Telework That Works:
Teleradiology and the Emergence of Nighthawk Radiology Firms

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Abstract

Information technology enabled remote work is typically seen as an imperfect substitute for spatial proximity (Armstrong and Cole 2002, Gaspar and Glaeser 1998, Olson et. al. 2002). For night radiology, however, the use of teleradiology applications to create a new type of radiology group appears to have facilitated improvements in productivity, life style, and quality of interpretations.

This paper describes the diffusion of teleradiology applications in the United States and the "nighthawk" radiology groups that have consequently emerged. The emergence of nighthawk radiology groups - a new type of radiology group which specializes in doing night reads - has had important ramifications for the delivery of radiological services in the United States. Based on interviews and observations of radiologists, the introduction of nighthawk radiology offered a series of benefits without threatening the quality of radiology services rendered remotely.

This research found that nighthawk radiology groups emerged, not out of a deliberate program of reengineering, but out of a reaction to a particular set of historical circumstances. The lessons that can be learned from the study of nighthawk radiology, however, are relevant to a host of industries with work tasks that can be easily relocated, but where relocation is seen as conflicting with quality concerns. The professional nature of radiology work, as well as the updating of quality assurance programs, played a crucial role in assuring quality, while shaping the outcomes of the use of teleradiology to outsource and offshore American radiology services.

Introduction

In recent decades, academic interest in teleworkers has steadily grown, along with the portion of the U.S. labor force which engages in telework, defined here as "working outside the conventional workplace and communicating with it by way of telecommunications or computer based technology" (Bailey and Kurland 2002, 384). Recent research has estimated that between ten and thirty million Americans were teleworking by the end of the twentieth century (Bailey and Kurland 2002; Gurstein 2001; Pratt 1999), with the wide range of estimates explained by differences in the definition applied by different researchers.

A growing body of literature has focused on the consequences of telework (Bailey and Kurland 2002; Bailyn 1989; Felstead et.al. 2005; Golden and Veiga 2005; Gurstein 2001; Hylmo and Buzzanell; Illegems and Verbeke 2003; Pratt 1999; Tremblay et.al. 2006) and the related growth in virtual teams (Fletcher and Major; Martins et. al. 2004) and distributed work (Armstrong and Cole 2002; O'Leary et.al. 2002; Sarker and Sahay 2003) . Following on past calls to make telework research more attentive to differences between particular industries and professions (Bailey and Kurland 2002; Golden and Veiga 2005) this research focuses on the recent genesis of a specific type of teleworker - the "nighthawk" radiologist.

Nighthawk radiology groups are private radiology groups which specialize in doing remote night reads of radiological studies. They emerged in the United States in the early 2000's following the widespread diffusion of teleradiology applications - computer applications which allow the radiologist to interpret images from remote locations. The ramifications of the emergence of nighthawk radiology for the U.S. radiology market with respect to offshoring have been described at length elsewhere

(Levy and Goelman 2005; Levy et. al. 2006). However, the consequences in terms of productivity and quality of the work remain unexamined. In examining the evolution of the night hawk radiology group, this paper calls attention to the organizational innovations required to leverage the use of new information and communication technologies (ICTs) to work from afar.

Telework and Virtual Teams

Information technology enabled remote work has been found to be an imperfect substitute for spatial proximity (Armstrong and Cole 2002: Gaspar and Glaeser 1998; Olson et. al. 2002)**.** Social experiments have consistently found that there are benefits to collocation that are difficult to replicate among workers collaborating from a distance (Sarker and Sahay 2002; Fletcher and Major 2006), with multiple research testifying to the issues of isolation and poor communication (Cooper and Kurland 2002; Sarker and Sahay 2002; O'Leary and Mortensen 2005).

Past findings are less clear with respect to productivity. The authors of a recent literature review on virtual teams (Martins et. al. 2004, 817) conclude, "researchers have consistently found that virtual interaction increases the amount of time required to accomplish tasks." However, research which has focused on teleworkers has consistently found that most workers report improved productivity when working from home (Bailey and Kurland 2002; Bailyn 1988; Baruch and Nicholson 1997; Belanger 1999; Pratt 1984). Studies of teleworkers have also come to mixed findings with respect to telework and work-family balance (Gurstein 2001; Rothbard et.al. 2005; Tremblay et.al. 2006), as well as telework and job satisfaction (Bailyn1989; Golden and Veiga 2005).

