A Spatial Structuring Approach to IT Use and Workplace Change: What's space got to do with it?

by

Ari Goelman

B.A. Economics
New College of Florida, 1995

M.Sc. Planning
University of British Columbia, 1999

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Signature of Author: ______________________
Ari Goelman
Department of Urban Studies and Planning
June 21, 2005

Certified by: ______________________
Frank Levy
Daniel Rose Professor of Urban Economics
Thesis Supervisor

Accepted by: ______________________
Frank Levy
Daniel Rose Professor of Urban Economics
Chair, Doctoral Program Committee

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Abstract

This dissertation uses the disparate spatial practices of radiologists and outpatient physicians to frame a study of the relationship between space, information technology use and workplace change, with a particular focus on relationships of control. Drawing from diverse urban, organization and economic literatures, I propose a spatial structuring approach to examining issues of space and work practices. From this perspective, spatial practices are seen as both shaping and being shaped by information technology use.

The spatial practices of outpatient physicians prior to adopting Electronic Medical Records (EMRs) shaped the implementations of the EMRs in that they led to a series of problems in coordinating outpatient work, problems that EMRs were adopted in part to solve. The EMRs, in turn, were successfully used to further extend physician work in time and space, as well as to better coordinate and control their work.

For radiologists, their historic spatial practices shaped the way they used teleradiology applications to respond to a recent, and overwhelming, scarcity of radiologists. Radiologists were able to successfully exert control over the offshoring of their work, in part due to their long history of working at a distance from their patients and other physicians. Radiology work has been done remotely since the inception of their profession, so the fact that it can now be done from thousands of miles away, rather than a hundred yards away, did not appreciably lessen their ability to exert professional control.

This research also links spatial practices at work to temporal practices at work. I use a comparison of the ways in which outpatient physicians and radiologists work in space and time to highlight the importance of these practices in shaping and being shaped by the use of information technologies. In both cases, information technologies that enabled physicians to extend their work in space were used to extend their work in time, as well. Once again I link these complex dynamics to issues of control, both of the information technologies in question, and of medical work more generally.

Thesis Supervisor: Frank Levy, Daniel Rose Professor of Urban Economics
Department of Urban Studies and Planning, MIT

A SPATIAL STRUCTURING APPROACH TO IT USE AND WORKPLACE CHANGE: WHAT'S SPACE GOT TO DO WITH IT?

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Chapter 1: Introduction

1. A Tale of Two Doctors

In the early 1980s futurists, led by Toffler (1980), famously predicted a new world of work. Telecommunication advances were to liberate workers from the despotic bounds of their offices, leaving them free to pursue their careers from the comfort and autonomy of their poolside decks. In subsequent decades, many of the assertions of these futurists were repeatedly debunked. Face to face contact continued to be crucial for many workers, as the importance of tacit knowledge became increasingly clear (Freeman 2002, Glaeser and Gaspar 1998, Olson et. al. 2002, Storper and Venables 2004). As for teleworkers, rather than the liberated workers predicted by Toffler, researchers found many teleworkers exhausted and isolated, working in a home that had lost its status as sanctuary (Gurstein 2001, Johnson 2002).

Thus, it was with some surprise that in December 2004, I found myself in an American professional's living room, enjoying a beautiful view of the Pacific Ocean lapping at Sydney Harbor. We were discussing the satisfaction and independence that went along with the well paid work she did for her U.S. clients. Moreover this professional was not a software developer, nor a highly paid management consultant. Rather, Dr. Ann Frances[1] was a "nighthawk" radiologist - a radiologist who can work from virtually anywhere, contracting to read night time emergency room tests so other radiologists can sleep through the night. A U.S. born and U.S. trained radiologist, Dr. Frances worked from Sydney, interpreting radiologist tests performed 8,000 miles away.

It was a typical December day in Sydney when we spoke - breezy and warm,

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[1] All participants in this research are referred to by pseudonyms.

about 70 degrees Fahrenheit. On that same day, the northeastern United States were receiving a record-breaking quantity of snow. Dr. Mazzini, an outpatient physician in a northeastern city, was shoveling his driveway and waiting for the roads to be plowed so he could get to work. Unlike Dr. Frances, Dr. Mazzini continues to do the bulk of his work in his office, face to face with his patients, doing the in-person consultations and physical examinations that have characterized medical work since well defined medical professions began to emerge from the welter of 19th century medical practice.

This dissertation uses the disparate spatial and temporal practices of these two types of physicians to frame a study of the relationship between space, time, information technology use and workplace change. I propose that the way in which people work in space and time both shapes their use of information technology and is shaped by it. While this is most evident in the case of Dr. Frances reading images generated thousands of miles away in order to mitigate the night work of radiologists in the United States, spatial and temporal work practices are also important in understanding the way that Dr. Mazzini's work has changed.

This research is not only interested in the spatial and temporal implications of information technology use, but the consequences of these dynamics for the physicians who use the information technology. A central focus of this research is investigating the connections between: i) the way that work was situated in space and time before and after the introduction of the technology; and ii) relations of power and control for the affected physicians.

I aim to contribute to a meso-level theory regarding technological change, work and space, linking the micro-theories of organizations and the macro theories of urban theory. By focusing on the processes of change, this dissertation brings together theories of organizational, spatial and professional change. I draw notions of spatial practices from urban geography and urban social theory into a process-oriented theory of organizational change, with the intention of producing insight into organizational, spatial and temporal change. In this dissertation I apply this framework to understanding the consequences of information technology use for relationships of control, but its application could be useful beyond this as well.

This dissertation illustrates the extent to which the ways these physicians worked in space and time prior to adopting an information technology shaped the control they were able to exercise over their use of information technologies and the subsequent outcomes for their work more generally. For the most part I leave considerations of temporal change for later chapters of the dissertation in order to first clearly lay out and utilize a perspective on spatial change. While spatial and temporal changes are closely related, I see this spatial perspective as the primary contribution of my research. In addition to these contributions, my research speaks to the question of how different professions maintain varying amounts of control over their work and makes some predictions with respect to more general trends.

2. Policy Context

This research has implications for workforce policy, urban policy and health care policy. In recent years, old concerns about the outsourcing of labor to developing countries have resurfaced, but with different jobs at risk. Whereas the outsourcing trends of the 1970s and 1980s impacted largely blue collar workers, the new outsourcing is placing pressure on previously untouched white collar occupations. While business services appear to be the most endangered (Kenney and Dossani 2003) and computer engineers have received particular attention (Thurm 2004), other occupations are often mentioned in the popular press, particularly radiology (Pollack 2003). Radiologists have long been one of the best reimbursed medical subspecialties (Kane and Loeblich 2003). If their jobs can be exported, the argument might run, then who is safe?

At the outset of this research it quickly became clear that the use of teleradiology to offshore U.S. radiology work has been a good deal more limited than popular accounts have suggested. In fact, U.S. radiologists have exerted a good deal of control over the offshoring of radiology work. Notably, all images that inform treatment of patients within the United States continue to be read by U.S.-trained radiologists, the vast majority of whom continue to be located within the United States.

Outpatient physicians, in contrast, have appeared to exercise less control over the use of information technology to change how and where their work is done. While their work is not in danger of offshoring, the spatial constraints within which they work have been loosened, and unlike radiologists they have showed little interest in playing an active role in shaping the subsequent changes.

How can one understand the differences between the changes that occurred in each of these subspecialties? This fundamental question motivates much of the dissertation, in an attempt to identify dynamics that apply beyond the medical professions immediately under investigation.

This research also speaks to the recently identified need (Goldstein 2003) for empirical research which differentiates between different types of remote work and between specific occupational and organizational contexts. All remote work is not the same. An increasing number of Americans are becoming occasional teleworkers, with many more Americans occasionally working from home than working as full telecommuters (Pratt 1999). By focusing on the variation between two occupations within the same profession, this research begins to illustrate the very substantive differences in the processes through which different types of remote work arrangements come about.

In addition to workforce issues, there are urban implications to this research. Urban policy makers need to understand the social, temporal and spatial effects of changing work practices. The ways in which sometimes-teleworkers work in space and time have direct consequences for their families and communities and should be incorporated into community and neighborhood planning. Insight into the changing spatial and temporal dynamics of work might better inform our understanding of such urban concerns as the malleability of commuting patterns, the price of urban office space and the use of public space.

Finally, with its focus on physicians, this research has clear implications for health care policy. While a good deal of research has been done with respect to the benefits of electronic medical records (EMRs), less work has focused on the barriers to adoption, especially with respect to the physicians who use them in an outpatient context. A recent study in the Journal of the American Medical Association (Koppel et. al. 2005) testified to the contingency of the benefits that accrue from an electronic system, identifying the importance of a detailed look at the physicians who work with the system. Still, remarkably little research has addressed this problem directly. My work with outpatient physicians in the process of adopting an EMR provides insight into the issues that shape physicians' reception of an EMR, as well as the spatial notions that are the focus of this dissertation.

The radiologist portion of the dissertation will also be useful to health care policy makers. The shortage of radiologists and other specialists has become an increasingly difficult and expensive problem to deal with in the last decade. Nighthawk radiology may allow the scarce supply of U.S. trained radiologists to be used more efficiently, but in-depth studies of the emerging nighthawk radiology industry remain sparse.

Health care and urban policy overlap as well. For instance, health care centers act as an economic anchor for many large cities (Harkavy and Zuckerman 1999). A massive restructuring in the space of health care work might lead to a further hollowing out of cities, or it might encourage a resurgence of urban life as large urban medical centers grow larger in order to provide more remote services to peripheral communities.

Many of these issues have been addressed elsewhere in various forms, but this dissertation offers a new perspective in its synthesis of attention to space and power, along with the focus on the intraorganizational processes through which information technology is used to change work. While this dissertation builds on the work of past research from several disciplines, it contributes a particular notion of space and a particular focus on the relationship between space, time, information technology use and control.

3. Methods

In addition to drawing from broad and disparate literatures in framing the theoretical context, I chose to draw on mixed methods in exploring the questions under investigation. Given my concern with understanding the *process* of change, qualitative techniques were the primary method on which I based this analysis. Maxwell (1996, 20) provides a useful distinction between the strengths of qualitative research and quantitative research:

> "Quantitative researchers tend to be interested in whether and to what extent variance in x causes variance in y. Qualitative researchers, on the other hand, tend to ask *how* x plays a role in causing y, what the process is that connects x and y."

This distinction should not be seen as absolute -- many quantitative researchers probe questions of causal processes (e.g., Autor et. al.'s (2001) statistical work linking changes in skill composition to wage trends) and many qualitative researchers do examine variance issues. However, Maxwell is convincing in the respective strengths that he identifies. I chose interview research based on the belief that it allows direct and nuanced insight into the process of change.

I also chose to emphasize qualitative methods due to the recent nature of the adoption of both teleradiology and EMR applications. The uses of both technologies are in such a state of flux that past general trends may be less useful in predicting the future than the perspectives of participants involved in the day to day work of being a doctor and using these technologies.

However, I was also interested in illustrating the broader context of the changes I was exploring in interviews. Kvale (1996, 94) writes that while questionnaires fail to provide the in-depth insights made possible by interviews, they allow investigators to test how prevalent certain conditions are among a larger number of participants. I chose to analyze recent survey data of radiologists for precisely this reason -- I wanted to explore the extent of teleradiology adoption in the wider radiology market place.

Also, I was interested in discussing the extent to which certain uses of technology correlated with other practice characteristics. As noted in the Maxwell quote immediately above, quantitative methods are ideal for precisely this sort of variance analysis.

3.1 Qualitative Methods: Interviews and Site Visits

I completed 69 open ended interviews of 60 participants, with 7 participants taking part in 2 interviews and 1 participant taking part in 3 interviews. While the majority of these participants were physicians, I also interviewed other individuals involved in either the implementation of EMRs or teleradiology. In the outpatient context, I completed a total of 40 interviews of 35 participants. I interviewed 22 outpatient physicians, as well as 3 administrators, 2 physician / computer scientists, 1 information technology officer, 1 filer, 1 nurse, 1 nurse-practitioner, and 1 physician-assistant. I also interviewed 2 executives at a large medical insurance provider and 1 health care informatics academic familiar with the development of EMRs in the region. At one outpatient clinic, I also facilitated a focus group with an additional 22 physician participants.

In the radiology sites that I studied, I completed 29 interviews of 25 participants. I interviewed 15 radiologists, as well as an additional 10 people involved in all levels of the nighthawk radiology groups. Sample interview guides that I used when interviewing outpatient physicians and radiologists can be found, respectively, in Appendix 3.1 and Appendix 4.7. I leave a discussion of site details for the relevant empirical chapters that follow, confining the current discussion to my methods of analysis.

Where possible, interviews were performed on site. This allowed me to combine site visits with interviews. However, a significant minority[2] of interviews were done over the phone due to scheduling or travel constraints. Most participants were identified by other participants through a snowballing process, but as the research advanced, some were also selected by theoretically motivated attempts to find contradictory evidence.

The majority of interviews were tape recorded and transcribed verbatim, with the exception of five phone interviews which were not recorded. Transcribing interviews verbatim lessens the possibility that researchers will misremember or misrepresent the words of their participants --mitigating what Maxwell (1996, 89) terms "threats to valid description." To Maxwell, transcribed interviews "provide a *test* of one's developing theories, rather than simply a *source* of supporting instances" (95) (emphasis in the original).

Coding refers to the "analytic processes through which data are fractured, conceptualized, and integrated to form theory" (Strauss & Corbin 1998, 3). I began the coding process by reading through early interview transcripts to establish categories related to my research question. I then coded the data using QSR's N6 qualitative software program. As Strauss and Corbin note (1998, 101), the coding of interview data is a "dynamic and fluid process." While it is conceptually useful to divide the coding of qualitative data into neat stages of "open coding" where categories are established and later stages where categories are classified and compared, in practice, these stages of analysis tend to coincide and recur. I performed my analysis in an iterative and ongoing process, cycling between literature review, data collection and data analysis.

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[2] 7 out of 41 interviews in the outpatient case, and 9 out of 29 interviews in the radiology case.

Maxwell (1996) suggests that qualitative researchers must address at least three types of validity threats: threats to valid description, valid interpretation and valid theory. As noted above, transcribing the interviews verbatim addresses descriptive validity. In order to address what Maxwell calls "interpretive validity threats" - the possibility that my interpretation of the interview data does not accurately reflect the perspective of participants - my coding was spot checked by other qualitative researchers familiar with the research material. I checked theoretical validity both by looking for discrepant data in existing interviews and by specifically attempting to choose interviews with participants who might contradict my current understanding. As a final, more general validity check, I shared and discussed my general insights with both participants in the field and researchers specializing in qualitative data analysis who were familiar with my data.

One limitation of interview research is that it relies on the perceptions of the participants. While a researcher can check participants' perceptions against one another, it is possible, for instance, that outpatient physicians share certain prejudices about patients that might lead them to systematically bias their response to certain questions. However, participants' perceptions of the changes to their work offer important insight into the question of workplace change, and allow a researcher to focus on more sites than an intensive ethnography.

A similar interest led me to focus my interviews on physicians. As described above, while I did interview a large number of non-physicians, most of the roughly 60 interview participants were physicians, especially in the outpatient sites. While this focus on physicians limited the questions this research could answer, it was a deliberate choice.

This study does not purport to examine the changes in outpatient clinics as a whole. Rather, it addresses itself specifically to the changes in physician work, with particular respect to spatial dynamics, temporal dynamics and relationships of control. In the radiology case, where I was interested in constructing a more global picture of an evolving industry, I both utilized quantitative methods, and focused my interviews more broadly on participants in the nighthawk industry.

3.2 Quantitative Methods

The survey data is drawn from a paper survey the American College of Radiology (ACR) conducted of 3090 radiologists in 2003, including every subspecialty of radiologist. The survey sample was taken from the American Medical Association's (AMA) Master File, a listing of every allopathic physician in the United States, and supplemented by a sample of ninety-two osteopathic radiologists randomly selected by the American Osteopathic College of Radiology (AOCR) from its list of members.[3] Usable responses were received from 1924 radiologists.

Given my interest in radiologists who could potentially make use of teleradiology applications, I eliminated 119 responses from vascular and interventional radiologists from the analysis. While diagnostic radiologists read and interpret radiological images, interventional radiologists actually perform procedures upon patients. For instance, if a blood clot is discovered in a patient's leg, an interventional radiologist might be called upon to put a filter in the leg. Thus interventional radiologists cannot work from a distance using teleradiology. Excluding them allowed the analysis to focus on the

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[3] Allopathic medicine refers to conventional western medicine, while osteopathic medicine constitutes an alternative approach founded in the 1890s (Starr 1986).

diagnostic radiologists that exemplify the technical and spatial traits in which I am interested.

Eliminating the interventional radiologists left me with a potential sample size of 1805. As with any survey, not every respondent answered every question on the ACR survey -- some questions were left blank or answered incompletely. When modeling data, I only used those observations which had values for every variable which I included in the given set of models. The result of this is that the sample size varies somewhat with each set of models described below, depending on what variables are included in the model. In most models the resulting sample size is between 1100 and 1200 radiologists.[4]

I used two types of regressions in this analysis: ordinary least squares (OLS) regression and binomial logistic regression. OLS regression is appropriate when the outcome variable is continuous, as for example in the case of hours worked in the last week of work. Binomial logistic regression is used to model a nonlinear function to data where the outcome variable is dichotomous, as for example a variable corresponding to whether or not a given radiologist's practice uses teleradiology.

When presenting regression results I was guided by the statistician John Tukey's admonition that most tables contain far more information than anyone wants or needs (quoted in Becker 1998, 79). I present only the most salient regression results in the main text of chapters 4 and 5. In addition to the models I present, I tested a number of subsidiary models, testing for model violations and influential data points. The results of these robustness analyses are presented in the appendices of the relevant chapters. I conducted all regression analysis using SAS 9.1 (SAS Institute Inc., Cary, NC, USA)

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[4] Please see appendices 4.1, 4.2, 5.1 and 5.2 for more details about deleted observations and robustness analysis.

running on a Windows XP_HOME platform.

4. Outline of the Dissertation

In the next chapter, I begin the body of the dissertation by situating this analysis within several discrete literatures. I argue that the relationship between spatial dynamics and the process of intra-organizational technological change has often been overlooked. Drawing from disparate streams in social theory, organizations research and urban geography, I formulate a spatial structuring approach which places spatial practices at the heart of its analytical focus.

I demonstrate this spatial structuring approach in Chapter 3 and Chapter 4. While the impact of spatial practices is most visible in a comparison between outpatient physicians and radiologists, in these two chapters I illustrate that the importance of spatial practices is visible even when the analysis is confined to a single profession. In Chapter 3, I focus solely on the case of outpatient clinics and their use of EMRs. I call attention to the importance of space in mediating relationships of control in outpatient clinics, and illustrate the way that information technologies were used to change these relationships, in part through the extension of social relations in space.

Next, in Chapter 4, I focus solely on the case of radiologists and teleradiology applications. Both chapters serve the purpose, not only of illustrating the utility of a spatial structuring approach in explaining workplace change, but in explicating the process of change in these two, rapidly changing, medical professions. In both cases, the particular technologies upon which this research focuses are contextualized within other organizational and technological changes currently taking place.

In Chapters 2, 3 and 4, I discuss space to the exclusion of time in order to illustrate the spatial structuring approach more clearly, as the spatial components of this model are the primary contribution of this research. However, while it may be useful analytically to separate space and time, my research also illustrates the extent to which spatial practices at work are linked to temporal practices at work. With Chapter 5, I broaden my analysis to compare the two professions and incorporate an awareness of time into the model. I use a comparison of the temporal and spatial practices with which outpatient physicians and radiologists work to highlight the importance of these practices in shaping and being shaped by the use of information technologies. Once again I link these complex dynamics to issues of control, both of the information technologies in question, and of medical work more generally.

Finally, I conclude in Chapter 6. After summarizing the findings and reiterating the primary characteristics of the spatial structuring model proposed in this dissertation, I draw out policy implications and suggest profitable directions for future research.

Chapter 2: Bridging Urban and Organizational Literatures -- A Spatial Structuring Perspective

1. Introduction

In the last chapter I contrasted the situation of two hypothetical physicians. One, Dr. Ann Francis, is a radiologist who lives in Sydney and spends her days interpreting emergency images transmitted from the United States. The other, Dr. Tom Mazzini, is a physician who works at an outpatient clinic at a large academic hospital. He continues to work in the same room with his patients, examining and interacting with them face to face.

The central contention of this research is that focusing on the ways in which work is conducted in space before and after workers adopt information technology allows us a better understanding of both the origins and the consequences of information technology use. One can imagine that several years ago Dr. Mazzini and Dr. Francis were both working in similar physical locations but enacting very different spatial practices in their work. While Dr. Francis, like most radiologists today, would have reviewed images at some distance from both her patients and her patients' physicians, Dr. Mazzini would have worked face to face with his patients. The differences in their spatial practices would even then have presaged the different ways they could use information technology to change how and where they do their work.

Like a growing number of radiologists, Dr. Francis uses information technology to work entirely from home. In contrast, Dr. Mazzini uses information technologies to change the ways he works at both the office and at home. Both doctors have used information technology to change the way they do their work in space, but they have changed the space and pace of their work, as well as relationships of control governing their work, in very different ways.

Spatial practices are presented here, not only as a result of information technology use, but as important factors in shaping the adoption of information technology. In this dissertation I will be focusing chiefly on the consequences in terms of relationships of control, but I propose that this model could be extended to other workplace consequences.

The fundamental argument that I am making is that spatial practices are important for all workers, not only for those engaging in the more dramatic manifestations of remote work. Comparing a medical subspecialty which does much of its work remotely to one which continues to do most of its work at an office, face-to-face with its patients, highlights the impact of spatial practices, while the in depth analysis of each subspecialty calls attention to the specific ways in which spatial processes shaped the adoption of information technology in these cases.

In order to inform these theoretical concerns, I turn to multiple literatures. I draw on several veins of urban social theory and urban geography to inform my conception of spatial practices and their relationship to power and technology. I then refer to organization theory and other workplace theories to enrich my discussion of workplace change, control and the use of information technologies. Finally, given my focus on physicians, I draw from the literature on professions, medical sociology and health care to inform the context of this investigation.

2. Rooting the Discourse in Social Theory

I begin this literature review by linking the theoretical concerns of this dissertation with themes of power and technology that have long motivated much social theory. After reviewing the relevant discourse around technology and space, I synthesize a variety of perspectives with regard to power, drawing from political science and geography, in addition to social theory.

2.1 Technology and Space

Social theorists have been interested in the relationship between technology and space since the inception of social theory in the writings of Marx, Durkheim and Weber among others (Marx 1847 [1978]; Durkheim 1883 [1984]; Weber 1958). The relationship was framed indirectly at first -- neither Durkheim nor Weber explicitly addressed themselves to the relationship between technology and space. Although technology is key to the Marxist dialectic, Marx was only peripherally concerned with explicitly spatial matters. However, in their general concern with the transition to modernity, each of these theorists dealt with the urbanization and industrialization of European society, transitions in which technological, spatial, and temporal changes played prominent roles.

By the late twentieth century, issues of space, information technology and power had moved to the foreground in the writing of several prominent social theorists. All three are key to Anthony Giddens' notion of time-space 'distanciation' – the idea that the use of various technologies have extended social relations in time and space (Giddens 1981). Giddens illustrates distanciation through the invention of writing, linking this to a fundamental extension of social relations in time and space. Giddens contends that this extension was primarily driven by the desire of those in power to better coordinate the people and resources over which they exerted power.

In a similar vein, Beck (1992) convincingly argues that a defining consequence of the spread of information technology in the workplace will be the increasing prominence of struggles over information flows, due in large part to the spatial changes in production enabled by information technology. Beck contends that as the location of production becomes more decentralized, information becomes increasingly essential. He writes,

> To the extent that the localization of production becomes worn and frayed, information becomes the central means that enables the connection and coherence of the production unit. Thus it becomes a key question who gets what information, by what means, and in what order, about whom and what, and for what purpose. (Beck 1994, 218)

Social theorists such as Beck and Giddens have informed both workplace research and urban research. However these two literatures have remained largely discrete. Broadly speaking, urban theorists who write on information technology have focused on the relationship between IT, power and space to the exclusion of the role of organization level processes in leading to outcomes, while workplace theorists have tended not to focus on space in their analyses of the relationship between the adoption of information technologies, control and workplace change. In the following sections, I summarize the pertinent findings of each of these literatures, before presenting a theoretical framework which synthesizes contributions from both streams. First, however, I further define the notions of power and control which flow through this discussion.

2.2 Perspectives on Power

Different notions of power are inherent in the different foci of the literatures discussed in this chapter. Thus far, I have simply referred to power and control without carefully defining either term. As Pred (1981, 34) notes "in the massive literature of the social sciences and social philosophy concerned with power, the concept has been decked out in a chaotic variety of definitional guises." In the decades since Pred wrote, the literature around power has only grown more multifaceted. My aim here is not to summarize the immense literature around power, but rather to draw from it as necessary to make my discussion of power more precise.

I follow a long line of political theorists (Bachrach and Baratz 1962; Gaventa 1980) in conceptualizing power as multi-dimensional – not only visible in overt struggles, but in processes which keep individuals from effectively realizing their own interests. Foucault's work in *Discipline and Punish* (1977) introduced the notion of panoptic power, a notion with particular salience to studies of information technology. In panoptic power, Foucault (1977) presents an image of power that does not stem from direct coercive power, but from the perception that others might be observing one's actions. Foucault writes,

> He who is subject to a field of visibility, and who knows it, assumes responsibility for the constraints of power; he makes them play spontaneously upon himself; he inscribes in himself the power relations in which he simultaneously plays both roles; he becomes the principle of his own subjection. (1977, 202-3)

In framing this concept, Foucault references the panoptic prison conceptualized by Jeremy Bentham, where inmates could potentially be observed at any moment, and they were never certain when the disciplining gaze of their superior was actually upon them or elsewhere.

Below, in the section specifically dealing with work, control and information technology, I will describe in more depth the ways in which Zuboff (1988) has expanded upon this concept. For now, I will draw out the salience of Foucault's depiction of power to this dissertation's spatial focus. The passage quoted above continues,

> The external power may throw off its physical weight; it tends to the non-corporal; and, the more it approaches this limit, the more constant, profound and permanent are its effects. (1977, 203)

Thus, to Foucault, power is no longer solely the province of a fixed location. Rather, panoptic disciplinary mechanisms have made the exercise of power "lighter, more rapid, more effective" (1977, 209). The implications are clear; by suffusing society with the capacity to observe, panoptic power frees power from some of the spatial boundaries that previously constrained it. Diken and Lausten (2002) expand upon this theme, writing that "postpanoptic forms of power target the conduct of mobile subjects."

In Foucault's writing, panoptic power both enables and constrains all participants. The masters of the panopticon are constrained as well as empowered by their position. The transparency of the panopticon has implications for the prison wardens as surely as for their prisoners, as an outside inspector "will be able to judge at a glance, without anything being concealed from him, how the entire establishment is functioning" (1977, 204). In addition, the warden's place in the center of the mechanism means that the warden's own fate is bound up in with the success of the panopticon. Given the focus of this dissertation, it is worth noting that Foucault goes on to cite physicians as an example of this dynamic. He writes, "the incompetent physician who has allowed plague to spread … will be the first victim of an epidemic or a revolt" (1977, 204).

Giddens' structuration theory expands upon the notion of the two-way nature of the exercise of power. Giddens (1982) terms this the "dialectic of control" where power is seen as implicating both the master and slave in this dialectic. He writes that,

> no matter how imbalanced they may be in terms of power, actors in subordinate positions are never wholly dependent … In all social systems there is a dialectic of control, such that there are normally continually shifting balances of resources, altering the overall distribution of power"

(1993, 243)

This understanding of power as both enabling and constraining flows through much subsequent writing about workplace control (Zuboff 1988; Orlikowski 1991; Bloomfield and Coombs 1992).

What precisely does Giddens mean by power? Giddens makes a distinction between a general notion of power as "the transformative capacity of human agency" and a more narrow definition of power as domination (1993, 110). In the more general sense, then, power refers to the "capability of the actor to intervene in a series of events so as to alter their courses," while in its more narrow sense, power is relational, realized through one person's ability to influence the actions of someone else, in the dialectic of control described above. I would argue that workplace control is an instance of this latter form of power, while in urban theory, power can often take the more general form.

In this dissertation I largely focus on control, or the more limited definition of power, as it appears particularly applicable to relations in the work place. However, relationships of control in the workplace and the more general sense of power as agency are closely connected. For instance, as I discuss in Chapter 4, radiologists have been able to maintain workplace autonomy, in large part due to the agency they exercise over broader political and institutional forces which safeguard their profession.

3. Space, Power and Work -- Urban Perspectives

Not unexpectedly, given the prominence of space in geographic thought, urban geographers have historically led the way in investigations of space and power. The French urbanist and radical geographer Henri Lefebvre (1974) called attention to space as a product of social practices, arguing that human intentions produce and reproduce space (33). Lefebvre's work stresses the malleability of space, as well as its social production, a position reflected in much subsequent work in Anglo-American geography (Gottdiener 1984; Gottdiener and Hutchison 2000; Harvey 1985a; Massey 1985). To Lefebvre the spatial practices of a society "secrete that society's space" (1974, 33). He defines spatial practices as embodying the perceptions and daily routines with which people link the places of their everyday life (38). Spatial practices are thus the ways that individuals make sense of everyday reality, and include "routes and networks, patterns and movements that link together spaces of work, play and leisure" (Merrifield 2002, 90).

The iterative nature of the process through which human action produces spatial structures which go on to enable and constrain their future actions was given further voice in the writings of geographers influenced by Giddens' structuration theory (Gregory 1985; Harvey 1985b; Pred 1981). To be clear, these theories are most concerned with the very material urban places and structures which result from the spatial practices of a society. My research, in contrast, focuses on the relationship between a profession's spatial practices, the use of information technologies and workplace control. What I draw from these geographers is their notion of the routine, everyday processes through which people's perception of space and their actions in space, shape daily life, as well as the dynamic and iterative nature of these processes.

I use the notion of spatial practices to conceptualize the space of work not only as an outcome of the use of information technology but as something which shapes the adoption of an information technology. By examining two medical subspecialties who enact notably different spatial practices in their work, I investigate the proposition that spatial practices not only lead to very concrete differences in physical location and distance, but that they shape information technology use and relationships of control. I approach space, not simply as location, but as a fluid set of spatial practices having to do with proximity to others, the physical arrangement of an examining room or home office, as well as geographic location. These aspects of spatial practices emerged as particularly important in the research sites I examined. I will further refine my usage of spatial practices throughout this chapter, drawing on workplace and medical sociology literature, to synthesize a framework for this study.

Urban geographers and other urban theorists also provide several useful antecedents to thinking about the relationship between power and space. While in 1973 Hagerstrand (1973, 84) could complain that the relationship between space-time and power constituted "an immense area for research in human geography which for some reason has hardly been touched," three decades later, this statement is manifestly no longer accurate, either for urban geographers or urban sociologists.

Early urban sociologists had tended to ignore power relations in their view of cities, where the use of space was seen as essentially dictated by available technologies (Hoyt 1939; Park et. al. 1925; Hawley 1986). However, by the 1980s these urban ecologists had been largely displaced by urban geographers / political economists who focused on the interacting roles of economic and political forces in changing spatial development.

Through the 1970s and 1980s several prominent urban geographers and urban political economists took a Marxist view of industrial change.[5] They portrayed a situation where capitalists desperately seek advantage through various combinations of

[5] As this passage intimates the boundary between urban geographers and urban sociologists / political economists is a blurry one, with writers like Gottdiener (1985), Castells (1972, 1983), Harvey (1985) informing the discourse in both urban sociology and geography.

location and technology (Harvey 1985a, 131) and where relocation is largely driven by the desire of management to find cheaper, more pliable labor (Gordon 1984). In the latter case, a neo-Marxist determinism replaces the earlier technological determinism of urban ecology. For instance, rather than arguing that technology enables a firm's relocation, Gordon contends that problems of "class control in production" (1984, 22) lead industry to relocate. Capitalists develop new equipment to permit them to relocate away from the bastions of organized labor. Thus, like Marx, Gordon sees class conflict as driving the use of technology to exert change - in this case, changes which lead to new patterns of spatial development. Other researchers in this tradition (Harvey 1985b; Gottdiener 1985; Gottdiener and Hutchison 2000) have been more nuanced in their view of causality, while still stressing the importance of the capitalist system in spurring the changing production mechanisms which have led firms to relocate.

While their work calls attention to the link between technology, location and control, these analyses did not focus on information technology as such. More recent urban theorists have focused squarely on information technology and spatial change, as well as calling attention to the importance of organizational and structural factors.

Castells (1989; 1996) argues that the aggregate effects of organizational and technological change has been to create a new 'informational' mode of development. This informational mode of development, in concert with the restructuring of capitalism, results in the prominence of a new spatial logic that Castells famously terms "the space of flows." When Castells writes about the new prominence of the 'space of flows,' he is arguing that, rather than power residing in a specific locale (the space of places), it has shifted to reside in networks of information and other resources (the space of flows).

Castells contends that these shifts have encouraged a global tendency towards spatial, social and economic polarizations.

Saskia Sassen's research (1991 [2001]) follows Castells in the polarizing logic of this new mode of development, but calls attention to the place specificity of these changes, in terms of the creation of "global cities." Rather than power being embodied in a placeless space of flows, Sassen describes power as progressively more concentrated in global hubs whose telecommunication infrastructures constitute increasingly insurmountable barriers to entry. As evidence of polarization, Sassen cites widening income gaps, not only between both rich and poor individuals, but between rich and poor localities. Subsequent urban scholars have drawn heavily from Castells and Sassen to inform their research on technology and space (Calhoun 1998; Clarke and Gaile 1998; Gurstein 2001).

Inasmuch as any of these urban researchers have focused on technology and the workplace, they have tended to overlook the role of the organization level processes through which information technology use comes to influence workplace change. In the next section I present selected research which has explicitly addressed these questions, before returning to the topic of space.

4. Information Technology Use , Work and Power

4.1 Information Technology Use and Work

A sizable body of research has revealed a complex and nuanced picture of the ways information technologies have been used to change work. Theorists have linked the introduction of information technology to: increasing wage differentials between high and low skilled workers (Autor et. al. 2001); shifts in power (Fountain 2001) which entail increasing control over some workers (Prechel 1994; Orlikowski 1991); and the automation of some jobs while improving and consolidating others (Zuboff 1988; Bresnahan et. al. 2000; Autor et. al. 2002). Given my interest in the organizational process of change, I will focus chiefly on the organizational analyses that are most relevant to an analysis of changing power relations in the work place. However, it should be noted that they comprise a fragment of a much larger, interdisciplinary literature dealing with technology and workplace change.

Organization researchers have been particularly focused on the organizational processes through which technologies are adopted. Within organizational studies, structuration theorists have long identified the importance of discussing technology in terms of the social structures in which they are imbedded. At the heart of structuration theory is the idea that "structures exist only in their instantiation in the knowledgeable activities of situated human subjects, which reproduce them as structural properties of social systems embedded in spans of time-space" (Giddens 1984, 304). Human actions create social structures which go on to shape future action, in an ongoing and iterative structuring process.

Structuration theorists who research the use of technology in the work place have postulated that technologies can be conceived of as social objects (Barley 1986). They describe a recursive relationship where technology is created and changed by humans but then comes to appear a part of the objective, structural properties of the organization, where it acts to both restrain and enable future human action (Orlikowski 1992, 2000). A distinguishing characteristic of this structurational model is the emphasis it places upon the role of human actors in producing, reproducing and changing structural properties, rather than the effective reification of structure which is typical of other theories in the field. Thus, structuration theory has been described as a process theory (Barley and Tolbert 1997).

The key elements that I wish to emphasize from these analyses are the recursive, contingent and context specific nature of a technology's use and impact upon an organization. I note, however, that while these theorists may believe that the consequences of information technology may ultimately be unpredictable, this does not prevent them from offering bounded generalizations. The point is that findings will be more robust if researchers recognize the temporal and contextual bounds on their conclusions.

4.2 Power & Information Technology in the Workplace

Workplace researchers have illustrated the relationship between information technology and control, documenting the increased centralization of managerial control enabled by information technology in various fields. In their studies of computer programmers, steel factory workers and mill workers, respectively, Orlikowski (1991), Prechel (1994) and Zuboff (1988) noted a movement towards increased managerial control enabled by information technology. Similarly, Fountain (2001, 32) has focused particular attention on the shifts in power that have occurred in public bureaucracies as a result of new information flows.

From where does this power come? Orlikowski describes a work place where a new computer tool came to be so taken for granted, that the constraints it placed on new programmers were invisible, even to the programmers themselves. In other workplaces, the increases in control enabled by information technology are more obtrusive, as in call centers where computers are used to closely monitor workers' pace of work, with the resulting increase in control used to pressure workers to further intensify their work (Batt 1999, Houlihan 2002).

Zuboff's work (1988) calls attention to the control that comes with transparency. Drawing on Foucault's notion of panoptic power, Zuboff (1988, 322) introduces the idea of the information panopticon, linking the transparency of a computerized workplace to the extension of the surveillance-disciplinary power about which Foucalt theorized. Zuboff draws our attention to the power of information technology to make information accessible, and the implications that this access has for discipline.

