radiology. Sometimes you just can't say whether a finding is one thing or another.

In contrast, however, one of the more senior radiologists told me:

> One of my problems with our resident dictations, one of my pet peeves, is that they will wax eloquent about the differential and findings and all this kind of stuff, and either never answer the question that was asked of them to begin with, or tell them [clinicians] what they think. They don't want to go out on a limb, and that's our job. Our job is to be a consultant and express an opinion, and that's what it is- an opinion, that's all it is. And you can be wrong, but it's important to say what you think! I think hedging is part of this mentality of worrying about being wrong, or not covering all the bases. We're not helping anyone by covering our… covering all the bases and listing everything under the sun that something could be. The idea is how to help the clinicians make decisions. We lose that focus sometimes.

This radiologist identifies what he sees as a difference of training and age, whereby residents are far more hesitant to be decisive in reports than more senior radiologists. It is perhaps not surprising that greater certainty comes with greater experience, although as Luhrmann (2000) points out in her study of psychiatrists, uncertainty can also be magnified by experience. The radiologist I quoted above also seems to think that uncertainty is linked to a mentality that includes fear of being wrong and "covering all the bases" rather than being decisive. Yet there is slippage between being "decisive," providing too much information, and providing too little information. For this radiologist not all findings are equal, and only some should be put in the report. What constitutes an "important" finding worthy of reporting seemed to be difficult to define, even for the most senior radiologist.

For example, while reading mammography films, Dr. Rose, one of the breast radiologists, remarked:

> Young radiologists comment on all this normal stuff in their reports, and nobody cares about that. All they [clinicians] want to know is, "What do you see?" and "What should I do?" Not all this other fluff that just pads out the report and you

> have to dig through it to find out what is important. I think the longer you read, the shorter your reports are, because you learn what is important.

Learning to read involves learning how to distinguish what is important from what is not, and a brief report reflects this. However, I also observed James, a fellow in the musculoskeletal reading room, express a contrary opinion. While reading a spine X-ray and comparing the new image with a prior study and the old report, which was dictated by Dr. Geshram, one of the attendings. James says out loud, to no one in particular, "See, that's the difference between the old guy [Dr. Geshram] and me- the old guy writes one sentence for the whole report, and the new guy [James is talking about himself] comments on each separate spinal level. How can you add value to your reports if they're only one line long? Clinicians are going to think we didn't even look at the study." Unlike Dr. Rose, James seems to think that *more* information is an "added value" in the report, whereas a brief, one-line report does not "add value" and implies that the radiologist (in this case Dr. Geshram) did not look carefully at the image.

Whether one line or many pages, Dr. Rose and James both point toward another key function of the report: to discipline and filter the seemingly infinite amount of information contained in medical images. In his classic work on photographs and advertising, Barthes argues that all images contain an excess of meaning that poses a threat to the order of society. He writes that "all images are polysemous; they imply, underlying their signifiers, a 'floating chain' of signifieds, the reader able to choose some and ignore others… in every society various techniques are developed intended to *fix* the floating chain of signifieds in such a way as to counter the terror of uncertain signs; the linguistic message is one of these techniques" (1980: 274).

Prasad makes a similar argument in his research on practices of gazing and MRI. He writes that "with pictures, there can always be an overflow of meaning leading to a destabilization of a singular and conclusive interpretation of the images" (Prasad 2005: 304). He argues that radiologists use practices of cross-referencing that include correlation with body atlases, epidemiological information, and knowledge of pathology and that these practices help to "discipline" the excess of the images and produce information that can be used by physicians. I extend Prasad's argument to include the radiologist's report as a method -- perhaps the primary method -- of disciplining imaging excess. By transforming the image into text, the report acts as a focusing device, helping clinicians to identify the "important" aspects of the image without being distracted or mislead by all the other information that the image contains.

Finding out "what's really going on" with a patient (see Chapter 5) can shift how a radiologist interprets an image in important ways, allowing a certain interpretive flexibility and openness to the image to exist when radiologists and clinicians interact with one another, even if the radiologists' report has already been signed.[34] The report itself, however, has no such flexibility. No matter what a radiologist and a clinician might discuss, the report is considered the "official" and definitive interpretation of the image. Or is it? Rather than simply a "CYA[35]" strategy, perhaps hedging language has a more generative role in the radiology report, holding open the interpretive possibility of images that might otherwise be closed.

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[34] Once signed, a radiology report becomes part of the patient's permanent record, and cannot be changed. If for some reason the report does need to be updated or altered, an addendum must be created that is added to the original report

[35] Short for "cover your ass," an abbreviation frequently used both by radiologists and by clinicians to describe radiologists

Yet I must also question the ability of a report to discipline the excess of medical images if that report is never read by anyone other than the radiologist. For radiologists the practice of reading in the PACS era also produces a key tension centered on the report. On the one hand, since clinicians are visiting the reading room far less frequently than they used to, the report has become an increasingly important way for radiologists to demonstrate their expertise to clinicians and to communicate the results of imaging studies. On the other hand, the report also functions to render the work of radiologists invisible, causing the reduction of reading to interpretation. Furthermore, clinicians only sporadically read radiologists' reports, making them a less than reliable form of communication between radiologists and clinicians. While this certainly makes it harder for radiologists to maintain their claims for expertise in reading images, more importantly it has consequences for patient care.

Clinicians

Unlike radiologists, clinicians at Central Hospital do not produce a report when they engage in the practice of reading images. Clinicians produce something else: patient care decisions. For example, when I asked Dr. Cohen about why he uses imaging in his daily practice, he responded:

> Well, we heavily rely on it. Anybody with anything related to stroke, whether it be bleeding stroke, ischemic stroke, that kind of stuff, they all get imaged. For us, imaging is crucial in clinical decision-making about treatments. So the most common example would be someone with an acute stroke, and we need to get a head CT to rule out that there is no bleeding in the brain – you have to do that before you give a drug which could potentially cause bleeding. So the scan in a way is confirmatory that a person is having a stroke but it also gives information beyond that we can tell clinically from a patient, so the imaging has information that could lead to treatment decisions. Secondly, as imaging technology advances,

> profusion imaging[36] that kind of stuff, there are elements of the image that we can use to predict, to give some prognosis. And that is fundamental I think for clinical decision-making.

For Dr. Cohen, images confirm the information he has gathered via physical exam and patient history but also produce new information that shapes his diagnosis and treatment decisions. Imaging also enables him to gaze into or even "read" the future, which both influences how the patient is treated and sets expectations for his or her response to treatment. Dr. Cohen also stresses (twice!) the importance of imaging for clinical decision making, saying it is both "fundamental" and "crucial."

Yet in medicine decisions must be made not only by clinicians but also by patients and their families. I found that clinician engazement did not produce decisions only for clinicians but also for patients and their families. For example, an attending neurologist named Dr. Lopez told me how he likes to use images to engage the patient, saying, "When patients are trying to understand illnesses, I like to take them to the PACS and I like to walk them through the images. Especially if people are having a difficult time believing the prognosis or deciding what to do, I find that sometimes a picture can really tell a thousand words about things." In this example a rather complicated, onion-like layering of seeing and saying emerges; Dr. Lopez reads the patient's images *to* that patient yet says that it is the picture *doing* the telling. The "picture" tells "a thousand words" to the patient (through the clinician), convincing the patient to "believe" the prognosis and make decisions based on this prognosis.

