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THE WIND OF CHANGE

INDIVIDUALS CHANGE WHEN TECHNOLOGY CHANGE

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To our daughter Anna,
Have a really good life and I know that You were a researcher long before me…

ABSTRACT

The production of digital images has been well-known within radiology for many years through its use of modalities such as computer tomography, ultrasound and magnetic resonance tomography. During the latter part of the 1980´s a new technology, Picture Archiving and Communication System (PACS) was introduced making it possible to manage X-ray pictures in their original, digital form. The changeover from an analogous to a digital environment was not just a change for the radiology departments; it was a change which concerned the entire hospital. Osteaux, et al. (1997) feels that digitalization is the largest change within radiology since X-ray technology was introduced. However, in order for PACS to be a successful project, both cultural and organizational changes are required.

The purpose of the study is to analyze and describe how the professional role of radiologists and radiographers, work practices and use of the technology are influenced by the introduction and use of PACS within the Region of Skåne.
The study is longitudinal and based on 119 interviews with radiologists and radiographers in Lund, the hospitals in Landskrona, Ystad and Simrishamn and the healthcare centres at Eslöv and Hörby. The study was performed from 1999 to 2006. During this time, PACS was implemented at all the units, however at different periods in time. The purpose was to study the entire digitalization process at all the units. Data collection and analyses were inspired by Grounded Theory, especially those techniques such as open interviews, coding and categorization to allow a reduction of data and a creation of terms to symbolize the occupational role, work practice and use of new technology during different points in time of the study.
In addition to digitalization the study focused on trying to understand what the radiologists themselves felt about the change. This description included three different areas: ***the professional occupational role, the diagnostic work*** and ***the technology used***.

With the new technology images were always available to all those having the PACS system. In practice, this meant that there were more discussions with clinicians and that radiologists changed from doing more individual work to becoming actors in a network consisting of different specialties. The radiologist also felt an increase in demands for sub-specialization in this process.

With regards to **the diagnostic work,** this was described by the radiologists in 1999 as work which partly required extensive medical skills but in addition, to its advantage, could include a special ability in interpreting images which can almost be described as a "form of art". During the period of changeover when PACS was implemented, the radiologist felt that the technology itself became more centralized at the cost of the diagnostics. In time the focus was transferred back to the diagnostics while the

radiologists saw the advantages of e.g. the availability of having access to image material.

The radiologist felt secure in using the analogous **technology**. Analogous films were tangible. Digital PACS images could be manipulated. The radiologist felt uncertain as to when the manipulation of images was "optimal". This uncertainty was reduced with time.

Along with the focus on digitalization, the study tried to find how the radiographers felt about digitalization and the use of PACS. This description included three different areas: ***the occupational role, the image-producing practices*** and ***the technology used.***

When the study began in 1999 and PACS was implemented, the radiographers were very positively inclined towards the change. They saw possibilities of filling ***the occupational role*** with new activities, such as quality review of images for diagnosis and being personally able to complete examinations. The needs for exposure skills decreased. In reality this meant an increased risk because the patients were exposed to unnecessarily high doses of radiation.
It was discovered that "sluice" area with the developing machine as its centre had disappeared. No one had previously thought of its being a central meeting place for communications and radiologists.
With time, the exposure parameters became once again more central to the professional role of the radiographers, however this time with a focus on patient safety.

To begin with, the radiographers saw great possibilities in the introduction of new work routines using PACS, since the images were available to everyone who had the PACS system. The opinion at the larger clinics was that the work method with PACS was adapted to the old analogous routines. It was discovered that the discussions within the work groups for the implementation had focused on the technology. It was realized that discussion on changes in work methods and organization should have been started much earlier.
It took many years before a new work method was successfully found through new and more open network configurations. As a contrast, the smaller departments had implemented work routines when PACS was implemented and its use was started.

In the digital context and the new **technology** the natural breaks at the sluice disappeared, creating an experience of an increase in stress. Another concern which also arose during the years was that the technology became more and more imaginary making it hard to understand errors when they occurred.