Zuboff is largely concerned with the hierarchical power of the information panopticon, e.g., managers observing workers. However, in its original formulation, Foucault recognized that panoptic power also acts laterally, with people observing and monitoring their peers and, most notably, themselves. The perception that others might be watching convinces individuals to internalize control, constraining their own actions with little additional coercion being exerted. This type of lateral panopticon is visible in Orlikowski's (1996, 31) description of computer workers becoming "very aware that their documention was publicly available", and so beginning to "monitor and censor what they entered into [the database]."

Zuboff's (1988) distinction between automating and informating technologies speaks to the degree to which some information technologies are used to change relationships of control in the workplace. Zuboff describes "automating" technologies as those technologies which embed workers' skills and which managers are thus able to use to "concentrate knowledge within the managerial domain" (1988, 69). In contrast, "informating" technologies act as an occasion for workers to develop a new set of skills - skills that are able to "exploit the informating capacity of the technology and to become a new source of critical judgment" (1988, 70).

As Orlikowski notes, Zuboff neglects to "acknowledge that technology's informating capacity can just as easily be used to increase systemic forms of control in organizations," (Orlikowski, 1991: 24). For instance, the implementation of a new computer system might allow workers to develop new skills, while at the same time enhancing management's ability to monitor their every key stroke.

Following on these analyses, this research explicitly adopts the assumption that the use of new technologies is not value neutral. Rather, I adopt Thomas' "power process" perspective (1994) where the political process through which groups contend and negotiate over a technology's adoption is viewed as playing an integral role in explaining disparate outcomes for different groups.

Like Thomas, I conceptualize politics as more than just a will to power, but as a group's attempts to "put in place a set of relations and practices that more nearly approximate a group's view of the way things should work" (230). This will become an important distinction in the context of physicians exerting power over their work. Physicians are not simply driven by the desire to protect their status or income. Rather, they are driven by a series of concerns. For example, providing high quality patient care is an important concern, in addition to maintaining their professional income and autonomy.

The point drawn earlier from Foucault and Giddens about control being both enabling and constraining resonates well with organization research into the adoption and use of information technology. Bloomfield and Coombs make a similar point in the context of the adoption of medical information technology. They observe that "when individuals submit to standards to regulate their behavior they are also empowered in the sense that a legitimate space for action is opened up for them" (1992, 477). They go on to cite the example of a junior physician who is able to learn existing medical practices more quickly and take more patient responsibility as a result of using an information technology that asks him / her to conform to a certain set of tests and drug therapies for a given diagnosis. Orlikowski (1991), too, illustrates that control can be enabling as well as constraining.

One notes that none of these analyses focused on the role of the spatial practices of workers. One would suspect, for instance, that the very ability to easily export call center jobs to the global periphery plays a role in the shifts of power relations within U.S. call centers.[6] While these spatial changes are at the foreground of Castells' analysis, they tend to be less prominent in workplace research.

5. Synthesizing literatures: A Spatial Structuring Approach

To some extent, the difference between the two groups of literature is a matter of emphasis. Some workplace theorists focus on spatial issues within organizations (Osterlund 2002). Research around distributed work groups is particularly likely to incorporate some mention of spatial location, albeit in a much less central way and generally without an explicit focus on the use of information technology to change work (O'Leary and Mortensen 2005; Hinds and Kiesler, eds 2002). Correspondingly, a sizable body of urban research attempts to incorporate workplace change into theories of urban

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[6] In a more general context, Osterman (1999) has observed the impact that the threat of layoffs have had in leading U.S. workers to increase their effort without receiving corresponding compensation.

change (Gaspar and Glaeser 1998; Gordon 1984; Gurstein 2001). This is especially true of research into telework where issues of work most obviously intertwine with urban issues of commuting, social relations and civic involvement. Researchers have found that teleworkers are predominantly spatially isolated women (Gurstein 2001, Johnson 2003), who are willing to work more, often contributing some of their own resources in return for additional autonomy (Gurstein 2001, Salaff 2002).

Researchers in both traditions reference some of the same social theorists, and their findings are often complementary. For instance, Castells' description of the way in which the new order "imposes itself as a natural phenomenon that cannot be controlled or predicted, only accepted" (1989, 349), seems to resonate with Orlikowski's analysis of the way in which a new computer tool came to be so accepted, that the constraints it placed on new programmers were invisible, even to the programmers themselves (1991). Similarly, Sassen's and Castells' focus on the growing polarization of wages, speaks to the hypothesis of skill-biased technical change, suggested by workplace theorists (Autor et. al. 2001; Johnson 1997) who explain the polarization of wages as being shaped, in part, by the use of information technologies which require higher trained workers.

What remains lacking is a systematic approach that links intra-organizational processes of workplace change to larger macro processes of spatial change. When workplace researchers refer to space, not only do they tend to limit themselves to physical location (O'Leary and Mortensen 2005) they are focused on space within an organization (Osterlund 2002). In contrast, when urban theorists speak of workplace change, they tend to be speaking in the aggregate without properly attending to the processes which underlie changes in the workplace. To speak to this gap, I propose a spatial structuring approach.

Orlikowski and Yates offer a useful perspective in their work regarding the structuring of time in organizations. They apply a structuration model to the analysis of time in organizations, treating temporal structures as "both shaping and being shaped by ongoing human action" (Orlikowski and Yates 2002, 684). As an illustrative example, they cite workers who work overtime so often that they transform the temporal structure of their work day.

My dissertation brings a similar understanding to bear with respect to the way spatial structures both shape and are shaped by human action. Following on Massey's hypothesis that "the spatial immobilisation of certain elements of capital is part of what conditions the introduction of changes in the organisation of production" (1985, 14), I propose that the ways in which workers enact their work in time and space shape the ways that they use information technology. Extending this argument, I further propose that information technology use is not only shaped by the way workers enact their work in time and space, but it goes on to shape the way they work in time and space.

In their work on computers and the work force, Levy and Murnane (2004, 152) argue that to the extent that a worker relies on information which cannot be easily represented digitally - their "tacit knowledge" - that worker's job is unlikely to be easily relocated. In a health care context, for instance, a physician seeing a patient in person gathers more information than can easily be transmitted through a digital interaction. In contrast, a radiologist reading an MRI - which is explicitly created as a digital image - can easily have the identical image transmitted digitally.

This approach recognizes that some highly skilled physician tasks (such as an outpatient clinician examining an ill patient) are performed remotely only with difficulty, although certain tasks performed by the same physician (such as documenting patients' visits) are easily completed remotely. Following on Autor et. al.'s (2001) emphasis on the task content of jobs, I begin with the understanding that every worker is performing a bundle of tasks, some of which are more susceptible to substitution or relocation than others.

My contribution is not simply to link structuration theory to time-space geography.[7] There is a fair sized literature devoted to doing just that, beginning not long after Giddens first formulated structuration theory (Pred 1981; Gregory 1985; Giddens 1985; McGrath-Champ 1993). Nor is it only to insert a spatial focus into the intra-organizational process of technological adoption. Rather, I am proposing a qualitatively different conception of time and space than that typically found in workplace studies, one that focuses particular attention on the spatial practices through which individuals work. I take these spatial practices as the variable of interest, and by selecting two professions which use significantly different spatial practices in their work, I illustrate the way in which spatial practices mediated by information technology use shape workplace change.

This approach not only allows insight into the role of space in shaping workplace change, it allows a corresponding insight into the role of workplace change in shaping

[7] My approach differs from time-space geography's traditional focus on the paths people take through time and space (Pred 1981, Hagerstrand 1973). Time-space geographers approach space and time as conditions through which humans move, where humans and their projects compete to consume certain amounts of "budget-space" (Hagerstrand 1973). In this dissertation I am interested in much more specific notions of time and space -- the temporal and spatial practices with which people perform their work. This quality of space is less linked to physical location and more linked to the enacted spatial and temporal practices within which people work.

spatial practices. Again, I aim to contribute to a meso-level theory regarding technological change, work and space, linking the micro-theories of organizations and the macro theories of urban theorists. In this dissertation I apply this spatial structuring framework to understanding the consequences of information technology use and spatial practices for relationships of control, but its application could be useful beyond this as well.

In Chapter 5 I will further discuss the literature around time at work, but for now I will emphasize that my focus on work practices brings with it a different notion of time than either that used by time-space geographers (Hagerstrand 1973; Pred 1981), or researchers who look at time at work. The former genre focuses on the ordering quality of time -- the sequence through which an individual takes actions. Its approach is accurately evoked by its vocabulary of "life paths" and "projects" (Pred 1981). Its adherents focus on the sequence of events in time. As Hagerstrand (1973, 79) writes, "order in time is first of all sequence, not necessarily periodicity."

My use is closer to that of work researchers who look at time at work as a commodity, examining the hours that workers spend doing their jobs (Jacobs and Gerson 2001; Robinson and Godbey 1997; Schor 1991). This simplified notion of time allows this analysis to speak directly to changes in hours worked. However, I differ from these latter researchers as well by recognizing the social construction of temporal structures, and the way in which these structures interact with spatial structures in mediating the outcomes in which I am interested.

6. Space, Control and Information Technology in the Context of Medical Work

Physicians offer a particularly interesting profession in which to situate an investigation of technology, control and the changing spatial nature of work. Both the spatial nature of their work, and the power that they have traditionally exercised over their work, allow an excellent vantage point to examine the interplay between space and power in the workplace. Different medical specialties work in space in very different ways, and yet they share much of the same training, professional norms and status. By framing this dissertation with a contrast between outpatient physicians and radiologists, I am able to focus on the role that the spatial dynamics of their work play in shaping and being shaped by the use of information technology.

6.1 Physicians and Control

The notion of control has played a critical role in the sociological literature around the medical professions. In *The Profession of Medicine,* Freidson (1970, 71) writes that "the most strategic distinction [between the professions and other occupations] lies in legitimate autonomy – that a profession is distinct from other occupations in that it has been given the right to control its own work." Similarly, Abbott (1988, 19) argues that it is through struggles over the control of work that professions maintain their identities as professions, and Van Maanen and Barley (1984) comment that professions vary from other lines of work "only by virtue of the relative autonomy each is able to sustain within the political economy of a given society" (287).

Where does this control come from? Eliot Freidson writes that "the foundation of medicine's control over its work is thus clearly political in character, involving the aid of the state in establishing and maintaining the profession's pre-eminence" (1970, 23). In *The Social Transformation of American Medicine,* Paul Starr (1982) painstakingly documents the process through which the medical profession established its ability to control medical work. In addition to the political nature of the struggle, Starr illustrates the role structural elements such as norms and institutions historically played in creating the profession of medicine.

While Starr focuses on the way in which these norms and institutions were used to create a well-paid and highly esteemed medical profession, it is important to note Grumbach's observation that "professionalism developed not just as an anticompetitive strategy, but in response to legitimate societal concerns about competence and quality with an unregulated health care workforce" (2002, 5). I would suggest that the structural elements identified by Starr have gone on to constrain, as well as enable, the actions of the medical professionals who have long benefited from them.

Structuration theorists have drawn our attention to the way in which human actors enact structural elements such as norms and institutions which go on to both enable and constrain future human action (Giddens 1993). Orlikowski (1991, 25) in particular has long noted the role of organizational norms in mediating technology use. I propose that attending to these norms around the spatial construction of medical work can inform our understanding of how medical professionals use information technology.

6.2 Physicians. Space and 'Core Work'

In focusing on the content of specific tasks, I draw attention to the distinction between core work and the terms and conditions of work. Medical sociologists have long distinguished between physician control of their core work and physician control of the terms and conditions of their work. While the distinction appears in various guises throughout the literature (Fielding 1990; Freidson 1970; Hafferty and Light 1995; Halaby and Weakliem 1989), the physician's core work is generally seen as the clinical aspects of the physician's work, while the latter applies to such factors as pay, hours, organizational structure and employment status. Thus, in the case of outpatient physicians, the core work would be examining and diagnosing their patients, while for radiologists their core work would be reading and interpreting films.

I propose that focusing on the spatial practices surrounding a subspecialty's core work will be particularly useful in exploring the role of space in the adoption of an information technology. For instance, I would expect the fact that the core work of outpatient physicians – examining their patients - continues to be performed when the physician is in the same room at the same time as the patient, to be particularly influential in shaping their use of information technology. A priori, I might have expected that professions who do their core work within more rigid time-space constraints would have more control over the use of information technology to change their work. As noted in the introduction, it quickly became apparent that the reverse appeared to be the case.

The spatial practices of radiologists enable them to work with much less contact with patients than outpatient physicians. Within a decade or two of the founding of radiology, an ancillary discipline of radiologic technology had evolved to take over the tasks of actually performing the examination and developing the images (Linton 2001, 23). Thus, radiologists have long been a paragon of what Abbott calls "professional regression" (1988, 118) where they largely communicate with other physicians, to the exclusion of patient contact. Abbott argues that within a profession such as medicine, the highest status professionals deal only with other professionals. Other researchers (Pfohl 1977) have argued that radiologists have lower status in the medical field for precisely the same reason, reasoning that medical professionals with the highest status are those like surgeons who interact directly with patients and who are charged with making life and death decisions (317). Thus, both schools of thought call attention to the importance of the extent to which a physician has direct contact with patients, a key distinction between radiologists and outpatient physicians.

In addition to these differences in spatial practices and patient interactions, there are a number of other important contrasts between outpatient physicians and radiologists. One of the crucial characteristics of the current radiology market in the United States is the scarcity of radiologists, a scarcity which does not exist to the same extent for the internists (internal medicine specialists) who become outpatient physicians.

6.3 Physicians and Technology

Another important difference between radiologists and outpatient physicians is the use they make of technology. While radiologists have been using technology to do their core work since the inception of their discipline (Linton 2001), using a growing panoply of medical technologies such as ultrasounds, magnetic resonance imaging devices (MRIs) and multi-slice CT scans, outpatient physicians have long done their work with few technologies more sophisticated than a stethoscope (first developed in the mid-1800s).

An enormous number of researchers have studied the use of technology by physicians. In addition to the work within the field of medicine, which has largely been concerned with medical outcomes, there has been a large amount written in the popular press, as well as the academic literature in the fields of organization, medical sociology and health care. For the most part, studies will be cited when they become relevant in the empirical chapters that follow. However, it is worth noting a few particularly salient contributions.

Barley (1986; 1990) explicitly uses a structuration theory perspective in his ethnography of the adoption of a CT imaging technology by two hospitals. His work illustrates the processes through which adopting a new technology was used as an occasion to revise existing power relationships between radiologists and technicians in two hospitals. Barley wrote at a time when radiological images were almost always interpreted in the same facility as the scans themselves, and so space plays only a marginal role in Barley's account of these changes.

Several organization theorists have researched the use of electronic medical records (Berg 1997; Osterlund 2002; Bloomfield and Coombs 1992). Osterlund's work is particularly relevant in terms of his focus on the time-space paths through which doctors document their work and communicate with each other. His research calls attention to the way participants use documents in space, but explicitly chooses not to focus on shifts in workplace control, nor to address the process of technological change.

While these studies have built a theoretical foundation which contributes to this dissertation, the relationship between space and power in medical work continues to be an uncertain one. With the extent of remote work likely only to grow in the medical workplace, it is important to understand the role of spatial practices in the process of adopting and using information technologies.

6.4 Hospitals

Most of the physicians who participated in this study, both radiologists and outpatient physicians, worked for a hospital, either directly or as contractors. Hospitals are a particularly interesting site in which to situate a study of information technology, space and workplace change. Given the complexity of hospital objectives, the case of hospitals offers particular benefits in terms of gaining insight into the political nature of technology decisions. Most U.S. hospitals continue to be non-profit and at least partially sheltered from market forces. Hospitals have several discrete constituencies who often operate under conflicting imperatives, and so, potentially approach information technology and other policy decisions in different ways. For instance, while hospital and HMO administrators are under increasing pressure to contain costs and minimize diagnostic procedures, doctors feel increasingly constrained to run more diagnostic tests, out of fear of malpractice suits (Fielding 1990).

In their classic piece on the importance of isomorphic forces in explaining institutional change (1983) Dimaggio and Powell cite hospitals as epitomizing the forces of what they term 'normative isomorphism.'[8] They argue that hospitals are not generally operating under the forces of competitive efficiency, but rather under normative pressures from physicians and hospital administrators. In recent decades, a spate of research has testified to the continuing difficulty of linking market stimulus to the provision of medical services by U.S. hospitals (Chassin et al 1996, Vladek et. al. 1988). Despite attempts to institute more market-driven health care, analysts continue to find that under the current system, health care providers face little market pressure with respect to the quality of the services they provide (Coye 2001), reflecting in part the nature of health insurance and reimbursement procedures which dampen standard market pressures.

Hospitals are also distinguished by their relative spatial immobility. While

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[8] Dimaggio and Powell understand organizational change and conformity to be driven less by efficiency and more by isomorphist forces. They contrast normative isomorphism - where institutions are driven to become similar by forces such as professional legitimation - to coercive and memetic isomorphism. Under coercive isomorphism, organizations conform due to pressure from organizations on which they depend, while under mimetic isomorphism organizations conform as a means of dealing with uncertain outcomes.

careful analysis is required, a first glance suggests that more of a hospital's functions require face to face interactions than many other organizations. Like many organizations, hospitals have faced increasing cost pressure as the result of recent economic and regulatory changes. Unlike most businesses, however, hospitals have been unable to cut costs by moving operations and jobs to the periphery. Given that their basic function - providing medical services - would appear to require proximity to population centers one can assume that large health care clusters will continue to be located in highly urban areas. This is an important assumption to examine, given the crucial role that medical clusters currently play in the economies of large U.S. cities (Harkavy and Zuckerman 1999).

7. Conclusion

I have argued that there is a gap between the literature addressing power, space and technology and the literature addressing the processes through which technology is used to change work. I propose to address this gap through my research examining and comparing the uses of information technology by two medical subspecialties - outpatient physicians and radiologists. These two subspecialties are notable for the contrast in the spatial practices with which they perform their work. While outpatient physicians continue to meet most of their patients face to face, many radiologists have long done their work remote in space from their patients and even the referring physician.

Despite these and other differences between radiology and outpatient physician work, both radiologists and outpatient physicians share many of the same human capital characteristics and are broadly similar in terms of the professional status associated with their jobs. Contrasting their use of information technologies will give valuable insight with respect to the way in which spatial practices shape information technology use and the consequences of that use.

More generally, the spatial structuring approach sketched above will allow my research to link the macro concerns of theorists interested in changing modes of spatial development with more micro scale research situated within individual organizations. This approach offers a flexible framework with which to investigate the nuanced relationship between information technology use, space and power.

Chapter 3: What's Space Got to do With It? Electronic Medical Records, Autonomy and the Work of Outpatient Clinicians

1. Introduction

For years, theorists concerned with space and information technology have speculated about the consequences of a world of work where workers are free to work wherever they want. As described in the last chapter, a good deal of research has focused on the relationship between information technology, power and space. Likewise, a good deal of research has focused on the way that information technology has been used to change work, independent of spatial change. In the last chapter I began the process of synthesizing these analytic concerns by formulating a spatial structuring approach to organizational change. In this chapter I apply this approach to three case studies of outpatient medical clinics and their adoption and use of electronic medical records.

Much previous research investigating issues around work and space has focused on information and professions which are relatively free to move in space (Castells 1989, 1996; Gaspar and Glaeser 1998; Florida 2002; Gurstein 2001). I suggest in this chapter that the space of work is also significant for professionals who enact tight spatial boundaries on their work.

By focusing on outpatient physicians, I investigate a profession that continues to do their core work within tight spatial constraints -- the vast majority of outpatient physicians continue to see their patients in person. A.C. Norris (2002) reports that in 1998 about 40,000 remote consultations were conducted in the United States in medical specialties aside from radiology, as opposed to the several hundred million office visits that patients make to physicians every year (Bernstein et. al. 2003, 23).

In this chapter I investigate the way in which these spatial practices both shaped and were shaped by the use of electronic medical records. I pay particular attention to links between the spatial dynamics of outpatient work and relationships of control in three outpatient clinics. I illustrate a situation where the spatial characteristics of outpatient work prior to the adoption of EMRs played a role in shaping the problems of coordination and control which EMRs were adopted to address. Subsequently, outpatient physicians used EMRs to change both relationships of control and the spatial dynamics of work in their clinics. In future chapters, I will argue that these spatial dynamics are closely linked to temporal dynamics, but for the purposes of analytic clarity, in this chapter I will focus on space, mentioning time only where necessary to complement the illustration of spatial processes and changes.

2. The Technology: Electronic Medical Records

EMRs are one of the most rapidly diffusing technologies in health care. In recent years, politicians from Hilary Clinton (Rose 2004) to George W. Bush (*Wall Street Journal* 2004) have called for the faster adoption of electronic records. EMRs are a technology that allows doctors to record and store patients' information electronically rather than on paper. While certain hospitals began storing patients' information electronically over three decades ago (Starr 1997, 94), by 2003 only 5% of United States primary care physicians stored their information about their client electronically (Jonietz 2003, 60).[9] Starr (1997) attributes this slow diffusion to privacy concerns and the fragmented nature of the U.S. healthcare system. Individual health care organizations are reluctant to trust outside organizations with their patients' information, and they have invested significant sums in systems that cannot communicate with one another (Starr 1997, 94).

However, there are signs that the rate of diffusion is beginning to increase. A series of studies indicating a related program's success in reducing prescription errors (Bates, et. al.

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[9] Similar figures apply to percentage of health care facilities (5-15%) (Kaisernetwork.org, November 21, 2003).

1999b) and lowering costs (Bates, et. al. 1999a, Wang, et. al. 2003) was followed by calls from the Institute of Medicine (2001, Aspden et. al. 2003), from prominent politicians (Rose 2004; *The Wall Street Journal* 2004), and by inducements from insurance companies and employers[10] to adopt these electronic record systems. These calls have been heeded, with 17% of hospitals planning to purchase or build EMRs in the next 10 years (Jonietz 2003).

In addition to studies attesting to EMRs' potential to foster cost reductions and quality improvements, there have been several studies examining the way that doctors have used EMRs in an inpatient setting. For instance, Osterlund (2002) documented the ways in which individual physicians in inpatient wards used documentation tools such as EMRs and whiteboards to construct and reconstruct a localized version of a patient's history. While Osterlund looked closely at the role of these documents in extending social relations in time and space, he explicitly chose not to focus on the political nature of EMRs, nor the process of change (2002, 36). Other organization theorists have called attention to the role of medical information systems in creating occasions to renegotiate power relations between actors (Bloomfield and Coombs 1992) and the historical processes that have led to EMRs taking the particular form that they take (Berg 1997).

There has been relatively little research done with respect to the process of adopting an EMR and the relationship between space and control in this context. None of the studies cited above examined the implementation of EMRs. Also, there has been very little research looking at EMR use in an outpatient setting, although early studies of cost and quality improvements are

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[10] In concert with several large employers (including General Electric, the owner of the EMR Logician software), Blue Cross Blue Shield, the largest health care insurance company in the United States, has recently instituted a pilot program, Bridges to Excellence, which provides financial inducements to medical practices for, among other things, utilizing electronic records.

beginning to emerge (Wang et. al. 2003).

3. The Research Sites

This portion of my research relied exclusively on qualitative data. As described in Chapter 1, I performed a total of 40 interviews of 35 participants. I performed 34 open ended interviews of 29 doctors, nurses and other health care professionals located at the sites described below, and I facilitated 1 focus group with an additional 22 participants at one of the research sites. The remaining 6 participants were 2 executives at a large medical insurance provider, a medical informatics academic familiar with electronic initiatives in the region, 2 physician / computer scientists who had worked on developing EMRs at another area hospital, and an outpatient physician at another area clinic which did not use EMRs. 33 of the 40 interviews were performed in person.

-Insert "Table 3.1: Summary of Research Sites" around here.-

The primary research sites were three outpatient clinics. Each used a different strategy in implementing their EMR and each has been using EMRs for a different length of time. While one site has been storing patient information electronically for almost two decades, another adopted an EMR one year before this research began in 2002, while the third was in the process of adopting an EMR when this research was conducted.

All sites are outpatient clinics in the same metropolitan area. Each site provides the same basic services, with physicians spending most of their working day seeing ill but mobile patients. In each site there is some variation between the schedules of the individual outpatient physicians, with varying amounts of time being spent on outpatient care, inpatient rounds, administrative duties and educational duties. I further distinguish the sites as follows:

In the "Urban Central" site, the general medicine outpatient clinic of an urban teaching hospital, the section chief essentially mandated the implementation of an EMR, hoping to save money associated with paper files and to centralize patient data in order to be better able to coordinate physician work practices. Accordingly his division adopted the Logician[11] EMR in August, 2001. Prior to adoption, each physician was allotted sixteen hours - four four hour shifts to be trained on the system. At the time of this research, this division remains the only one in their hospital to use Logician. While the entire hospital uses a custom-built Siemens system to make test results and other selected patient information available to physicians, this larger system is only partially compatible with Logician.

In the "Urban Network" site, a general medicine outpatient division of another urban teaching hospital, physicians use the centralized homegrown medical record which is part of a hospital wide system designed and implemented by an inhouse team of clinician / computer scientists over a period of decades. While the information system is more centralized, the hospital's outpatient practice is organized on a far more decentralized basis, with satellite outpatient practices spread geographically throughout the city. Due to the decentralized nature of the Urban Network clinic, it was possible to interview an outpatient physician who worked within the Urban Network clinic who did not have access to an EMR.

Finally, in the "Suburban Network" site, a general medicine clinic in a suburban practice, physicians also purchased a Logician EMR, but through a different process from that seen in Urban Central. Rather than a top-down, mandated process, several practicing physicians in the practice instigated the shift. This site was in the process of adoption when this research commenced, and so pre and post visits were possible. Physicians at Suburban were expected to learn the system as they went, with no extra shifts allotted to training or to pre-entry of patients'

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[11]The Logician EMR is an off the shelf system, developed by a clinician-computer scientist and currently owned by General Electric.

data.

Notably, the physicians in the first two sites are salaried employees, while the physicians in the third site are share-holders of their practice. Thus, only physicians in the third site would share in any fiscal risks or costs that might accrue from implementing an EMR.

The participants in this study ranged from third year residents to attending physicians who have been practicing physicians for over three decades. Of the 35 participants roughly one third were female.

4. Results: What's space got to do with it?

I begin by briefly describing the problems of coordination and control that the EMR was meant to address, calling particular attention to the spatial nature of these problems. I proceed to assess the success of EMR use in solving the problems it was meant to, as perceived by the physicians who used it. In doing so, I illustrate the extent to which its success stemmed in part from its spatial characteristics. Further, I show that the use of the EMR was not only shaped by spatial practices but went on to shape the way physicians worked in space. I conclude by describing individual physicians' reasons for conforming their documentation practices, once again highlighting the role of their spatial practices in shaping their responses.

4.1 Adopting an EMR

In this section, I suggest that the ways outpatient physicians worked in space created certain problems in controlling and coordinating their work. Participants made clear that their core work consisted of their face to face meetings with their patients. One Urban Network physician described all work aside from actual patient visits as "unreimbursed" despite the fact that his salary bore no relationship to the number of patient visits. An Urban Central physician was explicit about the importance of face-to-face meetings in obtaining medical information.

> A lot of things we do without the patient even knowing. For instance since you've been in here for half an hour I've been watching the way you're breathing and noting the ways your pupils react, good color in your neck -- things that we pick up automatically.

Other participants stressed the value of face-to-face communication in allowing physicians to respond in real time to potentially dangerous medical conditions or simply to provide emotional support.

Participants repeatedly made comments to the effect that seeing patients was their "real" work - the work for which they had been trained. They also commonly expressed the view that the patient interactions were the most enjoyable part of their job. When asked about the intensity of his schedule, one Urban Network physician responded, "I like being busy. I'd be busier if my wife didn't make me slow down. I like seeing patients. It's the most fun thing I do." Similarly, a Suburban Network physician commented, "I mean I love seeing patients, and afterwards, when I need to complete the paperwork, it's like ugh. The dragging time."

These spatial practices with respect to their core work - the fact that they saw patients face-to-face, alone in dispersed exam rooms - created certain difficulties in controlling and coordinating physician work, especially in concert with the spatial characteristics of a paper chart. Before adopting EMRs, physicians documented patients' visits on paper, using whatever idiosyncratic system they had developed over their years in practice. Many physicians wrote their notes by hand when they were in the room with their patients. Other physicians dictated or typed their patient notes, later printing them and attaching them to the paper chart. These paper charts were folders, often several inches thick, meant to contain all of a patient's documentation and test results. The paper chart could only be in one place at a time, yet participants saw patients in offices that were distributed spatially and occasionally took off-hours telephone calls from their homes which, of course, were still more distributed spatially.

In addition, when patients saw physicians aside from their primary care provider, these meetings often occurred in different offices and the patient's paper chart had to make the journey to the other office and back. The difficulty in accessing and understanding the charts was thus shaped by the ways that physicians worked in space.

At least three types of control / coordination were cited in interviews as having been problems prior to the introduction of EMRs: physicians had difficulty coordinating their work with their colleagues, physicians had difficulties controlling their patients, and clinic administrators had difficulty controlling the work of the physicians in their clinics. As described in Chapter 2, I conceptualize the desire to exert better control as driven, not by a simple will to power, but as a group's attempt to "put in place a set of relations and practices that more nearly approximate a group's view of the way things should work" (Thomas 1994, 230).

I would also reiterate that control ought to be seen as enabling as well as constraining. This former sense of control - what Orlikowski (1991), drawing on Boland, terms "control with" rather than "control of" - was particularly ubiquitous in interviews with physicians. Many of the physicians most involved in implementing the EMRs were explicit about their motivations -- they wanted the EMR to help them communicate better in order to coordinate better their treatment of patients. An attending physician at the Urban Central clinic explained,

> You don't go out and say I want the smartest doctors I can find. What you do, is you go out and find doctors who are willing and anxious to be on teams to work collaboratively with technology. Trust me. Medicine is not about being smart. It's about being careful. And technology helps you be careful. And communication and teamwork helps you be careful.

The dual notions of control are clear, if implicit, in this quote. By linking communication and better medical treatment, this physician is implicitly arguing that physicians need to be willing to work on a team, sacrificing some autonomy, in order to enable better care. Below I describe in more depth the three types of relationships where control was an issue.

Physician participants cited several difficulties in seeing other physicians' patients when they were relying on paper records. The most common complaints revolved around one of the following two requirements: one had to locate the paper record, and one had to understand the notes left by one's colleagues. This first requirement - that medical records had to be located - often went unmet for reasons closely related to the physical space of the clinics and the physical nature of paper charts. In order to see other physicians' patients, a physician needs patient information immediately accessible, but the distributed nature of outpatient work and the spatial characteristics of paper meant the records were often inaccessible. Unlike electronic charts, paper can only be in one place at one time, and in a large outpatient clinic, with physicians working in several different offices, there are many opportunities for the paper charts to be mislaid.

In Urban Central, for instance, the clinic had physicians on six floors. Each floor had a separate system for filing paper charts. When physicians would see each other's patients, or even their own patients, they would often find that the paper record was missing, illegible or was not up-to-date. An attending physician with thirty years of experience in Urban Central commented, "it really hindered communication among the providers. If you came in for a visit after you saw me and my note was misfiled, [your physician] wouldn't know what happened."

Every participant at Urban Central confirmed this impression of the problems with paper charts. A physician who had joined the clinic just a year before it adopted the EMR noted, "The main problem with the hand-written system is charts could be found only a certain percentage of the time - and it was not close to 90%."

The ad hoc quality of paper charts also made it very difficult for physicians to understand the notes of their peers. A physician in the Suburban Clinic admitted that "Before [the EMR was installed] I would have written stuff out, and no one, including myself, would be able to read what it was too easily." These comments were representative – in addition to the spatial problem of locating a patient's EMR, physicians often had problems reading another physician's note, or even – as this doctor remarked – their own notes.

Patients themselves were seen as an unreliable source of information on their past medical history. Patients' own abilities to remember their treatments were commonly discounted. The following dialogue, recounted by a physician at Urban Network was typical:

> It happens every day. A patient walks in and tells you. 'I forgot to tell you. I was in the emergency room last night.'
> 'You were? what did they do?'
> 'Well. My stomach hurt.'
> 'What tests did they do?'
> 'I don't know.'
> 'Did they give you any medicine?'
> 'Yeah.'
> 'Did it help?'
> 'Yeah.'
> 'What was it?'
> 'I don't know.'

Such interactions were alluded to by multiple physicians at each research site. A physician at Urban Central remarked,

> Patients always- often get confused about the names of things they're supposed to have. Whether something did or didn't get called into the pharmacy ... There's all these really medically crucial things. You can really hurt people if you screw it up.

Access to paper charts was especially an issue when physicians were on call, receiving emergency patient calls at night from their home. Without access to the patient's record they were dependent on their patients for all patient history and information. Before adopting the EMR, one participant described it as "flying blind." Another explained that

> You just had to take the patient's word for it. If a patient is on some sedative or hypnotic medication that is addictive and people abuse, you don't know if they're making it up or not. They say 'the doctor said he sent a prescription in but the pharmacy doesn't have it.'

Once again there is a clear spatial component to this issue of controlling patients. Because the physicians are interacting with patients from home when they are on call, they have no ability to check whether or not another physician had actually prescribed a narcotic medication, nor whether a patient had certain drug allergies nor anything else about their history.

The paper record was also problematic for the administrator of an outpatient clinic trying to exert better control over their patients. Consider that an administrator of a centralized outpatient clinic such as Urban Central manages a practice of 30 physicians. Every day these 30 physicians collectively see hundreds of patients. An administrator would like to keep better track of what physicians do with their patients, how they bill them, how they document, and how they treat them, but this was previously very difficult. As the Urban Central chief of medicine, and the major force responsible for bringing Logician to Urban Central, explained:

> The problem is that if I've got a panel of 2000 patients and I get asked by the HMO what's your rate of testing for diabetics? In the old days with a bunch of paper what I would do is pull out all my diabetics.
>
> But, wait, who are my diabetics? I have no list. I don't even have a patient list to start with. Let's say magically I have a patient list. I go through the list and check off the ones who I remember are diabetic.
>
> - Screw it.
>
> I can't do any of that stuff. And I don't get paid for that. No one gets paid for that. So are we going to have anybody managing and doing that kind of work? No.

He was explicit about his desire to increase administrator control over physicians. He emphasized that from his perspective, benefits in work flow were a side effect. The real benefit lay in the "centralization of control" enabled by the EMR. He cited the example of physicians forgetting to bill their patients, a surprisingly intractable problem in outpatient clinics. As he commented,

> Every morning I do a report on [patients who weren't billed] -- every morning there are about ten to fifteen names out of a practice of about 200-250 patients [per day]. That's all lost revenue unless I specifically go after the provider. It's lost revenue right off the top.

The ad hoc quality of paper records accentuated the problems with accessing patient information. The chief of medicine went on to explain that prior to the introduction of the EMR,

> Once you got the piece of paper from the check-in person that had the patient's vitals' on it, the provider could do whatever they want. The only thing that kept us relatively in the same ball park was the fact that we're drilled into our head as medical students that a note has a subjective, an objective, an assessment and a plan.[12]

Similarly, one of the administrator / physicians who first brought the electronic system into the Urban Network clinic, sketched this picture of the system prior to adopting an electronic system.

> I saw this enormous variety at all levels of medical practice ... When it came to documentation how poor the systems were. How illegible your colleague's hand writing was to you ... How difficult it was - even if you could read it - to find information in the medical record and how much energy was expended getting information.

Some of the difficulties with paper records could have been mitigated, if physicians could have been convinced to change their work practices. However, prior to the EMR, and at practices without the EMR, it could be very difficult to convince other physicians to change their documenting practices. A physician at an Urban Network practice which did not use an EMR explained,

> It's frustrating. We had one fellow here who we terminated because he really had organizational issues. You would read his records and you couldn't tell anything about what was going on. His writing was cryptic and his organization was

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[12]The "subjective" refers to the history of the illness and the review of systems; the "objective" refers to information gathered through the patient examination. "Assessment" and "plan" refer to the physician's assessment of the situation and their plan of action for treatment.

> around the edges of the page. So basically when you saw one of his patients you had to start from scratch and take the entire history all over again. I mean day one.

Although his colleagues had repeatedly asked the problem physician to keep better clinical records, in the end they found it easier to fire him than to convince him to standardize his documentation practices.

The problem of convincing physicians to standardize their documentation practices is a long standing one. Over three decades ago, Harold Garfinkel (1967) maintained that the doctors and nurses who kept 'bad' medical clinical records were acting in their own self-interest, if not the interest of information-gathering superiors. Garfinkel argued that physicians kept notes that were useful in their own day to day work, rather than the standardized notes that facilitate information gathering.

One way of considering the impact of spatial practices is imagining the situation if a different set of spatial practices had been used in outpatient work. If for example, outpatient physicians worked in a large room seeing patients, the problem physician above might have been more easily convinced to change his documentation practices, as his non-conformity would have been immediately evident to his colleagues working a few feet away. Also all the paper records would be in the same place, so there would be less chance of misplacing them. Alternately, if all patient interactions were done online, a program could automatically generate the necessary records, without the physicians changing their documentation practices.

These problems were seen as particularly acute in the sort of large outpatient clinics examined in this chapter, rather than a small one or two person practice. One physician / computer scientist who had worked for decades developing EMRs explained,

> Larger offices wanted information access and communication efficiencies and improved billing efficiencies, improved charge capture. The smaller offices

> basically wanted less of that... I think they just felt the economic impact was less. Smaller offices were doing fairly well they thought, because they didn't have to communicate across twenty physicians so that communication wasn't an issue. Whereas messaging for a larger group is a big deal.