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[36] This technique generally involves injecting contrast into the bloodstream to see (via CT or MRI) which areas of the brain are getting blood flow, and which are not, and to distinguish between areas that have reversible ischemic damage and areas that could recover if blood perfusion is restored

Similarly, the following excerpt from my field notes, written during morning rounds with the ICU team, shows how decisions are produced via clinician engazement:

> The last patient we round on is a 40-year-old woman (Sarah) who has been in the ICU for almost a month. She has severe brain damage from a ruptured aneurysm and has been in a coma since she was first admitted. The team stopped getting head CTs several weeks ago, when her clinical condition did not improve. However, Dr. Daniels [the ICU attending] has a meeting with Sarah's family later today, and asks the team whether they should get another CT to help the family assess whether to withdraw care. The intern taking care of Sarah wonders if they can get the study done in time for the meeting, and Dr. Daniels says, "I'm not pushing [to get the CT] either way, I'm just thinking about how it might help us communicate the prognosis to the family." The team members discuss the pros and cons of getting the study and decide to order it; they think that the images will help the family understand that Sarah has massive, irreversible brain damage that will not improve.
>
> After this discussion, the team breaks up to finish charting and write orders. I'm not able to accompany Dr. Daniels to the family meeting (they only want him in the room), but he tells me later that the images of Sarah's head were finished in time for the meeting, and that he felt they were extremely helpful in communicating to the family the extent of the damage to Sarah's brain. "I brought up the study on the PACS station in the conference room," he tells me, "and I could show them what had happened." The family decided to withdraw care later that afternoon, and Sarah passed away shortly afterwards.

Here, Dr. Daniels uses images to engage with the family of a patient, communicate to them the nature of their loved one's condition, and persuade them to withdraw care. In this case, images are even used to speak for the patient, who is unconscious; Sarah's head CT "tells" her family (through Dr. Daniels) that she is unlikely to get better. Thus, for clinicians, reading isn't just about investing images with meaning, but also using images to argue for, persuade, and convince patients and patients' families to make care decisions.

However, what if the image does not confirm clinicians' observations about the patient but instead contradicts them? For clinicians, engaging with images not only produce certainty and decisions, but also uncertainty. For example, one day during PACS rounds with a team of neurologists, we looked at the head CT of a patient who had just undergone chemotherapy treatment to shrink a tumor. As we looked at the patient's images, one of the residents commented, "Oh, it reacted, it looks much better," to which the attending replied, "Yes, but clinically there's no difference. That's the whole thing. The images mean very little without the clinical story." Again, we see the constant tension and slippage between images as photographic-like, objective expressions of "truth" and as representations that require interpretation and that mean "very little" without contextual understanding.

However, like radiologist engagement, the practice of reading by clinicians also produces an important tension centered on the radiology report. In talking with clinicians, I found that they view reading images as a part of providing good care to patients. However, they also acknowledge that part of "good care" involves reading the reports produced by radiologists; yet they do so only sporadically. As I have shown, the practice of reading for radiologists and for clinicians involves the cultivation of overlapping yet distinctly different kinds of expertise. Clinician engagement brings with it an intense and in-depth knowledge of individual patients and clinical signs and symptoms that the radiologist lacks. Yet radiologist engagement is aware of all the "tricks" up the image's "sleeve" (if you'll forgive a film-based imaging pun -- X-rays used to be stored in paper covers called "sleeves"), and brings to the image a broader focus not constrained by an individual's symptoms or history. With multiple reads generated by many different gazes, the medical image becomes newly productive and dynamic but also more difficult to discipline. Successful imaging in the future will require a balance of both types of gazes and new locations and methods for the negotiation of clinician-radiologist -- and patient -- relationships, communication, and trust.

Radiologists make mistakes when reading. Clinicians make mistakes when reading. Mistakes are a normal, unavoidable part of a larger practice (medicine) that must constantly negotiate between certainty and uncertainty, standardization and variability, anxiety and hope. Yet despite systems like Witness, which attempt to notify clinicians of critical or unexpected imaging results, important information is still slipping through the cracks of practice at Central Hospital. In order for these mistakes to be rectified, radiologists and clinicians need to take responsibility for creating an environment where both approaches to reading are valued.

Conclusion

The notion of engazement that I develop stresses that for radiologists and clinicians, reading is an embodied way of seeing that is constructed through ongoing interactions and entanglements with other actors, both human and non-human. These interactions can entail both conflict and cooperation, and involve the participants in relationships of obligation and responsibility. With PACS, reading has become an important practice not only for radiologists but for all physicians. Yet in contrast to Mol's (2002) conceptualization of practice that concentrates solely on action or "doing," I show that for the practice of reading, what people *think* about what they do (what Mol terms the "perspectives" or "principles" approach) is just as important as what they actually do. While I appreciate Mol's intervention against a long tradition of philosophic and social science scholarship that privileges thinking over doing, I show how principles or theories and practices co-constitute one another.

Further, Mol's focus only on practices (doing) rather than perspectives (thinking) ignores the fundamental role that anxiety and speculation about the future plays in shaping action in the present. As I have shown, for radiologists anxiety about the *future* of their specialty is a central influence on how they *currently* practice of reading. Adams and her co-authors call this forward-looking orientation anticipation, which they define as "thinking and living toward the future" (2009: 246). Anticipation involves a series of practices that bring the future into the present, such as risk assessment, simulation, and actuarial calculation. In turn, these practices rely on abduction, or the tacking back and forth from the present into the past and the future (Adams et al 2009: 255). Therefore, imagining, thinking, forming perspectives and principles about the future and the past are all a part of acting in the present, and indeed shape the very conditions of possibility for that action.

In Mol's (2002) investigation of practices, we do not see how objects can "push back" during practice; for her, objects come into being through human actions and objects are not allowed to act on their own. Therefore, her analysis ignores the ways that an object may *seem* knowing which I have argued is critical to understanding the desire for and power of medical images and drives the practice of reading. The slippage between object known and knowing object is an important component in engazement, yet would not emerge in an analysis focused solely on practice.

In addition, focusing solely on practices runs the risk of failing to appreciate that *not* acting can often be as significant as acting. With Mol's approach, we can only see the worlds of *actors* while *non-actors* are excluded from view. I show that for radiologists and clinicians both action and the decision not to act shape the practice of reading in important ways. Thus, my notion of engazement moves past Mol's myopic focus on "doing" to recognize the co-constitution of action and thought, memory and anticipation, as well as the significance of inaction.

CHAPTER 7: Diagnosis

Introduction

Diagnosis is central to how medicine gets "done" in the hospital as well as how different kinds of physicians think about and structure what they do. In this chapter, I explore the role of conflict, cooperation, and trust in the production of scientific knowledge, focusing on medical practitioners as they engage one another during the process of diagnosis. I show that for clinicians, trust emerges as central to the diagnostic process, allowing patient care teams to transform multiple sources of information (in this case, "reads" of medical images) into a single diagnostic label. I also examine the efforts of radiologists to reestablish relationships of trust with other medical practitioners, using two seemingly opposed techniques: what radiologists call "having a face" and quantitative measures of performance. Ultimately, I argue that rather than being undermined by the "explosion" of information in medicine facilitated by technologies such as PACS, relationships of trust between physicians have become even more important in the production of diagnosis.

Diagnosis

As I discussed in Chapter 3, the introduction and ongoing development of medical imaging technologies have had a profound impact on the process of diagnosis in biomedicine over the past century. The centrality of imaging to diagnosis may be partially explained by the continued dominance of the anatmo-pathological approach, in which physicians search for lesions that underlie and cause patients' symptoms (Foucault 1973). Medical imaging allows this movement into the recesses of the body to occur while the patient is still alive (as opposed to at autopsy), thus enabling physicians to "directly" visualize disease. Despite the increasing molecularization and genetization of medicine, the fixable lesion, even if only visible via a microscope or gene sequencing, remains central.

PACS has largely removed radiologists from participation in diagnosis, and has challenged the legitimacy of radiology as a medical specialty in the eyes of other physicians as well as among radiologists themselves. Yet considering Dumit's (2006) work that highlights the crucial connection for patients between diagnosis and legitimacy, it is perhaps not surprising that being involved in the *act* of diagnosis should be an important source of legitimacy for radiologists, who after all, are doctors.