These contradictory findings have been explained by the breadth of different alternatives that are subsumed under the general rubric of telework alternatives. Bailey and Kurland note that while much research into teleworkers seems to imply that most teleworkers work remotely full time, in fact most teleworkers work at home only a few days per month (2002, 390). Researchers have shown that, in fact, the frequency of telework correlates strongly with outcomes, particularly in terms of isolation (McCloskey and Igbaria 1998; Olszewski and Mokhtarian 1994) and job satisfaction (Golden and Veiga 2005). Golden and Veiga (2005) posit a curvilinear relationship between job satisfaction and telecommuting, with job satisfaction increasing with small amounts of telecommuting, but decreasing as the amount of telecommuting increases.

The frequency of telework is just one of the multiple axes which researchers have used to categorize and parse the effects of telework. Research has also found links between the type of organization (Cooper and Kurland 2002) for whom the teleworkers works, with public sector teleworkers being less likely to find their professional development hindered by telecommuting. Still other research has called for a distinction between those teleworkers whose remote work substitutes for their previously existing work and those teleworkers whose remote work adds to their previously existing tasks (Bailyn 1989; Goelman 2006; Perin 1991).

In this paper, I detail the results of research into the use of teleradiology applications by United States radiologists. I focus particular attention on nighthawk radiologists, particularly home-based nighthawk radiologists where their home-based remote work has entirely replaced their conventional collocated radiology work. I discuss the consequences of nighthawk radiology in three particular respects: the

productivity of radiologists, the lifestyle of radiologists, and the quality of radiological interpretations. I find that there is good reason to believe that the spread of nighthawk radiology, enabled by the diffusion of teleradiology and fast, secure, Internet connections, has had positive results with respect to nighttime radiologist productivity, quality of life, and perhaps most surprisingly, the quality of night radiology interpretations. In describing these results, I also outline the way that nighthawk radiology groups have dealt with some of the major barriers to relocating professional work, giving special attention to the means through which they have maintained quality

Methods

Due to the recent inception of nighthawk radiology groups, and following the argument that qualitative research is particularly appropriate in the early stages of research on a topic (Eisenhardt 1989, Maxwell 1996), I chose a qualitative research approach. This research primarily draws from 35 interviews of 31 individuals and 7 site visits conducted between 2004-2006. This work also draws from analyses, reported elsewhere (Goelman 2006) of a nationwide survey of radiologists conducted by the American College of Radiologists (ACR) in 2003. The use of extensive interview data allowed me insight into the ongoing process of change (Maxwell 1996), while the triangulation made possible by multiple methods of data collection and analysis provided for a stronger substantiation of hypotheses (Eisenhardt 1989).

I interviewed 21 radiologists, as well as an additional 10 people involved in the leading nighthawk radiology groups. The majority of these interviews took place via the phone (21 out of 36). The remaining 15 interviews were performed in concert with 7 site visits, including site visits to the reading room of a large teaching hospital, the home

offices of several radiologists - both nighthawk and conventional, and the headquarters of a large nighthawk radiology firm.

28 of the 35 interviews were tape recorded and transcribed verbatim. 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.”

The interview subjects included key personnel at each of four nighthawk radiology groups. 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. At the time of the research these three leading firms read images from roughly 1000 hospitals, almost 20% of the 5764 hospitals registered with the American Hospital Association in 2003.

Data Analysis and Validity

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. 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. Eisenhardt (1989: 538) writes that “a striking feature of research to build theory from case studies is the frequent overlap of data analysis with data collection,” and goes on to describe the process as “a strikingly iterative one” (1989: 546). Similarly, Strauss and Corbin (1998: 101) note that the coding of interview data is a “dynamic and fluid process.”

As these sources suggest, I performed my analysis in an iterative and ongoing process, cycling between literature review, data collection and data analysis. For instance, at an early interview a participant mentioned the degree to which working for a nighthawk firm made it easier to balance his work commitments with his family commitments as a parent of school age children. To further investigate this issue, I both revised the interview instrument to more explicitly address this issue and sought out additional nighthawk radiologists of both genders who had school age children.