One can easily contrast the situation at a small practice with the situations described above. Physicians at a small practice can keep all of their paper records in one place, and will only rarely be seeing other physicians' patients. Also, they are less able to distribute the fixed costs of adopting an EMR.[13]

4.2 Reinforcing Spatial Practices: The adoption of the EMR

In the last section, I discussed the importance of spatial practices in shaping the problems that EMRs were meant to address. I now turn to the actual results of EMR use at the three case study clinics. EMRs were used to overcome the problems identified above, largely through their ability to extend social relations in space and time, reinforcing and extending the existing spatial practices through which physicians did their work.

Such an extension of social relations in time and space - or distanciation - calls to mind the work referenced earlier by Giddens (1981) and Beck (1992), where these theorists argued that such changes would coincide with changes in power. These shifts in control appear to have occurred across each of the dimensions identified in the previous section, affecting relations between clinic administrators and physicians, physicians and their patients, and perhaps most notably, relations between physicians.

Physicians' methods of documentation were standardized to enable easier access to records from afar, and this easier access both enabled and required greater control over one

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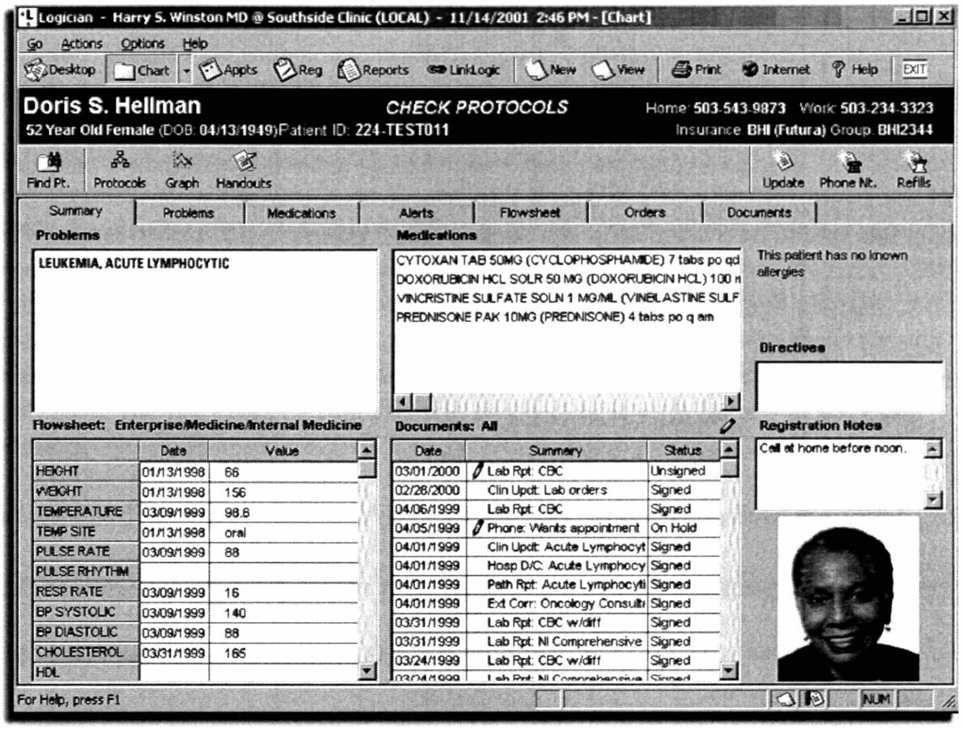
[13] There is an enormous variety in the costs of adopting an EMR, depending on the configuration and capabilities required. For instance, one can purchase a web version of an EMR with very limited capability for 99$/ month. However, purchasing a full service EMR for a single physician's office might be as high as 25,000$, including the initial costs of hardware required to run an EMR.

another, particularly reducing their autonomy in the realm of documentation. The corollary of more control over other physicians is that doctors have less autonomy in their own work. EMRs require doctors to record a relatively standardized set of information, in a relatively standardized way. With the introduction of the EMR, physicians' notes were structured to a far greater degree, with physicians explicitly required to separately enter the problem list, medication list and certain other information. Moreover, using an EMR made each physician's compliance transparent –physicans could easily look at one another's notes and gauge if their colleagues were utilizing the EMR to the required degree.

Physicians used EMRs to support their existing spatial practices around the core outpatient work of seeing patients, as well as to reshape spatial practices around documentation, both in the exam room and at home. Using the EMR allowed them much more reliable access to the medical history of their colleagues' patients, improving their ability to work with them, and mitigating the need to repeat a medical history with each patient. Participants agreed that they had access to their colleagues' records far more consistently after adopting an EMR and that this made it much easier to work with one another's patients. The sample screenshot[14] below gives a sense of the basic information that Logician made available.

[14] This sample, fictitious screenshot was taken from the Logician website at: http://www.medicalogic.com.



One notes that in this example the patient's medication list, problem list and vital statistics are immediately available to the clinician, just as they would be in the clinics I studied. In this example, the lab results are also available -- this was not always the case in the clinics I visited, as the lab system was not integrated with the Logician system at the two sites which had adopted Logician.

As noted above, the chief of medicine at Urban Central had pushed for the adoption of Logician in order to better control his clinic's practice. In the early stages of adoption he noted with satisfaction that:

> EMRS allow us for really the first time to take the three major parts of the economic event -- the schedule, the document and the bill -- and to basically cross reference the three across each other and to get clarity about what the heck's going on. If we didn't have EMRs, I'd still be back in the dark ages.

In an interview conducted eighteen months later, the next chief of medicine at Urban Central confirmed the success of the EMR in allowing the sort of control her predecessor had desired. She explained,

> We've run reports on a weekly basis now to see whether we're hitting our budget. And we're falling short, and part of the reason is there are a few selected people for whom the billing levels - their productivity has not been high enough. So in the past we didn't really know - at least on a weekly basis - who those people were. But now - I said well why don't I meet with the people who were on the bottom of the list - one on one and sort of go over it with them - in a special session.

She acknowledged that some doctors didn't like the additional oversight the EMR provided but suggested that "most people take it for granted that that's the way things are." Other interviews at Urban Central appeared to confirm this assessment.

A similar dynamic prevailed at Urban Network. Although at Urban Network the billing functions and medical record were handled by different systems, administrators regularly used the billing system to monitor the billing levels by physicians at their clinic.

The Suburban clinic used the same Logician EMR as Urban Central, but at Suburban the EMR was not used to facilitate administrator control over clinicians. These differences can be explained by contrasting the structures of each clinic. The Suburban clinic was a partnership, where physician' compensation corresponded directly to their level of billing. Also, as a partnership, the clinic administrator was not in a position to impose upon physicians in the same way as the administrator at the more hierarchical Urban Network and Urban Central clinics.

Changes also occurred in relations between physicians and patients. Several physicians noted that since adopting the EMR they felt they were better able to deal with patients who called the practice at night. The control was seen as enabling better medical treatments, as well as a better ability to regulate access to such commodities as prescription narcotics. A physician at Urban Central explained,

> It [the EMR] can also find - track down which patients are sort of problem patients that call every night and ask for [narcotic] medication that we don't ordinarily prescribe over the phone.

This additional control stems directly from the additional spatial and temporal distanciation allowed by EMRs. Social relations are extended at work, where doctors have easier and more complete access to patients' history, no longer needing to find the physical paper chart, as well as at home, where doctors can check patients' charts when they are on call.

One final dimension of control is patients' control over their own data. Several physicians explained that they were more likely to show patients their own records in the new electronic format. The trend towards increased patient access to their own data was particularly pronounced at the Urban Network Clinic. Several satellite clinics at the Urban Network were experimenting with a web-based tool where patients could access their own medical history, and comment on the accuracy of their medication list and medical history. Just as physicians were implicitly asked to spend more time on documentation in order to gain better access to patient data, patients purchase this additional control over their own data at the price of spending more time online prior to their appointment.

One of the physician / computer scientists responsible for implementing the system explained that part of the system's purpose was "to offload the somewhat burdensome data entry tasks from the physician to the consumer." It seems telling that in this context – and only in this context – this physician no longer referred to patients as 'patients' but as 'consumers.'

Some physicians found that providing patients with better access to their records was not without its dangers. One doctor recounted:

> One particular example I was with a patient who was sitting where they could see the screen. And I was not their regular doctor and they said 'Oh my god, Dr. Shore' - or whatever his name was - 'I can't believe he thinks I'm obese.' Sure enough her problem list said 'obesity.' There I was going 'ooh god.'

Notably, the lesson the physician drew from the incident is not that records ought to be less accessible, but more accessible. As she commented,

> You know, patients having access to their medical records -- it is their medical record. It is their story. I actually think it opens up better interactions with the patients when they can see what I'm putting in.

This incident also accents the additional transparency between physicians, and between physician and patient, that comes with the use of an EMR. Both the doctor and the patient here realized that the patient's regular physician had clearly failed to communicate an important medical condition to the patient.

This additional transparency was an important consequence of a shift in the nature of patient information. Using Blackler's (1995) terminology, patients' clinical data went from being 'embrained' to 'encoded" knowledge. When clinics used a paper chart, knowledge of a physician's patient was to a large extent the sole domain of the individual physician, given the difficulty of finding and / or reading the paper chart. The use of an EMR has made patient information more accessible, making it a property of the network to a far greater extent. This has made it easier for other physicians to access and understand the medical history of their colleagues' patients. It has also made it easier to assess the quality of the medical records kept by their colleagues.

As suggested by Berg's (1997) work with EMRs, the electronic record is modeled upon the paper records that preceded it. However, as described earlier, the form that these paper records took was ad hoc and informal. Given that the effective use of EMRs requires all physicians to enter certain information in a standardized way, their use not only enables more control, but requires more control.

The transparency of an EMR makes it much more difficult for physicians to subtly resist standardizing their documentation practices. Resisting an EMR is a necessarily explicit choice – a physician's colleagues and superiors become quickly aware of any physician who does not adopt an EMR to the desired extent. It is not the hierarchical information panopticon that Zuboff (1988) describes, but the transparency it provides creates a kind of lateral panopticon, with physicians understanding that their actions are visible to their peers and superiors.

The converse of more transparency is less privacy for the patient. One Urban Network physician who didn't adopt explained that he was reluctant to adopt the hospital-wide EMR offered by the Urban Network, within which his clinic operated, due in part to the transparency of the chart.[15] Notably, his objection to the transparency had to do with his patient's privacy, not with his own autonomy. He remarked,

> I could basically look at any record of any patient in the hospital and all I have to do is say that I'm doing it for medical patient -care reasons. Even if I was doing it for the wrong reasons and they had a secure system, by the time somebody figured it out I've already looked at the record. That's a problem...
>
> Everything is there [on the EMR]. So - you know - questions I ask about whether or not you've been a victim of abuse, whether you're using drugs, whether you're using hand guns - that's all in the record. And that's - you know. I wouldn't want that to be revealed to people.

Interestingly, this same provider would have liked to adopt an EMR within his individual clinic, but that was too expensive. Thus, one sees that as information networks get larger the issue of patient privacy looms larger and larger, even as the costs per doctor decrease, posing particular issues to the integration of different clinics' systems.

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[15] At the Urban Central and Suburban clinics every physician was required to switch to an EMR, but the Urban Network clinic was far more decentralized with many semi-autonomous clinics choosing their own documentation systems.

4.3 Spatial Practices Reshaped

The importance of space, and the relationship between space and control, is evident. The improved access to patients' records comes in part because unlike paper charts, electronic charts can be in more than one place at one time. Using the EMR reduced the importance of physical proximity, because one no longer had to be in the same place as a chart in order to read it. This seemingly simple change extended the relationship between physicians, patients and administrators in time and space.

Thus far, though, spatial practices have largely been visible in that they have been overcome -- EMRs were used to overcome the problem that outpatient physicians did their work in a spatially distributed fashion, and previous difficulties in standardizing documentation practices disappeared with the transparency allowed by the EMR. However, the way that physicians worked in space not only shaped the implementation of an EMR, it was also reshaped by the use of the EMR.

The addition of computers to the exam room forcibly limited the variation in documenting patient data; in so doing, it also severely constrained the way that physicians work within the exam room. While physicians continue to examine their ill patients in person, the introduction of the EMR led many physicians to begin taking notes via the computer. This required them to sit in a particular location in the exam room and look at the screen as well as at their patient – an arrangement markedly different from the ways in which many physicians previously documented patient visits. The exam rooms in which they met their patients were not fundamentally changed to make this easier for the physicians; in most cases, a small desk and computer was simply added to the old exam rooms.

While physicians weren't required to document visits on the computer *while* they met with patients, many participants chose to do so in order to limit the additional documentation work they would have to complete after the appointment. In the suburban clinic, the introduction of the EMR also coincided with the elimination of a dictation possibility, forcing all doctors to type their notes, whereas earlier they were able to choose between dictating or writing notes by hand. Even in those clinics which retained dictation programs, doctors who had previously hand-written their notes, now had to either dictate their notes afterwards or document them on the computer.

Changing the ways that they documented patient information was problematic for many of the participants. At least two participants reported an increase in neck and spine injuries due to the increased time they were spending on the computer. I interviewed one attending physician when he was recuperating from neck surgery, the necessity of which he attributed in part to the strain of spending more hours on the computer. He commented

> The intensity [of computer use] was quadrupled. Basically you go into work at 7:30 and you leave at 6:00 and everything is on the computer. Phone messages, flags, prescriptions. Everything is entered into the computer so you're constantly - if you're not doing the physical exam, you're at the computer. It's a sea change. An absolute sea change.

The outpatient participants in this survey took very little action to make their work stations more comfortable. When one outpatient physician at Urban Central invested her own money in a better chair for her office, it elicited chuckles and good natured disparagement from her colleagues. The feeling appeared to be that outpatient physicians were not supposed to spend their shifts at a computer, so there was no point in spending time and money to get comfortable. These feelings persisted despite the fact that outpatient physicians were in fact spending much of their day on the computer.

The use of the EMR not only reshaped the space of the exam room, it also extended the locations from which physicians would do their documentation work. More physicians worked from home after adopting the EMR, and they spent more time working from home. The implications of this spatial extension for the time that physicians spent working will be addressed at more length in Chapter 5.

Thus, one sees a seeming contradiction. EMRs allow the location of work to be spatially distributed, while implicitly constraining the physical ways physicians work in space. Such a dynamic reflects precisely the logic of the space of flows described by Castells (1989, 1996) -- networks are made up of specific places, but properties of the network frame what actions are possible in these places. It also reflects the contradictory tendencies noted by organization theorists such as Fountain (2001, 35) and Orlikowski (1991, 10) where information technology "facilitates decentralization and flexible operations on the one hand, while increasing dependence and centralized knowledge." Just as in the case examined by Orlikowski, a major aspect of this shift was the use of information technology to codify previously informal procedures, a shift encouraged by the increased transparency enabled by information technology.

4.4 Why did physicians change their documentation practices?

I have already noted the role of the EMR-enabled transparency in convincing physicians to standardize their work practices. However, I would argue that transparency alone does not explain their willing adoption of the EMR. Transparency meant that any resistance quickly became explicit, but it did not preclude the possibility of resistance. While some physicians were reluctant to adopt EMRs, not a single physician quit, nor was asked to leave, over the EMR. At the clinics where an EMR was adopted, every physician eventually conformed their documentation practices. Many participants complained about various aspects of the EMR, but overall they appeared to accept that adopting it was not only necessary, but desirable. In this section I will describe the importance of norms, and the way that they interacted with physicians' spatial practices to lead to physician acceptance of the EMR.

Following on Dimaggio and Powell's (1983) argument that normative pressures are particularly powerful in a hospital setting, I would propose that norms with respect to patient care played a key role in convincing physicians to adopt EMRs, making it difficult for physicians to resist changes that they believed would improve patient care. I would specifically suggest that participants accepted a tacit trade-off in which they gain better access to patient records and greater control over patient behavior in exchange for spending more time on records (including time spent at home) and ceding some autonomy in the way they kept records. In some cases this tradeoff was explicit in participant comments. As an attending physician at Urban Central commented, "It [the Logician EMR] extends your work day but it still gives me more peace of mind just to have more control over things."

In light of these norms, it is unsurprising that improved patient care was the most common reason participants cited for appreciating EMRs. At each site, more participants mentioned patient care as the reason they adopted EMRs than any other reason. Also, within each interview, most participants spent more time discussing the importance of EMRs in terms of patient care than in terms of any other potential benefits such as the financial benefits or workflow benefits. However, providing good patient care is clearly not the only norm that motivates physicians. As a technology officer at Urban Network explained, doctors often complain to him about the additional time the EMR takes.[16]

> You [the doctor] say, 'Listen buddy, I could also be a better husband, I could be a better spouse, I could be a better member of the community. All these people

[16] The issue of time spent at work is discussed at more length in Chapter 5.

trying to make me better, you're killing me.'

Physicians' spatial construction of their work is useful in explaining their acceptance of EMRs. EMR use complements physicians' face to face work with their patients by making information far more easily available in the disparate office and home locations where physicians might need to access it. At the same time, EMRs do not necessarily change the dynamic within the exam rooms, as physicians do not have to enter information while they are interacting with their patients, although many do.

In this context, it is useful to compare the physicians' use of e-mail to their use of the EMR. Increasingly, insurance companies have begun to compensate doctors for their e-mail correspondences with their patients (Kowalczyk 2004; Freudenheim 2005). Why were doctors willing to adopt the EMR, a technology which, like e-mail, required somewhat more time from them, without receiving additional compensation? I would suggest that e-mail's asynchronous, remote nature appears to conflict with what physicians see as the necessary spatial and temporal bounds on their work, allowing them legitimate grounds to resist using e-mail without compensation. [17]

Several participants made comments to this effect. The physician who instigated Suburban Network's EMR adoption, admitted he had both clinical and financial concerns with the concept of patient e-mail.

> If all the sudden, everybody is e-mailing and not coming to the office, then we may be losing revenue. And we also get a little worried about what people's perceptions would be of what we were do over the e-mail. If everyone suddenly decides they're going to get treated over the e-mail, then we're in trouble.

Other participants were concerned that patients might misuse e-mail in ways that threatened their health. For instance, they might e-mail about symptoms that actually signaled a

[17] This is not to imply that all participants refused to e-mail their patients, however most chose not to.

medically dangerous event and required immediate attention rather than the delayed response allowed by e-mail. One Urban Central physician remarked:

> My fear has been that patients would use it inappropriately. They will e-mail me when they're sick which is not appropriate. I may not read e-mail routinely or quickly enough… Some days I leave here and I don't have e-mail access until tonight. So it might be five hours. If somebody's calling me on e-mail - or e-mailing me - saying - I had one e-mail 'my lips are swollen up, I took that drug.' I mean, (laughter) you know - that just makes my heart pound. Cause something really bad could happen."

As long as it appeared to participants that EMRs would not fundamentally change what they viewed as their core work – e.g. the work of seeing patients - and in fact would improve outcomes, physicians appeared unlikely to raise strong protests to the implementation of the technology, despite privacy concerns. However, even giving the patients access to their own records when their physician was not present was seen as problematic by some participants. One physician stressed the importance of patients having better access to their information, but then quickly made clear that this was only beneficial when they were reading their information with their physician present. She had recently left a clinic which allowed patients remote access to their medical records and explained,

> I really hated it [the information system]. Patients could see their lab results and you'd get questions like
> 'how come my hematocrit is 39?'[18]
> Well, normal is 39.

She saw giving patients remote access as an invitation for misuse and misunderstanding, increasing stress for the patients and making more work for their doctors.

The administrator / physicians who brought the EMRs to their clinic appeared to recognize this necessity of assuring physicians that the EMR would not interfere with their interaction with their patients. They made no mention of physicians concerned about the

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[18] Hematocrit is a measurement used to test for anemia -- normal results for women range from 35%-48%.

additional time required by an EMR, but they each addressed at length the charge that using an EMR might detract from the patient-doctor relationship. After acknowledging that one had to be careful not to alienate a patient by staring at the computer too much, one Urban Central physician involved in the decision to adopt the EMR explained that the computer need not interfere with the patient relationship.

> People know instantly if you care about them. People know right away. Once they know you care, they'll cut you all kind of slack on the little stuff. You don't have to sit there quietly with eye contact for twenty straight minutes. You do have to early on build a relationship.

The administrators involved in implementing the EMR at the Urban Network site used the EMRs' proven ability to reduce medical errors to convince recalcitrant physicians to document their patient visits on the electronic systems. Mr. Jordan, the information officer at Urban Network, emphasized, "at the end of the day, I wear you [the physician] out on my appeal to you trying to be a better doctor, and make it as efficient as I possibly can."

4.5 Changing Norms and the Diffusion of EMRs

Conceptions of work change over time. A focus on the different implementation processes indicates the extent to which EMRs are becoming more accepted. Norms appear to be rapidly changing with respect to EMR use. As described above, in the case of Urban Central, attending physicians were given lighter caseloads to allow them to implement Logician, while two years later, when the Suburban clinic adopted the same EMR, physicians were given no allowances at all, simply expected to work more hours.

A priori, one would have thought that these differences would lead to significant differences in physicians' attitudes towards their EMR. However, no systematic differences in physician attitudes were evident, with one exception discussed below. In all three sites, participants viewed the additional time required by EMRs as incidental compared to the benefits.

I would suggest that changing norms explain a large portion of the increasing willingness of physicians to adopt EMRs without being given additional time allowances to adapt to the technology. As EMRs became more common, they became more accepted. These changing norms explain the finding that the clinics which adopted EMRs most recently offered their physicians less help in smoothing the transitions (in the form of training programs or free sessions without scheduled appointments).

Alternate explanations are possible based on my data. For instance, one alternate explanation would simply point to reimbursement schemes. Since physicians in Suburban are shareholders, they benefit fiscally from the additional demands made by the EMR. On the other hand, the physicians at the Urban Central and Urban Network clinics are salaried and thus needed more coaxing. If this explanation is true, one would expect the non-shareholders – e.g. the nonphysicians in Suburban – to be less enthusiastic than the physicians about the EMR.

In fact, the reverse appeared to be the case. A nurse / site administrator was one of the primary agents of the introduction of Logician to the Suburban Clinic. She volunteered to be responsible for Logician training and implementation throughout the eight branches of the Suburban Clinic. She expressed an overwhelming affinity for Logician.

> I decided to do this because I thought it was an awesome tool and I really felt compelled to really push it for Suburban to get it …I felt as though I could do this, it's a good tool, we need to do this. And I'm willing to do anything we can - you know - to get it done.

Throughout the Suburban outpatient clinic, the nurses, physician assistants and front desk clerical help were uniformly positive – at least as much as the physicians.

To be sure, the different reimbursement schemes mattered, especially in terms of accenting the perceptions that EMRs had financial benefits. Physicians in the Suburban clinic were more apt to stress the financial benefits thought to accrue through EMR use than physicians in the other clinics. Every physician interviewed at the Suburban Clinic mentioned the higher billing enabled by the EMR. One explained,

> Billing is based on documentation. It's not about how good of a job you do with the patient -- it's based purely on documentation. And with the EMR, because the system prompts you to document everything that you've done, or to check all the questions - the answers to all the questions you've already asked, you know the answers, so just go and check it, - so documentation is much easier.
>
> And because of that the billing goes up.

The physicians and administrators who brought the EMR to Suburban were less certain of the overall financial impacts. Like the Chief of Medicine at the Urban Central Clinic, the administrator of the Suburban Clinic, stressed that, "the primary reason for the EMR is not to save money. You will not save money. It truly is to make the doctor's life easier." Given these contrary opinions with respect to the financial impact of EMRs, as well as the positive reaction of salaried health care workers with no stake in the alleged financial benefits, it seems reasonable to assume that while the potential financial benefits associated with an EMR were part of the incentive to adopt an EMR, the financial benefits offer only a partial explanation of the willingness of physicians at Suburban Network to adopt an EMR without any additional slack to learn the program.

5. Conclusion

In this chapter I have argued that focusing on the way that professionals enact their work in time and space before and after adopting an information technology offers important insights into the process through which new technologies are used to change work. I have illustrated a relationship where the way physicians enact their work in space shapes their use of an information technology which, in turn, shape the way that physicians work in space. I have linked these spatial dynamics to important changes in relationships of control among physicians; between administrators and physicians; and between physicians and patients.

EMRs supported their spatial practices by making patient information more easily accessible from disparate locations. This same accessibility of EMRs played a role in the pressure felt by physicians to standardize their documentation practice, and the ability of other physicians and administrators to pressure recalcitrant physicians to use the EMR.

The fact that outpatient physicians viewed their face to face encounters with patients as their core work – bounded in both time and space – also played a key role in convincing them to accept EMRs. Using EMRs and changing documentation practices were seen as distinct from their core work, and so they appeared content to exercise only minimal control over the use of the EMR. At each of the outpatient sites physicians seemed to accept that the EMR would change their work in ways they could not control. Even at the Urban Network clinic, where physicians created the electronic record, physicians ultimate ceded control to a technology office. One of the creators explained, "Basically it was academic physicians wanting to design these things, and not wanting to continue with the administration of the process."

In subsequent chapters I turn to the situation of radiologists and their use of teleradiology applications. The spatial structuring approach takes a somewhat different focus in the radiology case. In contrast to outpatient physicians, problems of control linked to their spatial practices did not drive the adoption of technological innovation for radiologists. However, attention to their spatial practices prior to adoption help explain the heavy control radiologists exerted over the use of information technology to change their work, as well as the subsequent changes to their work.

Chapter 3 -- Tables and Figures

Table 3.1: Summary of Research Sites

	Urban Central	Urban Network	Suburban
Description	Outpatient clinic of large teaching hospital (centralized) 22-31 Attending Physicians, 60 Staff Physicians are salaried.	Outpatient physicians in large teaching hospitals which share EMR (decentralized) Physician compensation varies	Suburban Clinic (8 branches) 30 Physicians, 10 Nurse Practitioners 175 Support Staff Physicians are shareholders.
Process of Adoption	Rapid adoption of Logician EMR mandated by clinic chief, but allowed time for training and workload lessened to allow for data entry by physicians.	Gradually adopted inhouse EMR. Voluntary use for years, now mandatory in some satellite clinics, voluntary in others.	Staggered adoption of EMR by branch. Instigated by clinicians. No extra time allowed for data entry by physicians.
Date of EMR Adoption	August 2001	Incremental (over last 2 decades)	December 2003
Research Performed	10 participants 12 interviews 1 focus group (22 people) Observation	10 participants 10 interviews	9 participants 12 interviews Observation

In addition to the 29 interview participants at the three primary research sites, I interviewed:

- 2 executives at a large medical insurance provider in the area;
- 1 medical informatics academic familiar with electronic initiatives in the region;
- 2 physician / computer scientists involved with developing electronic medical systems at another hospital in the region;
- 1 physician at an area outpatient clinic which did not use EMRs.

Appendix 3.1 -- Sample Interview Guide

Note: These interviews were loosely structured and open ended. The following questions are examples of questions used to structure the conversations, and should not be taken as inclusive. Questions varied based on the context and the participant.

Introductory Statement (for consent purposes):

Thank you for taking the time to meet with me today. This research is interested in the way you use computers to do your everyday work, especially the way you use your clinic's EMR. We're generally interested in both sociological and economic changes -- questions like does it save you time or take more time? How does it change the way you communicate with co-workers? Does it help you bill more efficiently? How does it change the way you interact with patients?

I have a few questions to start the conversation, but first I want to make sure that you understand a few things: i) Participating in this interview is completely voluntary; ii) you don't have to answer any of these questions; iii) you can stop the interview at any time without any consequences; and iv) everything you say will be kept confidential -- if we use any information you give us we will make sure to remove any details that could be used to identify you.

With your permission, I'd like to tape record the interview. I'll be keeping the tapes and transcriptions in a locked cabinet in my locked office at MIT for a year, before destroying them. Understand that I'm doing these interviews as part of my dissertation research. While I may include this data in any eventual publications that come from this research, I will be certain to eliminate any details that would allow your thoughts or answers to be identified with you - e.g. I'll refer to an outpatient physician rather than [insert name].

Background:

1) How long have you been with this practice?

2) How many other doctors practice here? Nurses? Clerical Staff?

3) What were you doing before you came here?

Topic 1: Keeping Records

1) *How do you enter patient's records?

Probe: Do you complete them when they're in the room? Why or why not? If you finish them later, when do you finish them?

Probe: Has a patient ever looked over your shoulders as you write their notes?

2) How did you first hear about EMRs?

3) How did you hear that you were going to start using an EMR?

4) How did your clinic come to start using an EMR?

5) Have you ever had an experience where you couldn't read or find something that you yourself had written in your own patient's chart?

Probe: If so, how did you respond?

6) What is the best part about having an EMR?

Probe: reduction in paper files; easier to keep track of medication, reading other doctors notes, etc

Probe: How did this used to work before you had an EMR?

7) What is the worst part about having an EMR?

Topic 2: Communication with colleagues and patients

1) Have EMRs changed communication with your colleagues?

Probe: If so, how?

2) Do you give your patients your e-mail address?

Probe: If so, how many e-mails did you receive on your last full working day? Probe: When do you check your e-mails?

Probe: Can you give me an example of some recent e-mails that you received from patients and tell me how you dealt with them?

Topic 3: Keeping Busy

1) Do you ever bring work home?

Probe: About how many times in the last week?

Probe: How do you feel about bringing work home?

2) Are you ever on call? If so: How do you deal with patients who call you when you're on call?

3) About how many patients did you see on your last full working day?

Probe: Can you take me through the sequence of that day -- e.g. when did you get to work? How much time did you spend with patients, how much time on record keeping, etc.

4) In what ways has the work of being an internist changed since you started practicing medicine?

5) Do you feel like you're working more than you used to? Do you feel like you're doing different kinds of work than you used to?

Probe: If so, to what do you attribute these differences?

Closing:

How long have you been working as a doctor? How old are you?

Chapter Four: Nighthawk Radiology - Space and control in an electronic cottage industry

1. Introduction

In the last chapter I described the use of information technology by a medical subspecialty of physicians who continue to do their core work within tight spatial-temporal bounds. In this chapter I turn to radiology, specifically the phenomenon of nighthawk radiology, where radiologists interpret the night reads for patients who may be 10,000 miles away from them.

Radiologists have done their work at a space remote from their patients almost since the inception of their discipline. While the very first physicians to use x-rays utilized handheld fluoroscopes which produced an image only they could see, requiring them to be in the same place as the patients they were treating, this did not last long. By 1904 these fluoroscopes were already supplemented by machines which allowed images to be preserved and viewed elsewhere (Linton 2001, 13).

I draw two points from this history: for as long as there have been radiologists they have done their work heavily mediated by medical technology, and for almost as long, they have done their work at a distance from patients. Radiologists have continued to be a medical specialty at the forefront of technology use, in terms of using new and frequently changing technologies, and they continue to have relatively little face-to-face contact with their patients. I suggest that both of these qualities have shaped the way they have used technology to change their work, with particular reference to the power they have been able to exert over these changes. As I noted in the introduction, contrary to what one might have thought, radiologists have appeared to be capable of exercising a good deal of control in the way that they have used information technology to reshape their work.

Fundamentally I am interested in the power radiologists have been able to exercise over the use of teleradiology to change their work, and the benefits or detriments that they have received through these changes. As in the previous chapter, my research revolves around the consequences of the use of information technology, asking: how and with what consequences has teleradiology been used by radiologists to change the ways in which they do their work in space and the control they exercise over their work? In this chapter I approach the notion of space more broadly than in the previous chapter on EMRs. Teleradiology has been used to change the space of work in terms of the city and even the nation in which radiologists practice, thus my discussion moves beyond the focus on proximity which characterized the discussion of outpatient physicians, to encompass broader notions of location.

I begin this chapter by examining in more detail the context in which nighthawk groups have evolved and thrived, as well as briefly sketching the way in which nighthawk groups currently operate. The nighthawk industry has emerged recently enough that an industry overview is still lacking, and so I endeavor to provide a brief overview before beginning the substantive analysis.

I proceed to present the results of several statistical models estimating the traits of the radiologists and the radiology groups which tend to use both teleradiology in general, and teleradiology to out-of-group radiologists in particular. Groups which use teleradiology to out-of-group radiologists include radiology groups which buy radiological services from other groups as well as those which sell radiological services to other groups.

After discussing the importance of spatial location for both night hawk radiologists and their clients, I link the spatial location of nighthawk radiologists with their feelings of increased autonomy. As in the last chapter I argue that radiologists' spatial practices both shaped and were shaped by their uses of teleradiology. I expand the discussion of control to speak to the means through which United States radiologists have maintained jurisdiction over the reading of images, regardless of the location of radiologists. I end by suggesting the characteristics of radiology that have been particularly powerful in shaping these outcomes and looking toward the future of nighthawk radiology.

2. Research Sites & Methods

This chapter uses open-ended interviews to complement survey data gleaned from a 2003 survey conducted by the American College of Radiologists (ACR). As described in Chapter 1, I completed 29 interviews of 25 participants specifically with respect to the radiology portion of this research. Nine participants were radiologists at conventional radiology groups with some experience with teleradiology, either as clients or providers. The remaining sixteen were involved in one of four different night hawk groups, including radiologist employees, executives, technical officers, clerical help, founders, and one radiologist interviewing with several night hawk companies. Three of these four groups are the largest groups in the nighthawk field, commonly identified in the popular press, as well as by participants, as industry leaders. The nighthawk market is sufficiently small, that in order to protect the confidentiality of participants, I avoid linking group details to individual participants. In addition, all names are pseudonyms.

I recorded and transcribed verbatim eighteen of the interviews, which I then coded as described in Chapter 1. I was unable to record the remaining eleven interviews -- in those cases I took notes during and after the interview. I conducted several site visits - one to the headquarters of a nighthawk group, one to a private radiology group, two to a teaching hospital's radiology reading room, and one to the home of a nighthawk radiologist. I have attached a sample interview guide containing examples of the sorts of questions I asked participants in Appendix 4.7.

The survey data is drawn from a paper survey that the ACR conducted of 3090 radiologists in 2003, including every subspecialty of radiologist. The survey sample was taken from the American Medical Association's (AMA) Master File, a listing of every allopathic physician in the United States, and supplemented by a sample of ninety-two osteopathic radiologists randomly selected by the American Osteopathic College of Radiology (AOCR) from its list of members. Usable responses were received from 1924 radiologists. The variables drawn from this survey are individually defined in Appendix 4.1, with additional discussion of the treatment of categorical variables in Appendix 4.2. The survey itself is attached in Appendix 4.6.

It should be noted that the nighthawk business model is still rapidly developing and changing. One of the most striking findings to come out of the interviews was the rapid growth that participants have observed. However, while the use of nighthawk radiology has almost undoubtedly spread since this survey was completed, this survey nevertheless offers a useful opportunity to explore correlations between teleradiology use and other group attributes.

The information technology in question is more general in this chapter and consists of the communication system which allows hospitals to transmit tests results to radiologists. This includes the Picture Archival and Communication System (PACS) used to transfer and store images within the hospital, as well as a range of secure Internet technologies used to transfer images between sites.

3. The Emergence of the Nighthawk Radiology Group

While nighthawk radiology represents a recent development in radiology, teleradiology - the practice of radiology from remote locations - has been used for years. Beginning in the late 1980s, an increasing number of radiologists have provided on-call service to a hospital from their home via information transfers, rather than driving to the hospital. Teleradiology has been more widely used than all other forms of telemedicine put together.[19]

The development of the nighthawk firm ought to be viewed against the backdrop of a widely proclaimed scarcity of radiologists. This scarcity has been described at length in the health care and medical literature (Grumbach 2002, Batchelor 2004). In addition, mention of it permeated the interviews conducted with radiologists inside and outside of the nighthawk industry.

The scarcity has its roots in both supply and demand factors. The supply of medical labor is highly dependent upon government action in the United States, through both regulation and subsidy. The number of first-year places at U.S. medical schools has

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[19] A.C. Norris (2002) reports that in 1998 about 40,000 remote consultations were conducted in the United States in medical specialties aside from radiology, as compared to over 250,000 remote radiology consultations in 1997. These 250,000 remote consultations themselves composed a very small fraction of the consultations done for the roughly 474 million diagnostic radiology procedures estimated to take place every year in the United States (http://www.acr.org). However, the 1997 figure almost certainly understates the current figure as the practice of remote teleradiology has ballooned in the last five years.

been frozen at 17,000 for almost thirty years (Reinhardt 2002) and the numbers of residency slots frozen since 1997 (Grumbach 2002).

Conversely, the demand for radiology tests has steadily expanded. New imaging technologies such as ultrasound, MRI and CT produce more images per study, and they are more difficult to interpret. Whereas ER physicians can often make a provisional interpretation of a simple x-ray, they find it harder to interpret the results of an MRI or CT. Also, due to the rise in malpractice suits stemming from the failure to diagnose an illness (Stein 2003), emergency room physicians have become more inclined to have radiological procedures performed. One U.S. trained nighthawk radiologist working from Australia described it as follows:

> Someone comes with a headache in America, they're going to get a head CT, no question. Because it could be that one in a million person who doesn't just have a migraine, but actually has a bleed. And if you do not do a head CT, your career is over, basically. You'll never work again.

On the other side of the world, a radiologist in Massachusetts agreed that images have become more central to diagnosis.