When I asked why they decided to pursue radiology as a career, almost all the radiologists I spoke with, from the newest residents to senior attendings mentioned diagnostic puzzle solving as one of the main attractions of the specialty. As one resident told me, "I like the fact that you are sort of a consultant for other physicians, and, if things go well, you give them answers, you usually provide the diagnoses." Similarly, an attending with over 20 years of imaging experience said, "So I like the diagnostic aspect of it [radiology]. You diagnose the disease and you are more or less done, and you move onto the next case. So it's constant mental stimulation, and less dealing with patients and their questions."

In fact, several radiologists at Central Hospital expressed the opinion that a career in radiology enabled them to engage in all the intellectual stimulation of diagnosis, without having to provide day-to-day care of patients. As one second year radiology resident told me when I asked him why he decided to become a radiologist:

> I really liked figuring out what's going on, and [to] come up with diagnoses. And I felt like that is kind of what radiology is. I remember a few times in med school

> just on clinical rotations, you'd be running around with your team and I always felt like once you figured out what was wrong with the patient, then all that activity just kind of dropped off. I remember one time I was doing some trauma rotation, and this guy came in with head trauma. We did the standard thing and got a head CT, and the radiologist is telling everybody what injuries were there. I thought, "Oh that's the best part right there. This guy is telling us what's wrong." I felt like as a radiologist, you got to do what I thought was the most interesting part, you didn't have to do all that other patient care stuff that I wasn't that interested in.

Yet radiologists I interacted with at Central Hospital also felt frustrated that although they were still producing diagnoses by reading images, their skill as diagnosticians seemed to be valued less and less by their clinical colleagues. As one chest radiologist told me:

> I feel like I read the images and come up with these differential diagnoses and in the impression of the report I try to give my reasons for why I think it's one thing [diagnosis] and not another, but the reports just go out into a void. I think the reports are being ignored, and no one is coming down to the reading room to ask my opinion. And, I never find out what happens with patients anymore, like I used to when the teams would round in the reading room. I feel really isolated from patient care.

With PACS the diagnostic power associated with medical images has suddenly become widely available to all clinicians. Multiple practices of reading and multiple "reads" now circulate within the diagnostic economy of Central Hospital (discussed below). Negotiating among these different reads has become an important task for care providers engaged in the production of diagnosis.

But what is diagnosis? Like expertise, diagnosis is a complex concept: a process and a set of categories, a label and a practice (Jutel 2009). Diagnosis is a certain way of information gathering, questioning (and not questioning), interacting, relating, and dealing with uncertainty and ambiguity. It is a ritual, mode of communication, and mechanism for structuring interactions between doctors and patients, daily practices in the clinic, and administrative and bureaucratic tasks and demands (Rosenberg 2002). While it may *seem* to be a discrete act of placing a label on a collection of symptoms or findings, diagnosis is in fact “a collective, cumulative, and contingent process” that subsumes both prognosis and treatment (Rosenberg 2002: 256). Diagnosis is also a lively site for the production of tensions and paradox, challenges to medical authority, and complex negotiations among different individuals and groups engaged in the “politics of definitions” (Brown 1995).

Rosenberg (2002) argues that the practice of diagnosis and theories of disease cannot be considered apart from one another. He maintains that diagnosis must be understood as fundamentally linked to disease specificity, which he defines as the notion that diseases exist outside their embodiment in particular patients (Rosenberg 2002). Not only does diagnosis provide an explanation for the symptoms of individual patients, it also works to convert “the uniqueness of experience and particular clinical interactions into a portable and collectively accessible form of data” (Rosenberg 2002: 241). Thus, diagnosis becomes an important means for moving back and forth between particular experiences and practices and “universal” categories.

According to Rosenberg, the idea of disease categories has also tightly linked diagnosis with prognosis and treatment, whereby giving a name to disease also determines how that disease will be treated and what the future of the disease (and the patient) will be. Thus, we might describe diagnosis as a technology of anticipation in the sense developed by Adams et al. (2009), where the assignment of diagnosis brings the future into the present by determining which treatments will be given and, through prognosis, shaping what kinds of futures might be imagined.

Diagnosis is a form of expertise. Much of the authority and power claimed by medical experts is drawn from the way that diagnosis structures boundaries between the normal and the pathological and authorizes or condemns certain behaviors or roles among patients and professionals (Parsons 1951). Yet it is also the power and authority of biomedical experts that stabilize and promote the legitimacy of diagnostic categories (Jutel 2009). Practices of classification like diagnosis privilege some points of view while silencing others, and thus classificatory practices are practices of power, where "for any individual, group or situation, classifications and standards give advantage or they give suffering" (Bowker and Star 1999: 6).

Thus, diagnosis is an important source of both economic and symbolic capital for physicians (Bourdieu 1984). As Freidson pointed out over 40 years ago, diagnosis is the "foundation upon which the strength of a profession rests…which establishes and supports the profession's claim to honor, income, and power" (1970: 244). Diagnosis also shapes relationships of power and credibility among physicians. Using the example of psychiatry's development of the DSM, Jutel states, "Diagnosis also structures relationships *within* the profession, defining who should assume responsibility for particular disorders…this complaint to the general practitioner, that one to the immunologist, the hematologist, or the rheumatologist. Particular branches of medicine have used diagnosis to confirm their credibility" (2011: 7, emphasis added).

The popular image of the diagnostic process used to involve a knowledgeable physician examining and questioning a patient and then arriving at a diagnosis based on his or her observations. However, Webster maintains that diagnosis has been "socialized" through the development of the expert patient that, thanks to access to medical information, can now challenge the power and professional authority of the physician (2002: 448). The changing constellations of power surrounding and shaping diagnosis have also been recognized from within medicine. For example, a recent article in the *Journal of the American Medical Association* (JAMA) proposing the shortening of medical school training notes, “For decades, the ideal academic physician has been the triple threat: an incisive diagnostician and empathetic clinician, a productive researcher, and a scintillating teacher. Similarly, the clinical practitioner was supposed to be omnicompetent, capable of managing all illnesses” (Emanuel and Fuchs 2012: 1143). The consequences of this ideal, the authors argue, has been an educational model that emphasizes physician autonomy rather than team-based care. However, the authors write, a new model of medicine has emerged in the last few years, that “recognizes that with increasing clinical and scientific complexity, no physician can be a competent triple threat; that few clinicians will also be investigators; that no single clinician can know everything even in his or her own specialty; and that effective care requires collaborative, multidisciplinary teams” (Emanuel and Fuchs 2012: 1143).

Thus, diagnosis is increasingly becoming a collaborative process that requires negotiating among a variety of opinions, sources of information and knowledge, practices, and power hierarchies. While scholars such as Jutel (2009), Rosenberg (2002), Brown (1995), and Mol (2002) all acknowledge that diagnosis structures relationships not only between doctors and patients but also among doctors, little work specifically examining this aspect of diagnosis has been done. For example, Mol (2002) shows how the practice of diagnosis in the hospital relies on achieving coherence between multiple and sometimes conflicting diagnostic findings. She argues that if diagnostic findings conflict, one result is privileged while others are discarded, allowing a single unambiguous diagnosis to emerge. Yet despite this argument, Mol never addresses *how* physicians decide which result to privilege and which to discard. In contrast, I investigate how physicians rely on relationships of trust to negotiate among themselves and among multiple sources of information during the diagnostic process.