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. These researchers were asked to read and code entire interviews, after which we met and discussed similarities and differences between our respective coding.

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 radiologists share certain prejudices about the emergency room physicians with whom nighthawk radiologists work. These prejudices might lead them to systematically bias their response to certain questions. Despite these limitations, I believe that participants' perceptions of the changes to their work offer important insight into the question of workplace change. By using interviews to collect data, I was able to focus on broader trends than an intensive ethnography would have allowed.

Teleradiology & Recent Changes in Radiology Work in the United States

In recent years, telemedicine - the practice of medicine from a distance – has received a good deal of attention from both the academic press (Coopmans 2006; Delbanco and Sands 2004; Lobe 2004; Marcin et. al. 2004; Miller and Derse 2002; Stanberry 2000) and the popular press (Brink 2006; Freundenheim 2005; Kowlaczyk 2004; Stein 2005). The remote practice of radiology - teleradiology - has received particular attention (Kalyanpur 2003, 2004; McLean and Richards 2006; Pollack 2003; Saketkhoo et. al. 2004), and its use has grown particularly quickly. Radiologists have practiced at a distance from their patients, virtually since the inception of radiology as a subspecialty (Linton 2001), so it is unsurprising that the remote practice of radiology has grown particularly quickly.

The challenge of managing disruptive technologies in health care, as in other contexts, is to not only incorporate new technologies into existing processes, but to redesign processes to take advantage of new capabilities enabled by new technologies. Brown and Duguid (2000) have noted that there are particular difficulties in reengineering in contexts where the outputs of a process are not clearly defined and when the intermediary processes depend on the lateral transfer of information. Given the indeterminate nature of both medical work generally, and radiology specifically, where

the process of making a judgments is difficult to describe in terms of rules-based logic (Levy and Goelman 2005), it should come as little surprise that the nighthawk radiology group did not emerge out of a deliberate program of reengineering. Rather it emerged through the interaction of professional and institutional forces with a particular set of historical circumstances. In the late 1990s a marked scarcity of radiologists in the United States coincided with a newly enhanced capacity to provide radiology services from a distance. Nighthawk radiology groups evolved as radiologists leveraged the new capabilities of teleradiology applications.

A variety of demand and supply factors came together to create the scarcity of radiologists. On the supply side, the Balanced Budget Act of 1997 capped the total number of residency slots that could receive federal support. At the time, relatively few residency slots were devoted to radiology, as medical students perceived a weak job market for radiologists and federal policy was being designed around the primacy of the family practitioner (Grumbach 2002). With the legislated cap, the relatively small share of residency slots devoted to radiology became difficult to change, as specialties vied to maintain the number of slots devoted to them at the time of the cap.

Coincident to this reduction in the supply of radiologists, the demand for radiological interpretations surged, particularly at night. In recent decades, radiology changed from a service typically offered only during the day, to one which must be offered 24 hours a day, 7 days a week. Part of this shift stemmed from the increasing dependence of emergency room physicians on advanced medical scanning technologies such as magnetic resonance imaging (MRIs) and computed tomography (CT) scans. Most non-radiologist physicians are less comfortable reading CTs and MRIs than reading

plain x-rays, and so, emergency room physicians became more likely to refer such tests to radiologists for their interpretation (Goelman 2006, Levy and Goelman 2005). Emergency room physicians are also increasingly likely to have patients undergo these more advanced scans, due to the increased availability of the scanners as well as their fear of malpractice suits should they incorrectly diagnose a condition.

Thus, radiologists found themselves in a pinch, with fewer radiologists to read an increasing number of tests. Salaries increased, but still, radiologists were unhappy at the increasingly intense night calls they would have to work as often as twice a week. While in the past, radiologists were often on call at night without being awakened even once, increasingly they were awakened ten or more times every night that they were on call.

At first the introduction of teleradiology applications may have accentuated radiologists' work load. One radiologist participant remarked that with the advent of the ability to read tests from home,

> the (emergency room referring) physicians would pull the trigger much faster, because you didn't have to come. 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.'