> We [the radiologists] make the diagnosis all the time. They don't even have to examine the patient anymore. Just do a cat scan and it'll tell them what to do. You [the primary care physician] used to diagnose somebody with appendicitis, you took them to the OR [operating room], you didn't do a cat scan. Clinical skills are all abating, because there's so much technology.

The head of emergent[20] radiology at a large U.S. academic hospital, described image interpretation as being on the "frontlines in a very palpable way in diagnoses. [Emergency room] diagnoses depend on radiology in order to diagnose many common

[20] Emergent radiology refers to radiology practiced in an emergency context.

diseases such as renal stones, appendicitis, pulmonary thrombosis, etc." From his perspective, this increased reliance upon radiology has made emergency room physicians less willing to wait until morning for a radiologist's report.

While this radiologist's academic practice, like many academic radiology groups, has turned to their own full time night radiologists to meet this need, many smaller groups are unable to afford a full time night radiologist. In contrast to these larger academic radiology groups (groups located at teaching hospitals), many private radiology groups do not interpret enough night studies to justify paying the wages it requires to hire a night time radiologist.

Ironically then, this desire to provide immediate, face-to-face, emergency care has partially inspired the outsourcing of night time radiology reads. In a free market, the surge in demand coupled with the decrease in supply would have led to a surge in radiologist salaries, which in turn would have coaxed more entrants into the field. While radiologists continue to be among the highest paid medical specialties (Kane and Loeblich 2003), there is little opportunity for domestic supply to surge. As noted above, physician labor supply is heavily dependent on government funding. Instead of supply increasing, it simply became more difficult to find radiologists, regardless of the price. Given the increasing demands made on them, radiologists have become more concerned with lifestyle issues such as the numbers of nights and weekend shifts they are required to work. In combination with the use of emerging information technologies, these pressures led to the establishment of nighthawk radiology groups.

The use of night hawk radiology does not represent a case of foreign doctors being cheaper than American doctors. Rather it has to do with the benefits of consolidation and economies of scale – e.g., nighthawk groups consolidate enough images to keep a radiologist fully busy for an entire night-shift, something that a small conventional radiology group is unable to do. Also, the existence of time zones means night-hawk radiologists in foreign countries need not actually work at night, something which also lowers the wages needed to recruit radiologists for night shifts and eliminates the need for days off after a night shift (Kalyanpur et. al. 2003). It also mitigates quality problems which might result from waking radiologists up to read the images required for emergency room diagnoses.

The first radiologist firms that focused solely on remote night time readings opened in 2001. In the subsequent four years these firms have grown rapidly, with the three leading firms currently reading images from roughly 1000 hospitals, almost 20% of the 5764 hospitals registered with the American Hospital Association in 2003. The three largest firms are headquartered in Idaho, Minnesota and Texas, but as will be discussed below, their headquarters location has little relation to the location of either their clients or their radiologists.

Participants expect the intense growth to continue. Ron Stidwell, an executive at a night hawk firm, likened the situation to that in the American west before Oklahoma was opened up for land tenure. Just as settlers crowded the Oklahoma border in 1889, determined to stake their claim to as much land as they could, night hawk firms are anxiously competing with one another for their position in the emerging market. The founder-executive of another nighthawk firm independently made a similar assessment. "It's like the wild wild west," he said. "No one knows how the market will end up looking."

From where does this intense demand come? As the earlier discussion of the radiology market would suggest, many participants linked the intense demand for nighthawk radiology to problems with being on-call at night, due to the scarcity in radiologists described above. Dr. Ann Francis, a night hawk radiologist, spoke of the difficulty of being on call at some length.

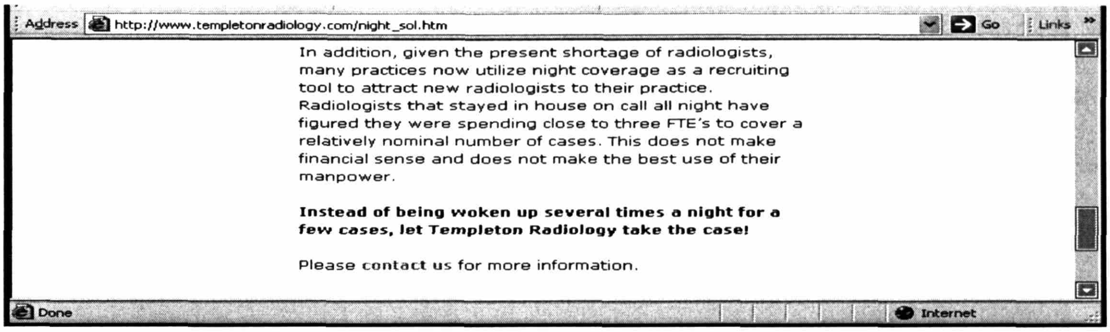
> Call ruins your life. If you're in a small hospital in rural America and you have 2 or 3 partners – just you and a few other guys. Staying up all night every fourth night for the rest of your life … it sucks. It ruins marriages. It ruins everything. So to be able to pay someone to take that away – it's brilliant. They love it.

One neuroradiologist at a teaching hospital founded a nighthawk radiology group in response to precisely these pressures. He recalled a change in emergency room policy when,

> The ER doctors said 'if we are here 24 hours a day, we expect the radiologist to be here 24 hours a day also.' The radiology department in an academic institution is extremely specialized, and there were three of us in neuroradiology … So I'm on call every third night, [I'm] a wreck the next day when I come in, and it's not worth it.

Dr. Michael Farrell is a radiologist who stopped being a partner at his private practice specifically to avoid the demands of call. As he explained, "That's why I'm part time. The call just got so barbaric. You're up basically all night because of the technology changes."

Several participants - both nighthawk radiologists and radiologists who had hired nighthawk firms - commented that for conventional radiology groups, a contract with a nighthawk group had become an asset in hiring new radiologists. Dr. Joel Hettinger, a radiologist at a community hospital practice which had contracted with a nighthawk firm, remarked, "I have a feeling in the very near future that if there's no night-hawk radiology lots of new residents will not be taking a job in that group." Nighthawk companies recognize this imperative and market themselves accordingly. The website of Templeton Radiology, a smaller nighthawk firm, includes the following statement:

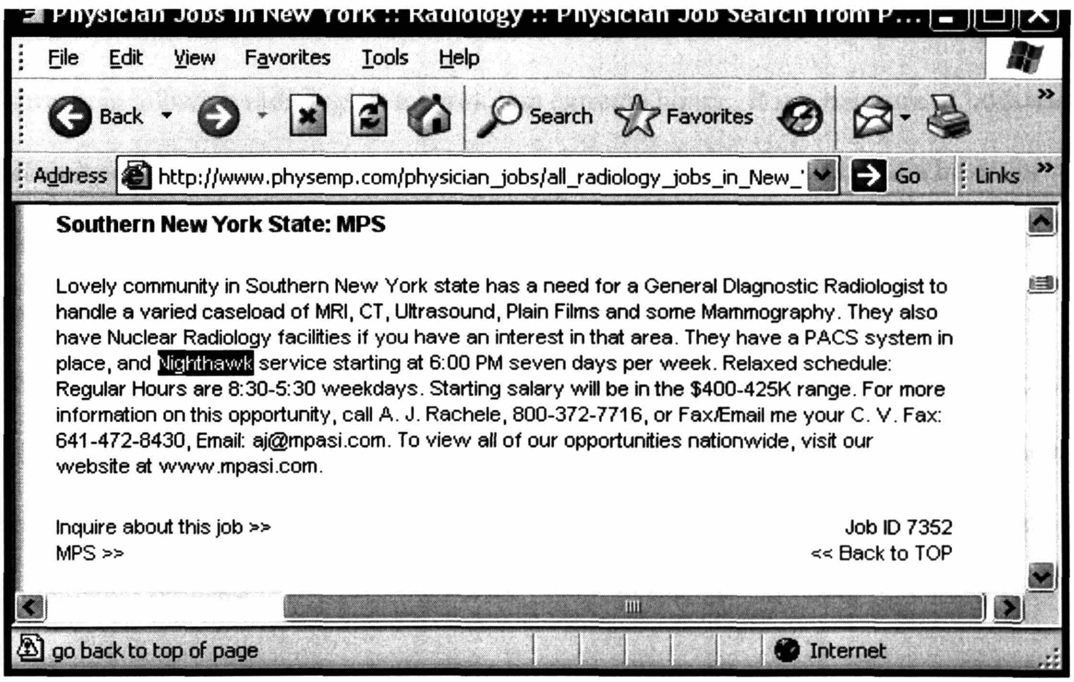

Address http://www.templetonradiology.com/night_sol.htm

In addition, given the present shortage of radiologists, many practices now utilize night coverage as a recruiting tool to attract new radiologists to their practice. Radiologists that stayed in house on call all night have figured they were spending close to three FTE's to cover a relatively nominal number of cases. This does not make financial sense and does not make the best use of their manpower.

Instead of being woken up several times a night for a few cases, let *Templeton Radiology* take the case!

Please contact us for more information.

A brief glance at the following job announcements for radiologists further attests to the use of nighthawk contracts to entice radiologists.

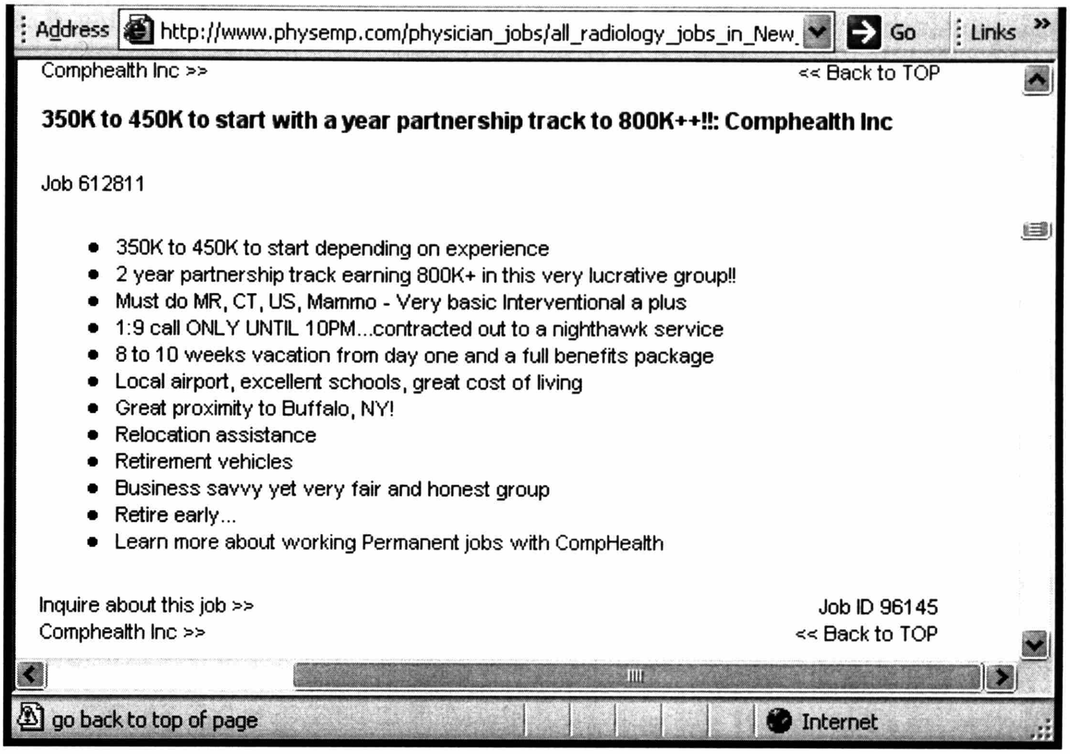

Address http://www.physemp.com/physician_jobs/all_radiology_jobs_in_New_

Southern New York State: MPS

Lovely community in Southern New York state has a need for a General Diagnostic Radiologist to handle a varied caseload of MRI, CT, Ultrasound, Plain Films and some Mammography. They also have Nuclear Radiology facilities if you have an interest in that area. They have a PACS system in place, and Nighthawk service starting at 6:00 PM seven days per week. Relaxed schedule: Regular Hours are 8:30-5:30 weekdays. Starting salary will be in the $400-425K range. For more information on this opportunity, call A. J. Rachele, 800-372-7716, or Fax/Email me your C. V. Fax: 641-472-8430, Email: aj@mpasi.com. To view all of our opportunities nationwide, visit our website at www.mpasi.com.

Inquire about this job >> Job ID 7352

MPS >> << Back to TOP



Comphealth Inc >> << Back to TOP

350K to 450K to start with a year partnership track to 800K++!!: Comphealth Inc

Job 612811

- 350K to 450K to start depending on experience
- 2 year partnership track earning 800K+ in this very lucrative group!!
- Must do MR, CT, US, Mammo - Very basic Interventional a plus
- 1:9 call ONLY UNTIL 10PM...contracted out to a nighthawk service
- 8 to 10 weeks vacation from day one and a full benefits package
- Local airport, excellent schools, great cost of living
- Great proximity to Buffalo, NY!
- Relocation assistance
- Retirement vehicles
- Business savvy yet very fair and honest group
- Retire early...
- Learn more about working Permanent jobs with CompHealth

Inquire about this job >> Job ID 96145
Comphealth Inc >> << Back to TOP

These job announcements are representative of the importance of nighthawk radiology groups in allowing radiologists to work less extreme hours. It is a measure of both the scarcity of radiologists and the attractiveness of nighthawk contracts, that a business model which only five years ago was seen as very risky is increasingly seen as a prerequisite to hiring new radiologists.

In the next chapter I focus at greater length upon the intensity of night work, and the part played by technology use in mitigating or exaggerating the situation. For now, however, I simply emphasize the role of the aversion to night call in creating demand for nighthawk services.

4. Nighthawk Radiology: Not A Fly-By-Night Business

Before examining the role of space and the use of information technology in nighthawk radiology, I will first describe the functioning of the industry in more depth. How do nighthawk radiology groups operate?

Nighthawk services earned their name because they were established to cover the night call duties of their client radiology practices. Radiology groups typically have a contractual relationship with a hospital or imaging center to provide image interpretation services; when they hire a nighthawk group they sub-contract their night time responsibilities to interpret emergency room images. Their client hospitals refer their emergency room call to the nighthawk group, which interprets all emergency radiology studies for the agreed upon period - usually something like 10 p.m. to 8 a.m., but with variation depending on the needs of the client radiologist group.

The nighthawk group provides a preliminary report or what is known as a “wet read” for the emergency room physician to use immediately. The next morning, the client radiologist practice reviews all wet reads and signs them in order to make them the final report or “dry read.” The client practice pays the nighthawk radiologist for the wet read, and is reimbursed in turn by the patients’ payer for the dry read.

The dry read is more than just a perfunctory signature. The participants in this study who used nighthawk services typically read over the wet reads as soon as they arrived at their office in the morning. As one radiologist described, “the following morning the films are kept on our desk, with the typewritten report. And we compare what they said with what we think should be the interpretation.” He went on to mention that one of the nighthawk radiologists wrote particularly good reports. While others’ reports occasionally needed to be amended for clarity, he stressed that even those reports were sufficient to insure that the appropriate emergency care was being provided. It was clear that this participant took the dry read seriously, as he devoted sufficient attention to drawing his own conclusions from the images that he was able to distinguish between the work of the multiple nighthawk radiologists who provided the service for his practice.

The margin between the price of a dry read and a wet read varies, but participants emphasized that the margin is not what drives clients to contract with night hawk services. Night hawk groups are not cheap, and their clients are generally content to simply break even. As suggested above, nighthawk groups are made viable due to the scarcity of radiologists and their reluctance to spend their nights on call for their local emergency room.

Radiologists can provide nighthawk service from virtually anywhere in the world where they can access a fast, secure broadband Internet connection. Currently nighthawk radiologists interpret tests for United States hospitals from locations as far flung as Bangalore, Hong Kong, Sydney and Zurich, as well as less exotic locations within the United States. Typically there are provisions in the contract that the client radiologist will have one of their own radiologists on a sort of supplemental call, in case some emergency requires a local radiologist.

There are several models of nighthawk radiology currently in use. Originally night hawk groups were large conventional radiology practices that attempted to sell their extra capacity at night. The term “nighthawk” was coined by one of these, a large private practice in California where the business manager had flown helicopters in Vietnam on “nighthawk” missions.

More recently, though, groups have arisen which exclusively practice nighthawk radiology. It is difficult to accurately count nighthawk groups, as smaller groups may enter and leave the market unremarked by the industry at large. Seventeen nighthawk firms had booths at the most recent annual meeting of the Radiological Society of North America (RSNA) in November, 2004; however several of them acknowledged having no clients at the time.

Participants generally agreed that there are only three nighthawk firms with a national presence, and these three firms account for the bulk of the contracts with hospitals. Participants at each of these three firms said they often encountered one another when bidding for contracts, but more rarely encountered other firms. One participant estimated that perhaps five percent of the market was divided between a remaining 10-20 nighthawk firms.

Within nighthawk groups there is also variation. Several practice conventional radiology from a distance. For instance, one nighthawk firm has famously established its reading room in Sydney, but the radiologists in Sydney continue to read in one room, much as they might do from a hospital's reading room. One important difference, of course, is that they can interpret images from 10 p.m. to 8 a.m. United States time, while working from noon to 10 p.m. in their local time.

In contrast, other night hawk groups utilize a much more decentralized model. They allow their radiologists to practice from anywhere in the world, although the majority tend to work from the United States. These groups perforce make more sophisticated use of information technology, providing their radiologists with several different means through which they can communicate with one another and with their clients.

The compensation model varies but generally includes a base pay supplemented by bonuses based on the number of studies a radiologist reads. A nighthawk radiologist working a full time night hawk schedule (seven days on, seven days off) can expect to earn a comparable annual income to a radiologist who is a full time partner at a regular radiology firm.

5. Who Uses Teleradiology?

Having described the practice of nighthawk radiology, I now turn my attention to attempting to ascertain what sorts of groups are most likely to use nighthawk radiology, as well as teleradiology in general. One of my primary interests here is investigating the extent to which group location correlates with use of teleradiology.

There are several reasons to believe that location shapes a group's decision whether or not to contract with a nighthawk service. If, as I suggested earlier, nighthawk groups are largely used to compensate for a scarcity of radiologists, this scarcity might vary by type of location. For instance, radiologists might tend to be located in certain type of areas, making it less necessary for groups in those areas to contract their night call out. Ron Stidwell noted,

> It's hard to recruit to Buffalo, New York. The guys that are retiring, they all want to live in Florida. If they're still working, they want to be somewhere warm, some kind of resort area.

Location might also be significant because small groups in larger metropolitan areas might be able to get serviced by a larger local group with extra capacity, rather than hiring a nighthawk firm. As Tara Robbens, the marketing director at a leading night hawk firm explained,

> For the most part, smaller communities hospitals in a major metropolitan area can get service by a facility that has a full time radiologist staff that has extra capacity. So you will see those tend to fall under a large facility.

Similar reasoning leads me to hypothesize that groups outside of large metropolitan areas are more likely to use teleradiology in general, as well. If radiologists are more scarce, their groups would presumably be more likely to need them to work nights, something facilitated by the use of teleradiology between the hospital and the home.

In addition to the location of group, the size of group and type of group almost certainly shape the decision to use nighthawk groups. For instance, radiologists at teaching hospitals have historically simply assigned their residents to night duty, eliminating much of the need to awaken the attending radiologist on call. More recently, some academic groups have begun to use attending "emergent" radiologists who are on full time call at night. In addition to providing more immediate care, having an emergent radiologist present at night also helps these academic radiology groups to fulfill their mission of teaching residents. Both of these schemes would presumably make academic groups less likely to utilize night hawk services, or indeed teleradiology in general, as they would have their own radiologists there in person.

I would also expect larger private groups to be less likely to use teleradiology to out-of-group radiologists, but more likely to use teleradiology in general. The bigger the group, the more radiologists they will have among who to distribute the onerous night-call duty, and so I would expect them to make less use of teleradiology to out-of-group radiologists. However, without residents to staff the night call, I would expect radiologists at private groups to be more likely to take calls from home, and thus more likely to use teleradiology in general. The expectation that larger groups would have more resources to spend on information technology, also leads me to predict that they would to be more likely to use teleradiology in general.

Based on the above discussion, I would propose the following a priori hypotheses:

Hypothesis 1: *Larger groups are less likely to use teleradiology to out-of-group radiologists, but they are more likely to use teleradiology in general.*

Hypothesis 2**:** *Academic practices are both less likely to use teleradiology in general, and less likely to use teleradiology to out-of-group radiologists.*

Hypothesis 3: *Radiologists outside of cities will be more likely to use both teleradiology to out-of-group radiologists and teleradiology in general.*

Using the dataset described above, I will present three logistic regression models which speak to the question: what types of groups are most likely to use teleradiology, both within their group and to out-of-group radiologists? While there is not a perfect match up between the use of teleradiology to out-of-group radiologists and the use of nighthawk groups per se, for the moment, I would propose that most radiologists who use teleradiology to out-of-group radiologists are contracting with night hawk groups. In addition to the two models predicting the probability of teleradiology use, I present a model that estimates the correlation between the probability of locating in a large metropolitan area and various other group attributes.

Before reporting the logistic regression models, I present relevant descriptive statistics in order to give a sense of the relationship between teleradiology use and group size and type. The use of teleradiology is fairly widespread among American radiologists with 79% of surveyed radiologists using teleradiology in their group. Teleradiology to out-of-group radiologists is much less widespread with only 15% of surveyed radiologists using it in their group.

As noted, the survey on which these numbers are based was conducted in 2003. Participants working in nighthawk groups reported a huge upsurge in business in the last two years, with the volume of business increasing by a factor of ten, so it is reasonable to assume that some of this increase would be reflected in an increased percentage of groups using teleradiology to out-of-group radiologists. Dr. James Thrall, the head of radiology in Boston's Massachusetts General Hospital recently estimated that 25-30% of radiology groups currently use outside services to cover off hours (Thompson 2004). A recent survey of emergency rooms found that 82% use teleradiology services in some form (Saketkhoo et. al. 2004).

Turning back to the 2003 survey data, one wonders where the radiologists who use teleradiology are located?

*Insert **Table 4.1: Location of Radiology Groups** around here*

It is clear from the outset that the largest plurality of radiologists - just shy of a majority - practice in larger metropolitan areas. Also, one notes that a larger percentage of radiologists outside of cities use both teleradiology in general and teleradiology to out-of-group radiologists. While this appears to hint at a correlation between location and the use of teleradiology to out-of-group radiologists, this apparent correlation is further investigated below in a logistic regression which controls for other group variables as well.

*Insert **Table 4.2: Type of Radiology Group** around here*

Most radiologists surveyed worked in private groups. Teleradiology use in general was most common among these private groups with 85% of private groups using teleradiology. Teleradiology use in general was also relatively common among academic groups (67%), but these practices used teleradiology to out-of-group radiologists less than any other type of group.

These initial impressions are largely borne out in Table 4.3 below, reporting the results of a series of logistic regression models predicting the probability of using teleradiology.

Insert ***Table 4.3: Logistic regression Predicting the Use of Teleradiology (in general)*** *around here*

In order to further explicate this model, I present six prototypical fitted logistic curves in figure 4.1 below, plotting the curves only in the ranges where observations actually exist.

-insert ***Figure 4.1: Prototypical fitted logistic curves plotting the probability of using teleradiology versus size of practice*** *around here*

As these figures demonstrate, groups outside of metropolitan areas are significantly more likely to use teleradiology. Also, private groups and larger groups are significantly more likely to likely to use teleradiology. Each of these findings match the hypotheses detailed above.

These hypotheses did a worse job of predicting the findings with respect to teleradiology to out-of-group radiologists.

Insert ***Table 4.4: Logistic Regression Model predicting probability of using teleradiology to out-of-practice radiologists*** *around here*

Drawing the reader's attention to model five, one immediately notes that only two variables appear to be significantly correlated with the probability of using teleradiology to out-of-group radiologists. Academic groups appear significantly less likely to utilize teleradiology to out-of-group radiologists, but a significant interaction effect exists such that as academic practices get larger they become more likely to use teleradiology to out-of-group radiologists. These effects are demonstrated graphically in Figure 4.2.

Insert ***Figure 4.2: Prototypical fitted logistic curves plotting the probability of using teleradiology to out-of-practice radiologists versus size of practice*** *around here*

At the median private group size of ten radiologists, the fitted odds that a private group will use teleradiology to out-of-group radiologists are almost five times that of an academic group of the same size.[21] This gap closes as we estimate the use by larger groups. Due to the interaction between academic group type and group size, this model predicts that the largest academic groups grow more likely to use teleradiology to outside practices. The fitted odds that an academic group will use teleradiology to out-of-group radiologists are almost three times as great in an academic radiology group with forty-five radiologists as they are in an academic radiology group with ten radiologists.

This suggests an interesting post-hoc question - are larger academic groups significantly more likely than the very largest private groups to use teleradiology to outside groups? This is less clear than Figure 2.2 might suggest. Private groups tend to be significantly smaller than academic groups, and one must test this hypothesis for a group size at which both exist. Asking this question for groups in the largest 95th percentile of private groups - those with 45 radiologists - one discovers that private groups remain significantly more likely than academic groups to use teleradiology to out-

[21] See Appendix 4.3 for the derivation of these fitted odds.

of-group radiologists.[22] The relevant p-value is .0002 - there is about a 1 in 500 chance that one would see the usage patterns evident in the sample if there were no difference in the overall population of radiologist groups with forty-five radiologists.

The interaction effect between academic groups and size is difficult to understand until one realizes that the use of teleradiology to out-of-group radiologists includes large groups that offer their services to their smaller neighbors, as well as the use of night hawk radiology. I would suggest that the counter-intuitive interaction effect stems in part from the fact that large academic groups tend to sell radiology services. This suggestion was substantiated by interviews with radiologists from two very large academic groups, both of which offered night radiology services to outside groups.

While hypotheses i) and ii) were both verified in the models above, contrary to the first half of hypothesis iii), the logistic regression analysis found no significant correlation between spatial location and the probability of using teleradiology to out-of-group radiologists. Comparing models 5 and 6 in Table 4.4, one observes that when the interaction effect between academic groups and group size is controlled for, group location is no longer significant.

This intimates that there is some relationship between the interaction effect and group location. I explore this notion further in another set of logistic regression models, presented in Table 4.5, which estimates the probability of a group being located in a large metropolitan area. My findings suggest that not only are larger academic groups more

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[22] The technical details of the analysis are described in Appendix 4.4.

likely than other academic groups to use teleradiology to out-of-group radiologists, they are also more likely to be located outside a large metropolitan area.

Insert ***Table 4.5: Logistic Regression Model predicting probability of being located in a large metropolitan area*** *around here*

As Figure 4.3 makes clear, unlike private groups, larger academic groups are less likely than smaller academic groups to be located in large metropolitan areas.

Insert ***Figure 4.3: Prototypical fitted logistic curves plotting the probability of being located in a large metropolitan area vs. size of practice*** *around here*

The size of this interaction effect should not be overstated. Most academic groups are more likely than private groups to be located in a large metropolitan area, and even the largest academic groups are still more likely to be located in a large metropolitan area than not. This tendency is simply less pronounced in the very largest groups, perhaps because academic institutions are often located in secondary cities.

There are several potential explanations for the fact that variation in location did not correlate at a significant level with use of teleradiology to out-of-group radiologists. Later interviews called into question the statements referenced earlier by the nighthawk marketing director to the effect that small groups in large cities would be serviced by their larger neighbors. On the contrary, some small groups deliberately avoid contracting with their larger neighbors, for fear of also losing their day business to them. In fact, concerns about location and control made some potential clients of nighthawk groups actually prefer distance nighthawk groups over local groups.

Michael Farrell, a radiologist at a small Midwestern group, recounted that his group had recently been approached by a very large local group. The local group handled its own night reads, but had some excess capacity they were eager to sell to Farrell's group. Farrell's group chose not to hire them, although their night rates were so low that it would have been considerably cheaper to hire them, rather than pay their own radiologist to stay on call. However, Farrell's colleagues were concerned that if they hired the local group, the emergency room physicians might get to know the radiologists in the larger group better and eventually contract with the larger firm for their day reads as well. Thus, they chose to continue to handle their night call in order to insure their control over their group's existing business. According to Farrell, for these reasons his group is far more likely to contract with a distant nighthawk firm than a local firm.

The crudeness of the location variable hindered the ability of the model to even account for variation in location. The location variable measured only city size, to the exclusion of other aspects of location, such as region. As described earlier, interviews intimated that region would correlate with the tendency to use teleradiology to out-of-group radiologists, as some regions would tend to have more radiologists.

Interviews also suggested that regional variation existed because nighthawk groups are still so early in the process of diffusion that the clients tend to be clustered in geographic regions where the founders happened to have contacts. For instance, the founder of one nighthawk firm did his residency in New York State, and consequently, a disproportionate number of his firm's clients are clustered in the northeastern United States. Similar dynamics led to competing firms with clients clustered in the southeastern and western United States.

Interestingly, these clients do not necessarily cluster near to where either the nighthawk firms are headquartered, nor to the location of their radiologists. On the contrary, 2 out of the 3 largest firms have clusters of clients at a distance from either their headquarters or radiologists. This is true even of the firms that have most of their radiologists in the United States. While their radiologists are often geographically clustered, as word of the nighthawk firm spreads via word of mouth, these clusters of radiologists do not necessarily correspond with the clusters of clients. What then, influences where nighthawk radiologists locate? In the next section I turn to this question.

6. Spatial Location and Nighthawk Radiology

6.1 Working Where They Want: The location of nighthawk radiologists

Based on the above regression analyses I concluded that the type of city in which a group was located was not a significant variable in predicting the use of nighthawk services, at least with the admittedly crude variable these models used to measure location. In contrast, location certainly appears to matter to the radiologists who provide the night hawk services.

From the start, many of the pioneers in the nighthawk industry saw their ability to locate in distant countries as key to their competitive advantage. Difference in time zones would allow their radiologists to work during the day, while reading night reports for U.S. groups.

For many individual nighthawk radiologists, nighthawk radiology offers a vehicle to live in a location which they choose, while making the salaries of a U.S. radiologist. For instance, one Indian nighthawk radiologist returned to India after spending several years training in the U.S. and receiving her American board certifications. She spoke of her desire to have her children grow up in India,

> In terms of lifestyle here, I think it's different than [in the U.S.]. For one

> thing it's a warmer environment, so you spend a lot more time outdoors all the year round. And the communities are smaller, so unlike the suburban United States where you may not feel you have a neighbor for miles and miles, here you just step out of your house and you have friends to play with.

Similarly, a U.S. nighthawk radiologist hoped to move his family to Spain for lifestyle reasons.

> They live differently than we do in America. Live life instead of work all the time. They're real family oriented. You know, they go to work in the morning, then at 1 or 2 all the shops close and everyone goes home. Back to work at 3 or 4 then you work until eight and go out to dinner with your family... That's my dream. To get there and work for this nighthawk group.

Of course, many professionals might dream of moving to southern Spain. This radiologist, however, can make that move while keeping his job and U.S. salary, in part due to the particular way in which his nighthawk firm chooses to organize radiology work.

The firms in this study showed some range in their approach to the issue of location and communication. As mentioned earlier, while some nighthawk firms utilize an entirely decentralized model spatially, others continue to have all of their radiologists located in one or two central reading rooms. The founder of one of the centralized firms noted that she believes the face-to-face contact with other radiologists is important.

> Having radiologists reading during the day is a more long term solution. There's a collegiality to the centralized reading room that isn't there when people are doing the interpretations alone from their basement offices.

It seems clear that this founder was influenced by the traditional spatial practice of academic radiology. Historically, academic radiology groups have used precisely such a centralized reading room in order to encourage the learning and collaboration that collocation encourages.

This awareness of past radiology practices also influenced participants at more decentralized firms. They, however, argued that through the judicious use of information technology they could facilitate the same or better communication as their competitors who collocated radiologists. Their electronic communication systems created a 'virtual reading room'[23] environment which allowed their radiologists to live wherever they want, while communicating throughout their shift.

An executive at one of the firms which utilizes a more decentralized model also emphasized that spatial proximity does not automatically equate with better communication. He cited the example of a radiologist who had previously worked for a nighthawk firm with a centralized reading room, but never spoke to the radiologist sitting in the next cubicle in that firm.

It should be noted that the same tension between distributed and centralized reading rooms exists in conventional radiology groups as well. Participants noted a fair amount of variation in the types of rooms in which radiologists do their work, with academic groups tending to use more centralized reading rooms, while private groups tended to use a number of smaller reading rooms. The problem with a centralized set up, one private practice radiologist explained, is that:

> One person comes in to chat and everyone stops working. A surgeon comes in to ask another radiologist about an interpretation. Or someone starts talking about the ball game last night. Either way it becomes really hard to concentrate.

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[23]The term 'virtual reading room' is service marked by the nighthawk firm, Virtual Radiologic Consultants.

> The ideal thing is to work like a monk in a cell and just call people when you have a question. But that's not very fun.

In some respects, radiologists working for decentralized nighthawk services work precisely like those sequestered monks to which this radiologist alluded. To some nighthawk radiologists, this isolation appeared to have benefits beyond the potential of working without disturbances.

For example, the head of human relations at a nighthawk firm conceded that some radiologists would find the ten hour shifts alone difficult, but explained that those individuals were weeded out in the selection process. Further, she suggested strongly that many of the radiologists employees were drawn to her company by the potential of working alone and thus avoiding office and hospital politics. "I'd say the bulk of it is hospital politics, office politics, and the lifestyle that they can spend with their family."

One nighthawk radiologist independently brought up the issue of office politics, while noting that she occasionally missed working with other people.

> Working with other people physically, as you do in a hospital setting, adds another element of variety, that keeps it a bit more interesting. But that has its downside as well. That brings in politics … And the politics in a hospital can be severe. Politics between departments – surgeons and radiologists and everyone else. Politics within a department – different radiologists. I don't like that aspect of it. Human contact can be good is what I'm saying, but it can also be bad.

Similar sentiments were voiced by participants at other groups. The issue of office politics was often cited by participants as an attraction of nighthawk radiology. Radiologists are perceived as being at the center of several turf wars with other medical specialties. Orthopedic surgeons, cardiologists and other specialists are seen as intruding on the traditional territory of radiologists when they do their own image reading.

Radiologists, in turn, are seen by non-radiologists as intruding on other specialties. One outpatient physician casually assured me that "radiologists will rule the world," citing the way that new multi-detector CT scans performed by radiologists had replaced angiograms that were performed by cardiologists.

As in the last chapter, technology was used to change the spatial dimensions of work even for physicians who continued to work onsite. A radiologist at a large academic group expressed some ambivalence with respect to his practice's electronic reporting system. While radiologists are still in the same facility as the primary care physician, they see each other less. He thought the system tended to lead to better outcomes, but noted,

> We have suffered, because we don't get that interaction from the primary care physicians. [Previously] if one of the doctors comes by and says 'what did Mr. Jones show?' then I might say, 'by the way, I saw Mr. King two weeks ago who had something what did that turn out to be?' he says, 'oh, that turned out to be appendicitis.' [Now] I never get that feedback.

6.2 Making Nighthawk Radiology Work: Techniques and Social Practices for Working from Afar

Several participants explained the spread of nighthawk firms as a situation where the technology finally arrived to meet the pent up demand. As one nighthawk firm executive put it, "Broadband access created the capability to match the demand. The two needed each other to grow."

However the availability of the technology was not enough even with the demand for radiologists. Participants noted that many radiology departments found the idea of contracting with radiologists working hundreds of miles away "absolutely crazy" when it was first proposed. In addition to the technical and economic factors, nighthawk radiology is enabled in part by a series of social practices that compensate for the distance between the nighthawk radiologists and their client emergency room physicians.

For instance, previous to the adoption of nighthawk groups, a radiologist taking night call for a hospital from her home could be called into the hospital on those occasions when it was deemed necessary. Clearly, a nighthawk radiologist working in Australia cannot. Night hawk groups deal with these occasions by requiring their clients to keep a local radiologist on call. In addition to the relatively common occasions of technical failure, ranging from an emergency room's malfunctioning fax machine preventing them from receiving a faxed report from a nighthawk radiologist to problems with computer system interoperability, these local radiologists also prove essential in certain kinds of emergencies.

Jason Biggs, an associate at a night hawk firm, recalled a recent case where a small hospital was dealing with a large car accident and mislabeled several of the imaging studies. The nighthawk radiologists on duty realized the studies were mislabeled, but straightening out the confusion in the chaotic operating room took several hours. Mr. Biggs felt it would have been best to call in the local radiologist.

> The guy could have just walked in and immediately assigned the chart to the right patients. He could access all the information at once, hold the charts in his hands, see the time of the scans, see the patients. There's something to be said for being physically present. Get the local radiologist there and if he reads the wrong film it's his malpractice not ours. Sometimes being there is better than not being there.

Thus collocation appeared to be particularly important in non-routine situations such as this one.

Radiologists who were not in nighthawk groups also called attention to the occasional need for the radiologist to be present in person, and to the dual role of technology and social practices in dealing with these challenges. Dr. Ben Anderson, the head of the emergent radiology department at a large academic hospital, argued that the "ambient nature" of information in the emergency room was difficult to duplicate with communication technologies. He cited a situation where he might be reading one test, overhear an attending physician talking to a resident about a car accident, and have that snippet of overheard conversation inform his decisions about when to read the case and what protocols to order. When interviewed, Dr. Anderson's own group was in the midst of instituting a small nighthawk element, providing night time reads to several small hospitals in the area. In order to overcome the loss of this ambient information, he noted that they make a point of phoning every positive result to the emergency room physician.