LIST OF PUBLICATIONS

I. **The Impact of PACS on Radiologists´ Work Practice**
Fridell K, Edgren L, Lindsköld L, Aspelin P, Lundberg N
J Digital Imaging,Vol 1, No 1, 2006:1-10

II. **PACS Influence the Radiographers´ Work**
Fridell K, Aspelin P, Edgren L, Lindsköld L, Lundberg N
Submitted for publication

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1 INTRODUCTION

''Images Anytime, Anywhere: They'll Love You for It...or Not'' (Mazurowski 2005)

During the Renaissance, the sculptor and painter Michelangelo wrote: *"The greatest artist has no conception which a single block of marble does not potentially contain within its mass, but only a hand obedient to the mind can penetrate to this image."* According to Michelangelo, it was up to the sculptor to free what was inside the material. This is a powerful metaphor for today's radiology, a profession which today offers methods for extracting very useful medical information which can be found in enormous blocks of binary data. In order to fully understand the potential of these methods, new strategies and new work processes will be required. It is not simply a matter images in digital form (Thrall, 2005 part II).

Commitment to IT and its share of the cost burden have increased both within companies and in preventive healthcare and healthcare (Gäre, 1999; Lundberg 2000). For the year 2007, a budget of 200 billion SEK has been allotted to preventive healthcare; six billion of these are for IT. (Sveriges Landsting- och kommunförbund, The Swedish Association of Local Authorities and Regions), (Statistiska Centralbyrån, Statistics Sweden), (Socialstyrelsen, The National Board of Health and Welfare), (Dagens Medicin 2006)

The production of digital images has been well-known within radiology for many years. Modalities such as computed tomography, magnetic resonance tomography and medical ultrasound have, since their introduction, been based on the production of images in digital form. In many cases, these images have been converted into analogue form for further handling, e.g. for display during rounds or for archiving. During the 1980s a new concept called picture archiving and communication system (PACS) was introduced, which allows continued handling of X-ray pictures in their original digital form (Lamminen, 2003). Lawrence (2007) writes that technology is increasing and spreading in an explosive way to areas other than radiology, e.g. cardiology, pathology and ophthalmology. Lempke (2003) and Foord (2001) report on studies of the expansion of PACS as an IT tool within radiology. Both articles show the same trend: greater distribution and extended use of the production system.

Lundberg (2000) shows that the use of PACS influences how the work is performed and in which order the different activities are carried out. However, there is a lack of studies on the sociological aspects of the introduction of PACS with a focus on how humans accept it and their opinion of the new technology. Such studies can help us to understand the influence PACS has on the context it is introduced into.

The study is longitudinal, extending over a period of five years, which means that certain respondents were the same and certain were new. However, the purpose was not to measure the individual opinions, but to describe the different opinions which existed within the change process on a particular occasion.

2 AIM OF THE STUDY

The purpose of the study is to analyze and describe how radiologists and radiographers feel that their profession, work organization and use of the technology have been influenced at the radiological departments of the Region of Skåne following the introduction of digital image management and PACS.

3 BACKGROUND

In this section a brief description of the radiological services and work as well as the information and communication technologies (ICT) applied at the radiology department is provided.

3.1 RADIOLOGICAL SERVICES

A radiology department is mainly a service department for healthcare wards within the individual hospitals and primary care centers; however, depending on the nature of the radiology department, it may also be a service unit for other hospitals. The department may vary in size from a few employees to over 100 employees. The larger radiology departments do not only perform diagnostic tasks; in combination with diagnostics, they can perform various treatment interventions. This may include, for example, the opening of clogged arteries in blood clots and different treatments for cancer diseases as well as providing support in interventions for kidney diseases. At the larger or medium-sized departments, these interventions are usually divided between sections. These sections perform examinations within orthopedics, urology, gastroenterology, thoracic conditions and mammography; there may also be a special section for children. Today, a modern radiology department performs a large number of examinations, approximately 20,000 to 200,000. Included in these are conventional examination methods, magnetic camera examinations, computed tomography, and ultrasound examinations; there is also a section for artery examinations and treatments, where interventions are performed.