Multiple reads, multiple diagnoses

Because medical imaging is a primary technology of diagnosis, different interpretations of an image can occasionally produce more than one diagnosis. Take, for example, the following excerpt from my field notes:

> It's a little after 8 in the morning, and the MICU team is going over the new admits from last night. The first new patient to be presented to Dr. Phelps, the current MICU attending, was admitted for trouble breathing. A chest X-ray done in the ED showed 'likely pneumonia' according to the night radiologist. Another chest X-ray was done when the patient was transferred up to the MICU ward, as well as a head CT. Dr. Phelps gets up and walks over to the COW to take a closer look at the second chest X-ray while the resident in charge of the patient's care continues to summarize the medical history, and then switches to the head CT and starts to scroll through it, and it's clear even to me, sitting across the room, that the patient has something major going on, either a bleed or a mass. Dr. Phelps comments, "I think this is the most helpful head CT we've ever gotten!" He's partly joking, but partly serious- the patient wasn't showing signs of a neurological problem, but clearly there is one. No one on the team seems to know exactly who decided to get the head CT, or why, but now that it has been done, the team is far more concerned about her neurological issues than her trouble breathing, which is why she was originally admitted.
>
> The resident continues, "So, due to the head CT findings, we consulted neurosurgery. The official read from radiology was concern for an aneurysm, but neurosurgery was more concerned about malignancy, specifically a meningioma. Radiology suggested getting a CTA, but with her creatinine, we can't do that. Neurosurgery recommended an MRI/MRA…" The resident trails off as Dr. Phelps looks closely at the CT. He points to an area and says, "Yeah, I think this is calcification in the brain, which would indicate a meningioma. Have you re-CT'd her since this one was done? The resident responds that they hadn't gotten another head CT yet, but that he is planning on ordering one. Dr. Phelps responds, "Yeah, let's hold off on the CT and go ahead with the MRA that the neurosurgeons want. I don't trust the night radiologist's read of the head CT anyway. So, let's get the MR and see what the neuroradiologists say, but I'm inclined to agree with Dr. Aarons [the neurosurgeon who looked at the images] that this is menigioma."

This excerpt illustrates the complexities, contradictions, and uncertainties inherent in the process of diagnosis. Dr. Phelps and his team must somehow move from a collection of diagnostic tests, recommendations, opinions, and observations done across time to a diagnosis (or diagnoses) that explain the patient's symptoms. As with most diagnostic practices taking place in the hospital, imaging is crucial to how the patient's symptoms are understood and explained. Yet these diagnostic technologies that are so central to determining both "what is wrong" as well as "what to do" have not provided a conclusive answer. Instead, multiple "reads" from multiple specialists have circulated into this morning's rounds, and Dr. Phelps and his team must negotiate among them in order to reach a diagnosis. During my observations, the need for physicians to engage in this kind of negotiation across different "reads" of medical images was not uncommon.

However, I found that the complexities of these negotiations are not just confined to sorting out a discrepancy among different interpretations of an image. As always, there are also power dynamics to consider. For example, in the situation above, whether the patient is suffering from an aneurysm or a malignancy, the neurosurgeons will most likely be the ones "doing" the treatment. A difference of opinion between the doctor in charge of the patient's overall care and the one performing surgery on the patient could bode poorly for their professional relationship. Further, even if the patient's kidneys were functioning well enough to allow for a CT angiogram, the neurosurgeons would most likely insist on a MR angiogram before taking the patient to surgery. Should Dr. Phelps order the study that the radiologist has recommended, the one that he knows the neurosurgeons will insist on anyway, or both? Clearly, hierarchies of power in the hospital shape which diagnosis will ultimately be made "fact."

However, another dynamic can also be identified that involves the radiologist who read the original CT, the neuroradiologist who will read the MR if it is ordered, and Dr. Phelps. In negotiating among the different "reads" to determine a diagnosis, Dr. Phelps states that he doesn't trust the read by the night radiologist. This lack of trust is important in Dr. Phelps's decision to trust his own opinion and that of Dr. Aarons, the neurosurgeon, and, ultimately, the production of "meningioma" as the diagnosis. As I observed radiologists and clinicians as they negotiated among multiple reads in the process of diagnosis, trust emerged repeatedly as a central issue.

In her work on atherosclerosis, Mol points out that the intertwining of doubt and confidence is key to the practice of diagnosis (2002). Yet I want to argue that for the doctors at Central Hospital, trust is crucial to the production of both doubt and confidence *per se*, and, therefore, central in the process of diagnosis. In my research I found that it was often individual relations of trust among doctors that decided which "reads" of images were used to guide patient care, and which were ignored. Thus, the production of a singular diagnosis from a collection of heterogeneous observations and "facts" often depended on individual, context-specific, and variable negotiations of trust among heterogeneous medical practitioners.

Trust

To examine how trust is negotiated among physicians during the process of diagnosis, I draw on Beard's (2008) insights from her ethnographic study of patients and doctors in U.S. Alzheimer's clinics. She shows that trust is an interactional, relational process involving expectations for the future behavior of someone or something that is context specific and can involve both the calculation of risks and benefits as well as emotional or affective bonds between people. In addition, trust is shaped through engagements among individuals and institutions. I agree with Beard that the widespread assumption of autonomy by scholars investigating issues of trust needs to be questioned not only for patients but for medical practitioners as well. Just as patients' autonomy is constrained in important ways during the doctor-patient relationship, physicians themselves are rarely completely autonomous in their decisions or actions.

Issues of trust often emerge when distance is introduced between the production of knowledge and the use of that knowledge (Jimenez 2011). The adoption of PACS has indeed produced distance between reads and readers in some ways. Yet in others it has also enabled new forms of intimacy with images to emerge, and thus new sites for the production of knowledge have developed. How, then, are notions of trust used by clinicians and radiologists at Central Hospital as they engage in diagnosis? In answering this question, I focus particularly on the negotiation among multiple reads of an image during diagnosis and the friction generated between trust and information.

Clinicians' trust of radiologists

As I accompanied various kinds of clinicians as they saw patients, conducted rounds, did surgery, and talked to families, I noticed that on the rare occasion when questions arose about imaging that the clinicians themselves felt couldn't answer, they would preferentially seek out certain radiologists over others, or look at the reports written by specific radiologists and disregard others.

2:20 p.m.- I'm back in the MICU, following Dr. Roth, an attending. He's worried about a patient who got admitted this morning with ARDS[37], and has been waiting impatiently for the chest CT he ordered a few hours ago to show up on PACS. He checks

[37] Acute respiratory distress syndrome

the PACS on one of the work computers in the MICU and finds that the study has been completed. He scrolls through the image, saying to me, "Now she has pneumoceles all over the place, and I don't like the look of her apices at all… these little bubbles here [gestures at film]. And it looks like there's a small pneumothorax right here [points with mouse]." He plays with the contrast level to bring out the lung apices more clearly, and says, "Who read this?" He navigates to the screen that displays the radiologist's report, and says, "Judith read it, damn it. I totally don't trust her reads. Well, she's not calling a pneumothorax. Ugh. Who's down in the chest reading room today?" He shifts to the computer next to the one he's been working on, and pulls up the chest reading room schedule. "Well, Mark isn't on, so I'm not going to bother going down there. He's the only one I trust. It's a pretty small pneumo [pneumothorax] so I'm not going to put in a chest tube, but we'll need to keep an eye on it to make sure it doesn't get bigger."

Dr. Roth clearly has strong opinions about which chest radiologists he trusts, and which he doesn't. Trust influences his decision to diagnose the patient with a small pneumothorax, as he trusts his own read of the image more than he trusts the read of the Judith, the chest radiologist. Trust also determines Dr. Roth's actions, in that he decides not to go to the reading room to discuss the image further because the radiologist he does trust isn't working. In the absence of his own certainty about what the image shows, Dr. Roth uses trust to negotiate uncertain terrain.