From this radiologist's perspective, referring physicians were more likely to rouse radiologists at night precisely because they knew radiologists no longer needed to physically come into the hospital to answer their requests. Thus, the increase in the number of tests swamped the time savings consequent to being able to read from home.

As reported elsewhere (Goelman 2006), regression analysis of an American College of Radiologists (ACR) national survey of radiologists in 2003 confirmed this radiologist's assessment of a correlation between the use of teleradiology from home and

a likelihood to work more hours. In 2003, the use of teleradiology was fairly widespread, with around 80% of survey respondents using some form of teleradiology. At that time radiologists who used teleradiology to work from home tended to work an average of 2.19 additional hours per week when compared to similar radiologists who did not use teleradiology from home. This effect is statistically significant to the .05 level.

The interview data suggest that this correlation diminished strongly in subsequent years, as nighthawk teleradiology groups emerged to deal with much of the night demand. This shifting use of teleradiology applications is reminiscent of technical diffusion in other industries, as for instance, the diffusion of commercial electricity described in David (1990). At first the fundamental organizational structure of radiology remained the same. Most private practice radiologists continued to take call at night, in addition to working full shifts during the day, just as they had for decades. As the number of tests continued to increase, however, radiologists grew increasingly resistant to receiving call at night. One radiologist participant who switched to part time radiology work in order to avoid night call remarked, "It just got so barbaric. You're up basically all night because of the technology changes."

The tight market for radiologists placed practices seeking to hire radiologists under increasing pressure to reduce the call requirements. Nighthawk radiology emerged in response to these pressures, with specialized 'nighthawk' radiology groups using teleradiology applications to contract with conventional radiology groups to take their night work. The first of these nighthawk firms continued to operate on the principle of centralized reading rooms. However, early innovators such as Minneapolis-based Virtual

Radiologic Corporation (VRC) quickly moved to a decentralized 'virtual reading room'[2] arrangement where radiologists were scattered around the United States and beyond, but connected via the Internet and instant messenger technologies.

Much of the past writing on teleradiology and nighthawk radiology has revolved around whether or not U.S. radiology jobs are at risk. While the issue continues to draw speculation (Mclean and Richards 2006), recent accounts have been clear that to date, at least, U.S. radiology jobs are not being offshored to cheap foreign radiologists (Levy and Goelman 2005; Levy et. al. 2006). The majority of nighthawk radiologists continue to live in the U.S., and notwithstanding ongoing anecdotal accounts to the contrary, for a variety of regulatory, legal and social reasons, the vast majority of nighthawk radiologists who currently interpret images for U.S. hospitals have been trained in the United States.[3]

There has been confusion around this last point. Night hawk radiologists currently read tests from locations as far flung as Sydney, Australia; Bangalore, India and Hong Kong. However, all nighthawk radiologists who supply readings that inform treatment in U.S. hospitals are certified to provide treatment in each hospital for which they are supplying interpretation, and they are licensed to practice medicine in the state where the hospital is located.

A good deal has been written explaining the factors which have shaped the adoption of teleradiology and the rise of nighthawk radiology groups (Goelman 2005,

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

[3] The single non-U.S. trained nighthawk radiologist found in the course of this research found was not an Indian radiologist, but a Canadian radiologist. It was possible for this radiologist to be certified to practice in the U.S. without receiving U.S. training, in part because the American Board of Radiology, the body that certifies radiologists to practice in the United States, accepts Canadian training in lieu of training in the United States.

2006; Levy and Goelman 2005; Levy et.al. 2006). In particular this past research has identified the importance of the cognitive nature of radiology work (Levy and Goelman 2005; Levy et.al. 2006), as well as malpractice fears on the part of referring hospitals, radiologists' professional power, and the particular ways in with which radiologists completed their work in time and space before adopting teleradiology applications – e.g. working at a distance from their patients and other physicians (Goelman 2005, 2006). All of these factors have been identified as crucial in limiting the offshoring of U.S. radiology jobs.