The study included six radiology departments. Of these, three departments performed all kinds of examinations. Three departments only performed conventional examinations. The introduction of PACS to these departments was included in a commitment to pair hospitals, which meant that hospitals in the region collaborated in pairs as a method of increasing availability and effectiveness.

Berggren (1982) studied the introduction of computed tomography (CT) and the changes in professional roles that occurred in conjunction with it, concluding that it was generally not possible to predict developments prior to the introduction of the new technology. The same conclusion would seem to apply to the context of this study focusing on digital imaging and PACS.

Radiological work is complex, with large numbers of contacts both within and outside of the radiology department. The main radiological task is to give a diagnosis; however, as mentioned, treatment can be performed as well. In order to facilitate the workflow, there is support available for different systems, including PACS.

In this study radiological practice, is defined as a radiological occupation, i.e. a community of practice with defined tasks and a set of relations between them. New radiologists and radiographers learn by conducting the defined tasks and also through the interactions and relationships within the community. The professional role is defined as the staff's interpretation of core abilities needed to perform work and properties of work.

The starting point for the work of the radiology department is a question which is sent via a referral to the department. From this, a number of activities are started which interact with each other. One activity must be completed before the next can be started.

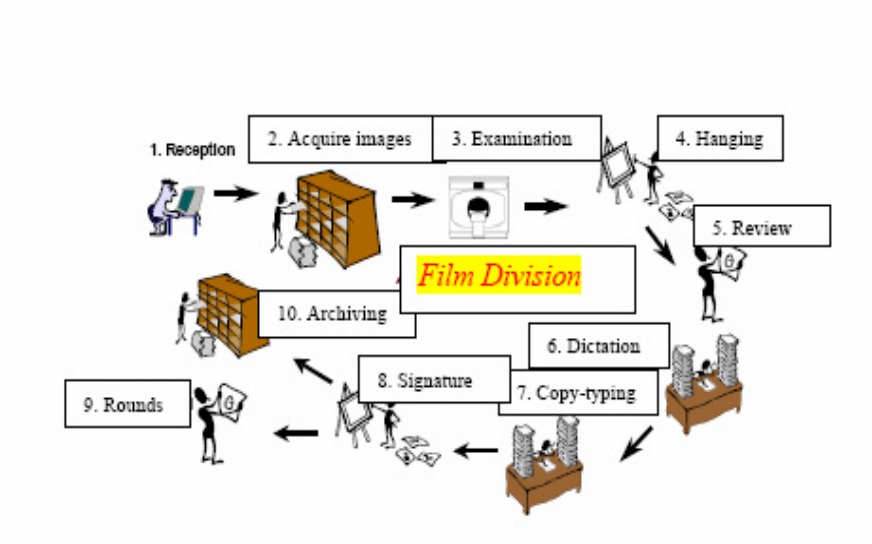

Fig. The picture illustrates the radiological workflow.

3.2 COMPUTED MODALITIES, PACS AND RIS

The change from an analogue to a digital environment has been described as dramatic, and one of the greatest changes in the history of radiology (Osteaux, Van den Broeck, Verhelle & de May 1997). The interactions between work practice, digital technology and changes within professions have not been analyzed sufficiently (Crump & Pfeil 1995; Schrader, Kotter, Pelikan, Zaiss, Timmerman & Klar 1997).

X-ray radiation was discovered in 1895, and it was realized at an early stage that one of the properties of this radiation was the ability to darken photographic film. As a result photographic film was used to document X-ray examinations when the method was introduced into healthcare. Today, this method of documentation of examinations is presented as the analogue work method. This entails the direct imaging of the patient

on a photographic film. Examinations were documented in this way until the 1990s. At this time, photographic plates were introduced instead. These could collect the X-ray radiation which passed through the patient and transfer it into a computer. However, the image, which was now in digital form, was still being transferred onto the usual photographic film. The reason for this was that there were not sufficient technological possibilities within radiology to transport or store the film in digital format. It was this problem that the introduction of PACS addressed.

Until the 1970s, radiology relied on two methods: one was the conventional method of examination with X-ray tubes and photographic film, and the other used angiographs. The latter method entails injection of a contrast medium into the patient's blood vessel to enable diagnosis. This method of examination was also documented using photographic film.