A radiologist at a community hospital which employs a nighthawk firm for their night reads, also emphasized the importance of phone contact between radiologists and the physicians with whom they worked. He also suggested that there would always be a necessity for some radiologists to be located onsite. While he acknowledged that he rarely sees patients face to face, he noted that situations do arise where radiologists must explain their diagnoses directly to the patient. For instance, he might find something in a scan for a patient who will not see their primary care physician for a few days. In such cases, he explained:

> You have to be there. You have to talk to a patient if she has breast cancer on the mammogram. You don't call her on the phone from home and say 'you have breast cancer.' You go and talk to them and say, 'Look, there's something going on with you, with your mammogram, which needs additional investigation.'

> Technology is great but you still need, you know, person to person contact. I mean, try to put it in a nice way. Sometimes the cancer stares at you, but still, you try to tell them in a nice way. Which you can't do over the phone. And I don't think any patient would tolerate that.

He noted, however, that these issues would not come up in the night time emergency reads performed by nighthawk radiologists. Rather, he put these issues forward as part of what would keep remote radiology from becoming the norm during the day, as well.

Finally, information technology and social practices undergirded the functioning of large decentralized nighthawk firms. One of the most successful nighthawk firms uses a secure variant of instant messenger program to allow their radiologists to stay in touch with one another, as well as the headquarters, throughout their shifts, in addition to a centralized phone system through which they can connect to the emergency room doctors as necessary. Radiologists use this instant messenger program to build social relationships as well as to swap professional opinions and consult with one another about images. This technology mitigates a major problem that might have stemmed from the distant location of radiologists relative to each other.

Non-nighthawk radiologists also bore witness to the relationship between technology and social structures. The case of Phyllis Tang, a radiologist at a large academic group, is instructive. Dr. Tang took part in an abortive attempt at teleradiology from her home.

> I lived very far away, so we tried to put a station in my home, so I wouldn't have to come in every day. I still came in two days a week. Instead of 5 days a week. But there were issues. It was dependent on the cooperation of the computer PACS people, and really it wasn't their priority or interest in serving that.

After six months of unremitting technical problems, Dr. Tang gave up and moved closer to the hospital and resumed working full time shifts at the hospital. It should be noted that at the same time Dr. Tang was having enormous technical problems working about fifty miles from her hospital, nighthawk radiologists were successfully interpreting images from thousands of miles away.

7. What's Space Got to do With It? (Part II): Location and Control in Nighthawk Radiology

I previously mentioned the issue of office politics which emerged from several interviews. This notion of office politics begins to speak to the issues of power and physician autonomy around which the last chapter centered. In this section I address these themes at more length, tying this chapter into the arguments which emerged in the last chapter's analysis of outpatient physicians.

Following on the spatial structuring perspective outlined in previous chapters, I propose that the fact that radiologists have long done their work at a distance from their patients played a key role in shaping the control that they were able to exercise over the use of teleradiology applications to change their work. Due in part to their history of working remotely, radiologists were able to exert control over their remote work, both as individuals exercising autonomy in their work, and as a profession, exerting control throughout a series of institutions and regulations.

To further illustrate this point, one might ask: what work can be done remotely? For outpatient physicians the work that can be done remotely - documentation and remote contact with their patients - is definitely not perceived as their core work. However, in the case of radiologists, they can do their core work of interpreting images remotely.

While this implies the capacity of offshoring to threaten the heart of their work, it also appeared to allow radiologists to bring the full weight of their professional status to bear on controlling the use of information technology to do this work remotely.

7.1 Autonomy and Remote Work

Radiologists who work from home appeared to be very different from the disenfranchised and stressed teleworkers that have emerged from past studies of telework (Gurstein 2001). I found that for those radiologists who work from their home, working from afar has led to feelings of additional autonomy. Dr. Ann Francis mentioned this sense of autonomy when asked why she chose to start working for the nighthawk firm.

> It's almost like I'm working for myself. Like I'm self-employed… I'm pretty much just doing my own thing. That's why I started this – a combination of money and lifestyle.

Part of these feelings of autonomy may come from the complete control they exercise over the physical space of their work. Nighthawk radiologists who worked from home had put a good deal of thought and expense into making their work stations comfortable, attempting to mitigate the physical intensity of a long session of computer use. Some participants choose to work from a recumbent position, using reclining chairs with lumbar support, along with a foot stool to mitigate the circulation problems attendant with long periods of time sitting. The monitors are suspended over the seat, so the radiologist can lie back as she interprets images, placing as little weight as possible upon her spine.

Some of the benefits of autonomy appeared to come directly from the distance from other physicians. One nighthawk doctor working from home had recently left a partnership under very bitter terms with his former partners. When explaining why he did not mind working nights, he remarked that for him working alone was an advantage. He went on to explain,

> I actually like it. I sit there in my little study. I look out the window at the mountains. I have a little television on in the corner. If I get hungry, I go to the kitchen and make myself a sandwich. I have a weight machine in the basement and I go lift weights if I get tired. It's quite enjoyable. Radiologists are a weird breed. Financially we do well, but it breeds greed. In the hospital everyone can just be trying to work as much as you possibly can. This - you can pace yourself.

The notion of "pacing" himself runs throughout this passage, as he relishes the ability to eat when he chooses, and to exercise when he chooses.

There is another side, however, to this radiologist autonomy and lack of office politics. A corollary of self-control is a lack of control by others. Office politics plays a useful role in enforcing common norms within an office. With the dissipation of office politics, comes a dissipation of the enforcement of norms. A nighthawk radiologist displeased by the behavior of another radiologist at the firm, had no mechanism of communicating their displeasure. Nor are the executives seen as having the power to significantly chasten the radiologist employees, in part because they are so remote in time and space from the workers. One nighthawk teleradiologist commented.

> I just don't think he [the executive] is in a position to do much. He can write people a nasty letter, and say 'look this is the way we've been doing it, and you should do it that way as well.' The fact is, he goes to bed at night. He's not there working with us. So he doesn't know what goes on unless I say something to him.

Given this lack of control, professional norms are more important than ever. Past research has called attention to the importance of socialization and trust (O'Leary et. al. 2002) as well as the role of anticipated group longevity (Walther 2002) in controlling spatially distributed work teams. The radiologist quoted above went on to explain that despite his annoyance with the some of his colleagues, he would never simply ignore a question they posed to him, saying, "You don't want to leave them twisting in the wind either. If they're really in a tough spot."

In response to the question of why radiologists would help one another when they had a fiscal incentive to read their own tests quickly, executives at the decentralized nighthawk groups stressed the importance of hiring the right people. One executive explained that not only must their radiologists,

> have good training and come with great references… They have to have some interest in being part of a group. Because no matter what - nobody is a specialist in everything. They're going to need to ask someone else their opinion on something else. And you know - it kind of evens out.

I would suggest that part of what allows decentralized nighthawk businesses to function are the powerful professional norms inculcated in radiologists through their lengthy training process. Radiologists were already accustomed to both working cooperatively and working from a distance - the former from training in centralized radiology reading rooms and the latter from working from offices at a distance from the referring physician and patients, including offices located in their homes. These historic spatial practices shaped the way that nighthawk radiologists worked from home, with participants continuing to help their peers when asked, despite fiscal incentives to read as many tests as they could.

7.2. Controlling Nighthawk Radiology

As a profession, radiologists also exerted control over the use of teleradiology through a variety of regulations and institutions. It is difficult to overemphasize the importance of political and institutional factors in shaping the ways that nighthawk groups have evolved. Several different types of regulation shield U.S. radiologists from an influx of virtual foreign competitors. One of the most important is the perception that all reads - wet or dry - that inform medical treatment in the United States can legally only be done by radiologists licensed in the state and credentialed in the hospital where they will be informing treatment. While the precise laws governing teleradiology are likely to remain unclear until regulations are rewritten to explicitly incorporate the new practices of teleradiology or until the practice runs afoul of malpractice litigation, participants widely expressed a belief that all reads that informed medical treatment, *including preliminary or wet reads,* had to be done by radiologists who were licensed in the state and credentialed at the hospital where the treatment was taking place.

Even for a firm employing only United States trained radiologists, the licensing and credentialing process is no small process. A large nighthawk firm must get and keep its radiologists licensed in dozens of states and credentialed at hundreds of hospitals. To give a sense of the magnitude of this task, the largest nighthawk firms in this study employed around fifty radiologists and had 15-25 employees who did nothing but manage the credentialing and licensing processes.

Emily Beckerson was in charge of this process at one nighthawk firm. She estimated that it took roughly five hours to get a single state license for a radiologist and approximately the same for a hospital credential. Given the number of hospitals and states at which the average radiologist is licensed, this comes to something like 260 hours, or about six and a half weeks of employee work, to get each radiologist fully licensed and credentialed.

Radiologists at the client sites control the credentialing processes. A typical credentialing process, for instance, will require applicants to prove their expertise to the satisfactions of radiologists at the accrediting organization. Often, this involves a face to face interview where the applicants meet with a radiologist at the client site.

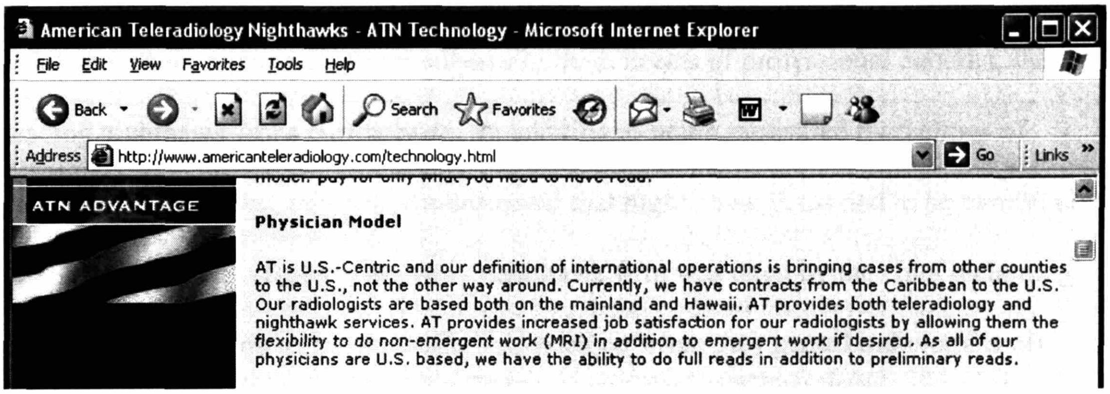
The complexity of the process entails several different economies of scale for a nighthawk firm. A larger firm get more expertise in the credentialing and licensing process. Beyond this, the more clients they have in each state, the fewer licenses they must get for each radiologist. For instance, if a firm has a dozen client hospitals in Massachusetts, they can keep several radiologists fully occupied with Massachusetts reads, mitigating the need to license them in other states.

Another important economy of scale comes to the larger nighthawk groups which are able to get themselves accredited as credentialing institutions through the Joint Commission on the Accreditation of Healthcare Organizations (JCAHO). Although this accreditation process is itself time consuming, it allows them to avoid the lengthy credentialing process of any of their clients who will accept reciprocity with their JCAHO approved credentials, as the JCAHO credentialing process serves in lieu of the client's own process.

In addition to licensing and credentialing, getting malpractice insurance is a major institutional hurdle for a nighthawk firm. Given the novelty of their business model, and the uncertainty of the risk involved, there is no standard model of how to set premiums for nighthawk companies. As a result, nighthawk groups can be very secretive about the source of their malpractice insurance, to the extent that some nighthawk radiologists were not even told the source of their own insurance.

Several respondents also cited the importance of Medicare regulations that disallow payments to radiologists working outside of the United States. These regulations were often portrayed as the reason that out-of-country radiologists are typically asked to do wet reads, rather than dry reads. Medicare regulations only allow hospitals to bill for services provided within the United States. By preserving the dry read for the client practice, they are assured that they can bill Medicare.

However, it is important to be cautious before accepting such explanations at face value. In one published study, Yale University successfully stationed one of its radiologist in Bangalore, India (Kalyanpur et. al. 2003). The Yale radiologist was able to do dry reads as well as wet reads, through the simple expedient of the group segregating Medicare cases and only sending the overseas radiologist non-Medicare studies to interpret. Given that ability, it seems clear that there is more than simply Medicare regulations shaping the practice of wet reads. Also, as noted above, there are many nighthawk radiologists located within the United States -- this could be seen as a competitive advantage for their company, as they could perform dry reads as well as wet, if their clients chose. In fact at least one of the smaller nighthawk companies has tried marketing itself in precisely this way. As the screen shot shows, this agency stresses the stateside location of its radiologists both as a matter of patriotism, with the red and white stripes flowing in the background, and as a matter of business, offering the ability to do full reads.



Given the widespread capability to do dry reads, the fact that the vast majority of reads continue to be wet reads seems to be the result of the desire of the client radiologist groups to protect their prerogatives. As one overseas nighthawk radiologist put it,

> I think they feel like they retain the ultimate control by coming in the next day and doing the final read themselves. It's not like they're giving away a portion of their practice. They're still holding onto the whole practice. They're just giving away a part of the call.

Thus, it is not simply a matter of radiologists being effected willy-nilly by regulations. They are powerful participants in the use of teleradiology, with nighthawk radiologists very sensitive to the opinion of their peers. This power operates directly, through the direct interactions between nighthawk and conventional radiologists, as well as indirectly through the credentialing and licensing processes which are generally controlled and monitored by radiologists.

Currently the largest and most successful nighthawk services make a point of contracting directly with the radiology departments themselves. Dr. James Shoroplav was typical in his explanation.

> We talk to the radiologist, and we will not proceed if the radiology group in the hospital will not say 'yeah we want to go ahead.' Because we are radiologists, at least the founders are radiologists, and we will not go behind the group to underbid their services to hospitals.

While not every nighthawk group adheres to these norms of professional conduct, the leading nighthawk firms currently do. In addition to being motivated by feelings of professional solidarity, other executives noted that night hawk firms had to be careful not to alienate potential clients. One early nighthawk firm was cited by the chief technology officer at another firm as having really "screwed up when they pissed radiologists off," by overly aggressive expansion tactics. Its competitors had learned the lesson that they ought to be certain to avoid making conventional radiologists feel threatened. Thus, even the practice of wet reads, allegedly driven by Medicare policy, can also be understood as a means to avoid threatening the control client groups feel over their practice.

Some of the control exercised by radiologists is enabled by the difficulty in measuring the quality of image interpretation. The quality of the interpretation of a radiological image is a very difficult thing to measure. Nighthawk groups which keep their radiologists licensed and credentialed in a dizzying array of jurisdictions are signaling that their radiologists are high quality. Similarly, when radiologists at client groups finalize all nighthawk reads when they arrive in the morning, they are assuring themselves of the quality of the service nighthawk groups provide. One client radiologist commented, "they do a pretty good job. We haven't found anything obvious that was missed." According to this participant, when a report had to be amended, it was generally not that something important had been missed, but that "the report was not as clear or concise" as it could have been.

In this section I have illustrated the power U.S. radiologists have wielded over the use of teleradiology to change their work. I have suggested that their past spatial practices - especially their longstanding practices of reading images remotely and mediated by technology made radiologists very comfortable in exerting power over the particular form taken by nighthawk radiology. However, given the rapid flux in the industry, what might the future hold?

7.3 A Future Threat?

Social and political pressure have convinced some nighthawk groups to shift their operations to the United States. One nighthawk executives explained delicately that, in light of the political climate towards outsourcing, it seemed "a little bit tenous if you decide to put a radiologist outside of United States soil." In addition to the opinion of radiologist clients, they worried about laws being passed which might reduce the outsourcing of American data and jobs. As I write, Congress is considering legislation that would restrict the ability to send medical information overseas altogether (Wiley 2005).

However, there continues to be a good deal of concern in the field about the potential damage that exporting radiology reads might do to the U.S. profession in the future (Featherly 2004). One radiologist participant at a large academic hospital was leading a tentative investigation into the potential of sending images overseas for interpretation and found himself receiving hate mail from other radiologists who felt such moves threatened their jobs. It is certainly conceivable that the current situation will change to the detriment of radiologists. With diagnostic imaging one of the fastest growing physicians services in the United States (Butcher 2004,) and scanning costs Medicare's fastest growing item (Armstrong 2005,) one would expect there to be continued price pressure from payers to reduce rates. This, in turn, may translate into continuing pressure to buy tests from foreign radiologists who are not U.S. trained, and so, are significantly cheaper than the handful of U.S. trained and certified foreign radiologists currently employed by nighthawk firms.

One nighthawk executive noted that about 5% of the images that his company interpreted were being done as dry reads and he expected that to increase. Other nighthawk firms are also beginning to market their ability to do dry reads both during the night shift and during the day. This shift might be seen as radiologists relinquishing control over their night work. Dr. James Thrall, the radiologist-in-chief at Boston's Massachusetts General Hospital addressed the prospect at the most recent annual meeting of the Radiological Society of North America (RSNA). Dr. Thrall acknowledged that "under the control of radiologists to improve their practices, globalization may be all right," but he worried that the use of nighthawk groups might ultimately undercut radiology's professional standing, as hospital administrations learn that "radiology coverage can be accessed easily through outsourcing" (Thompson 2004). Such concerns are increasingly common in the radiology press (Wiley 2005).

However as long as norms and regulations insure that only U.S. radiologists are doing reads it would appear that the status and income of U.S. radiologists will remain protected. Only if the situation changes such that U.S. radiologists are forced to compete with foreign radiologists, will their status seriously be threatened. Given the widespread uncertainty about the quality of foreign radiologists, in addition to the current regulatory regime, such changes are unlikely in the near future. In fact the reverse seems more likely, with Congress currently considering legislation that will make it more difficult even for U.S. trained radiologists to read from overseas.

What accounts for this difficulty in hiring overseas radiologists? Radiologists work with information that is easily digitized, but it is difficult to evaluate the quality of their decisions. Several participants made comments to the effect that radiology was as much an art as a science. To some degree it is precisely this uncertainty that undergirded the creation of the medical profession as a whole. As Grumbach (2002) points out, "professionalism developed not just as an anticompetitive strategy but in response to legitimate societal concerns about competence and quality with an unregulated health care workforce." Without any clear mechanisms to evaluate the quality of foreign radiologists, U.S. radiologists will continue to control the use of teleradiology to offshore radiology work.

Even if foreign radiologists could be certified to read U.S. tests, I would propose that short term change is unlikely. Abbott considers precisely this point in his discussion of the long run and professional power. He posits that market forces, or what he terms "equilibrating forces" will prevail over professional power in the long term, but that the validity of this position depends upon the definition of 'long term' (Abbott 1988, 135). He argues that while workplace change can take place over a 2-3 year period, changes that require modifications of existing laws will take between 20 and 50 years to take place. Given the network of laws, institutions and regulations that govern the reading of radiology tests in the United States, this would suggest that any major change is some years away.

8. Conclusion

I began this chapter by restating my central argument - that the ways professionals work in space both shape and is shaped by their use of technology. The second part of this statement is clear in the very existence of night hawk groups -- the capacity of radiologists to work in night hawk groups thousands of miles distant to their client hospitals is shaped and enabled by information technology.

The first part of this statement is more subtle, but in this chapter, I have shown that the ways in which radiologists worked in space prior to the creation of nighthawk groups, shaped the use of teleradiology to create these groups. For instance, one nighthawk firm used information technology to retain a centralized reading room, simply moving it to Sydney to take advantage of time differences, while another used information technology to set up a 'virtual reading room' for its distributed network of radiologists. Both were clearly influenced by the reading room typically used in conventional radiology groups, with the former adhering to the centralized model typical of academic practices and the latter conforming to the distributed, but connected, model typical of private practices.

In this chapter, I have also illustrated the extent of the control radiologists have exercised over the use of teleradiology to change their work. While radiologist are now able to work from virtually anywhere in the world, the reading of radiology tests continues to be a highly regulated affair. Radiologists are highly influential, both in the regulation of the traffic in radiology tests, and as actors in the nighthawk radiology industry. At least two preconditions appear fundamental to the twin dynamics of control and the relocation of radiology work: i) the information that radiologists use is easily digitized (and so relocated); ii) the work tasks that radiologists perform are highly complex and uncertain, and so, it is difficult to monitor the performance of foreign radiologists. However these alone do not account for the control radiologists have exercised over the use of teleradiology.

I have argued that the control radiologists exercised over the nighthawk industry stemmed in part from the prior spatial practices of radiologists. The fact that they were already performing remote readings as their core work - the focus of their accumulated professional expertise - made radiologists immediately alive to the potential benefits and dangers of teleradiology use. They were not only protecting their jobs from offshoring, but protecting their patients from low quality radiology reads - quality that they, and only they, were qualified to assess. This lent their efforts to shape the uses of teleradiology the full moral authority and power of their professional status, with the results outlined above.

Throughout the last two chapters, I have occasionally alluded to the relationship between time, space and the use of information technology. In the next chapter I pick up this discussion in more depth, turning now to a discussion of time at work.

Chapter 4: Tables and Figures

Table 4.1. Location of Radiology Groups (N=1231)

Location	Percent of total practices	Percent in location that use teleradiology	Percent in location that use teleradiology to out
Large Metropolitan Area (pop >1,000,000)	47%	75%	12%
Small Metropolitan Area (50,000<pop<1,000,000)	38%	80%	16%
Non-metropolitan Area (pop<50,000)	16%	86%	20%
Entire Sample	100	79%	15%

* Due to rounding this column adds up to 101 %.

Table 4.2. Type of Radiology Groups (1231)

Location	Percent of total groups	Percent of type that use teleradiology	Percent of type that use teleradiology to out
Private Practice	73%	85%	15%
Academic Practice	16%	67%	10%
Solo Practice	5%	49%	16%
Government Practice (e.g. military or VA)	3%	64%	14%
Entire Sample	3%	79%	15%

Table 4.3: Logistic Regression Model Predicting Probability of Using Teleradiology (N= 1186)

	M0	M1	M2	M3
Intercept	1.33	1.16***	.86***	1.36***
SMALLCITY		0.21	.28~	0.12
NOCITY		.64**	.86***	1.07***
SIZE			.02**	.02**
ACADEMIC				-1.16***
SOLO				-1.92***
LOCUM				-1.72***
GOVERNMENT				-1.06**
Sensitivity (at prob=.60)	0	16.8	32.6	67.9
Specificity (at prob=.60)	100	89.5	75.8	61.1
-2 Log Likelihood	1216.29	1207.83	1178.31	1096.04

Key: ~p<0.10; *p<0.05; **p<0.01; ***p<0.001 (Wald statistics)

Table 4.4: Logistic Regression Model Predicting Probability of Using Teleradiology to Out-of-Group Radiologists (N=1151)

	M0	M1	M2	M3	M4	M5
Intercept	-1.79***	-1.931***	-2.093***	-2.062***	-2.042***	-1.778***
SMALLCITY		0.171	0.189	0.133	0.131	0.035
NOCITY		.438~	.559*	.48~	.497*	0.305
SIZE			.008~	.01*	.013*	-.001
ACADEMIC				-.704*	-.709*	-1.854**
SOLO				0.145		
LOCUM				0.151		
GOVERNMENT				0.091		
ACADEMICxSIZE						.035**
Sensitivity (at prob=.1447)	100	58.7	36	46.3	48.2	48.2
Specificity (at prob=.1447)	0	47.6	66.5	57.8	59.7	48.1
-2 Log Likelihood	958.54	955.03	936.51	929.87	930.11	919.66

Key: ~p<0.10; *p<0.05; **p<0.01; ***p<0.001 (Wald statistics)

Note:
Reference group is private practice in large metropolitan area. All interactions involving main effects tested, but only significant effects displayed.

Table 4.5: Logistic Regression Model Predicting Probability of Being Located in a Large Metropolitan Area (population > 1,000,000) (N=1169)

	M1	M2	M3	M4
Intercept	-.61***	-.64***	-.93***	-.91***
SIZE	.03***	.02***	.04***	.04***
ACADEMIC		.95***	2.17***	2.16***
GOVERNMENT		1.22**	1.35**	1.33**
LOCUM		-1.65**	-1.50*	-1.51*
SOLO		-.15	0.12	
ACADEMICXSIZE			-.05***	-.05***
Sensitivity (at prob=.403)	71.6	67.7	63.1	63.1
Specificity (at prob=.403)	42.3	58.8	65.7	63
-2 Log Likelihood	1550.18	1497.95	1462.31	1462.47

Key: ~p<0.10; *p<0.05; **p<0.01; ***p<0.001 (Wald statistics)

Figure 4.1: Prototypical fitted logistic curves plotting the probability of using teleradiology versus size of group

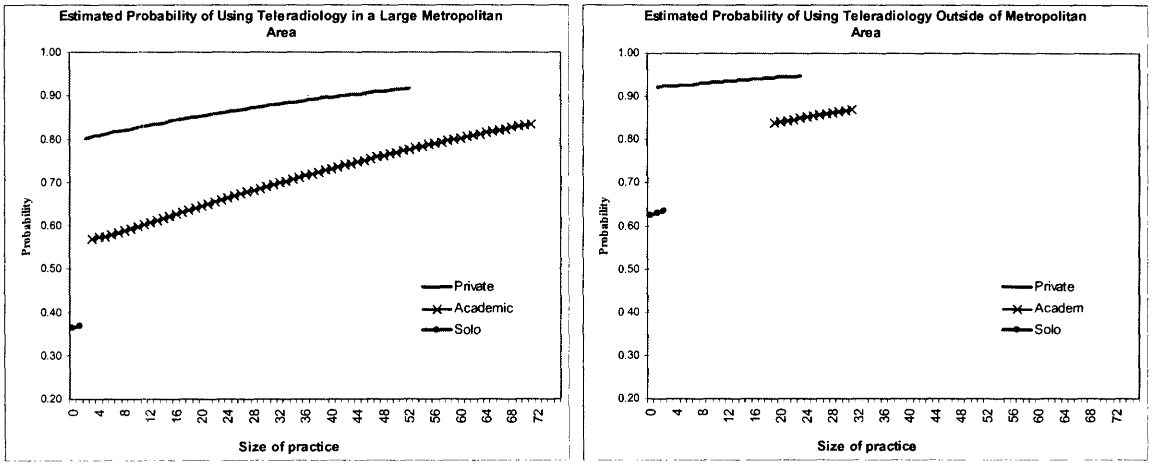


Figure 4.2: Prototypical fitted logistic curves plotting the probability of using teleradiology to out-of-group radiologists versus size of group

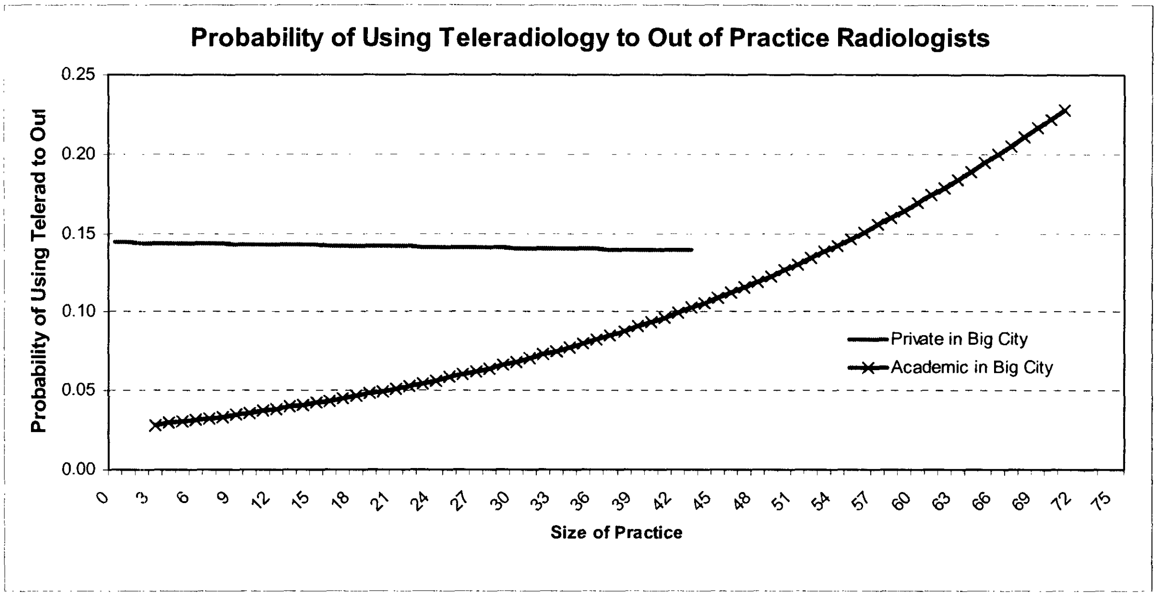
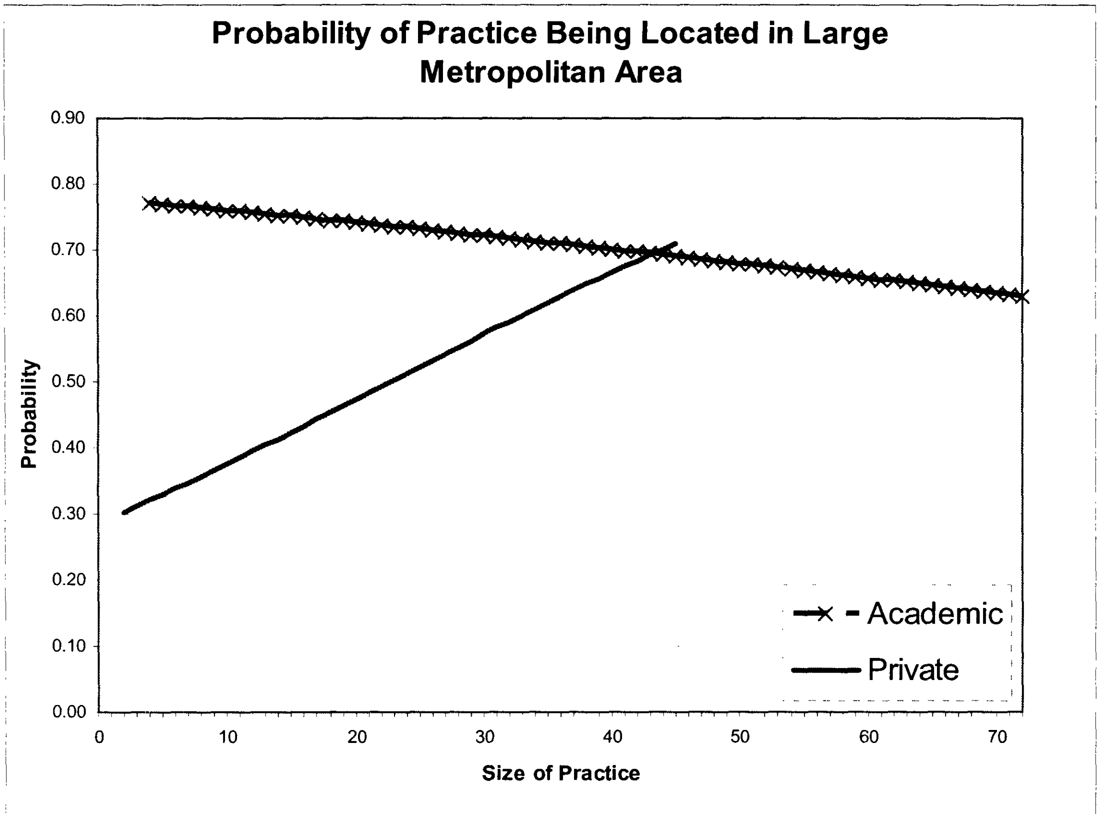


Figure 4.3: Prototypical fitted logistic curves plotting the probability of being located in a large metropolitan area vs. size of group



Chapter 4 - List of Appendices

Appendix 4.1: Description of Variables

Table 4.1.1 Variable Descriptions

Variable Name	Description
SMALLCITY	a dichotomous variable that takes on a value of 1 if the radiologist works in a metropolitan area with a population between 50,000 and 1,000,000 and a value of 0 otherwise
NOCITY	a dichotomous variable that takes on a value of 1 if the radiologist works in a metropolitan area with a population of less than 50,000 and a value of 0 otherwise
SIZE	Number of full time radiologists working in radiologist's main practice
SIZE_2	SIZE variable squared
ACADEMIC	a dichotomous variable that takes on a value of 1 if the radiologist works in an academic practice and a value of 0 otherwise
SOLO	a dichotomous variable that takes on a value of 1 if the radiologist works in a solo practice and a value of 0 otherwise
LOCUM	a dichotomous variable that takes on a value of 1 if the radiologist does contract work and a value of 0 otherwise
GOVERNMENT	a dichotomous variable that takes on a value of 1 if the radiologist works in a government practice and a value of 0 otherwise
ACADEMICXSIZE	an interaction variable between SIZE and ACADEMIC
SOLOXSIZE	an interaction variable between SIZE and SOLO
LOCUMXSIZE	an interaction variable between SIZE and LOCUM
GOVERNMENTXSIZE	an interaction variable between SIZE and GOVERNMENT

Appendix 4.2: Treatment of Categorical Variables

The statistical models detailed in this chapter involve two categorical variables - the variables describing the type of practice and the size of city. In this appendix I explain and justify the respective transformations applied to these categorical variables

Table 4.2.1 - Distribution of Participants by Practice Type (N=1266)

Group Type	Number	Percentage
Private Radiology	515	41%
Private MultiSpecialty	357	28%
Academ	194	15%
Solo Practice	66	5%
Locum	47	4%
Government	39	3%
Other	48	4%

Table 4.2.2 - Distribution of Participants by Practice Location (N=1260)

Location of Group	Number	Percentage
Big City - Main	347	28%
Big City - Suburbs	231	18%
Small City - Main	374	30%
Small City - Suburbs	88	7%
Non - City	191	15%
Other	29	2%

As Table 4.2.1 demonstrates, in the case of practice type the two practice types with the largest number of radiologists were private multi-specialty practices (29%) and private radiologist practices (41%). Exploratory regression analysis showed that the participants in these two types of practices exhibited similar behaviors in terms of hour worked, size of practice and use of teleradiology technology. Thus I chose to merge these types and use these as the referent case for practice type.

Similarly, in the case of practice location I merged the categories for big city and suburbs into one 'BIG' variable and the categories for small city and suburb into one 'SMALL' variable. Rather than group very different types of suburbs together, I chose to merge all large metropolitan areas. This creates a broader variable, but a more consistent one. Ideally, city size would be a continuous variable, but this dataset was collected by an association of radiologists, and so, was not as concerned with geographic location as much as other attributes of the radiologists they surveyed. By amalgamating location into three broadly defined development types, I also deal with the ambiguous undefined nature of "area" in the question.

I deleted the cases categorized as "other" for both variables, due to uncertainty about the content of these cases.

Appendix 4.3: Calculating the Fitted Odds of Using Teleradiology to Out-of-Group Radiologists

My final logit model M5 can be generalized as follows to estimate the probability of using teleradiology to out-of-group radiologists for radiologists located in a large metropolitan area (only significant effects are included):

$$\hat{p}(teleradout = 1) = \frac{1}{1 + e^{-(-1.78 - .001SIZE - 1.84ACADEMIC + .035ACADEMICXSIZE)}} \quad (1.0)$$

Thus, one can estimate the probability of using teleradiology to an out-of-group radiologists at a private practice as follows:

$$\hat{p}(teleradout = 1) = \frac{1}{1 + e^{-(-1.78 - .001\,SIZE\,)}} \quad (2.0)$$

For an academic practice the fitted probability can be written as :

$$\hat{p}(teleradout = 1) = \frac{1}{1 + e^{-(-1.78 - 1.85) + (.035 - .001)SIZE)}} \quad (3.0)$$

This can be simplified to:

$$\hat{p}(teleradout = 1) = \frac{1}{1 + e^{-(-3.63 + .034SIZE)}} \quad (3.1)$$

Estimating the probability of using teleradiology to an out-of-group radiologist at the median private practices size of 10 we find for a private practice:

$$\hat{p}(teleradout = 1) = \frac{1}{1 + e^{-(-1.78 - .001*10)}} = 0.14 \quad (4.0)$$

The probability that that same practice doesn't use teleradiology is .86. Dividing .14/.86= .17. Thus, when a radiologist works for a private practice with ten radiologists, the fitted odds that that they will use teleradiology to out-of-group radiologists is .18 times the fitted odds that they will not use it. Alternately, the fitted odds that they will *not* use teleradiology to out-of-group radiologists is six times the fitted odds that they will use it.

Turning to an academic practice in the same sort of city with the same number of radiologists, one finds

$$\hat{p}(teleradout = 1) = \frac{1}{1 + e^{-(-3.62 + .034 * 10)}} = 0.04 \qquad (5.0)$$

Through a parallel process, I find that when a radiologist works for an academic practice w/ ten radiologists, the fitted probability that that they will use teleradiology to out-of-group radiologists is .4 times the fitted probability that they won't use it. Alternately the fitted probability that they will *not* use teleradiology to out-of-group radiologists is 27 times the fitted probability that they will use it.

Comparing these ratios (.18/.4), I find that the fitted odds that a private practice with ten radiologists will use teleradiology to an outside practice versus not, is 4.5 times the fitted odds of that for an academic practice with the same number of radiologists. Thus, my statement that private practices are almost five times as likely as academic practices to use teleradiology to out-of-group radiologists at their median practice size of ten.