However, the very real impacts of these innovations upon radiology work, and the concomitant outcomes of quality, productivity and lifestyle, have yet to be addressed with the exception of a quality evaluation of an in-house nighthawk program at a large academic radiology group (Kalyanpur 2003). Stand alone nighthawk groups have yet to receive this kind of evaluation with respect to quality, productivity or quality of life. This paper turns to these topics.

Findings

Efficiency

Nighthawk radiology offers significant efficiencies to radiologists. The most obvious has to do with the possibilities of consolidation. While the demand for night interpretations remains too diffuse for most private practice groups to keep a radiologist fully occupied throughout the night shift, by consolidating the reads of several private practice groups, nighthawk radiology groups are able to keep their radiologists fruitfully engaged for their entire shifts. An executive at a nighthawk radiology firm explained,

> Our value is that we can take one of our radiologists and keep them very busy and professionally satisfied. They do that by covering say - thirty or

> fifty hospitals - depending on the size of the facilities. That way we're aggregating across a broad span of the market to the individual.

There are also efficiencies in the workflow. At a well organized nighthawk practice, radiologists are able to spend virtually every moment of their shift interpreting images. Unlike a typical practice where radiology work is subject to interruptions and delays, these are minimized for the solitary nighthawk radiologist. Some of this change is due to technological fixes. As another nighthawk radiology executive remarked,

> There's no breath in between one study and the next. Think of the irritating things that you do on your computer that take you three seconds and a mouse click. And then somebody says, 'you can just do this.' And they show you a new way. And you feel like you just got a whole bunch of time back in your day…those 3 seconds add up.

Interviews with radiologists and site visits confirmed this analysis. While radiologists remained in close telephone contact with the emergency room physicians, and - at the larger nighthawk practices - with each other, these contacts were established with a minimum of workflow interruption. For instance, many nighthawk radiologists at the larger nighthawk groups relied almost exclusively on instant messenger to communicate with one another. This allowed relatively immediate contact without interfering with radiologists' concentration on image interpretation. The individual radiologist could choose how best to integrate their communications and their image interpretation. They might reply to an instant message question from a colleague or contact an emergency room physician while they were waiting for a particularly bulky study to download.

In most nighthawk radiology groups, as in most conventional radiology groups, radiologist pay is linked to their productivity. The large number of studies interpreted on an average shift means that a radiologist's productivity is fairly transparent. Radiologists

regularly read one hundred or more studies on a ten hour shift, making their relative productivity easy to measure. This is in contrast, for example, to a profession such as law, where a single legal brief might take weeks to write, making productivity difficult to measure in terms of output.

Radiologists at the larger nighthawk groups were aided by technologies and support staff that further streamlined their communications. At one nighthawk group, should a radiologist decide they need to speak to an emergency room physician, they could notify support staff with a single click of their mouse. The support staff would call the hospital, wait until an emergency room physician had been summoned and was on the line ready to speak, and only then transfer the call to the radiologist.

Another efficiency gain from working alone is enabled by teleradiology but is not technological in nature. As one private practice radiologist explained, the problem with a centralized set up 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.
>
> 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. They work alone for the most part, but when necessary, they consult with others electronically.

As the radiologist quoted immediately above also noted, there are costs to working alone. It is socially isolating. To some extent radiologists self select -- for instance, medical students who choose radiology know they will be working with less

patient contact than if they were to specialize in internal medicine. Presumably this process of self selection continues among those nighthawk radiologists who choose to work alone from their homes.

However, reasonable concerns remain about the impact of nighthawk radiology work on both the working life of radiologists and the quality of the reads they produce. The founder of one nighthawk group which utilizes a more centralized model argued,

> 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.

I turn now to examine these issues of lifestyle and the quality of radiology work in more depth.

Lifestyle

Many participants reported that they initially saw nighthawk radiology as the province of antisocial, unmarried radiologists. However, this research found that, in fact, radiologists from a variety of life circumstances were drawn to the nighthawk groups. For instance, both female and male nighthawk radiologists with young children prized the flexibility of nighthawk radiology groups. They spoke of putting their children to bed before they went to work for the night, working for the requisite ten hours, having breakfast with their children, and then going to sleep while their children were in school. Nighthawk radiology was also attractive to radiologists in a range of family circumstances for allowing them to work fewer hours annually -- most nighthawk radiologists work a schedule where they are on for seven days and then off for seven days, working 26 weeks a year while earning six, and sometimes seven, figure salaries comparable to their colleagues at conventional practices.