I asked Dr. Roth how he determines which radiologists to trust. He answered:

> I try to assess how good their reads are, whether they agree with my reads, or if they help us out and tie things together. There are radiologists where you look at the scan, and then look at their reading, and say to yourself, "Oh, that's not a good read." These guys tend to be vague, or waffle about findings, or even miss things, which isn't that uncommon, surprisingly. Their reports are too brief, like maybe they saw something and didn't comment on it, or missed it entirely; you don't know. These are the people I tend not to talk to when I have a tough question or there's a difficult scan. It took me a couple of weeks before I trusted Mark. He called me about a patient when I was in clinic and told me, "This patient probably needs a bronch[38]." And I thought, "Oh, wow. This guy is making a clinical recommendation!" Also, he is proactive about contacting us [clinicians] and wants to interact with the clinical side of things, which helps build trust. Plus, his reads are helpful and provide more information, and are more definitive than the others [reads by other radiologists].

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[38] Bronchoscopy

It seems that Dr. Roth determines whom to trust on the basis of several factors. The first is the quality of information that the radiologist supplies through the report. It is interesting to note that despite his not regularly looking at radiologists' reports, they seemed to be an important factor when clinicians were deciding whom to trust. The amount and accuracy of the information contained in the reports is raised as a significant indicator of the "trustworthy" radiologist, although accuracy seems to be defined by how much the radiologist's read agrees with the clinician's read. Dr. Roth indicates that his own expertise in reading images is one key standard by which he evaluates the expertise of radiologists.

Information is not the only factor in determining who to trust. Dr. Roth also mentions that being proactive about communication and involved in the clinical aspects of care are important. Here we see another tension emerging. On one side are the assertions of clinicians that the report and communication with radiologists are key for determining which radiologists' reads are trustworthy. On the other side is the fact that PACS has drastically reduced radiology-clinician communication and clinicians' own admission that they read radiologists' reports only sporadically. A delicate balancing act among clinicians seems to have emerged, in which their own claims for expertise in reading images are leveraged against the continued need for "trustworthy" information through radiology reports.

Similarly, when I asked Dr. Phelps, another MICU attending, whether there were certain radiologists he trusted more than others, he responded:

> Definitely. I trust Dr. Wyatt, because my reads match his reads, and his reads are correct. I mean, he tells what he sees, and correlates that with the clinical information, and gives a differential for what's going on, and tells me what he thinks. He doesn't hedge a lot. When Mark [Dr. Wyatt] got here a few years ago,

> it was like a breath of fresh air. Plus, he's a really nice guy, which helps. He's always happy to go over studies or talk, and he always calls us if he thinks there's something we need to know.

Like Dr. Roth, Dr. Phelps first mentions the perceived quality of information contained in the radiologist's reads when considering who to trust. However, he also mentions decisiveness and willingness to engage with clinicians.

Upon further questioning, I also found out that a few years ago a dispute arose between the previous group of chest radiologists and the Department of Radiology administrators at Central Hospital, causing the chest radiologists, who were highly respected and trusted according to Drs. Phelps and Roth, to leave as a group and go work for another hospital. The Radiology Department then tried to cover the chest radiology service using radiologists from other specialties, which was received poorly by Central Hospital clinicians, especially those who specialized in diseases of the heart and lungs. As Dr. Roth told me, "Those guys were terrible. It was clear they hadn't looked at a chest X-ray or CT since their residency and were making lots of mistakes. That's why it was so great when Dr. Wyatt got here, but there's still a lot of ground to make up." Institutional politics had a serious impact on the relationship of trust between certain clinicians and radiologists, which is only now being resolved.

Another clinician, a neurologist named Dr. Singh, suggested that technology, specifically PACS, had shifted how she determined who to trust, remarking:

> For me, PACS has put into very sharp focus, which I don't think used to be there, the difference between good radiologists and great radiologists. And so, you know, you used to say, really, anyone can help me with this. But now you get to the point where you say, I know just as much as this radiologist or that radiologist, but this study needs to be shown to Dr. so-and-so, because he has such a better perspective, because he's seen more of radiology than anyone… more neuroradiology than anyone. So it's created a situation where I'll often go down to the reading room not just to find out what people have to say, but to find

> a specific person who I want to ask a question to, that I really trust. So, yesterday [in the neurorad/neurosurg correlation conference], there was this conversation you heard me having with Dr. Kern [a neuroradiologist], because she is fantastic with perfusion-based imaging. And you heard me say, "Dr. Kern, what do you think about that perfusion, what does that do?" and that's not, "Hey, what does anyone think?" but I want to know what the expert thinks about that.

Dr. Singh indicates that with PACS and the development of her own "counter-expertise" in reading, her trust has shifted from radiologists as a group to specific radiologists she believes have developed particular expertise. The notion of expertise as mastery of a particular body of knowledge (in this case, perfusion imaging) gets linked to trust, as well as experience.

An interesting dichotomy arose among clinicians between trusting radiologists as a group and trusting individual radiologists. For example, as I was walking one day with the MICU team to round on the team's last patient, one of the residents told me about an incident that happened to another resident who is a friend of hers. She related, "My friend is on the medicine service, and she's been so busy she doesn't have time to actually look at the chest X-rays themselves, so she was trusting the radiology reads. And it basically bit her in the butt because a patient had a collapsed lung for 24 hours and the read was 'unchanged atalectasis!'"[39] I ask, "So radiology didn't call your friend to tell her?" and the resident replies, "No, they didn't, and the read was just 'continued atalectasis!'" This story was a hot topic among residents on the wards that week, and there seemed to be two major points that the residents drew from it: first, always look at the images yourself, and second, never trust the radiology reads. While trusting specific radiologists was common practice, trusting radiologists as a group was considered "risky." As one resident told me, "Yeah, I guess I trust the radiologists, but I always verify what they say by looking at the

[39] Collapse or closure of lung alveoli

studies myself. Trust, but verify. That's how things are in the hospital." Again, the link between trust, uncertainty, and information is emphasized, yet this resident says that trust, by itself, is never sufficient in the hospital; rather, trust must be "verified" *with* information.

I also found that many clinicians seemed to have a "consumerist" (Rose 1999) approach to determining whom to trust. For example, a cardio-thoracic surgeon told me:

> The radiologists I trust, that are most valuable to me, are the ones that value service, that will make time to call or go over a study with me, and explain why they've interpreted something the way that they have. I really trust Dr. Atkinson [an abdominal radiologist], because he helps me figure out the best study to get for a particular question that I need answered. He's not just telling me the most expensive study, or even the one that gives the most information, but the one that will help the most with the question I'm trying to answer.

In this case trust is linked with notions of value and service as well as information. The surgeon positions himself as a consumer, choosing to trust radiologists based on the "value" of their service. That act of "making time" is seen as valuable and as an indicator of trustworthiness it is also significant, as much of hospital practice is structured according to an economy of time (cf. Higashi et al. 2012). Yet just as the amount of information in a radiologists' report must negotiate the ever-shifting boundary between "too much" and "not enough" or "relevant" and "extraneous," the act of "making time" is haunted by the cardinal sin of the hospital – wasting time. Radiologists who were deemed too communicative were generally not seen as trustworthy. As one emergency medicine resident told me, "There's this one guy that works nights, and I hate it when he's on. He calls us for every little finding, instead of just the important stuff, and totally wastes our time. I don't trust him, because he clearly isn't able to distinguish what is clinically important from what isn't, and a good radiologist should know that."

It is also informative to note what clinicians did not mention when characterizing a “trusted” radiologist. While experience did seem to matter -- most radiologists who were considered trustworthy had been practicing for some years – the place where a radiologist did their training was never mentioned as a significant factor in determining trust. In fact, most clinicians I spoke with had little or no idea about the personal or professional backgrounds of the radiologists.