One can make the same calculation for practices with 45 radiologists, finding respectively for private and academic practices that:

$$\hat{p}(teleradout = 1) = \frac{1}{1 + e^{-(-1.78 - .001 * 45)}} = 0.14 \qquad (6.0)$$

$$\hat{p}(teleradout = 1) = \frac{1}{1 + e^{-(-3.62 + .034 * 45)}} = 0.11 \qquad (7.0)$$

Going through the same set of calculations, one finds the fitted odds that a private practice with 45 radiologists will use teleradiology to an outside practice versus not is .16, while the fitted odds that an academic practice with 45 radiologists will use teleradiology to an outside practice is .12. The odds are still greater for the private practice, but clearly the difference between the two has greatly diminished.

Appendix 4.4 Testing the post-hoc question: Are large academic practices as likely as large private practices to use teleradiology to out-of-practice radiologists?

In Figure 4.2 it appears that large academic practices and large private practices have the same probability of using teleradiology to out-of-practice radiologists. To test this post-hoc hypothesis we consider the hypothesized logistic model:

$$\log\left[\frac{p}{1-p}\right] =$$

$$B_0 + B_1 NOCITY + B_2 SMALLCITY + B_3 SIZE + B_4 ACADEMIC + B_2 ACADEMICXSIZE \quad (1.0)$$

Consider an academic practice in a large metropolitan area with 45 radiologists (placing it in the 95th percentile of private practices in terms of size):

$$\log\left[\frac{p}{1-p} | ACADEMIC = 1; SIZE = 45; NOCITY = 0; SMALLCITY = 0\right] =$$

$$B_0 + 45\,B_3 + B_4 + 45\,B_5 \quad (2.0)$$

Whereas for a private practice with the same number of radiologists in the same city:

$$\log\left[\frac{p}{1-p} \mid ACAD = 0; SIZE = 45; NOCITY = 0; SMALLCITY = 0\right] = B_0 + 45B_3 \quad (3.0)$$

Thus, the difference between the two can be described as:

$$\Delta p : B_4 + 45B_5 \quad (4.0)$$

Which can be rewritten as:

$$\Delta p : B_{ACADEMIC} + 45B_{ACADEMICXSIZE} \quad (5.0)$$

The null hypothesis - that there's no difference between private and academic practices at that range would set this expression equal to zero:

$$B_{ACADEMIC} + 45B_{ACADEMICXSIZE} = 0 \quad (6.0)$$

Using the "test" statement in the logit function of SAS 9.0, I reject this null hypothesis with a chi square of 14.08 and a p value = 0.0002.

I conclude that in the population of radiologists there is a very small chance that similar sized private and academic practices have the same tendency to use teleradiology. Rather, even very large private practices are more likely to use teleradiology than academic practices of the same size. Only in a range in which private practices don't exist do academic practices begin to use teleradiology to a greater extent.

Appendix 4.5 Outlier analysis of logistic regression models

An initial analysis predicting the use of teleradiology to out-of-group radiologists found several significant interaction effects relating to radiologists who worked for solo practices. This model is displayed in Table 4.5.1 as the "Final" model.

Table 4.5.1: Outlier analysis of logistic regression model predicting the use of teleradiology to out-of-group radiologists

	Final	M1*	M2*	M3*	M4*	M5*
Intercept	-1.686***	-1.686***	-1.686***	-1.686***	-1.772***	-1.758***
NOCITY	0.058	0.058	0.058	0.059	0.242	0.286
SIZE	-.004	-.004	-.004	-.004	-.001	-.001
ACADEMIC	-1.932**	-1.932**	-1.932**	-2.045**	-1.853**	-1.869**
SOLO	-3.536*	-4.487*	-23.168	-3.536*		
SOLOXNOCITY	2.996*	2.613*	12.736	2.995*		
ACADEMICXSIZE	.038**	.038**	.038**	.041**	.035**	.036**
SOLOXSIZE	1.246*	2.478~	11.176	1.246*		
Sensitivity (at prob=.1505)	48.2	47.9	47.8	47.9		23.8
Specificity (at prob=.1505)	47.4	47.4	47.5	47.4		84
-2 Log Likelihood	907.08	904.2	895.67	903.76	908	919.7
Removed Observations:	None	2 largest solo	7 largest solo	2 largest academ	7 largest solo	None
Key: ~p<0.10; *p<0.05; **p<0.01; ***p<0.001						

As Table 4.5.1 makes clear, at first there appeared to be a significant interaction between SOLO and both size and location variables in predicting the use of teleradiology to out-of-group radiologists. These effects, however, relied heavily on a handful of unusual responses. Of the sixty-three respondents who reported working in solo practices, seven of them reported that more than one full time radiologist was employed by their practice: one reported 3, one reported 4, and five reported 2. (Solo practices have one radiologist owner, but they might employ more than one radiologist.)

When these seven observations were eliminated, the significance of being in a solo practice was eliminated. For this reason, I removed the interaction effects involving SOLO from the summary table displayed in the text. However, comparing Model 4* to Model 5*, it was clear that eliminating those seven observations from the analysis did not appear to have an effect on the other parameter estimates, and so I chose to report Model 5* which includes those observations.

A similar analysis was applied to the logistic regression model predicting practice location to insure that the finding that larger academic practices tended to be located outside of large metropolitan areas did not depend on a few observations. While five out of the seven largest academic practices are located in small cities, eliminating these five observations, did not change the findings of this model -- large academic practices remained significantly more likely to be located outside of large metropolitan areas.

Appendix 4.6 American College of Radiology 2003 Survey of Radiologists

American College of Radiology

2003 Survey of Radiologists

Person who filled out survey: ____

Phone Number(s): ____

All responses to this ACR research survey will be kept strictly confidential. This identifying cover sheet will be detached and destroyed once the information you provide has been checked for completeness.

To enhance confidentiality, your responses are being processed by the

Center for Survey Research
University of Virginia
P.O. Box 400767
Charlottesville, VA 22904-4767

If you require additional space for any question, please attach a separate sheet of paper and indicate the number of the survey question.

Thank you for your participation.

1. Is our information correct that your main field is, or was, diagnostic radiology, nuclear medicine, and/or interventional radiology, or subspecialties of these?

☐ Yes ☐ No → ***If "No," STOP HERE and return the questionaire. Thank you.***

2. Are you board-certified in diagnostic radiology or radiology (or earlier, similar designations) by the ABR or other relevant boards such as the Canadian or AOBR?

☐ Yes ☐ No ***(Go to Question 4)***

3. Do you have a CAQ or a "special competence"?

☐ Yes ☐ No

3a. ***If "Yes": (Mark all that apply)***
- a. ☐ Pediatric Radiology
- b. ☐ Neuroradiology
- c. ☐ Vascular and Interventional Radiology
- d. ☐ Nuclear Radiology
- e. ☐ Body Imaging (AOBR)

4. Are you currently: ***(Mark only one)***
- 1. ☐ In residency training → ***(Go to Question 7)***
- 2. ☐ In fellowship training → ***(Go to Question 7)***
- 3. ☐ Working full-time in radiology
- 4. ☐ Working part-time in radiology
  - → 4a. ***If "part-time," % Full-Time Equivalent:*** ____
- 5. ☐ *Temporarily* not working in radiology → ***(Go to Question 6)***
- 6. ☐ *Permanently* not working in radiology → ***(Go to Question 6)***

5. ***If "working full-time in radiology" or "working part-time in radiology,"*** would you eventually like to: ***(Mark all that apply)***
- a. ☐ Keep working full-time in radiology, never retire
- b. ☐ Change careers → 5a. ***At what age?*** ____
- c. ☐ Go part-time before retiring → 5b. ***At what age?*** ____
- d. ☐ Fully retire → 5c. ***At what age?*** ____

5d. Is the current economy affecting your future work plans?

☐ Yes ☐ No

5e. ***If "Yes," how?:*** ____________________

5f. Have you returned to work full- or part-time after being retired?

☐ Yes ☐ No

If you answered any part of Question 5, Go to Question 7.

6. ***If "temporarily not working in radiology" or "permanently not working in radiology,"*** please give main reason: ***(Mark only one)***
- 1. ☐ Working, but not in radiology
- 2. ☐ Raising children
- 3. ☐ Caring for other family member(s)
- 4. ☐ Deliberately taking time off
- 5. ☐ Involuntary unemployment
- 6. ☐ Disabled
- 7. ☐ Retired
- 8. ☐ Other, ***specify:*** ____________________

If "fully retired" complete the following, otherwise Go to Question 7:

6a. Year you last worked in radiology before full retirement:

19 ____ / 20 ____

6b. Did you work part-time for a period before full retirement?

☐ Yes ☐ No

6c. ***If "Yes," # of years part-time before full retirement:***

____ ***# yrs.***

6d. Would you consider returning to radiology part-time?

☐ Yes ☐ No

6e. Has the current economy influenced your retirement decision(s)?

☐ Yes ☐ No

7. After completing your residency, did you, or will you, take a fellowship?

☐ Yes ☐ No ***(Go to Question 8)***

7a. Principal fellowship field? ***(Mark only one)***
- 1. ☐ Abdominal Imaging
- 2. ☐ Body Imaging/Cross-Sectional Imaging
- 3. ☐ Breast Imaging/Mammography
- 4. ☐ Cardiac/Cardiovascular Imaging
- 5. ☐ Chest (Thoracic) Imaging
- 6. ☐ CT
- 7. ☐ Emergency and Trauma Radiology
- 8. ☐ Gastrointestinal Radiology
- 9. ☐ Genitourinary Radiology
- 10. ☐ Imaging Informatics/Computed Radiography

Question 7a, continued on next page...

Question 7a, continued:

11. ☐ Interventional/Angiography
12. ☐ Molecular Imaging
13. ☐ MR Imaging
14. ☐ Musculoskeletal Radiology
15. ☐ Neurointerventional Radiology
16. ☐ Neuroradiology
17. ☐ Nuclear Medicine/Nuclear Radiology
18. ☐ Pediatric Radiology
19. ☐ Radiation Physics
20. ☐ Ultrasound
21. ☐ Women's Imaging
22. ☐ Other, *specify:* ____________________

____

8. Year first entered or expect to enter post-training practice:

19 ____ / 20 ____

If you are "permanently" or "temporarily not working" in radiology, stop here. Thank you.

ALL OTHERS, PLEASE CONTINUE.

9. Thinking about all aspects of your work, what is your feeling about working as a radiologist?

1. ☐ Enjoy very much
2. ☐ Enjoy somewhat
3. ☐ Neither enjoy nor dislike
4. ☐ Dislike somewhat
5. ☐ Dislike very much

10. In your last normal, full work week, what were your total work hours? ***(A normal, full work week is a week without holidays, illness, professional society meetings or other non-standard events. Include clinical practice, hours actually worked when on-call, administrative duties, required hospital activities, research, teaching, etc., but not professional society meetings, CME, or time only on-call):***

10a. Number of hours worked that week:

_____ **# hrs.**

10b. Number of days or fractions of days you worked that week: ***(Mark only one)***

1. ☐ 4 days or less
2. ☐ 4.5 days
3. ☐ 5 days
4. ☐ 5.5 days
5. ☐ 6 days
6. ☐ More than 6 days

11. What is the approximate percentage of professional work time you personally devote to the following ***(Do not count CME/professional education or attendance at professional society meetings. Items should total 100%. If none, enter "0"):***

a. _____ **%** Clinical practice in radiology at hospitals

b. _____ **%** Clinical practice in radiology at non-hospital offices and centers

c. _____ **%** Clinical practice in fields other than diagnostic radiology, nuclear medicine, or interventional radiology

d. _____ **%** Teaching

e. _____ **%** Research

f. _____ **%** Practice management/administration and work for professional societies other than society meetings

g. _____ **%** Other, *specify:* ____________________

____

h. _____ **%** TOTAL ***(should add to 100%)***

12. *Thinking back over the last 12 months*, how many work days did you spend away from your usual practice/workplace locations for the following reasons ***(Don't report any days off more than once. Don't report days you would not normally work. Thus, a week of vacation will generally be 5 days, not 7. If none, enter "0"):***

a. _____ Days for professional education and society meetings

b. _____ Days working, but away from usual practice/workplace locations *(e.g., sabbatical, military reserve duty, visiting lectures, site visits at other institutions)*

c. _____ Days for vacation

d. _____ Days for maternity/paternity leave

e. _____ Days for illness/disability

f. _____ Days for other personal reasons

g. _____ Days unpaid furlough *(involuntary unpaid leave)*

h. _____ Days unemployed *(unwanted time off)*

i. _____ Days off between jobs *(deliberately chosen by you)*

If you are resident or fellow, stop here. Thank you.

ALL OTHERS, PLEASE CONTINUE.

13. Are you a member of any of the following professional organizations or societies? ***(Mark all to which you belong)***

a. ☐ I don't belong to any professional organization(s)/society(ies) ***(Go to Question 15)***
b. ☐ ARRS
c. ☐ AUR
d. ☐ RSNA
e. ☐ ACR
f. ☐ Radiology subspecialty society(ies) → **13a. *How many?*** _____ **# societies**
g. ☐ AMA
h. ☐ County medical society
i. ☐ State medical society
j. ☐ None of these

13b. Of all the professional organizations to which you belong, ***including subspecialty societies***, which are ***most important to you?*** (***specify below***):

1. ***Most*** important to you: ____________
2. ***2nd*** most important: ____________
3. ***3rd*** most important: ____________
4. ***4th*** most important: ____________

14. Generally, who usually pays your professional organization or society membership dues? ***(Do not include costs of meetings)***

1. ☐ I pay all my membership dues from my own personal funds
2. ☐ My practice/employer pays all my membership dues
3. ☐ Both my own personal funds and my practice/employer pay for my dues

14a. *My practice/employer pays up to $_______, and the rest is paid using my own personal funds.*

15. After starting your first permanent position after completing residency or any fellowship, how many times have you moved from one radiology practice/group to another?

15a. Number of moves:

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 or more

15b. Number of years in your present practice: ____ **# yrs.**

16. Within the past 5 years, have you moved from academics to private practice or vice versa?

☐ Yes ☐ No

16a. ***If "Yes," list the main reasons why you've moved from one type of practice to the other.***

____

____

17. ***Complete the following and proceed as directed.***

☐ ***Mark here if <u>you subspecialize, even to a small extent within radiology</u>. Answer Questions 17a, 17b, and 17c.***

☐ ***Mark here if <u>you don't subspecialize</u>. Go directly to Question 17b.***

17a. ***If you subspecialize:*** Mark a "1" for your main subspecialty and a "2" for your second subspecialty (if any) in the boxes in the left column below. ***(Use each number only once—a maximum of two subspecialties should be marked. Don't use check marks).***

17b. ***Whether or not you subspecialize:*** Indicate the approximate % of your clinical work time spent in each field in the right column below. Use the field names that ***best*** reflect how you think of your work. ***(Don't count any work twice. Percentages should total to 100%).***

17a. Subspecialty(ies)	**17b. % Work Time**
a. ☐ I don't subspecialize *(Go to Question 17b)*	
b. ☐ Abdominal Imaging	____ % b1.
c. ☐ Body Imaging/Cross-sectional Imaging	____ % c1.
d. ☐ Breast Imaging/Mammography	____ % d1.
e. ☐ Cardiac/Cardiovascular Imaging	____ % e1.
f. ☐ Chest (Thoracic) Imaging	____ % f1.
g. ☐ Emergency and Trauma Radiology	____ % g1.
h. ☐ Gastrointestinal Radiology	____ % h1.
i. ■ General Radiology *(Not a subspecialty)*	____ % i1.
j. ☐ Genitourinary Radiology	____ % j1.
k. ☐ Interventional/Vascular Radiology	____ % k1.
l. ☐ MR Imaging	____ % l1.
m. ☐ Musculoskeletal Radiology	____ % m1.
n. ☐ Neurointerventional Radiology	____ % n1.
o. ☐ Neuroradiology	____ % o1.
p. ☐ Nuclear Medicine/Nuclear Radiology	____ % p1.
q. ☐ Pediatric Radiology	____ % q1.
r. ☐ Ultrasound	____ % r1.
s. ☐ Women's Imaging	____ % s1.
t. ☐ Not involved in any clinical activity	____ % t1.
u. ☐ Other, *specify:*	____ % u1.
Go to 17b, above TOTAL (should = 100%) →	____ % v1.

17c. Generally, who principally covers your subspecialty(ies) in your absence? ***(Mark only one)***

1. ☐ I don't subspecialize
2. ☐ A radiologist from the same subspecialty from <u>within your practice</u>
3. ☐ A radiologist from a different subspecialty from <u>within your practice</u>
4. ☐ A general radiologist from <u>within your practice</u>
5. ☐ A radiologist from the same subspecialty from <u>outside your practice</u>
6. ☐ A radiologist from a different subspecialty from <u>outside your practice</u>
7. ☐ A general radiologist from <u>outside your practice</u>

ABOUT YOUR MAIN PRACTICE

Note: ***In this section, we will mostly be asking you about "your main practice." This is the practice that you own (either partly or completely), or are employed at, where you spend most of your professional work time. We will also ask you a few questions on what you personally do, such as what procedures you personally perform, or the number of locations you personally practice at.***

18. Is your main practice mostly in a: ***(Mark only one)***

1. ☐ Main city of a large metropolitan area (total area population 1,000,000 or more)
2. ☐ Suburb of a large metropolitan area (total area population 1,000,000 or more)
3. ☐ Main city of a smaller metropolitan area (total area population greater than 50,000 but less than 1,000,000)
4. ☐ Suburb of a smaller metropolitan area (total area population greater than 50,000 but less than 1,000,000)
5. ☐ Non-metropolitan location (total area population 50,000 or less, or rural)
6. ☐ Varied locations, no one type is principal

19. Which best describes your main practice? ***(Mark only one)***

1. ☐ Solo practice
2. ☐ Locum tenens
3. ☐ Primarily academic practice *(any ownership)*
4. ☐ Private, multi-specialty practice, not primarily academic
5. ☐ Government practice, such as military or VA, not primarily academic *(If private practice on contract do not use this category)*
6. ☐ Private radiology, nuclear medicine, and/or interventional radiology practice *(or practice involving some of their subspecialties)*, not primarily academic
7. ☐ Other, ***specify:*** ______________________

20. Does your main practice serve? ***(Mark only one)***

1. ☐ Hospitals only
2. ☐ Non-hospital sites only *(e.g., non-hospital multispecialty sites, radiology offices/clinics or freestanding centers—omit billing or administrative offices)*
3. ☐ Both hospitals and non-hospital sites

21. Which (if any) of the following does your main practice use to improve its productivity and efficiency? ***(Mark all that apply)***

a. ☐ PACS
b. ☐ Wet reading phone line for hearing dictated reports
c. ☐ Clerical staff to hang films, including comparison films, on alternators
d. ☐ Nurses and/or physician assistants to do tasks technologists can't do
e. ☐ Voice recognition software
f. ☐ Templates and/or standardized report language to lessen the work of dictation

Question 21, continued:

g. ☐ Teleradiology ***(Mark all that apply)***
  - g1. ☐ Teleradiology to home
  - g2. ☐ Teleradiology within a facility/facilities
  - g3. ☐ Teleradiology between your practice's facilities
  - g4. ☐ Teleradiology to outside-of-practice radiologists

h. ☐ Other, ***specify:*** ______________________

i. ☐ None of the above

22. Who owns your main practice? ***(Mark only one)***

1. ☐ All owners are physicians practicing in the group
2. ☐ Some owners are practice members and some are not *(e.g., entrepreneurs, joint ventures with referring physicians)*
3. ☐ Owned by federal, state, or local government *(including military, but not a private practice on contract to the government)*
4. ☐ Privately owned, all physicians are employees *(e.g., owned by a university, hospital, or HMO)*
5. ☐ Other, ***specify:*** ______________________

23. Are you currently an owner of your main practice or solely an employee? ***(Mark only one)***

1. ☐ An owner *(partner, shareholder in the professional corporation)*
2. ☐ Solely an employee
3. ☐ Other, ***specify:*** ______________________

24. Number of physically separate locations in which you personally practice:

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 or more

Note: *In questions 25-30, we will ask you about the number of post-training, full- and part-time radiologists in your main practice. If you don't know the answer to any of these questions, please check with the head or administrator of your practice. Include only diagnostic radiologists, nuclear medicine physicians/nuclear radiologists, and interventional radiologists. Exclude all other physicians. Exclude residents and fellows.*

25. *On January 1, 2003*, number of **FULL-TIME (FT) RADIOLOGISTS** in your main practice *(If none, enter "0")*:

_____ **# FT**

26. *On January 1, 2003*, number of **PART-TIME (PT) RADIOLOGISTS** in your main practice *(If none, enter "0" and Go to Question 28)*:

_____ **# PT**

27. ***ANSWER 27A & 27B ONLY IF THERE ARE PART-TIMERS IN YOUR MAIN PRACTICE (If none, Go to Question 28):***

27a. Approximate average # of hours a part-time radiologist works per week in your main practice:

_____ **# hrs/week**

27b. Approximate average # of hours a full-time radiologist works per week in your main practice:

_____ **# hrs/week**

28. *In calendar year 2002*, did your main practice actively seek to recruit radiologists?

☐ Yes ☐ No ⟶ ***(If "No," Go to Question 31)***

29. *In calendar year 2002*, what was the total number of separate radiologist positions *your main practice* actively sought to fill?:

_____ **# separate positions sought to fill**

30. *In calendar year 2002*, what was the total number of radiologists actually hired by your main practice? ***(Count those hired in 2002 who had a later start date. If none, enter "0")***

_____ **# actually hired**

31. Do you believe there is a shortage of radiology technologists?

☐ Yes ⟶ ***31a. If "Yes": (Mark only one)***
1. ☐ There is a minor tech shortage
2. ☐ There is a serious tech shortage
3. ☐ There is a very serious tech shortage

☐ No

☐ Don't know

31b. What is the percent of radiology technologist positions that are NOT filled at your main practice? ***(If no vacancies, enter "0." If you don't know, enter "DK")***

______ ***% positions NOT filled***

32. *For the most recent 12 months for which data are conveniently available*, what is the total # of procedures performed by your main practice ***(If you don't know, please check with your practice head or administrator)***:

_____ **# procedures performed**

33. Currently, which of the following categories and subcategories of procedures do you personally perform and which does anyone in your main practice (*including yourself*) perform? ***(The list of subcategories is sometimes deliberately incomplete in order to shorten this survey. Mark all that apply for "you personally" and for "anyone in your main practice")***

	Performed by: (a) You Personally	Performed by: (b) Anyone in Your Main Practice
1. Nuclear Medicine	☐	☐
a. SPECT	☐	☐
b. PET	☐	☐
c. Hybrid PET/CT	☐	☐
d. Myocardial perfusion imaging	☐	☐
2. Interventional	☐	☐
a. Extremities	☐	☐
b. Head/Neck	☐	☐
c. Spinal	☐	☐
d. Renal	☐	☐
e. Abdominal	☐	☐
f. Pelvic	☐	☐
g. Cardiac	☐	☐
3. CT	☐	☐
a. Neuro	☐	☐
b. Body	☐	☐
c. Screening for lung cancer	☐	☐
d. Whole body screening	☐	☐
4. MR	☐	☐
a. Neuro	☐	☐
b. Body	☐	☐
c. Neuro MRA	☐	☐
d. Body MRA	☐	☐
e. Cardiac	☐	☐
f. Musculoskeletal	☐	☐
g. Spectroscopy	☐	☐
5. Ultrasound	☐	☐
a. 1st trimester OB	☐	☐
b. 2nd &/or 3rd trimester OB	☐	☐
c. Vascular	☐	☐
d. Echocardiography	☐	☐
e. Endoscopic	☐	☐
f. US from emergency room	☐	☐
6. Breast Imaging	☐	☐
a. US-guided breast biopsy	☐	☐
b. Stereotactic breast biopsy	☐	☐
c. Localizations for surgical breast biopsy	☐	☐
d. FNAC	☐	☐
e. CAD	☐	☐
f. Full field digital mammography	☐	☐
g. MRI of the breast	☐	☐
7. Plain Film and/or Fluoro	☐	☐
8. None of the above	☐	☐

33c. *If you personally interpreted mammograms in the last year,* about how many *(including second readings)* did you interpret? ***(If none, enter "0")***

_____ **# mammograms**

34. *Given that income largely depends on work done,* how does the amount of work you have compare with what you'd like?

1. ☐ About right
2. ☐ I'd like my work and my income reduced by about _____ %
3. ☐ I'd like my work and my income increased by about _____ %

35. Compared to five years ago, would you say you enjoy radiology now:

1. ☐ Much more than five years ago
2. ☐ Somewhat more than five years ago
3. ☐ About the same as five years ago
4. ☐ Somewhat less than five years ago
5. ☐ Much less than five years ago

(1–5) → ***(Go to Question 36)***

6. ☐ I have not been in the field for five years → ***STOP***

36. Tell us the main reasons that contributed to your response in Question 35. ***(Check all the main reasons that apply. If there are other main reasons not listed, mark "other" and specify):***

a. ☐ Changes in arrangements for after-hours coverage
b. ☐ Completion of training
c. ☐ Government regulation
d. ☐ Income
e. ☐ Interest
f. ☐ Lifestyle/workhours
g. ☐ Medico-legal climate
h. ☐ New technology
i. ☐ Paperwork
j. ☐ Practice governance and/or organization
k. ☐ Reimbursement/financial pressures
l. ☐ Shortage of radiologists
m. ☐ Staffing—support and administrative personnel
n. ☐ Workload
o. ☐ Other, *specify:* ______________________

THANK YOU!

Please return your responses in the enclosed, stamped reply envelope.

For questions, contact Yasmin Cypel, Ph.D., ACR Research Department

[(703) 648-8984 (toll free: 800-227-5463, ext. 4984)].

Appendix 4.7 Sample Interview Guide Used with Radiologists

Note: These interviews were loosely structured and open ended. The following questions are examples of questions used to structure the conversations, and should not be taken as inclusive. Questions varied based on the context and the participant.

Introductory Statement (for consent purposes):

Thank you for taking the time to meet with me today. I have a few questions to start the conversation, but first I want to make sure that you understand a few things: i) Participating in this interview is completely voluntary; ii) you don't have to answer any of these questions; iii) you can stop the interview at any time without any consequences; and iv) everything you say will be kept confidential -- if we use any information you give us we will make sure to remove any details that could be used to identify you.

With your permission, I'd like to tape record the interview. I'll be keeping the tapes and transcriptions in a locked cabinet in my locked office at MIT for a year, before destroying them. Understand that I'm doing these interviews as part of my dissertation research. While I may include this data in any eventual publications that come from this research, I will be certain to eliminate any details that would allow your thoughts or answers to be identified with you - e.g. I'll refer to an outpatient physician rather than [insert name].

Background:

How long have you been with this practice?

How many other radiologists are in this practice?

What were you doing before you came here?

Are you a partner here, or a staff radiologist?

Probe: Is this new, or is this always what you've done?

Topic 1: Teleradiology

Tell me about your experience when you started working from home.

Probe: When was that?

How long did it last?

How was it meant to work?

How did it actually work?

Do you ever interpret images from home now?

Probe: How often? Under what circumstances?

Has this changed since you've been working?

Are there some tests you would interpret from home, some tests that you wouldn't?

When did your practice start using teleradiology?

If you were here when they started using it, what was that switch like?

Can you give me an example of any (other) problems you've run into with your current system?

Topic 2: Nighthawk Practices

When did your practice start using a nighthawk practice?

Why do you think they started using one?

Probe: Who made the decision to start using it?

Probe: Were there any problems under the prior system?

What did you think about it when your practice started using a nighthawk service?

Probe: Worried (about job), relieved to not work nights, mixture?

How does it work in your practice?

Probe: When do they take over? Are there any radiologists working at night? Do you sign off on their wet reads in the morning?

In general, why do you think nighthawk radiology practices have recently taken off?

Probe: For example, did it seem like the scarcity of radiologists grew worse, or more that information technologies enabled a service that was already demanded.

How has using a nighthawk practice changed your work? How about the work of the night internists?

Can you give me an example of any problems with using a night hawk service?

Topic 3: Working

I'm trying to get a sense of what radiologists do -- can you tell me about a typical shift?

Probe: When did you start working today?

About how many hours a week?

What shifts?

How does night call work in your practice?

When you're interpreting images, do you usually consult with other people?

Probe: When was the last time you consulted with someone else about an image?

Probe: Who was it?

When you do consult with someone else, do you usually do it in person?

Probe: Are there certain circumstances (a certain test, unclear image, etc.) under which you would only consult in person?

Probe: Are there certain circumstances where you would be more apt to consult remotely?

Do you usually talk to the patient's referring physician?

Probe: If so, how? (face-to-face, via telephone phone ...)

Probe: How important are these conversations to treatment?

Closing:

Can you think of other doctors who might have an interesting perspective on this?

Probe: Who works closest with the nighthawk service?

Chapter 5: As Time Goes By -- Incorporating time into a spatial structuring perspective

1. Introduction

In chapters 3 and 4 I focused on the role of space in the use of information technology to change medical work. To the extent that I have discussed time at all, I have treated it as an outcome, rather than an integral part of the process of change. I have also dealt with the two medical specialties separately, addressing the same themes of space, control and information technology, but not speaking to the comparisons that could be made.

In this chapter, I expand the discussion in both these areas. Again I ask: how and with what consequences has information technology been used by these physicians to change the ways in which they work. However, in this chapter I explicitly include time and temporal practices in my model of change. Through a comparison of the ways that radiologists and outpatient physicians work in time, I illustrate the extent to which time is connected to the issues of space, autonomy and information technology addressed in previous chapters. While I previously addressed spatial practices and structures as though they were discrete from temporal structures, in fact the two are intertwined.

Drawing from the research sites and methods described in previous chapters, I begin this chapter by approaching time at the most simple level, illustrating how hours at work changed with the adoption of the information technologies in question. Once again I use mixed methods to make my argument. I present an ordinary least squares (OLS) regression model demonstrating the correlations between hours worked, use of teleradiology and various other group attributes, including spatial location. I bolster this quantitative work with a discussion of interview data expanding upon these findings.

Before linking these temporal changes to the spatial changes addressed in Chapters 3 and 4, I describe the differing perception of time which I found in the various research sites. Finally, I contrast the temporal changes in radiology and outpatient work, using this contrast to highlight the extent to which temporal structures shaped the use of information technology and the corresponding utility of a spatio-temporal structuring approach. I end by tying issues surrounding time at work back to the themes of control, space and information technology that have run through this dissertation.

2. Research on Time at Work

In Chapter 2, I focused on theories and past research with respect to workplace control, information technology and space. Before turning to my empirical findings on time at work, I will first introduce the rich literature on hours spent working, with a particular focus on the relationship between the use of information technology and time at work. The relationship between technology and time at work has been a concern of social theorists and economists since at least the mid 19th century with the publication of Marx's "Wage Labour and Capital" (1847). This, then, will be a necessarily abbreviated overview of a vast literature.

In her influential book *The Overworked American* (1991) Juliet Schor articulated what has since become a common critique. Schor's work, based on Current Population Survey (CPS) data, found that working hours for the average American have been increasing steadily since the standardization of the 40 hour work week in 1940. According to Schor, this increase has been largely driven by a combination of weak unions and an increase in materialism.

In what would appear to be stark contrast, other researchers, led by Robinson and Godbey's 1997 study of time diary data, have documented an increase in leisure time.

Robinson and Godbey argue that Americans actually have more leisure time, much of which they spend watching an average of 15-20 hours of television a week (1997, 144, 260).

Jacobs and Gerson (2001) convincingly resolve the differences between these groups of literature by demonstrating that opposing shifts occurred among different demographics. Increases in education and early retirement among men increased leisure time among certain demographics, while an increase in labor participation rates among women increased working hours among other demographics. They demonstrate that the average working American performs roughly the same hours of paid work as they did forty years ago, with a slight increase only among the poorest and richest workers. However, they document a large increase in dual earner families between 1970 and 1997. In 1970, 35.9 % of married couples younger than 65 were dual earner couples. By 1997 this figure had risen to 59.5%. The authors argue that this increase in dual earner families has led many working Americans to feel that they are working more, presumably because the unpaid work tasks previously done by the non-earner are now shared by both members of the couple, in addition to their paid work.

Professions such as medicine have long been associated with particularly long work hours (Epstein et. al. 2002). Epstein et. al. write that a larger and larger number of professions are time 'greedy' professions like medicine, requiring their practitioners to be available seven days a week, twenty four hours a day. They link this shift to the twenty-four hour working day to technologies "that enable communication between people in different time zones, across national divides, and at any location" (2001, 8).

Freeman (2002) confirms the correlation between the use of information technology and longer working hours. He presents a regression analysis based on the Current Population Survey (CPS) which correlates computer and Internet use at work to a tendency to work 5-6% more hours.[24] Other researchers have also suggested that "IT mediated communication increases workloads" (Goldstein 2003, 38).

The use of information technology, though, is just one of several competing explanations for time intense professions. Research into particularly time intensive industries offer multiple explanations for the reasons behind their time intensive quality. A multinational study of engineers found that the way in which work is coordinated plays a heavy role in the time intensity of jobs (Perlow 2001). Hierarchical coordination structures, where engineers are highly compartmentalized, were linked to the tendency to work long hours and take fewer vacations, as individual engineers and managers find it difficult to substitute for one another.

Other research points to social roots of overwork; Wharton's (2001) study demonstrates that American finance professionals are much less likely than counterparts in Hong Kong and Great Britain to express interest in working part time. It is also possible that shifts in management-labor power are responsible for increases in work time. Osterman (1999) does not speak directly to hours at work, but notes workers' general willingness to contribute higher levels of effort to high-performance work systems (HPWS) despite the lack of increased benefits. Osterman links this willingness to the perceived threat of restructuring -- workers are willing to work harder simply to fend off the threat of downsizing.

My research into radiologists and outpatient physicians speaks to the use of

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[24] As Freeman notes, the CPS probably understates the hours that people work from home on off hours, but it may include time at work spent on non-work related e-mail and Internet use.

information technologies by a profession which has long been regarded as time greedy. By pairing qualitative work with a focused quantitative study, this chapter speaks to the processes through which these medical subspecialties changed the way that they work in time.

This chapter also contributes an awareness of the link between time and space. I illustrate the way that information technology use, by enabling an expansion of work in space, tacitly enabled an expansion of work in time. Finally, this chapter also serves as an exemplar of the way in which temporal structures and practices can be included in the spatial structuring model discussed earlier. Thus, its theoretical contributions are threefold: it illustrates the process through which medical professionals have changed the hours they work, addresses the relationship between time, information technology use and space, and contributes a temporal element to the spatial structuring model outlined in past chapters.

3. Time and Information Technology Use

In this section I investigate the question: how have physicians used information technology to change the hours they work? As Freeman's work would predict, I found that both outpatient physicians and radiologists used information technology to spend more time at work.

Throughout the research in outpatient clinics, one of the most consistent perceptions expressed by participants was the additional time required to use an EMR. From the most ardent proponents of the EMR to the most skeptical participant, outpatient physicians widely agreed that they worked more hours after the adoption of electronic medical records. The following comments were representative of perceptions at each research site.

> The only possible down side, I'd say really is that some things take a little bit longer to do in the computer than they take to do on paper… There's still probably nothing faster than writing your note on paper as you talk to the patient.
>
> Physician, Urban Network Clinic

> I used to dictate and it would take me five minutes at the most to dictate a note. Well now I might need -- especially if the information is not computer pre-entered, and I didn't have time during the visit to include that, it might take me half an hour to conclude the note.
>
> Physician, Suburban Clinic

> I think at one point I figured out that I was spending about an hour more per four hour session typing in my notes, as opposed to just writing a handwritten note and being done. I think that's certainly much less now, as I dictate. But I think I probably spend a little bit more time in comparison to just handwritten note. Because I would write a handwritten note while they were talking - and then boom, done. After the patient left, I would be done with the note.
>
> Physician, Urban Central Clinic

Similarly, the radiologist participants linked the use of teleradiology to the shift to more intense night and weekend 'call' shifts. One private practice radiologist noted that when he started practicing as a radiologist, he would take night call for a week at a time and be called in only once or twice over the course of that week. Now he estimates that a radiologist working for the same emergency room would be called around twenty times during a single midnight to morning shift.

I am not suggesting that teleradiology use has been chiefly responsible for this increase. As described in Chapter 4, since radiology images became more central to diagnosis, the quantity and urgency of nightly reads increased. However, several radiologists explained that when teleradiology enabled them to take call from home, emergency room physicians became more apt to wake them. I return to this dynamic later in this chapter where I discuss the relationship between space and time as reflected in these increases in working hours.

Examining the descriptive statistics presented in Table 5.1, it is apparent that radiologists who use teleradiology work more hours per week on average (51.48) than radiologists who do not use teleradiology (46.69). Similarly, radiologists who use teleradiology to out-of-group radiologists work more hours per week on average (51.92) than radiologists who do not (50.28).

Insert ***Table 5.1: Descriptive Statistics for hours worked***

For the remainder of this section, I present an OLS (ordinary least squares) regression which further investigates the correlation between weekly hours worked by radiologists and their use of teleradiology, as well as their spatial location. After presenting the regression results I refer back to the interviews I conducted, in order to explain the findings.