Particularly for those who work for decentralized practices, nighthawk radiology allows its practitioners to live where they choose and to read as many studies as they choose. To the extent that they are flexible with respect to where they live, they can control the actual shifts they work, moving to Australia for instance, if they wish to work a day shift. As nighthawk groups grow larger, even nighthawk radiologists who have chosen to stay in the United States have increasing flexibility with respect to the hours they work.

However, most nighthawk radiologists continue to live and work in the United States, and most of these continue to work nights. Working at night remains something which few participants enjoyed. The participants with small children especially struggled with the night shift, as they were especially likely to switch their sleep cycles between shifts, in order to share more awake time with their children. As one radiologist explained, working nights was simply the price she paid for additional flexibility and a shortened schedule. For her, working nights was, "like the commute back and forth for normal daytime people. They may not like that, but it gets them to their job."

As for working alone, most nighthawk radiologists appeared not to mind that aspect of their work. Interestingly, several participants who did complain of loneliness, noted that they found themselves particularly lonely on their off weeks, without the virtual company of their fellow nighthawks to keep them company.

Thus, rather than making radiologists more isolated, using teleradiology and Internet applications to work from home had mixed effects. The geographic diffusion of demand for radiologists has historically been such that radiologists could be physically near only a few of their colleagues. Home-based nighthawk radiologists have used ICTs

to connect with more peers more often than the previous organization of night radiology work would have allowed. However, they have given up much of the social intercourse that went along with working days, particularly the face to face interactions with support staff and other physicians.

Quality

In discussing the effect of nighthawk practices on quality, it is useful to sketch out the work process at a typical nighthawk group. Typically conventional radiology groups contract with a nighthawk group to provide only a preliminary interpretation, or a "wet read," for their night images. The wet reads are important, in that many emergency room decisions are made on the basis of the wet read. However, radiologists at the conventional radiology group will typically come in the following morning and perform the final interpretation, or the "dry read," for which the payer will reimburse them.

Under this system, every imaging study produced at night is read by at least two radiologists. Moreover, when a discrepancy is found between the wet and the dry reads, the leading nighthawk radiology groups will initiate a quality assurance process, where other radiologists provide third and fourth reads to assess the quality of the read provided by the first radiologist. Thus, nighthawk radiologists at these firms are systematically exposed to the opinions of their peers on almost every read. While this sort of feedback regularly occurs at teaching hospitals, where attending radiologists discuss the reads performed by the residents at the end of every shift, this happens far less regularly, if at all, at most private radiology practices.

It is important to contrast this system, not to the way in which conventional radiologists work during the day, but rather, to the actual alternative to the use of a

nighthawk firm. Generally, the alternative at a conventional practice would be to wake a radiologist to do the reading from home. Thus, the night radiologist at a conventional practice would tend to be less alert, awakened to read a single study before returning to sleep.

Additionally, despite the geographic isolation of radiologists who work from home, radiologists who worked from home for the large nighthawk groups tend to have a greater ability to consult with other radiologists than their colleagues who are on call at conventional radiology groups. As one nighthawk radiologist explained,

> A really great benefit of working in this remote environment [is that] you have such a deep bench of radiologists on. It's more than you would ever have in a regular standard practice. In a reading room you might have two or three radiologists there, but you're never going to have fifteen - twenty- other radiologists to ask their opinion in a reading room at one time. The only way you could possibly do that is to have a remote environment.

Again, the benefits are particularly clear when compared to the alternative ways of organizing nighttime radiology work. For instance, a neuroradiologist at even the largest conventional practice would almost never be on night call with another neuroradiologist. One neuroradiologist who participated in this study had recently moved from a large private radiology group to a large nighthawk radiology group. She recalled that although she and the other neuroradiologist in her conventional practice would often ask each other's opinion during the day,

> I would say that most of the questions I had would come up when I was in the emergency room on the weekend or evening or whatever, and in that case nobody else was there because that's their off hours.
>
> So anyway it's true that some of the time, yeah, there were people, plenty of people, but probably the times when I might have had the most questions, when I was covering other areas, like the emergency room, I was pretty much on my own.