During the 1960s, experiments were performed where instead of the conventional method of taking a photographic image of the patient; a cross-section of parts of the patient was created. For this method to develop, very powerful computers were required for the mathematical calculations involved in creating the examination images. These powerful computers were introduced during the 1970s. This was also the start of the development of primarily computed tomography and the magnetic resonance tomography.

Computed tomography is an X-ray tube which rotates around the patient. The radiation transmitted through the patient is gathered and the measured values are sent to a computer. The computer then reconstructs a cross-sectional image of the organ being examined onto a matrix. This meant that the images produced were digital, but in order to transport and store them they were transferred, as mentioned earlier, onto photographic film.

The other method, the magnetic resonance tomography, which produced cross-section images of the patient, was introduced into healthcare during the 1980s. The method is based on the patient lying within a powerful magnetic field. Radio waves are then sent within this magnetic field, which are absorbed by protons in the tissues of the patient. As the radio signal is switched off, radio waves are returned to the transmitter where they create measured values of the signals. In a method similar to computer tomography, we could now, with the help of powerful computers and a matrix, create cross-section images of the patient's organs. This meant that the images in this case were also digital, but for further transport and storage, they were transformed into photographic film.

The new methods of examination produced large amounts of photographic images and together with the conventional methods this meant extensive problems with

management and archiving. Large storage areas and personnel for administration were required.

When PACS was introduced during the 1990s, it was as an easier way to manage examination material produced by the radiology departments. PACS was based on managing images in digital format and as described, there were already prerequisites for these digital images, since photographic plates and computed tomography as well as magnetic cameras produced images in digital format during examinations.

PACS – Picture Archiving and Communication System – is a world-encompassing computer-based system for the archiving, distribution, communication, display and processing of digital images. PACS has existed for about 25 years and was developed in Europe. However, the first system was not installed in Europe, but in the USA in the beginning of 1980 at the University of Pennsylvania, UCLA, and Kansas City University. A few more or less successful installations also took place in the Netherlands, Belgium, Austria, England, France, Italy, Scandinavia and Germany. Most of these systems were installed with a focus on a system to be coupled to a radiology departments. The first system to integrate other users as well was implemented in the beginning of 1990 at the Hammersmith Hospital, London and in Vienna (SMZO). There are a number of references describing the development of PACS (Huang 2003; Lempke 2003).

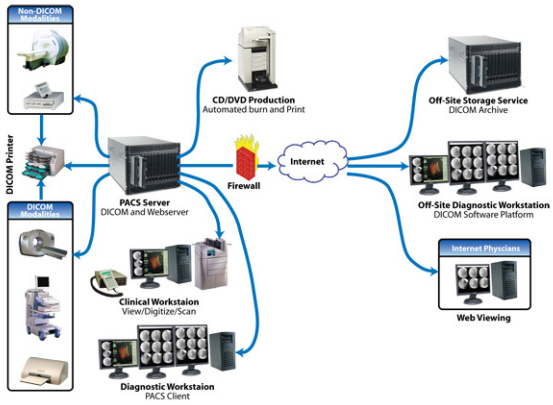

Fig. Schematic illustration of a department using PACS

The main function of PACS is to archive and distribute images. However, PACS is also designed to facilitate other tasks within radiological work. Examples include: 1) the manipulation of images by changing the gray scale or enlarging sections of the image or by taking measurements of the image, 2) the possibility of creating work lists for the organization of the work, 3) retrieval of previous radiological examinations, 4)

reconstructing three-dimensional images of, for example, CT or MR examinations (Lundberg 2000)

PACS is closely related to RIS (Radiology Information System), which is an administrative system used to manage administrative routines related to the performance of X-ray examinations. The patient is booked for examination using RIS, which then ties the patient's ID to the examination images to be stored in PACS.

The computed modalities PACS and RIS have together created the distributing radiology department. The distributing radiology department can be defined as the sharing and transferal of data within and across health organizations (Orlikowski, 2002). In this study, the term "PACS" refers to both the communications and archiving system as well as digital images.