3.1 Hypotheses

A priori, I would suggest the following hypotheses with respect to the use of teleradiology. On the one hand teleradiology can be used to expand the space in which radiologists perform their work, and this capacity might be used to expand the time in which they do their work. On the other hand, teleradiology to out-of-group radiologists can shift work away from the most burdened radiologists, and so I would expect the use of teleradiology to out-of-group radiologists to correlate with fewer hours worked. While the descriptive statistics displayed above would seem to contradict this second hypothesis, estimating an OLS model allows further insight with respect to this correlation between hours worked and the use of teleradiology to out-of-group radiologists.

Hypothesis 1: *Access to teleradiology correlates with working more hours.*

***Hypothesis 2**: Access to teleradiology to out-of-group radiologists correlates with working less hours.*

I would also suggest that the hours at work vary with the type of metropolitan area in which a radiologist is located. Non-urban areas tend to be underserved by physicians (Fink et. al. 2003), and one would expect this to place additional time pressures on those radiologists who are located outside of cities. Also, as discussed in the last chapter, radiologists who work for teaching hospitals tend to be located in large metropolitan areas. They may handle much of the overflow with which radiologists in private radiology groups would otherwise be forced to deal.

***Hypothesis 3:** Radiologists who work outside of metropolitan areas work longer hours than radiologists who work within urban areas.*

3.2 Findings

*Insert **Table 5.2: OLS Regression predicting hours worked in the last full week of work**[25]*

As is visible in Table 5.2, access to teleradiology correlates with working more hours. According to the final model, on average, radiologists who use teleradiology work 4.83 hours more per week than radiologists who do not use teleradiology. There is a less than a one in one thousand chance that such a large difference would be visible in the sample population if there was not a correlation between hours worked and teleradiology use in the population of radiologists as a whole. The charts below clearly illustrate the degree to which this OLS model associates teleradiology use with increased weekly hours.

[25] Initially there appeared to be an interaction effect between government practices and the use of teleradiology to out-of-practice radiologists. However, upon removing two high influence observations, this interaction effect lost its significance. Accordingly, I chose not to report it. For more details on the robustness analysis and the coefficients of these models please see Appendix 5.1.

Insert ***Figure 5.1: Prototypical Fitted Curves plotting the estimated hours worked in the last full week of work***

While hypotheses 1 and 3 were substantiated, hypothesis 2 was not. I found a statistically significant correlation between using teleradiology to out-of-group radiologists and working more hours, rather than less hours, as hypothesized. In part, this unexpected correlation can be explained by the nature of on-call work and the way in which hours at work were measured by the ACR survey. The survey asked radiologists not to count hours spent on call as worked, except for hours actually worked. Radiologists who are woken five times during a night might only work three hours over the ten hour period; however, these three hours leave the radiologist as tired as a whole day of work might. As one radiologist commented, even a slow emergency room was "busy enough to nickel and dime you all night long," leaving you exhausted the next day.

Thus, some radiologists who use nighthawk services may register as working more hours, because they are no longer accepting call and this enables them to work longer days and more days during a given week. However, to the radiologist it may feel they are working less hours, as they are no longer handling night call.[26]

Interviews at a nighthawk firm testified to the additional work many of their client radiologists do subsequent to contracting with a nighthawk firm. An executive at a large

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[26] At first glance, another potential explanation for the correlation between use of teleradiology to out-of-practice radiologists and hours worked would look to the way that nighthawk radiologists allocate shifts. Nighthawk radiologists typically work seven days on / seven days off shifts. Thus, if a nighthawk radiologist answered the ACR survey question "In your last normal full work week, what were your total work hours?" with '70' - this could mean they worked 70 hours last week, or 70 hours in the next to last week, because they had last week off. Thus the survey would tend to systematically register them as working longer average hours / week than they actually do. However, given the very small proportion of U.S. radiologists that were nighthawk radiologists in 2003 - probably less than 50 out of tens of thousands of diagnostic radiologists in the U.S.- it is unlikely that they had a significant impact in skewing the results.

nighthawk group explained that his firm's clients were able to dramatically increase the amount of work they could do.

> The radiologist group that contracts with us gets their health back. They get their life back. Their wife's not divorcing them anymore. The kids know who their dad is. The group is nicer to the people in hospital because they're not so grumpy and overtired all the time, and they end up, because of that, just going out and selling their services to other hospitals. And they get a great reputation. Turnaround times are good. Study quality is good. So they grow.

In addition to the correlation between radiologist hours and their use of teleradiology, Figure 5.1 also illustrates a statistically significant difference between radiologists who work in large metropolitan areas (population > 1,000,000) and those who work outside of large metropolitan areas. Whether a radiologist is working in a smaller metropolitan area or outside of any metropolitan area altogether, they are likely to work several more hours a week on average than a private practice radiologist who works in a large metropolitan area.

After noting that the correlation coefficient for being located in a small metropolitan area (2.06) was quite close to the correlation coefficient for being located outside of a metropolitan area altogether (3.03), I wondered if the truly salient fact was whether or not they were located in a large metropolitan area. Among the broader population of radiologists, did it matter if a radiologist's group was located in a small metropolitan area or a rural area? This question led me to test the null hypothesis $\beta_{NOCITY} = \beta_{SMALLCITY}$ for the model presented above.[27]

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[27] The PROC REG 'test' statement in SAS 9.0 automatically tests such a general linear hypothesis for an OLS model without necessitating the manual computation given in the similar situation in the last chapter (e.g., in Appendix 4.4).

I arrived at a p-value of .4 for this joint test, meaning I could not reject this null hypothesis. There is a good chance that in the population as a whole, a radiologist's location only correlates with hours insofar as the radiologist is located in or out of a large metropolitan area. There is no statistically significant difference between hours worked and whether a radiologist is located in a small city or located outside of a metropolitan area altogether.

Table 5.2 also displays several control variables that correlate with statistically significant differences in the hours worked per week. Just as in the logit models presented in the previous chapters, working for an academic practice correlates with significant differences in hours worked. The average radiologist who works in a teaching hospital tends to work 3.18 more hours a week than the average radiologist in private radiology group.

Also, much as one would expect, younger radiologists tend to work more than older radiologists. The more recently a radiologist has entered (or expects to enter) practice, the more hours they tend to work -- for every additional year a radiologist has been in practice they tend to work an average of .13 less hours.

Finally, there is an intriguing interaction effect, displayed graphically in Figure 5.2, between the size of radiology group and the use of teleradiology. Among radiologists who did not use teleradiology, those at larger groups tended to work more hours than radiologists in smaller groups. However, this dynamic was reversed for radiologists at groups which used teleradiology. Among these radiologists, larger group size correlated with working fewer hours, presumably as radiologists at these groups used teleradiology to better distribute the work within their facilities and between facilities, making use of teleradiology to consolidate the work of the radiologists in their group. For the most part, though, as Figure 5.2 illustrates, this effect was swamped by the correlation between teleradiology and working more hours. This model predicts that with the exception of radiologists at the largest groups, radiologists who use teleradiology tend to work more hours, on average, than radiologists who do not.[28]

While I am arguing that the use of information technology enabled greater hours, this regression analysis does not necessarily prove this. The perennial difficulty of distinguishing causality from correlation is particularly evident in this case. It could be that rather than the use of teleradiology enabling longer hours, those radiologists who are working the longest hours are the most likely to adopt teleradiology. In economic terms, there is a potential for model endogeneity, with the apparent correlation between teleradiology use and hours worked actually due to some missing variable. Typically one would test for such a spurious correlation by creating an instrumental variable to predict the ex ante probability of using teleradiology and then attempt to correlate this instrumental variable with hours worked. However, in order to do so, one requires variables which correlate with the use of teleradiology but not hours worked. A perusal of the statistical models presented indicates that no such variable is readily available in the dataset used for this analysis.

With that caveat not withstanding, I would suggest that a causal path does exist between teleradiology use and the higher average weekly hours worked. Based on the interview data referenced earlier, it appears that radiologists used information technology

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[28] General linear hypothesis (GLH) tests indicate that the use of teleradiology no longer correlates with a statistically significant increase in the hours worked for the largest private. For instance, for private practices in the 90th percentile in terms of size, with 35 radiologists in their practice, the resulting p- value is .47.

to work longer hours. In the next section I turn back to the interview data to further illustrate the relationship between time at work, space of work and the use of information technology. For this discussion I draw from both radiology interviews and interviews with outpatient physicians, illustrating very similar dynamics in both cases.

4. What's Space Got to do With It (Part III): 'We can bring work home now, so we can never leave work'

Space plays an important role in mediating the relationship between time spent working and information technology use. In this section I present interview data illustrating the process through which spatial changes in work enabled by information technology use led to increased hours spent working.

Dr. Johnson, a physician participant at the Urban Central Clinic, offers a particularly interesting case. When he was interviewed, he had recently lost access to the EMR from his home, having purchased a home computer that appeared to be incompatible with the clinic's security system. Thus he was able to compare his work patterns before he had home access to the EMR, while he had home access to the EMR, and after he no longer had home access to the EMR. He explained,

> I preferred to do [documentation work] at home. Although the only thing is the work week then started on Sunday, rather than on Monday. Sorta back to work Sunday, Sunday at nine o'clock. Or ten o'clock after Alias or something like that.

This quote not only encapsulates the relationship between space and time, it also illustrates the way that the extension of work in space can lead to the blurring boundary between home activities and work activities. Similarly, when one of Dr. Johnson's colleagues at Urban Central, was asked if she liked the ability to access patient records from home, she responded,

> I like that I can. I don't like that I have to, because I think we work more.

> And you're not - if you add up the hours that you're working in a week, it's definitely more now. Some of it's my own doing. Because - you know I don't have to do it. But it's there so you can. And you do. So yes, I like that I can, but I really don't like that I do.

Again, one clearly sees that the expansion of the space in which this physician can do her work is linked to her decision to work more. One also sees the influence of the physician norms discussed in Chapter 3 -- this doctor feels that if she can work from home, she must work from home.

This dynamic was also forcefully given voice at a focus group of Urban Central physicians. One physician succinctly explained, "We can bring work home now, so we can never leave work." The agreement appeared to be widespread throughout the group. One older physician remarked that, "now I work 24 hours, 7 days a week," while another chimed in that "people end up extending work days."

At the Suburban Network clinic, where participants were not yet connected to the EMR at their homes, several participants voiced a reluctance to get connected at home. One nurse practitioner at the Suburban Network clinic was candid about her reluctance to be connected to the EMR from her home. "I'm not hooked up to the computer at home," she explained, "And I have to be honest, I prefer not to be. Children, family life… If it has to happen, it will, but for right now..." She shook her head.

Radiologists' description of using teleradiology from home evokes many of the same dynamics, albeit to an even greater extent, as radiologists are likely to be awakened on call many more times than the outpatient clinicians interviewed in this study. Their distaste for night call was described at some length in the last chapter. Dr. Hettinger, a private practice radiologist, was one of several participants who linked the increase in the intensity of night call to the introduction of teleradiology,

> The [emergency room] physicians would pull the trigger much faster, because you didn't have to come in. So there was a disadvantage as well as an advantage. Before teleradiology, they would think twice because they didn't want us to be going back and forth four or five times. But once you get teleradiology they think, 'oh, he's at home. He can look at it.'

This quote also highlights the social nature of the change enabled by teleradiology use. Radiologists were contacted more often in part because emergency room physicians were less reluctant to disturb their nights when it became possible to interpret images from home.

To some degree information technology and spatial change are substitutes. One outpatient physician who did not use an EMR moved closer to his clinic in order to be better able to work during the evenings and weekends. Whenever he felt it necessary to work during the evening or weekend he simply walked to his office, half a block away from his home. Thus, he blurred the boundaries between home and work time by bringing the actual work and home space closer, rather than the virtual intrusion of which some of his peers complained.

One can meaningfully compare his situation with that of Phyllis Tang, the radiologist described in Chapter 4 who was frustrated in her attempts to work from home a few days a week. Recall from Chapter 4 that after her unsuccessful attempt to telecommute, Dr. Tang chose to move closer to the hospital and abandon her attempt to work remotely. Again one sees the degree to which successful information technology use and spatial proximity are substitutes. The successful use of information technology can stretch the spatial constraints upon work, while spatial collocation can make the use of certain information technology unnecessary.

The differences between the two cases are instructive as well. The outpatient physician preferred to keep information technology out of his actual home as he saw it as intruding into his home life, layering more tasks atop already existing tasks. However, in the case of the radiologist, she looked to information technology to free her from the necessity of going to work, with work at home substituting for work at the office. What accounts for these differences? In chapters three and four I argued that the spatial practices utilized by these physicians prior to adopting the information technologies in question shaped their use of information technology to change their work. I now move to explicitly incorporate time into this framework.

5. Contrasting Perceptions of Time at Work

Time is not as constant as the discussion has thus far suggested. Notions of time change over time and across professions, and these perceptions can impact professionals' willingness to work more hours, and the way that they work. E.P. Thompson's seminal paper (1967) links the beginning of industrial society with a shift from a society where workers had a task-oriented notion of time, to one where a more standard notion of clock time prevails. Thompson's distinction between clock time and event time remains particularly relevant to a discussion of professional work, as I would argue that many professionals continue to structure their work around concrete tasks, rather than time, especially as they use information technology to work from multiple spaces.

Orlikowski and Yates's (2002) notion of temporal structuring suggests that the distinction between clock time and event time is a blurry one. Generally, they argue that seen from a practice perspective the distinction is rarely a clear one -- depending on one's place in an organization, or the task at hand, the orientation people use will change.

Outpatient physicians and radiologists have historically conceptualized and worked in time in very distinct ways that are salient to this analysis. All medical subspecialties are not equally greedy. Historically, radiology was known as a comfortable 9-5 job. One nighthawk radiologist, remarked,

> Radiology has always been a nine to five profession. Even now it's regarded as one of the sweetest lifestyles. It used to be 9-5 Monday to Friday – no call, because everything was elective, everything was scheduled. So it was beautiful.

Recent surveys have substantiated that the potential for defined hours remains important to medical students who choose to enter the field of radiology (cited in Applegate 2005, 135).

Nighthawk clinics continue the tradition of measuring radiology shifts in hours, be they eight hours or ten hours shifts. In contrast, while outpatient physicians might see patients for a four hour shift, they are expected to complete the associated work of entering patient data for as long as is necessary. Although their patient shifts last for four hours, the EMR work would often extend into their evenings and weekends. Outpatient physicians, then, would appear to work more in what Thompson (1967) would call 'event' time, while radiologists work more in 'clock' time.

As Orlikowski and Yates (2002) note, use of event time and clock time can shift depending on a person's role in an organization or the task at hand. I observed variation in the treatment of time at work within the same organization, especially between the high status physicians and the low status clerical workers. Interestingly, the direction of this difference varied between the two subspecialties.

In outpatient clinics I observed a sharp distinction between the way the higher status health care professionals, such as the physicians, measured time, and the way that the clerical and reception staff measured time. At the Urban Central outpatient clinic, for instance, each clinic floor has a time card clock. Every receptionist and filer thrusts a yellow time card into an old fashioned mechanical punch clock - once when they arrive and once when they leave. Their shifts are measured by the quiet ticking of that clock; they arrive at the same time and leave at the same time every day. The Urban Central physicians, on the other hand, did not clock in. As noted above, their four hour patient shifts actually extended long beyond the four hours and far beyond the bounds of the clinic walls.

The support staff in one of the largest nighthawk groups appeared to be less oriented to clock time than the support staff in the outpatient clinic. During one site visit, a dozen of the support personnel volunteered to stay late in order to help the company get ahead on a number of licensing and credentialing applications. Both their compensation scheme and the corporate culture encouraged them to feel an ownership in the company that kept them engaged beyond the hours that they were on shift. The radiologist employees of that same firm, however, worked a shift that was determined months in advance. One radiologist employee commented, "It's pretty good actually. I can plot it out into the future. I know when I'm going to be working in 2007."

The different reimbursement schemes used by each subspecialty appear to reflect differences in the temporal bounds they enact on their work. Radiologist compensation varies directly with the number of image interpretations a radiologist does. Most radiologists work in private radiologist firms structured as partnerships. Their earnings tend to be directly related to the volume of tests that they read, as they are typically directly reimbursed by the payer. The volume of reads roughly corresponds to the time they spend reading.

Outpatient physician compensation is more loosely connected to patient procedures. This is especially true among outpatient physicians who are salaried employees of a clinic, but even those outpatient physicians who were partners expected to do a good deal of follow up and documentation work for any given patient visit.

Compensation schemes are closely linked to the way physicians think of time at work. I would expect that if these physicians constructed their temporal practices differently, they would be compensated differently. If, for instance, outpatient physicians saw themselves as working in clock time, they would require a more direct relationship between the time consumed by a given patient and their compensation. For instance, patients would be charged for phone calls, just as they have begun to be charged for e-mail consultations (Freudenheim 2005).

6. Contrasting Time at Work

Earlier in this chapter, I focused on the similarities in the ways that outpatient physicians and radiologists used information technologies to shape the hours that they worked. In both the case of outpatient physicians and radiologists, the expansion of the space of work appeared to lead to an increase in the hours they spent working. However, once one looks beyond a simple focus on the number of hours at work, one sees pronounced differences in the way that radiologists and outpatient physicians used information technology to change their time at work.

In order to explain these differences, I draw from a similar analytical framework to that used in the previous two chapters, but I explicitly expand the model to include time, as well as space. I link the respective changes in the way they use information technology and the control each group appeared able to exert over this use, to the ways that each group historically conceived of time at work.

Outpatient physicians and radiologists used their additional time at work in quite different ways. In particular, while radiologists used teleradiology applications to focus more time on their core work, outpatient physicians used EMRs to layer additional non-core work tasks atop their existing core work. As a consequence, radiologists tended to be paid for additional work, while outpatient physicians tended not to be paid for the additional time required to use an EMR. In this, as well as several other important respects, radiologist appeared to exercise more control over the use of information technology to change their work.

Nighthawk groups in particular aim to peel away as much of the non-core work as possible for their radiologists. Nighthawk radiologists have no committee responsibilities in the nighthawk organizations, no meetings, nothing but their core work of reading images and dictating reports. One nighthawk group even has support personnel to wait on the phone in lieu of the radiologists when they want to speak to emergency room physicians. The radiologist can continue reading tests until the instant the emergency room physician picks up. As one human resources director at a large nighthawk group commented, "We really cater and spoil our doctors completely. We make the work flow efficient. They don't have to do anything but read."

Thus, in nighthawk groups, radiologists used information technology not only to improve the working situation of radiologists at the client radiology group, but to allow the night hawk radiologists to focus only on their core work of interpreting images. In another context this might appear to be done with the intention of sweating labor.

However, the nighthawk radiologists felt that they controlled the pace at which they worked. Loosely speaking, reading more reports translated into higher compensation, but it was understood that radiologists would read at whatever rate they determined, with a wide range expected and seen between the number of studies that individuals radiologists would read on a given shift. The support structure was simply designed to eliminate all other tasks, aside from that reading.

As described in Chapter 3, several outpatient physicians were frustrated with precisely the reverse of this dynamic. A physician at Urban Central explained,

> The perception is that we're doing more work, but it may just be that we're doing more non patient care related work so it feels more like work. I mean it's not what we were really trained to do. We aren't just going between room to room and room with the patient. That would be great.

Several outpatient physicians commented that they had never expected to spend so much of their time on the computer. As one Urban Central focus group participant remarked, "They never told us in medical school that we'd spend more time staring at a computer screen than looking at patients." For these physicians, adopting an EMR simply layered additional tasks atop their core work of seeing patients.

These differences were also reflected in their impact on their family life. One outpatient physician participant mentioned that his wife had taken to calling him a "virtual husband" as he came home from work only to be immersed in work e-mail and other electronic tasks for hours every night. Other outpatient physicians were reluctant to be connected for precisely those fears.

In contrast, nighthawk participants explained that nighthawk radiology allowed radiologists to spend more time with their family. Not only did the seven days on / seven days off schedule leave nighthawk radiologists with every other week off to spend as they chose, they could also manage their schedule on their "seven days on" to spend more time with their spouses and children.

For instance, one U.S. based nighthawk radiologist spoke of having dinner with his children, praying with them and putting them to bed before going to work at around 10 p.m. In the morning, when his shift ended, he had breakfast with his wife and children, before the children went to school and he went to sleep.

While the perception of time may shift depending on the context, I am suggesting that the perception of time with respect to a profession's core work is particularly salient in shaping the ways in which their time at work changes. One reason radiologists were able to use teleradiology to mitigate the long hours of call was their historic perception that their core work was meant to be bounded in clock time. The fact that outpatient physicians historically did their work bounded in event time shaped their tendency to use the EMR to do work outside of the spaces and times officially designated for work.

These temporal dynamics are closely related to the spatial dynamics described previously. Radiologists saw their core work as relatively unbounded in space so they both needed temporal bounds and felt empowered to enforce temporal bounds. In contrast outpatient physicians saw their core work as bounded in space. This made it appear less necessary to enact temporal bounds on work or hard controls on the use of information technology, as it appeared to them that there were inherent constraints given the enacted spatial nature of their core work.

These differences can also be considered in terms of the potential threat each subspecialty faces. Unlike outpatient physicians, radiologists do not see their work as inherently constrained in space. Their work's susceptibility to relocation meant that if radiologists did not enact temporal bounds upon their work and exert control over the uses of information technology, their work could be degraded in a much more fundamental way than was possible for outpatient physicians. Their work could be offshored to other countries or it could expand to take much more of their time at home, if they did not enact temporal structures which required them to be paid for this extra time.

Thus, understanding physicians' conception of time and space at work is helpful in understanding the control each subspecialty has been able to exert over the uses of information technology to change their work. Radiologists saw their core work as mediated by information technology, done from a distance and enacted in clock time. Not only did this create the threat described above, it also enabled them to feel comfortable with controlling the hours of their work and the use of IT. Their perceptions of their core work help explain the quickness with which nighthawk groups have grown - nothing is seen as lost through the changes. In the next and final section, I will return to the issue of radiologist control over their work, describing the multi-faceted relationships between spatial and temporal structures in allowing radiologists to maintain control over their work.

7. What do space and time have to do with it? Contrasting Control Over Information Technology Use

One measure of radiologists' control is the degree to which they could make their workspace more comfortable. All time at work - even all time spent on a computer - is not the same. As discussed in past chapters, radiologists changed their office set-up to allow for long hours on the computer, while outpatient physicians essentially continued to work in their old chairs in examination rooms into which computers had been shoehorned.

In a broader sense, the expanded space of work enabled by information technology has been used by radiologists to exert more control over the hours that they work. As detailed in Chapter 4, many of the first nighthawk groups were founded in part to take advantage of time zones differences. A nighthawk radiologist working from Australia explained,

> I work two to twelve at this time of year, and then day light saving time happens. America goes forward and we go back, or visa versa. There's a two hour difference. So I change to noon til ten at night.

Time zones are one of the most concrete examples of the intersection of spatial, temporal and social structures. Humans have collectively decided to draw lines in space that demarcate temporal structures. In theory, nighthawk radiologists could work whatever shift they choose, simply by changing location. The reality is somewhat different, with radiologists being influenced by a variety of social and political factors, but time zones do allow additional control for a radiologist who is flexible with respect to geographic location. One of the first nighthawk groups opened their main office in Sydney, Australia for precisely this reason - to let their radiologists take advantage of time zone differences so they could cover nights in the United States, while working days in Australia.

Irrespective of time zones, as nighthawk groups get larger, they are able to accommodate more flexibility in their radiologists' schedules - not necessarily requiring them to relocate spatially in order to change shifts. The larger nighthawk groups are already allowing some of their radiologists to customize schedules that suit their particular circumstances.

The larger firms can also overcome quality problems that might otherwise arise with radiologists always working night shifts. One conventional radiologist commented that, “the problem with people working alone at night is they won’t have a neuroradiologist or other specialist to consult with when they need it.” In fact, the larger nighthawk groups now have dozens of radiologists on call on any given shift, including a wide variety of specialists. Asked if he had recently consulted with another radiologist, a U.S. nighthawk radiologist replied, “Sure. All the time. Like yesterday I instant messaged a neuroradiologist in India, and a few minutes after we reached consensus.”

Another aspect of this use of temporal structures to exert control is visible in conflicts between radiologists and non-radiologists. The traditional turf of radiologists has come under increasing threats with the spread of Picture Archiving and Communication Systems (PACS), allowing non-radiologist physicians easy access to patients’ imaging studies (Barnes 2004). This dynamic has been part of the motivation for many radiology groups at teaching hospitals to institute full time emergent radiologists. The head of emergent radiology at a large teaching hospital, explained that radiologists needed to be available all night, in order to maintain their control over image interpretation. Nighthawk radiology groups can be seen as an alternative response to this same type of threat.

Nighthawk groups help radiologists to maintain control over their core work, without requiring them to have their own radiologists working nights. By offering their services 24 hours a day, 7 days a week they insure that emergency room physicians continue to rely upon radiologists for image interpretation. As noted in previous chapters, nighthawk radiology allows small groups, which do not receive sufficient image studies to support a full time night radiologist, to offer this amenity.

The very foundation of some nighthawk groups stemmed from precisely this goal. In the mid 1990s, Dr. Susan Lipman was a partner at a large private radiology group in California when she became concerned by what she saw as the growing tendency of non-radiologist physicians to read tests -- Dr. Lipman felt that not only did this take business from radiologists, it led to lower quality medical outcomes. As a response, she started an inhouse nighthawk system, where the group began to have at least one radiologist reading tests throughout the night, every night. A few years later, Dr. Lipman went on to start one of the first wholly nighthawk groups.

8. Conclusion: A reinforcing process

I would stress that the process detailed above is an iterative one, with current spatial structures, temporal structures and technology use shaping future spatial structures, temporal structures and technology use. For instance, medical students have historically been drawn towards radiology in part due to the defined hours it was seen as offering. Above, I argued that this conception of their work as bounded in clock-time, led to them being willing and able to exert power to keep their hours defined.

Similar dynamics may be realized in the future. Today, radiology is seen as a subspecialty which allows its practitioners to focus the bulk of their work time on their core work of interpreting images. I would suggest that this has led to it attracting physicians who are particularly concerned with maintaining this situation. A young radiologist in the fourth and last year of her residency training, explained that radiology was becoming increasingly appealing to medical students in part because

You don't have to deal with a lot of busy work. You're making a

> diagnosis all day long… There's a lot of busy work involved with dealing with health care and reimbursement. All those problems are not as difficult in radiology. And then so you're just doing your job all day. You don't have to worry about gathering information... There's minimal paperwork.
>
> Our job is to read an image, and we get all the images, as opposed to you know, finding out this lab value and changing this a little bit. For one patient [in general medicine] you have tons and tons of that note writing and forms. In my mind, it seems like crappy busywork. And I think that people are sort of starting to sense that in medical school.

If she is representative of the type of medical student who is choosing to enter the highly competitive subfield of radiology, one would expect the next generation of radiologists to be similarly concerned with focusing on core work. Thus, current temporal practices shape the future processes through which radiologists use information technology to change their work.

In this chapter, I have drawn from all research sites to bring together the themes of control, information technology and the spatial-temporal nature of work that have run through this dissertation. In the next and final chapter, I conclude by drawing these themes into higher relief, and suggesting the questions that future research might usefully address.

Chapter 5: Tables and Figures

Table 5.1: Descriptive Statistics for Hours Worked

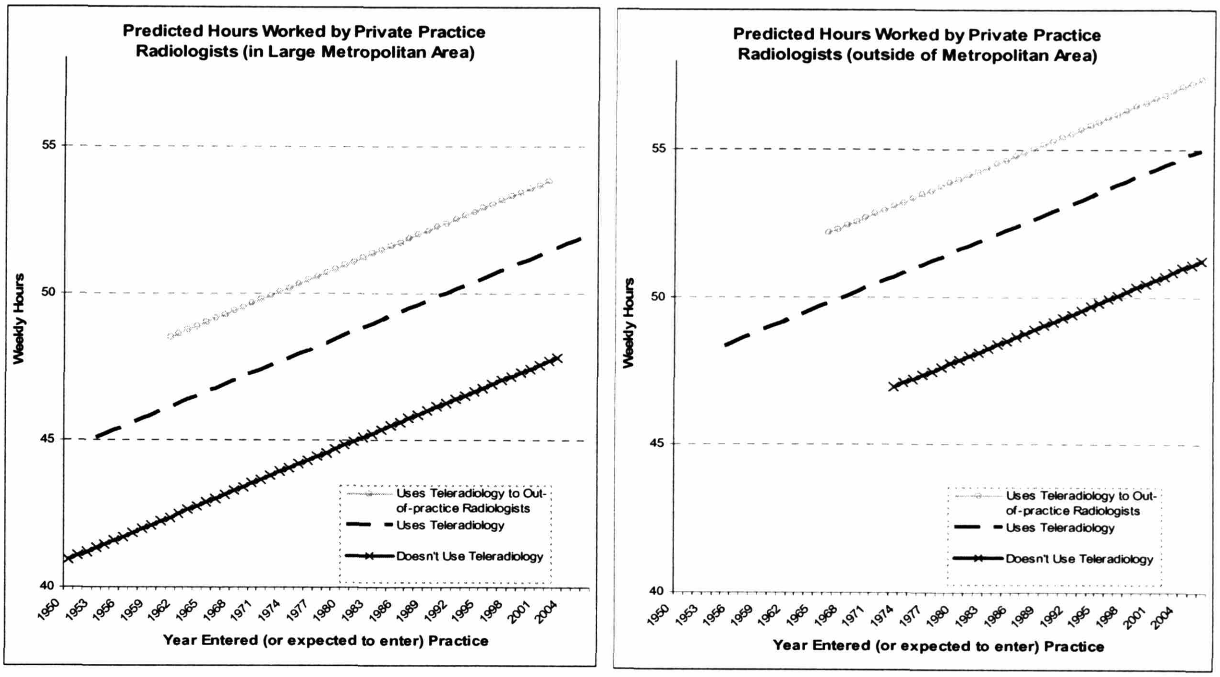
Subgroup	N	Minimum Hours Worked	Mean Hours (Standard Deviation)	Maximum Hours Worked
Large Metropolitan Area (pop >1,000,000)	549	5	49.58 (12.31)	107
Small Metropolitan Area (50,000<pop<1,000,000)	441	4	51.1 (13.75)	150
Non-metropolitan Area (pop<50,000)	183	8	52.17 (13.34)	100
Use teleradiology	924	4	51.48 (12.80)	90
Do not use teleradiology	232	8	46.69 (12.81)	150
Use telerad-out	164	4	51.92 (14.04)	100
Do not use telerad-out	992	8	50.28 (12.74)	150
Across entire population	1173	4	50.55 (13.06)	150

Table 5.2: OLS Regression predicting hours worked in the last full week of work (N=1008)

	M1	M2	M3	M4	M5	M6	M7*
Intercept	47.7***	46.96***	46.22***	-238.73***	-227.68**	-218.51**	-213.46**
TELERAD	3.46***	3.31***	3.18**	2.67**	2.7**	4.24**	4.83***
TELERAD TO OUT	1.76	1.7	1.65	1.76	2.01~	2~	2.40*
NOCITY		1.89~	2.55*	2.71*	3.24**	2.98*	3.03*
SMALLCITY		1.52~	1.74*	1.73*	2*	1.95*	2.06*
YEAR				.14***	.14***	.13***	.13***
SIZE			0.04	0.04	0.01	.08~	.09*
ACADEMIC					3.06**	2.99**	3.18**
SOLO					-2.47	-1.95	
LOCUM					-1.3	-1.09	
GOVERNMENT					-2.8	-2.64	
TELEXSIZE						-.1~	-.11*
R2	0.02	0.02	0.03	0.04	0.05	0.06	0.06
df Error	1005	1003	1002	1001	997	996	997
SSError	146693	146022	145568	143282	141608	141122	138621
Key: ~p<0.10; *p<0.05; **p<0.01; ***p<0.001							

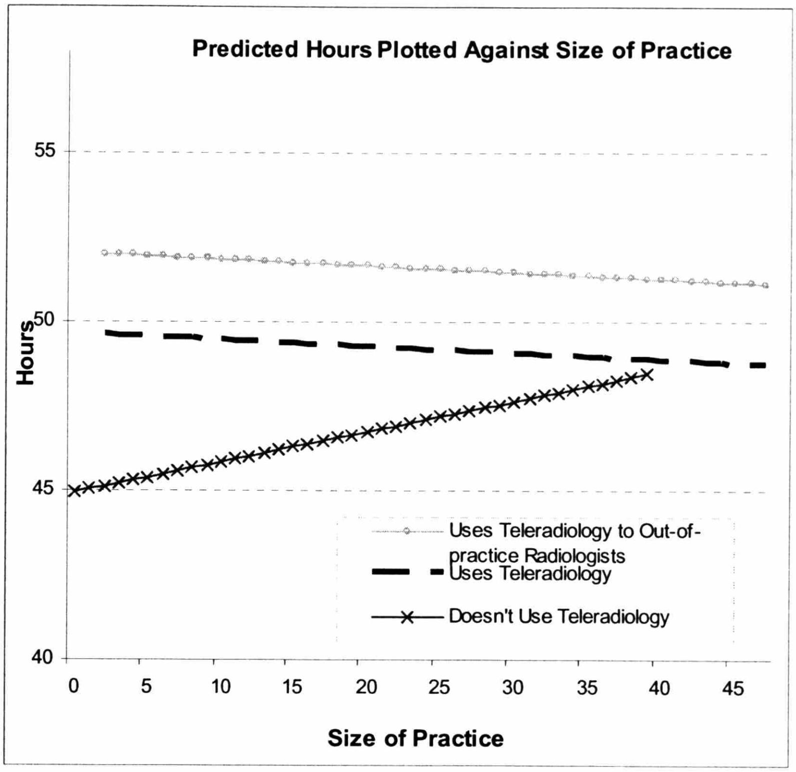
Note:
Reference group is private practice in large metropolitan area. All two-way interactions between each teleradiology variable and all other control variables were tested for significance and found to be insignificant.
*Model M7 uses a reduced dataset where two outliers were eliminated, leaving a sample size of 1006 -- see Appendix 5.2 for details.

Figure 5.1: Prototypical Fitted Curves plotting the predicted hours worked in the last full week of work versus year entered (or expected to enter) practice



Note: For the purposes of this illustration, group size was held constant at the median size for a private practice (10).

Figure 5.2. Prototypical fitted curves plotting predicted hours worked in the last full week of work versus size of group



Note: For the purposes of this illustration, prototypical radiologists were presumed to be private practice radiologists practicing in a large metropolitan area, with year entered practice held constant at 1987 (the median year private practice radiologists within the sample entered practice).

Chapter 5 - List of Appendices

Appendix 5.1: Description of Variables

Table 5.1.1 Variable Descriptions

Variable Name	Description
HOURS	number of hours a radiologist reported working in the last full week of work.
TELERAD	a dichotomous variable that takes on a value of 1 if the radiologist's group uses teleradiology applications and a value of 0 otherwise
TELERAD TO OUT	a dichotomous variable that takes on a value of 1 if the radiologist's group uses teleradiology to out-of-group radiologists and a value of 0 otherwise
SMALLCITY	a dichotomous variable that takes on a value of 1 if the radiologist works in a metropolitan area with a population between 50,000 and 1,000,000 and a value of 0 otherwise
NOCITY	a dichotomous variable that takes on a value of 1 if the radiologist works in a metropolitan area with a population of less than 50,000 and a value of 0 otherwise
ACADEMIC	a dichotomous variable that takes on a value of 1 if the radiologist works in an academic radiology group (i.e. a group that contracts with a teaching hospital) and a value of 0 otherwise
SOLO	a dichotomous variable that takes on a value of 1 if the radiologist works in a solo practice and a value of 0 otherwise
LOCUM	a dichotomous variable that takes on a value of 1 if the radiologist does contract work and a value of 0 otherwise
GOVERNMENT	a dichotomous variable that takes on a value of 1 if the radiologist works in a government practice and a value of 0 otherwise
YEAR	the year the radiologist entered, or expected to enter, post-training practice
SIZE	number of full time radiologists working in radiologist's main group
TELEXSIZE	an interaction variable between TELERAD and SIZE

Appendix 5.2 Robustness Analysis of OLS Models Predicting Hours Worked / Week

Outlier Analysis

After arriving at a final model, I estimated three types of influence statistics: press residuals, HAT statistics and Cook's D statistics.[29] I plotted and visually examined those observations that were exceptional. On the basis of this inspection, I selected eight outliers for additional analysis. I proceeded to group outliers thematically and remove each group from the data set to ascertain the effect, if any, this removal would have on the model fit.

I found that there were four radiologists who worked for government practices, used teleradiology to out-of-group radiologists, and who had very high HAT and Cook's D statistics (see table 5.2.1 below). I split this group in half, as two of them worked in exceptionally small groups and worked below average hours, while the other two were less exceptional in those attributes. When I removed the pair (labeled 'Group A' in table 5.2.1) a previously significant interaction between government practices and teleradiology use was no longer significant. Given their anomalous character for virtually every variable of interest, I decided that this pair was exceptional and that leaving them in the sample gave rise to misleading estimates of significance. Thus, I chose to remove these two outliers from the sample.

I grouped the remaining six outliers according to common characteristics, and then removed each group, one by one. However, as table 5.2.2 demonstrates, removing the additional outliers had little effect on the parameter estimates, and so I chose to leave them in the sample.

[29] A press residual measures the difference between the actual outcome for a given radiologist (e.g. the actual hours a radiologist reported working) and the value that would have been estimated had that radiologist been left out of the model. The HAT statistic measures the standardized distance of a given observation from the average observation. The Cook's D statistic measures the overall impact of each radiologist on the regression fit.