Potential quality improvements also stem from the additional specialization that comes with nighthawk work. The nature of night radiology work means that the images are almost entirely those produced by emergency departments. Thus, nighthawk radiologists are essentially specializing in interpretation of the particular types of images that tend to be generated by emergency rooms at night, such as images stemming from car accidents and potential strokes. Whereas this kind of emergent work comprises just a portion of the average radiologist's work load, it composes the vast majority of the studies that nighthawk radiologists interpret. If specialization and increased volume are associated with better outcomes in radiology, as they have been found to be in other medical specialties (Birkmeyer et. al. 2003, Halm et. al. 2002), then this would constitute another reason to believe that nighthawk radiologists are likely to provide higher quality interpretations for the emergency room images in which they specialize.

Finally, one should note that nighthawk radiologists, like conventional radiologists, must be certified at the hospitals at which they practice and licensed for the states in which they practice. Although most nighthawk radiologists are providing only wet reads, given that wet reads do inform the treatment of patient in the United States, all nighthawk radiologists are required to maintain appropriate certifications and licenses.

Discussion

In this paper, I have described the emergence of nighthawk radiology. Based on interviews and observations of nighthawk radiologists it appeared that there were benefits in terms of efficiency, life style and quality. These impressions are subject to quantitative verification, but observation, interviews and logic all seemed to support the conclusions reported above. Once more, I stress the importance of contrasting the practice of nighthawk radiology to the actual alternative, rather than to the ideal alternative.

This research illustrates the necessity to bring a finer nuance to portrayals of telework. It is necessary, but not sufficient, to distinguish the amount of time spent working from home. Contrary to Golden and Veiga's (2005) finding that job satisfaction diminished as workers spent a larger portion of their time telecommuting, I found that the nighthawk radiologists, who spent one hundred percent of their time telecommuting, tended to be more satisfied than their peers at professional practices who continued to handle call from home as a frequent duty in addition to their regular hours. Each of these improvements identified in this paper, stemmed not from teleradiology as such, but from the reorganization of work which allowed radiologists to better consolidate their work, while also seeing improvements in lifestyle and quality. Following on Bailyn (1989) and Perin (1998), this research indicate the continuing importance of examining whether telework replaces other work or is addition to other work.

This case also demonstrates the importance of looking at the degree to which ICT use aligns or does not align with previous spatial practices in medicine. Part of the explanation for nighthawk radiology's success is the extent to which using teleradiology to work from a distance aligned well with the previous ways that radiologists worked. Radiology work was historically done remotely from both patients and other physicians, so it was a relatively small shift to use teleradiology applications to support a further extension of radiology work in space. This is not to suggest that these previous spatial practices are inflexible -- rather, as suggested elsewhere (Goelman 2005) they are flexible and both shape and are shaped by the process of technical change and growth.

This case offers several lessons to industries where jobs are mobile and quality is important. The success of nighthawk radiology in improving quality, as well as

productivity, rested on the additional consolidation allowed by teleradiology. Teleradiology allowed the reading of geographically diffuse tests to be centralized. This consolidation allowed sufficient efficiencies, that the readings could be duplicated on a broad scale without overly burdening the radiologists. These double readings were crucial in the quality improvement program, highlighting any discrepancies or potential flaws in radiologists' reports.

A few caveats are in order. Radiologists are powerful professionals. Research has consistently found that medical professionals are capable of protecting their interests in the face of potentially disruptive technology (Abbott 1988; Barley 1986; Black et. al. 2004; Lapoint and Rivard 2005). Professional or market power of some kind may well be prerequisite to obtaining simultaneous improvements in quality of life and improvements to the quality and productivity of the service provided. The emergence of nighthawk radiology was heavily shaped by the power wielded by U.S. radiologists and the scarcity of U.S. radiologists in the late 1990s. Nonetheless, if health planners had set out to reengineer radiology work, hoping to optimize the use of teleradiology and aware of the importance of communication among radiologists and between radiologists and referring physicians, the results may well have borne a strong resemblance to the nighthawk radiology industry.

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