Becoming (re)visible: radiologist trust

At Central Hospital some radiologists I observed did occasionally refer to clinicians whom they “trusted” more than others. In one instance, I saw one of the radiology residents ask one of the attendings about the appropriateness of an imaging study a certain clinician had ordered. The attending looked at the image requisition form and said, “Oh, it’s Dr. King who wants the study. He knows what he’s doing, and I trust him to order the right thing. Go ahead and tell the techs to schedule the study.” Rather than feeling the need to carefully scrutinize the order, the attending trusted in Dr. King’s ability to select the appropriate imaging exam for his patient.

However, in marked contrast to clinicians, radiologists were primarily concerned with transforming *themselves* into “trustworthy” consultants and “building trust” using a variety of strategies. One of these strategies, known as “having a face,” involved radiologists’ efforts to re-engage with clinicians by emerging from reading rooms to participate more frequently and actively in multi-disciplinary conferences, seeking out clinicians on the wards, and even moving entire reading rooms into clinical areas. While radiologists saw the campaign as a general effort to increase their visibility among clinicians, I argue that “having a face” was also a specific response to the widely acknowledged (by both clinicians and radiologists) trend among clinicians to frequently ignore the radiology report. Indeed, by seeking out clinicians and attempting to participate more actively in the process of diagnosis, radiologists were transforming their "reads" from something written in a report that was fixed and static and could be easily ignored into a flexible, adaptable verbal performance that was far more difficult to ignore. As Dr. Gifford, one of the more senior radiologists, commented, "With PACS, we have no face. We are lost in day-to-day management of patients, and the radiologist who is ultimately doing the work has become invisible. You have to be visible…the more interaction you have the more they [referring providers] know your value and trust you. The more you just put out a report, then it is like nobody exists behind that." Dr. Gifford associates loss of visibility with lost of trust, and loss of radiologists' perceived value by clinicians. Trust is again linked with the idea of "value," and with the cultivation of personal interactions with clinicians, by way of "having a face."

As another radiologist pointed out, because radiologists are dependent on clinicians for patient referrals, trust is an important political tool as well. He commented, "We have very little control over patients, and if the clinicians don't trust us, then they'll stop sending their patients to us for imaging. We're dependent on them [clinicians] for our livelihoods." Like patients, radiologists are not autonomous, and the power relationships are asymmetrical. Thus, negotiating trust with clinicians is as much political as it is social or epistemological.

As I previously mentioned, multi-disciplinary conferences or tumor boards were one of the primary venues that radiologists at Central Hospital were using to become known to clinicians (i.e., have a "face"), deliver a verbal performance of the "read," and build relationships of trust. In general, these conferences were topic specific (a breast tumor board or a spine conference, for example), met once a week usually in the early morning, and involved review of cases that were identified as particularly challenging or complex. Many different specialties would participate in these conferences.

For example, the weekly neurologic tumor board would involve neurologists, neurosurgeons, neuro-oncologists, neuroradiologists, pathologists, residents working with these various services, the neurosurgeons' nurse practitioners, and a scheduling assistant. These meetings usually lasted about an hour, and between eight and fifteen cases were discussed. Each case was presented to the group in the same way: the physician most responsible for the patient's care (usually a neurologist or a neurosurgeon) would give a brief history and present the problem to be solved (for example, should we try a surgical approach with this tumor, or should we try chemotherapy first?). The neuroradiologist would then present any relevant imaging studies that had been completed, followed by a summary from the pathologist. Then a general discussion would take place to develop a treatment plan or talk about any relevant issues.

One radiology resident explained to me why these conferences had become so important to radiologists:

> Inter-disciplinary conferences I think are really important, both for the patient getting a diagnosis and figuring out how to treat them, but also for the docs to get all on the same page, and review the imaging and the pathology. Once you have a relationship with a group, they at least know whether or not they can trust you. That is the first thing a doc needs to do is figure out whether they can trust the people they work with. Whether it be a pathologist, or a radiologist, or a neurologist who is doing clinical exams, you got to know how good your information is in any science.

Like the clinicians I spoke with, this resident sees trust as a relationship with information, one that involves "knowing" whether a person can trust someone else's knowledge or information. Multi-disciplinary conferences not only produce knowledge, in the form of a diagnosis or a treatment plan, but enable the evaluation of colleagues, generating information about who can be considered trustworthy.

One of the radiology attendings told me:

> The rapport that you develop with people, the trust, is so important in radiology. I think a lot of that comes with time, you have to earn people's trust. Especially when you are new, new to a situation, it takes a while for people to warm up to you and trust you and you have to kind of prove yourself. I think it is a lot easier to do that in person when you are in front of people, when you are able or willing to put yourself out there and put yourself on the line, and it is hard to do that electronically. I think that is a really important part of what we do at multi-disciplinary conferences.

In contrast to the MICU resident I discussed above, this radiologist links trust with a different sort of risk. While the MICU resident perceived the risk involved with trust as the risk of not getting correct information or not getting information at all, this radiologist suggests that the *giving* of information can be risky. "Putting yourself out there" and offering information involves the risk of being wrong. Thus, being trusted and trusting both involve risk.

Dr. Reece, one of the musculoskeletal radiologists recruited by Central Hospital, believed so strongly about the importance of "having a face" and being available for clinician consultations that, as a condition of his hiring, he required that the musculoskeletal reading room be moved from the basement to the Orthopedic Clinic on the fourth floor of the outpatient wing. The reading room was directly across the hall from the orthopedic surgeons' dictation room and close to patient care rooms, and it featured an open design and no doors. Thus, any clinician who happened to be walking down the hall could glance into the reading room and see who was working. I asked Dr. Reece about why he wanted to relocate his reading room, and he replied:

> The battle that radiologists have lost is a battle of perception of our utility. By removing ourselves from the clinical experience and putting ourselves in a box somewhere and just generating a report, we have largely become a target of litigation rather than a useful adjunct to the clinical process. We [radiologists] have to be not only in the hospital, but in the clinic, as close to your referring physicians as you possibly can…so instead of picking up the phone you yell across the hall, you go track them down and say, "I see that you are seeing this patient and I am seeing this on the radiograph, do you think this is pertinent?" Unlike the other reading rooms, we see our referring clinicians all the time. They come by to look at images, but they also come by to discuss cases, and to ask us about some of the procedures we do. We also participate in a lot of inter-disciplinary conferences. We just try to be as active as possible.

Dr. Reece's strategy seems to be working. When I observed in the musculoskeletal reading room, clinicians and nurse practitioners would frequently come by the reading room and ask questions or get one of the radiologists' opinions about a film. I even conducted a quantitative study comparing the rate and types of communication among the various reading rooms at Central Hospital and found that there were six times as many visits and twice as many calls to the musculoskeletal reading room than to the abdominal or neurological reading rooms during similar time periods. However, Dr. Reece explains that being visible also has its drawbacks: "I feel like we've been really successful in forming solid relationships with our clinicians, but it's also a bit of a curse because now my pager just blows up from people calling that want my opinion, and I'm so busy answering their questions that it's hard to keep up with The List."[40]

The health care system currently only reimburses radiologists for interpreting images. Attending conferences, conferring with colleagues, talking on the phone, or providing advice are not directly reimbursed. Yet radiologists acknowledge that without spending the effort and time to "have a face" and establish and maintain relationships of trust with clinicians, the perceptions of the value they provide and the future of their

[40] See Chapter 4 for a discussion of The List

specialty are at risk.

Another technique that radiologists at Central Hospital are using to gain visibility among their clinician colleagues involves not relations among people, but relations with numbers. “Quality metrics” have become another important way for radiologists to “prove” their value and trustworthiness. “Quality metrics” means quantitative calculations of radiologists’ productivity and accuracy. As one journal article stated, “As a specialty, developing and endorsing quality metrics and aiding radiologists with tools by which to generate these metrics would make it easier for radiologists to convince patients, referring physicians, third-party payers, and the general public that we provide greater quality in what we do” (Forman et al. 2011: 844).