Table 5.2.1 Typologies of Outliers

Group	Unique ID	Hi Cook	Hi Hat	Hi Press	Telerad	Telrad_out	Hours	Rads in Pract.	City Size	Type	Year
A	2005750742	**1**	**1**	0	**1**	**1**	25	**1**	Small	**Govt**	1982
A	602680523	**1**	**1**	0	**1**	**1**	8	**2**	NoCity	**Govt**	1973
B	3409831092	**1**	**1**	0	**1**	**1**	**56**	21	**Large**	**Govt**	2001
B	3740610454	**1**	**1**	0	**1**	**1**	**60**	7	**Large**	**Govt**	1975
C	2407791119	0	**1**	0	0	0	**50**	**130**	**Small**	Acad	1985
C	5505961285	0	**1**	0	0	0	**50**	**130**	**Small**	Private	2002
D	2746860618	0	0	1	1	0	100	60	Large	Acad	1994
E	49421870222	0	0	1	1	0	106	11	Small	Private	2002

Table 5A2.2 OLS Regression removing outlying observations

	M7	M7_A	M7_B	M7_C	M7_D	M7_E	M7*
Intercept	-221.95**	-213.22**	-214.29**	-218.81**	-216.12**	-207.55**	-213.46**
TELERAD	4.79***	4.83***	4.83***	5.45***	4.86***	4.74***	4.83***
TELERAD TO OUT	2.32*	2.31*	2.32*	2.31*	2.39*	2.39*	2.40*
NOCITY	2.77*	3.07**	2.83*	2.91*	2.73*	2.79*	3.03*
SMALLCITY	1.95*	2.09*	1.99*	2.09*	1.99*	1.83*	2.06*
SIZE	.09*	.09*	.09*	.15**	.09*	.09*	.09*
YEAR	.13***	.13***	.13***	.13***	.13***	.13***	.13***
ACADEMIC	3.13**	3.2**	3.16**	2.89**	2.92**	3.16**	3.18**
GOVT	-.14	-.07	-.11	-.01	-.15	-.07	
TELEXSIZE	-.11*	-.11*	-.11*	-.17**	-.12*	-.11*	
TELE_OUTxGOVT	-15.2*	6.18	-21.17**	-15.32*	-15.28*	-15.29*	
R2	0.06	0.06	0.06	0.06	0.06	0.06	0.06
df Error	997	995	996	995	996	996	997
SSError	140517	138547	140097	140095	138271	137753	138621
Group removed	None	A	B	C	D	E	A (Reduced)
Influence Statistics (of removed obs)		Hi Cook, Hi Hat	Hi Cook Hi Hat	Hi Hat	Hi Press	Hi Press	Hi Cook Hi Hat
Key: ~p<0.10; *p<0.05; **p<0.01; ***p<0.001							

Checking OLS Assumptions of Normality and Homoscedasticity

I plotted the press residuals of the final model (with the two observations removed) against the independent variables and found that the residual variation appeared to be both homoscedastic and normal. When I used the Shapiro-Wilk test to examine the normality of their distribution, though, I discovered that the press residuals were not normally distributed. However, the outcome variable, HOURS, was similarly abnormal, and I attributed the lack of normality in the residuals to this. OLS regressions are relatively robust to normality violations, and so I present these results.

Chapter 6 -- Conclusion

1. Introduction

I began this dissertation by recalling Toffler's oft-debunked prediction of the imminence of the "electronic cottage industry." Several decades ago, as home computers were just beginning to emerge as a viable technology, Toffler (1980, 210) predicted a new mode of development where production would move from the factory back into the home, carrying with it increased worker autonomy, improved working conditions and featuring workers who related extensively to one another through computer mediated communications.

In this dissertation I have examined the emerging industry of nighthawk radiology, a seeming exemplar of such an electronic cottage industry, explaining the attributes of radiology work which led to such an outcome. I contrasted the work of radiologists to the more limited remote work performed by outpatient physicians. This comparison highlighted the utility of examining the specific spatial practices with which all people work, not only those engaging in the more dramatic manifestations of remote work.

Drawing from diverse urban, organization and economic literatures, I have suggested a spatial structuring approach to examining issues of space and work practices. From this perspective, spatial practices are seen as both shaping and being shaped by information technology use. For simplicity's sake I initially presented this approach as purely spatial in orientation, but in Chapter 5 I illustrated the extent to which spatial and temporal structures are intertwined. In this dissertation, I applied this framework to consequences in terms of relationships of control, but I would propose that it could easily be extended to address other consequences and dynamics in organizational change.

2. Summary of findings

I first illustrated the utility of the spatial structuring approach in Chapter 3, with the case of outpatient physicians. The spatial practices of outpatient physicians prior to adopting EMRs shaped the implementations of the EMRs in that they led to a series of problems in coordinating outpatient work, problems that EMRs were adopted in part to solve. The EMRs, in turn, were successfully used to further extend physician work in time and space, as well as to better coordinate and control their work.

I also described the importance of spatial practices in shaping outpatient physicians' desire to control the use of information technology to change their work. Their perception that seeing their patients in person was their core work, left them with little ability or desire to exert control over the use of EMRs, particularly with respect to working in remote locations. I further explored these questions of professional control, spatial practices and information technology use in Chapter 4, where I turned to radiology work.

For radiologists, their historic spatial practices shaped the way they used teleradiology applications to respond to a recent, and overwhelming, scarcity of radiologists. Radiologists were doing their core work in darkened rooms at a distance from their patients long before the introduction of computers. Their current procedures and technologies allow them to look at far more images than they once did, but it came as no surprise to any radiologist that they spent much of their time peering at a screen, at a distance from both their patients and referring physicians. My research suggests that this history is partially responsible for their greater ability to make their work on computers comfortable, as well as to control their use of information technology more generally. Unlike the case of outpatient physicians, where information technology was used to remotely accomplish only tasks physicians viewed as inessential, teleradiology allowed radiologists' most essential core work to be done at a distance. This raised the stakes for radiologists, as suddenly their work appeared to be susceptible to offshoring.

Ironically, the very qualities that made their work susceptible to offshoring prepared radiologists to exert control over the use of information technology and the organizations and institutional processes that regulate the interpretation of medical images in the United States. Radiologists were able to exercise control, in part, because they *had to* exercise control in order to survive as a high status profession. The core tasks of their work - reading radiological images - are mediated by information technology and performed from a distance. If they let someone else control the use of information technology, they would be ceding control over the essence of their work.

However, it was not simply the threat to their profession that allowed them to exercise power, or many other U.S. workers would have been as successful as radiologists in keeping their jobs from being offshored. Healthcare is different than other commodities, and medical doctors have long been distinguished as a profession by the power they have been able to exert over their work (Abbott 1988; Freidson 1970; Van Maanen and Barley 1984).

Nor does this power exist in isolation from their professional expertise. It would be both unrealistic and unduly cynical to view professional power as simply self-serving. In fact, I would argue that radiologists would not be able to exert power solely to preserve their status and scarcity, even if they wanted to. I have cited Grumbach's observation several times that "professionalism developed not just as an anticompetitive strategy, but in response to legitimate societal concerns about competence and quality with an unregulated health care workforce" (2002, 5). In this research it appeared that radiologists were able to exert control over the offshoring of their work, precisely because they had legitimate concerns about quality, quality which they felt uniquely competent to gauge.

All of radiologists' professional prestige is directed at their ability to control the particular work of interpreting radiological images. To reiterate the spatial argument: this core aspect of radiology work had been done remotely since the inception of their profession. The fact that images could now be interpreted from thousands of miles away, rather than a hundred yards away, did not appreciably lessen radiologists' ability to exert professional control over their work.

I highlighted a different dynamic between spatial practices, information technology and control in each case, but the logic of both cases could be extended to the other. For example, in the outpatient case, I illustrated that spatial practices beforehand helped shape spatial practices afterwards. Although this logic occupied a subordinate role in the description of the radiology case, it was visible in that case as well. Nighthawk radiologists used teleradiology applications to create new reading environments that were clearly based upon either the centralized reading rooms of radiology groups in a teaching hospital (e.g., the large centralized nighthawk reading rooms in Sydney and Zurich) or the decentralized but connected reading rooms of private practices (e.g., the distributed network of nighthawk radiologists connected via a virtual reading room).

Similarly, one can extend the argument with respect to radiologists and professional power to outpatient physicians. I linked the relative lack of power outpatient physicians exerted over the use of the EMR to their perception of their core work as constrained in space and performed unmediated by information technology.

Admittedly, there were important differences between the two cases. While the radiology case was primarily about the application of professional power, the outpatient case was concerned more about relationships of control among physicians. Another important difference lay with the scarcity of radiologists driving the growth of the nighthawk radiology market. However, in both cases spatial practices played an important role in shaping the use of IT to change work.

It was analytically useful to initially focus on the role of spatial structures to the exclusion of temporal structures, but in the final empirical chapter I demonstrated that the two are intertwined. For both radiologists and outpatient physicians, extending the space of their work led to them spending more time working. Differences in the temporal practices used by both types of physician, especially when viewed in concert with spatial practices, helped explain different outcomes in terms of time spent at work. Radiologists were better able to use teleradiology applications to confine their work to certain hours, and to make the time spent at work more comfortable. They also were able to use the spatial and temporal flexibility lent by teleradiology to maintain more control over their core work vis a vis other medical specialties.

3. Policy Implications

This work has distinct policy implications, both in health care and in the broader policy arena. In terms of health care, both EMRs and teleradiology have been at the heart of distinct policy debates.

For decades, politicians from across the political landscape have issued calls for a national electronic health record system (Connolly 2005; Rose 2004; Starr 1997.) The Bush administration recently estimated that the electronic health records will "save the economy, conservatively, 140 billion a year" (Rovner 2004), one tenth of what the U.S. currently spends on health care.[30] Even more recently, the unlikely duo of New Gingrich and Hilary Clinton appeared together to proclaim the importance of establishing better electronic health records (Hernandez 2005).

While the three outpatient clinics examined in this research were each successful in using an EMR, their cases point to the difficulties in successfully completing an initiative to get the entire country on an integrated health record system. My research suggests at least three particular challenges that the national initiative must overcome to be successful: making EMRs more affordable for very small clinics; convincing clinics which do use EMRs to make them interoperable and mitigating the potential for burnout among those physicians who do adopt EMRs.

I have described the reasons clinics adopted EMRs -- most of these reasons simply do not pertain to smaller groups, with one or two physicians. Physician in such practices can keep all of their paper records in one place and only rarely see other physicians' patients. Also, they have less physicians among who to distribute the sizable fixed costs of installing an EMR.

Interoperability is also a difficult problem to overcome. This study was confined to EMRs that operated within single organizations. In the case of the Urban Central outpatient clinic, the EMRs had no interoperability even between the outpatient clinic and

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[30] The provenance of the 140 billion figure is uncertain, but speaks to the high hopes placed on electronic health records.

the rest of the Urban Central's information system. Several of the dynamics that aided in the adoption of EMRs and convinced physicians to use them will be absent in the broader endeavor.

For instance, privacy concerns will be more acute as systems become interoperable. Some physician participants in this study were concerned about their patients' privacy, even in the context of the bounded EMRs that their clinic had adopted. Systems which cross boundaries between organizations must walk the line between the ease of access that will convince physicians to use them, and the restriction of access that will convince physicians that their patients' privacy is assured.

Finally, if EMRs are to be widely embraced without placing an untenable burden on individual physicians, EMRs must be implemented in a way that is sensitive to physicians' previous work practices. Recent research (Koppel, et. al. 2005) has shown that some electronic entry systems have not attained appreciable cost saving and error reducing benefits due, in part, to the excessive demands they make on individual physicians. Thus, minimizing the time required to use an EMR will not only reduce burnout among physicians but make the system more effective in reaching its goals.

The research on outpatient physicians also called attention to the importance of the transparency of the system in concert with physician norms. As systems get larger, physicians may be less conscious of the surveillance of their peers and superiors, as they are just one of 2000 physicians using a system, rather than one of 30 physicians. These expanded systems will need to be easier in order to convince physicians to make the changes required to use them.

Another barrier that will exist in a larger system to a greater extent than in these more limited systems is the discrepancy between the division of costs and benefits. In the clinics I studied, individual physicians incurred additional costs to their time, but their clinic saw some immediate financial rewards from implementing an EMR -- for example, they are able to bill at higher levels than similar clinics without the system. If every clinic began using an electronic system, the individual clinics would presumably no longer be relatively better off. They would still be paying for their own system, while patients and insurers would be the ones benefiting.

This is not to say that an integrated electronic health system is impossible or unimportant. Participants - both outpatient physicians and radiologists - recognized the need for integrated systems. Outpatient physicians spoke of their frustration at the boundaries of their EMR, with test results and specialist visits often going unrecorded. One radiologist complained of having to keep track of half a dozen of computer network passwords for the different hospitals at which he worked, each of which had to be changed every thirty days. Nighthawk radiology also points out the fundamental irrationality of a state-based licensing system, in a world where thousands of tests cross state boundaries every night.

My work also has specific implications with respect to the future of radiology work. In the past, technology's historical centrality to radiology as a field has proven helpful to radiologists in fighting turf battles. As one outpatient physician laughingly remarked, "Radiologists are going to rule the world," citing procedures they have developed in recent years to perform medical tasks that would previously have required invasive and dangerous surgical procedures.

Radiologists are not as assured about their own future. They worry about turf encroachments from cardiologists and orthopedic surgeons. They are concerned that they will lose control of teleradiology and be forced to compete with foreign radiologists. If the scarcity of radiologists does not abate in the next few years, one wonders if the need for radiologists will not simply overwhelm their ability to control the offshoring.

From a cost standpoint, government action is called for to abate the scarcity of radiologists and other medical specialists. While residency positions are expensive, presumably increasing the supply will ultimately decrease the price one has to pay for medical labor. One would think that the demand for radiologists is sufficiently inelastic that increasing the supply would lower the overall amount spent on radiology labor.

This research also has ramifications beyond the health care industry. Diverse working arrangements such as those enabled by nighthawk groups can coax more people into the work force, and allow increased satisfaction for those workers who wish to work in non-traditional work arrangements. It is important to further investigate the extent to which these arrangements are being used, and the obstacles which continue to stop professionals from taking advantage of them. In addition to the personal benefits workers might reap, there are economic benefits to encouraging more work force participation. Technology offers policy makers another tool for facilitating more flexible work places and work-family balance.

The potential of exporting radiology work to foreign radiologists trained in the United States is also important with respect to the issue of the "brain drain" of foreign medical professionals by the U.S. healthcare system. Saxenian's (2002) research into Chinese and Indian software engineers in Silicon Valley, found evidence that the one way passage of high skilled individuals from developing countries to the United States was being replaced by what she terms "brain circulation, or two-way flows of highly-skilled professionals, between California and fast-growing regions in India and Greater China" (2002, 51).

In the health care context, the United States has long relied on other countries' education systems to fill the deficit between the number of physicians it needs and the number it actually trains (Mullan 2002). To the extent that nighthawk radiology allows foreign trained radiologists to return to their native countries after becoming certified in the United States, it enables a switch from the brain drain dynamic to the brain circulation dynamic evident in Saxenian's research.

4. Directions for Future Research

This dissertation suggests several profitable directions for future research. Within healthcare, more work is necessary to explore the physician-patient relationship and how information technologies are being used to change that relationship. While the outpatient physician participants in this study suggested that EMR use had only a negligible influence on physician-patient interactions, it would be impossible to make a strong conclusion to this effect without actually observing the physician-patient interaction. Testing this claim would be a valuable contribution to the understanding of the impact of health information technology use on the delivery of health care. As more and more interactions between the patient and physician are mediated by web sites, e-mail, instant messenger and other new information technologies, the impact of healthcare information technology use on the physician-patient relationship is a rich one for further research, including the ramifications of such technology use for patient privacy.

More generally, one might investigate the use of the Internet to find medical information, bypassing medical professionals altogether. A recent study found that about 95 million American adults used the Internet to find health information in 2004 (Pew Internet and American Life Project 2005). To what extent do these Internet searches substitute for phone calls or doctor appointments, and to what extent do they complement traditional medical treatment? Additional focused research is necessary to learn precisely how individuals are using the Internet, and how this use changes their access to health care.

The work force policy implications of this research might also be pursued further, particularly with respect to the radiology portion. Currently there are roughly equal numbers of men and women in U.S. medical schools, yet women make up only 25% of the residents in radiology programs. Teleradiology applications would seem to allow the flexibility and family time that are particularly important to female doctors (Applegate 2005), making radiology a more family friendly application. Thus, one would expect to see more women taking advantage of nighthawk radiology groups to work from home and to integrate their work schedule with their family life.

Nighthawk groups have also been of particular interest to older radiologists. In the late 1990s the stock market bust convinced many radiologists nearing retirement age to remain in practice for a few more years. However these older radiologists were no longer interested in working the sorts of shifts that were being required of them. My research suggests that nighthawk radiology has been influential in convincing this older demographic to stay in the workforce. Future research could further look at the effects of nighthawk radiology in terms of enabling more flexibility in the labor market.

Future research is generally needed to further examine the relationship between work and space. The very term "work" has long been conflated with certain places or types of spaces. In American society, you could traditionally speak of going to "work" and your listener would understand you were leaving your home and going to your workplace. However, it has become increasingly common that work comes to your home. More and more Americans are occasionally working from home, with recent studies estimating that up to 38 million Americans worked from home part time (Gurstein 2001, Pratt 1999). Given the number of teleworkers, empirical research must begin to distinguish between the types and intensity of remote work. In this research it appeared that workers who only worked from home - e.g. the nighthawk radiologists - were better able to manage family-work divisions than those outpatient physicians and conventional radiologists who worked from home in addition to their office work. Future research could assess the robustness of this finding in other professions and workplaces.

Bibliography

Abbott, Andrew. 1988. *The System of Professions: an essay on the division of expert labor*. Chicago: University of Chicago Press.

Applegate, Kimberly E. 2005. "The Future Workforce in Academic Radiology: Gender, Generational, and Cultural Influences." *Journal of the American College of Radiology* 2:133-138.

Armstrong, David. 2005. "MRI and CT Centers Offer Doctors Way to Profit on Scans." *Wall Street Journal*.

Autor, David H.; Frank Levy & Richard Murnane. 2002. "Upstairs, Downstairs: Computers and Skills on Two Floors of a Large Bank." *Industrial and Labor Relations Review* 55(3):432-447.

Autor, David H; Frank Levy & Richard Murnane. 2001. "The Skill Content of Recent Technological Change: An Empirical Exploration." in *NBER Working Paper 8337*. NBER.

Bachrach, Peter and Morton S. Baratz. 1962. "Two Faces of Power." *American Political Science Review* 56(4):947-952.

Barley, Stephen. 1986. "Technology as an Occasion for Structuring: Evidence from Observation of CT Scanners and the Social Order of Radiology Departments." *Administrative Science Quarterly* 31:78-108.

—. 1990. "The Alignment of Technology and Structure through Roles and Networks." *Administrative Science Quarterly* 35(1):61-103.

Barley, Stephen and Pamela Tolbert. 1997. "Institutionalization and Structuration: Studying the Links between Action and Institution." *Organization Studies* 1(18):93-117.

Barnes, Eric. 2004. "Radiologists beware: PACS could make you obsolete." *Aunt Minnie.com*, July 1, 2004.

Batchelor, Jonathan. 2004. "Technology, technique help ease radiologist shortage." auntminnie.com.

Bates, David; Gilad Kuperman; Eve Rittenberg; Jonathan M. Teich; Julio Fiskio; Nell Ma'Luf, Andrew Onderdonk; Donald Wybenga; James Winkelman; Troyen Brennan; Anthony Komaroff; Milenko Tanasijevic. 1999a. "A Randomized Trial of a Computer-based Intervention to Reduce Utilization of Redundant Laboratory Tests." *The American Journal of Medicine* 106:144-150.

Bates, David; Jonathan M. Teich; Joshua Lee; Diane Seger; Gilad Kuperman; Nell Ma'Luf, Deborah Boyle & Lucian Leape. 1999b. "The Impact of Computerized

Physician Order Entry on Medication Error Prevention." *Journal of the American Medical Informatics Association* 6(4):313-321.

Batt, Rosemary. 1999. "Work Organization, Technology, and Performance in Customer Service and Sales." *Industrial and Labor Relations Review* 52(4):539-564.

Beck, Ulrich. 1992. *Risk Society: Towards a New Modernity*. London: Sage Publications.

Becker, Howard S. 1998. *Tricks of the Trade*. Chicago: University of Chicago Press.

Berg, Marc. 1997. "Of Forms, Containers, and the Electronic Medical Record: Some Tools for a Sociology of the Formal." *Science, Technology and Human Values* 22(4):403-433.

Bernstein, AB, E Hing, AJ Moss, et al. 2003. "Health Care in America: Trends in Utilization." National Center for Health Statistics.

Blackler, Frank. 1995. "Knowledge, Knowledge Work and Organizations." *Organization Studies* 16(6):1021-1046.

Bloomfield, Brian and Rod Coombs. 1992. "Information Technology, Control and Power: The Centralization and Decentralization Debate Revisited." *Journal of Management Science* 29(4):458-484.

Bresnahan, Timothy F.; Erik Brynjolfsson and Lorin M. Hitt. 2000. "Technology, Organization and the Demand for Skilled Labor." p. 145-184 in *The New Relationship: Human Capital in the American Corporation*. the Brookings Institution Press.

Butcher, Lola. 2004. "Radiologists: Docs don't get the big picture." *The Business Journal of Kansas City*, August 27, 2004.

Calhoun, Craig. 1998. "Community Without Propinquity Revisited: Communications Technology and the Transformation of the Urban Public Sphere." *Sociological Inquiry* 68(3):373-397.

Castells, Manuel. 1989. *The Informational City: Information Technology, Economic Restructuring and the Urban-Regional Process*. Oxford: Basil Blackwell.

—. 1996. *The Rise of the Network Society*. Cambridge, MA: Blackwell Publishers Ltd.

Chassin, Mark, Edward Hannan and Barbara DeBuono. 1996. "Benefits and Hazards of Reporting Medical Outcomes Publicly." *The New England Journal of Medicine* 334(6):394-398.

Clarke, Susan and Gary Gaile. 1998. *The Work of Cities*. Minneapolis: University of Minnesota Press.

Connolly, Ceci. 2005. "Cedars-Sinai Doctors Cling to a Pen and Paper." *Washington Post*, March 21, 2005.

Coye, Molly. 2001. "No Toyotas in Health Care: Why Medical Care Has Not Evolved to Meet Patients' Needs." *Health Affairs* 20(6):44-56.

Diken, Bulent and Carsten Bagge Laustsen. 2002. "Zones of Indistinction: Security, Terror and Bare Life." *Space and Culture* 5(3):290-307.

DiMaggio, Paul and Walter Powell. 1983. "The Iron Cage Revisited: Institutional Isomorphism and Collective Rationality in Organizational Fields." *American Sociological Review* 48(April):147-160.

Durkheim, Emile. 1883. *The Division of Labor in Society*. New York: The Free Press.

Epstein, Cynthia Fuchs & Arne L. Kalleberg. 2001. "Time and the Sociology of Work." *Work and Occupations* 28(1):5-16.

Fielding, Stephen L. 1990. "Physician Reactions to malpractice Suits and Cost Containment in Massachusetts." *Work and Occupations* 17(3):302-319.

Fink, Kenneth, Robert Phillips Jr., George E. Fryer, et al. 2003. "International Medical Graduates and the Primary Care Workforce for Rural Underserved Areas." *Health Affairs* 22(2):255-267.

Florida, Richard. 2002. *The Rise of the Creative Class*. New York: Basic Books.

Foucault, Michel. 1979 [1995]. *Disciple and Punish: the birth of the prison*. New York: Vintage Books.

Fountain, Jane. 2001. *Building the Virtual State*. Washington, D.C.: Brookings Institution Press.

Freeman, Richard. 2002. "The Labour Market in the New Information Economy." National Bureau of Economic Research (NBER) working paper.

Freidson, Eliot. 1970. *Profession of Medicine: A Study of the Sociology of Applied Knowledge*. New York:: Dodd, Mead & Co.

Freudenheim, Milt. 2005. "Digital Rx: Take Two Aspirins and E-Mail Me in the Morning." *New York Times*, March 2, 2005.

Garfinkel, Harold. 1967. "Good Organizational Reasons for Bad Clinic Records." p. 186-204 in *Studies in Ethnomethodology*. Prentice-Hall.

Gaspar, Jess and Edward Glaeser. 1998. "Information Technology and the Future of Cities." *Journal of Urban Economics* 43:136-156.

Gaventa, John. 1980. *Power and Powerlessness: Quiescence and Rebellion in an Appalachian Valley*. Urbana, IL: University of Illinois Press.

Giddens, Anthony. 1979. *Central Problems in Social Theory: Action, Structure and Contradiction in Social Analysis*. London: MacMillan.

—. 1981. *A Contemporary Critique of Historical Materialism*. London: Macmillan.

—. 1982. *Profiles and Critiques in Social Theory*. London: MacMillan.

—. 1984. *The Constitution of Society; Outline of a Theory of Structuration*. Berkeley: University of California Press.

—. 1985. "Time, Space and Regionalisation." p. 265-295 in *Social Relations and Spatial Structures*. St. Martin's Press.

—. 1993. *The Giddens Reader*. Stanford, CA: Stanford University Press.

Goldstein, Nance. 2003. "IT at Work: Information Technologies and Remote Working in the United States." SRI International.

Gordon, David. 1984. "Capitalist Development and the History of American Cities." p. 21-53 in *Marxism and the Metropolis: New Perspectives in Urban Political Economy*. Oxford University Press.

Gottdiener, Mark. 1985. *The Social Production of Urban Space*. Austin, TX: University of Texas Press.

Gottdiener, Mark and Ray Hutchison. 2000. *The New Urban Sociology*. New York: McGraw-Hill.

Gregory, Derek. 1985. "Suspended Animation: The Stasis of Diffusion Theory." p. 296-336 in *Social Relations and Spatial Structures*. St. Martin's Press.

Grumbach, Kevin. 2002. "Fighting Hand to Hand Over Physician Workforce Policy: the invisible hand of the market meets the heavy hand of government planning." *Health Affairs* 21(5):13-27.

Gurstein, Penny. 2001. *Wired to the World Chained to the Home*. Vancouver: UBC Press.

Hafferty, Frederic and Donald Light. 1995. "Professional Dynamics and the Changing Nature of Medical Work." *Journal of Health and Social Behavior* 35(Special Issue):132-153.

Hagerstrand, Torsten. 1973. "The Domain of Human Geography." in *Directions in Geography*, edited by Richard J. Chorley. Methuen and Co Ltd.

Halaby, Charles N. and David L. Weakliem. 1989. "Worker Control and Attachment to the Firm." *American Journal of Sociology* 95(3):549-591.

Harkavy, Ira & Harmon Zuckerman. 1999. "Eds and Meds: Cities' Hidden Assets." The Brookings Institution.

Harvey, David. 1985a. "The Geopolitics of Capitalism." p. 128-163 in *Social Relations and Spatial Structures*, edited by Derek and John Urry Gregory. St. Martin's Press.

—. 1985b. *The Urbanization of Capital*. Baltimore: John Hopkins University Press.

Hawley, Amos. 1986. *Human Ecology: A Theoretical Essay*. Chicago: the University of Chicago Press.

Hernandez, Raymond. 2005. "Gingrich and Clinton Agree: Let's Share." *New York Times*, May 12, 2005.

Hinds, Pamela and Sara Kiesler (eds.). 2002. *Distributed Work*. The MIT Press.

Houlihan, Maeve. 2002. "Tensions and Variations in Call Centre Management Strategies." *Human Resource Management Journal* 12(4):67-85.

Hoyt, Homer. 1939. *The Structure and Growth of Residential Neighbourhoods in American Cities*. Washington D.C.: U.S. Federal Housing Administration.

Institute of Medicine. 2001. "Crossing the Quality Chasm: A New Health System for the 21st Century." Institute of Medicine, Committee on Quality of Health Care in America,.

—. 2003. "Patient Safety: Achieving a New Standard for Care." Institute of Medicine, Committee on Data Standards for Patient Safety.

Jacobs, Jerry & Kathleen Gerson. 2001. "Overworked Individuals or Overworked Families?: Explaining Trends in Work, Leisure, and Family Time." *Work and Occupations* 28(1):40-63.

Johnson, George. 1997. "Changes in Earnings Inequality: The Role of Demand Shifts." *Journal of Economic Perspectives* 11(2):41-54.

Johnson, Laura. 2003. *The Co-Workplace: Teleworking in the Neighborhood*. Vancouver, BC: UBC Press.

Jonietz, Erika. 2003. "Paperless Medicine." *Technology Review*, April, 2003.

Kalyanpur, Arjun, Joy Weinberg, Vladimir Nklesa, et al. 2003. "Emergency Radiology Coverage: technical and clinical feasibility of an international teleradiology model." *Emergency Radiology* 10:115-118.

Kane, Carol and Horst Loeblich. 2003. "Physician Income: The Decade in Review." p. 5-11 in *Physician Socioeconomic Statistics*, edited by John Wassenaar and Sara Thran. AMA.

Kenney, Martin and Rafiq Dossani. 2003. "Went for Cost, Stayed for Quality?: Moving the Back Office to India." Working Paper, The Berkeley Roundtable on the International Economy.

Koppel, Ross, Joshua Metlay, Abigail Cohen, et al. 2005. "Role of Computerized Physician Order Entry Systems in Facilitating Medication Errors." *Journal of the American Medical Association* 293:1197-1203.

Kowalczyk, Liz. 2004. "The doctor will e-you now." *The Boston Globe*, April 24, 2004.

Kvale, Steinar. 1996. *Interviews*. Thousand Oaks, CA: Sage.

Lefebvre, Henri. 1974 [1991]. *The Production of Space*. Oxford: Blackwell.

Levy, Frank and Richard Murnane. 2004. *The New Division of Labor*. Princeton: Princeton University Press.

Linton, Otha W. 2001. *Radiology at Massachusetts General Hospital: 1896-2000.* U.S.A.: General Hospital Corporation.

Maanen, John Van and Stephen Barley. 1984. "Occupational Communities: Culture and Control in Organizations." p. 287-365 in *Research in Organizational Behavior*, edited by Barry Staw and L.L. Cummings. JAI Press Inc.

Marx, Karl. 1847. "Wage Labor and Capital." p. 203-218 in *The Marx-Engels Reader*. Norton.

Massey, Doreen. 1985. "New Directions in Space." p. 9-19 in *Social Relations and Spatial Structures*. St. Martin's Press.

Maxwell, Joseph. 1996. *Qualitative Research Design*. Thousand Oaks, CA: Sage.

McGrath-Champ, S. 1993. "Labor management, space and restructuring of the Australian coal industry." *Environment and Planning A* 25:1295-1318.

Merrifield, Andy. 2002. *Metromarxism*. New York: Routledge.

Mullan, Fitzhugh. 2002. "Some Thoughts on the White-Follows-Green Law." *Health Affairs* 21(1):158-9.

Norris, A.C. 2002. *Essentials of Telemedicine and Telecare*. England: John Wiley and Sons, Ltd.

O'Leary, Michael, Wanda Orlikowski and JoAnne Yates. 2002. "Distributed Work over the Centuries: Trust and Control in the Hudson's Bay Company, 1670-1826." p. 27-54 in *Distributed Work*, edited by Pamela Hinds and Sara Kiesler. MIT Press.

Olson, Judith, Stephanie Teasley, Lisa Covi, et al. 2002. "The (Currently) Unique Advantages of Collocated Work." p. 113-135 in *Distributed Work*, edited by Pamela Hinds and Sarah Kiesler. MIT Press.

Orlikowski, Wanda. 1996. "Evolving with Notes: Organizational Change around Groupware Technology." in *Groupware and Teamwork*, edited by C. U. Ciborra. John Wiley and Sons.

Orlikowski, Wanda J. 1991. "Integrated Information Environment or Matrix of Control?: The Contradictory Implications of Information Technology." *Accounting, Management and Information Technologies* 1(1):9-42.

—. 1992. ""The Duality of Technology: Rethinking the Concept of Technology in Organizations." *Organization Science* 3(3):398-427.

—. 2000. "Using Technology and Constituting Structures: A Practice Lens for Studying Technology in Organizations." *Organization Science* 11(4):404-428.

Orlikowski, Wanda J. & JoAnne Yates. 2002. "It's About Time: Temporal Structuring in Organizations." *Organization Science* 13(6):684-700.

Osterlund, Carsten. 2002. "Documenting Dreams: Patient-Centered Records versus Practice-Centered Records."

Osterman, Paul. 1999. *Securing Prosperity*. Princeton, NJ: Princeton University Press.

Park, Robert, Ernest W. Burgess and Roderick D. McKenzie. 1925. *The City*. Chicago: University of Chicago Press.

Perlow, Leslie. 2001. "Time to Coordinate." *Work and Occupations* 28(1):91-111.

Pew Internet and American Life Project. 2005. "Health Information Online." Pew Internet and American Life Project.

Pfohl, Stephen. 1977. "The 'Discovery' of Child Abuse." *Social Problems* 24(3):310-323.

Pollack, Andrew. 2003. "Who's Reading Your X-Ray?" *New York Times*, November 16, 2003.

Pratt, Joanne H. 1999. "Cost/benefits of Teleworking to Manage Work/life Responsibilities." The International Telework Association and Council.

Prechel, Harland. 1994. "The Economic Crisis and the Centralization of Control over the Managerial Process." *American Sociological Review* 59(5):723-745.

Pred, Allan. 1981. "Power, Everyday Practice and the Discipline of Human Geography." in *Space and Time in Geography: Essays dedicated to Torsten Hagerstrand*, edited by Allan Pred. CWK Gleerup.

Reinhardt, Uwe. 1999. "The Predictable Managed Care Kvetch on the Rocky Road from Adolescence to Adulthood." *Journal of Health Politics, Policy and Law* 24(5):897-911.

Robinson, John & Geoffrey Godbey. 1997. *Time for Life: The surprising ways Americans use their time*. University Park: Pennsylvania State University Press.

Rose, Derek. 2004. "Hil Pushes New Health Care Plan." *New York Daily News*, January 13, 2004.

Rovner, Julie. 2004. "Health - Thompson Unveils Initiatives for Electronic Medical Records." *Congress Daily*, May 7, 2004.

Saketkhoo, Daniel, Mythreyi Bhargavan, Jonathan Sunshine, et al. 2004. "Emergency Department Image Interpretation Services at Private Community Hospitals." *Radiology* 231(1):190-197.

Salaff, Janet. 2002. "Where Home is the Office." p. 464-495 in *The Internet in Everyday Life*, edited by Barry Wellman and Caroline Haythornthwaite. Blackwell Publishers, Ltd.

Sassen, Saskia. 1991. *The Global City*, 2nd ed. Princeton, NJ: Princeton University Press.

Schor, Juliet. 1991. *The Overworked American*. New York: Basic Books.

Staff. 2004. "Bush Creates Office On Health IT System." *Wall Street Journal*.

Starr, Paul. 1982. *The Social Transformation of American Medicine*. New York: Basic Books.

—. 1997. "Smart Technology, Stunted Policy: Developing Health Information Networks." *Health Affairs* 16(3):91-105.

Stein, Charles. 2003. "Partners program aims to rein in skyrocketing costs of diagnostic imaging." *Boston Globe*, June 27, 2003.

Storper, Michael and Anthony Venables. 2004. "Buzz: Face-to-Face Contact and the Urban Economy." *The Journal of Economic Geography* 4(4):351-438.

Strauss, Anselm and Juliet Corbin. 1998. *Basics of Qualitative Research*. Thousand Oaks, CA: Sage.

Thomas, Robert J. 1994. *What Machines Can't Do: Politics and Technology in the Industrial Enterprise*. London, England: University of California Press.

Thompson, E.P. 1967. "Time, Work-Discipline and Industrial Capitalism." *Past and Present* 38:56-97.

Thompson, Tracie. 2004. "Thrall cites risks of outsourcing in RSNA opener." *AuntMinnie.com*, November 28, 2004.

Thurm, Scott. 2004. "Lesson in India: Not Every Job Translates Overseas." *Wall Street Journal*, March 3, 2004.

Toffler, Alvin. 1980. *The Third Wave*. New York: William Morrow & Co.

Vladeck, Bruce; Emily Goodwin, Louis Myers and Madeline Sinisi. 1988. "Consumers and Hospital Use: The HCFA "Death List"." *Health Affairs* 7:122-5.

Walther, Joseph. 2002. "Time Effects in Computer-Mediated Groups: Past, Present and Future." in *Distributed Work*, edited by Pamela Hinds and Sarah Kiesler. MIT Press.

Wang, Samuel, Blackford Middleton, Lisa Prosser, et. al. 2003. "A Cost-Benefit Analysis of Electronic Medical Records in Primary Care." *The American Journal of Medicine* 114:397-402.

Weber, Max. 1958. *The City*. Glencoe, IL: The Free Press.

Wharton, Amy S. 2002. "The "Overtime Culture" in a Global Corporation." *Work and Occupations* 29(1):32-63.

Wiley, George. 2005. "Teleradiology 2005: Cracks in the Nighthawk Egg." *Decisions in Imaging Economics*, February, 2005.

Zuboff, Shoshana. 1988. *In the Age of the Smart Machine*. New York: Basic Books.