Yet while nobody seems to be exactly sure how to measure quality, especially when it comes to radiology, there is little skepticism about the *need* for quantitative performance measures. As one radiologist succinctly told me, “You can’t manage what you can’t measure.” Therefore, despite a general lack of agreement about which metrics to use and lack of evidence that measuring quality will lead to improvements (cf. Wiener 2000), quality measurement and audit techniques have been embraced by the Central Hospital radiology department and by biomedicine.

Metrics calculated by the department include: exam appropriateness (stated reason for exam as compared with American College of Radiology (ACR) appropriateness criteria); time between when the exam is ordered and when it is performed; the waiting time of patients before and during the exam; patient satisfaction with the imaging experience; time for the report to be completed and finalized; and radiation exposure. In addition, the productivity of individual radiologists (calculated as number of studies read per hour) is carefully scrutinized. Furthermore, as I noted in Chapter 6, many of the reading rooms try to correlate imaging interpretations with surgical diagnoses to get a sense of the “accuracy” of radiologists’ reads. Yet these calculations are notoriously fallible. Often several weeks or months can elapse between imaging and surgery, during which injuries can heal or change in significant ways.

Other attempts to quantify accuracy include the development of the RADPEER program by the American College of Radiology (ACR). Using a web-based interface, radiologists who are interpreting imaging studies that have prior images and imaging reports available to them are supposed to indicate whether they agree or disagree with their colleagues’ interpretations of the prior studies. The ACR offers individual, group, and national statistics about the “accuracy” of radiologists’ reads based on this system. Discussion of developing departmental and personal “quality dashboards” to track (in “real time”) performance of radiologists individually and as a group is also a hot topic among imagers at Central Hospital.

How are we to understand this seeming contradiction between “having a face” and becoming visible through quantification, audit, and accountability measures? One strategy emphasizes the need for personal connections and relationships of trust, while the other attempts to abstract individual behavior into statistics and other kinds of quantitative “proof” of trustworthiness. Yet both are strategies to transform the invisible into the visible: in this case, it is the visibility of radiologists and their expertise that are at stake. In his work on the emergence of the figure of “the scientist” historian Steven Shapin argues against what he calls “the myth of late modernity,” which claims that trust has been replaced by audit and “objective” calculation. He writes:

> Familiar people and their virtues have *always* been pertinent to the making, maintenance, transmission, and authority of knowledge…Late modernity proliferates uncertainties; radical uncertainties mark the venues from which technoscientific futures emerge; and it is the quotidian management of those uncertainties that the personal, the familiar, and the charismatic flourish. [Shapin 2008: 5]

In a related vein, Rabinow shows that among scientists developing PCR, trust established through face-to-face interactions was important in determining which knowledge claims were accepted and which were disregarded (1996). Yet he also notes that trust has been "redefined and recombined with other mechanisms to produce different subjects, different objects, and a different milieu" in science (1996: 15).

But what are these "other mechanisms" that Rabinow mentions? Based on my observations of and interactions with physicians at Central Hospital, I argue that these other mechanisms include the techniques of audit to which Shapin refers. Trust has not so much been replaced by audit and accountability measures but is co-constructed with them. For radiologists and clinicians, assessing "trustworthiness" involves the evaluation of certain kinds of knowledge and information; audit and accountability *and* "having a face" are two mechanisms for the generation of knowledge as well as information.

To speak of trust in the current moment is to engage notions of risk, knowledge production and distance, and doubt. Information does not supplant the need for trust, but rather the two form what might be thought of as "constitutive antagonisms," a notion developed by Connolly (1988). Trust and information cannot exist without each other; trust and information are that which the other is not. In contrast to Tsoukas's (1997) claim that more information undermines trust, for clinicians at Central Hospital who are engaged in the practice of diagnosis, more information (in the form of multiple "reads" of an image) requires that trust become an even more important mechanism for negotiating among a variety of sources of information and knowledge. The dream of "complete information" -- the ability to *know* rather than *trust* -- is an ever receding horizon, one that science and medicine chase through the promise of technology and through the practices that constitute diagnosis.

CHAPTER 8: Conclusions and Future Directions

> The relevance of "good" HIS [health information systems] for high-level quality of care is obvious…as without having appropriate access to relevant data, practically no decisions on diagnostic, therapeutic or other procedures can be made, with fatal consequences for patients. [Haux 2006: 270]

This quote characterizes the largely unchallenged assumption in biomedicine that the widespread adoption and use of information technologies, including PACS, results in better care for patients. This assumption is tightly linked with what I call "The Law of More" in medicine. Here I am making a deliberate pun on Moore's Law in computer science, which predicts that about every two years the number of transistors on a circuit will double. This doubling of transistors has meant exponential increases in computer processing power and memory capacity, enabling information technologies like PACS to be developed. This pun highlights two things: first, the fact that PACS adoption is part of a larger story -- that of the "computerization" or "digitization" of medicine and the increasingly central role of information technologies in health care (Clarke et al. 2010); and second, that technologies like medical imaging and PACS are part of a fundamental orientation towards knowledge in biomedicine in which *more* is always better. Increasingly, "good care" for physicians, health care organizations, and patients seems to be synonymous with "more information."

Medical imaging and information technologies like PACS are indeed inextricably linked to the belief in biomedicine that there is nothing that cannot be known (or seen) given technological advances and the powers of Science (with a capital S). As Strathern points out, "If the assumption is that much of what is invisible is what is simply *not yet made* visible, then there will always be more to learn…further realities to uncover"

(2000:312).

Strathern is talking about academic organizations, but her argument, I think, can be extended to clinical medicine as well. As particularly powerful techniques that penetrate and make visible the inner recesses of the living body, imaging techniques like CT and MR seem to offer total knowledge and at the same time create a desire for more images in finer detail and better technologies that will go deeper and see more clearly. Van Dijck has called this “the myth of total transparency,” where “better imaging instruments automatically lead to more knowledge, resulting in more cures” (2005: 7). Yet as Renee Fox has shown, technological and scientific developments produce both new knowledge and new uncertainties (2000).

This dissertation takes the adoption of PACS in a U.S. hospital as a case study for examining some of the new knowledges and uncertainties that information technologies can produce. Specifically, I investigate how the production and circulation of medical information reshapes notions of expertise, risk, responsibility, and patient care in biomedicine. Through an examination of the ways that PACS has amplified the intensity of some relationships (such as those between clinicians and images and radiologists and reports) while reducing others (between clinicians and radiologists, for example), I have explored the complex links among the production and circulation of information and knowledge, expertise, and diagnosis. I have described how these shape responsibility to the hospital administration, the clinician-radiologist relationship, and patient care.

In many ways, my exploration of how PACS has shifted the boundaries of expertise and authority in biomedicine has required an engagement with the notion of distance and how it relates to the production of knowledge. One of the common arguments about information technologies, particularly tele-technologies, is that they are able to collapse space and time, "leading to the simultaneity and proximity of everything and everyone in an almost unblinking present" (Elden and Mendieta 2009: 7). According to this vision, technologies like PACS enable physicians to "overcome" distance and have access to unlimited information from anywhere in the world.

Tele-technologies aren't new, nor is the link between these technologies and claims that they "flatten" distance and erase time. The telegraph, letters, smoke signals, the locomotive, even prehistoric cave art have all troubled the divide between near and far, now and later, presence and absence. Yet distance remains problematic. With PACS both radiologists and clinicians struggle with the question of how to evaluate knowledge or information that is produced "somewhere else." Before PACS, radiologists, clinicians, and images would encounter one another in the reading room, where "reads" of images and diagnoses based on those reads were jointly produced. Among other things, PACS facilitated the geographical separation of events that were formerly linked; at Central Hospital, images could be acquired from imaging equipment scattered throughout the hospital and almost instantly viewed by a radiologist in the reading room and a physician in the ICU. As I showed, this fairly small geographic separation (just two floors separate most reading rooms from the ICU), coupled with the clinicians' new access to images, has had major effects on notions of expertise, authority, responsibility, and trust among radiologists and clinicians, in addition to significantly impacting patient care. So if a few floors can facilitate such a dramatic shift in medical practice, what about a few hundred miles?

As I discuss in Chapter 2, PACS also has enabled radiologists to easily and cost-effectively practice teleradiology - that is, the viewing and interpretation of medical images from locations outside the hospital or clinic. While PACS allows non-radiology clinicians to view images from locations outside of the reading room, teleradiology enables radiologists to read images on computer stations hundreds or thousands of miles away from where those images are acquired and the patient and clinical team are located. While Central Hospital did not use teleradiology services at the time of my research, the "outsourcing" of medical image interpretation to teleradiology companies, even among academic hospitals, is a trend that seems to be increasing (Hillman and Goldsmith 2011). With teleradiology, not only are clinicians not visiting reading rooms, but in many cases the reading rooms are located in another state.

In the beginning (that is, the 1990s), teleradiology services arose primarily as a way to provide night and weekend coverage for hospital and clinic-based radiologists. These service providers (dubbed "nighthawks" after one of the first teleradiology companies) were not viewed as particularly threatening by many radiologists and were in fact seen as an important boon to radiology practice; the radiologist no longer had to take call, and smaller radiology groups could supplement their practice with the subspecialty interpretations offered by many teleradiology services.

However, teleradiologist groups quickly realized that by extending their services to include daytime coverage, they could offer imaging interpretation at a lower cost than many "local" radiology groups. During the mid-2000s, the demand for imaging services seemed limitless, and there was enough work for teleradiologists to expand into daytime reading without seriously jeopardizing the practices of "local" radiologists. However, recent studies indicate that the volume of medical imaging in the U.S. is leveling off (Rao et al. 2011). This, combined with the trend of decreasing reimbursements for imaging and uncertainty about how radiologists will be compensated under the Affordable Care Act, have caused many radiologists, including those at Central Hospital, to fear that they may have to compete for imaging contracts with teleradiology providers. These fears seem to be somewhat warranted. For example, a company called Telerays located in Bellaire, Texas, has an eBay-like website where contracts for providing imaging interpretations are awarded to the lowest bidder.

However, this kind of auction-based approach remains the exception rather than the rule in telemedicine. In general, teleradiologists work for large private companies that contract with multiple hospitals or imaging centers (often in many different states) to read images. For example, in a recent article in the journal *Radiology*, a former teleradiologist wrote, "During my teleradiology tenure I held 30 state medical licenses[41], served more than 400 different hospital institutions, and rendered more than 50,000 preliminary interpretations[42] for sites throughout the United States" (Abramson 2012: 318).

How will notions of expertise, authority, trust and responsibility be negotiated among radiologists and clinicians when radiologists serve over 400 different institutions? What will be the impact of this degree of distancing of between physician and hospital

[41] Federal law requires radiologists to obtain a medical license for every state from which images are sent and be credentialed in each hospital that they provide services for. Only practitioners with a US medical license may interpret exams originating from the US, although the radiologist may live abroad

[42] The fact that this radiologist says he gave "preliminary interpretations" indicates that he worked for a teleradiology company that provided "on-call" or night/weekend coverage. In general, the teleradiologist offer a "preliminary" read of any images taken during the "on-call" period, and the staff radiologist would then re-read the image during normal working hours and either confirm or revise the teleradiologist's interpretation

for diagnosis and patient care? How will radiologists “have a face” and remain members of the patient care team from across state lines? These are but a few of the questions that beg for future ethnographic exploration.

APPENDIX A: Handmaidens of PACS: Associated Technologies

RIS

Along with a system to acquire, store, distribute, and view medical images, radiologists quickly realized they also needed a system to keep track of patient information, imaging requests, the status of imaging studies, and billing. Thus, computerized radiology information systems (RIS) evolved along with PACS, although they are technically considered to be separate systems. The first efforts by radiology department to use computers to keep track of patients, orders, and scheduling took place at Massachusetts General Hospital in the late 1960s. Researchers designed a system to automate scheduling of imaging studies and management of the film library.

Concurrently, hospitals were hard at work developing hospital information systems (HIS) to track and store patient information. Two well-known examples of early HISs include MUMPS (Massachusettes General Hospital Utility Multi-Programming System) and GEMISCH (GEneralized Medical Information System for Community Health). MUMPS was later widely adopted by many medical institutions, including the DOD and VA networks of hospitals and clinics (Collen 1995).

Of the hospitals that did have an HIS in regular use, these systems were often separate from the RIS or PACS, making the retrieval and viewing of health information much more cumbersome for clinicians and radiologists alike. Some RISs had a limited ability to interface with HISs, and a few (at MGH, for example) were totally integrated with one another. At the time of my research, Central Hospital had a basic HIS for outpatient but not inpatient care, a separate HIS for the Emergency Department, and a non-integrated RIS. Paper-based charts were still in use for recording all inpatient care, although labs and pathology results could be accessed via the outpatient HIS. A radiologist wanting to look up patient information would need to log in to each system separately, or physically track down the patient chart. However, shortly after I left Central Hospital, they began the process of migrating to an integrated, enterprise-wide paper-free HIS that would replace the older system.

Digital Dictation

Another key component of more recent PAC systems is software that allows radiologists to dictate their findings directly into a computerized report template. The software is constructed to "learn" the speech patterns and pronunciations of individual radiologists as they speak into a microphone connected to the PACS workstation. Digital dictation has been shown to decrease "turnaround time," or the amount of time it takes for a radiologist to interpret an image and make the final report available to clinicians, and it also allows a degree of cost savings by eliminating the need for transcriptionists. However, while these systems have improved greatly in the last few years, it is still common for radiologists to need to make quite a few corrections during the dictation process. Interestingly, many of the radiologists I spoke with at Central Hospital felt that with their digital dictation system (which I call "PowerVoice"), they had to spend a significant amount of time proofreading and correcting mistakes that the dictation software had made, which caused them to be less efficient. With this in mind, some departments (but not Central Hospital) use digital dictation for generating the primary report, which is then reviewed by a human transcriptionist for errors, rather than by the radiologist.

Critical Test Result Management (CTRM)

Radiologists are legally responsible for assuring that urgent, critical, unexpected, or unanticipated imaging findings are delivered to caregivers. Thus, documentation that findings have been communicated to the referring provider is important to ensure both appropriate patient care and that the radiologist has discharged their legal duty. Urgent or critical results are still primarily communicated by radiologists directly to physicians either face-to-face, or, more commonly by phone. However, in an effort to make the communication of non-emergent yet important imaging findings more efficient and reliable for both radiologists and referring physicians, systems designed to replace more 'informal' modes of radiologist-clinician communication have been developed. These systems, known as Critical Test Result Management (CTRM), are highly structured, unidirectional, automated electronic communication systems that feature methods to track and confirm the delivery of imaging results from radiologist to referring clinician. Some CTRM systems send an email to referring providers that contain relevant findings, while others send a page to clinicians, notifying them that they need to log into an associated voice messaging system where they can listen to messages left by radiologists. These systems are designed to reduce the amount of time radiologists spend trying to track down referring providers and to minimize interruptions in radiologists' work flow.

At Central Hospital, the CTRM system (which I call "Witness") was integrated into the digital dictation system. After finishing a report dictation, the radiologist could select the option to send a Witness message to the referring physician, and would then record a brief voice summary of the radiological findings. Witness would then page the physician who ordered the study, and notify them to log in to the Witness voicemail system. The system records the time that the message was listened to and sends a confirmation to the radiologist. If the physician does not log in and listen to the message, Witness continues to page him or her until the message is accessed. If the physician continues to ignore the pages, the hospital administration is notified.

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