3.3 RELATED RESEARCH

Having described the radiological services and work as well as the ICT systems applied within radiology, I wish to turn to the related research, which represented the background literature for these studies. Related research in healthcare has focused on technical, economical, workflow and sociological issues.

The initial research on PACS was, naturally, focused on the technological and economical issues (Strickland 1996; Bryan, Weatherburn, Watkins & Buxton, 1999); Brelstaff, Moehrs, Anedda, Tuveri & Zanetti 2001). Recent studies of the costs involved show wide variation, from findings that large savings are possible to reports of never being able to receive returns from the investments (Eggers 2007; Friedman, Halpern, Fackler 2007). The costs cannot only be compared to expected savings; they must also be compared with other and changed possibilities (Arenson 2000; Saaranummi, Inamura, Okabe & Laerum 2001). The challenge is, according to Saaranummi et al (2001), to realize that reorganization can result in extensive possibilities for savings. Siegel and Reiner (2002) agree. PACS is described as the system which resulted in a review of the workflow, which in turn resulted in large profits.

> In 1998, Reed Gardner, an informatics pioneer, stated: *"In my opinion, the success of a project is perhaps 80 percent dependent on the development of the social and political interaction skills of the developer and 20 percent or less on the implementation of the hardware and software technology!"* (Lorenzi & Riley 2000)

The introduction of new technology tends to erase professional borders for those professions within the environment where the new technology is introduced (Foster 1986). Cabrera (2002) points out that it was only following the implementation of PACS that the need for a reformation of professional roles was realized. Carrino (2003) states that the relationship between humans should be examined - technology can change.

Work tasks which can be performed by the computer can free time for radiologists so that they can focus on more complex tasks. Lundberg (2000) shows that implementation not only influences the technology which is to be integrated, but also the people, work routines and organizational aspects. Larsson et al. (2006) identified and analyzed the effects of (PACS) on radiographers' work practice. They found that the introduction of PACS did not simply entail the transfer of data and information from the analogue to the digital world, but also led to the introduction of new ways of communicating, and new activities and responsibilities for radiography staff.

Saaranummi et al (2001) stress that PACS open up a possibility to implement new diagnostic routines. However, the real challenge is reorganizing the workflow within the radiology department (ibid.). The same ideas are expressed by Siegel and Reiner (2002), who describe the changes in routine work and workflow that took place during eight years' experience of PACS. They found that PACS brought about a review of the workflow in the department, resulting in greater flexibility.

The focus related to the PACS implementation process has shifted from the technological aspects towards workflow issues. According to Sacco (2002), cost savings result from reductions in staff rather than from the elimination of film and chemicals. Such staff reductions are highly dependent on optimizing the workflow in the department. To realize the potential of PACS, the implementation process must be considered as a whole, including users, strategic decisions, and insight into the risks involved in the process. Van Essen and Hough (2001) stress the importance of adapting the PACS to the radiological profession and not the other way around.

Early implementation of a RIS (Radiology Information System) is important because this may help to reorganize the workflow in the radiology department (Mulvaney, 2002). The RIS supports the management related to patients and radiological examinations, reducing the bottlenecks that, according to Nanni, Carnassalle, Napoli, Campioni & Marano (2003), occur in the planning of digital radiological examinations and image management.

The importance of good management is stressed by Hasley (2002) and Carrino (2003). The management should have vision, strong support from people in the immediate surroundings, and a strong conviction that the project will succeed.

Research has slowly started to focus on PACS not only being a technological project but also a project of change (Knepper 2007). Cohen, Rumreich, Garriot & Jennings (2005) write that in order for PACS to be a successful project, "cultural" changes at the individual's level are also required. If the introduction is considered on the basis of the change in perspective, the processes which evolve from changes also come to light, e.g. the resistance towards these changes (Gäre 1999 and Cohen et al 2005).

The transition from an analogue to a digital environment is not just a change for the X-ray diagnostic clinic (Thrall, 2005 part III). It is a change which influences the entire hospital (Cohen, 2005) and seems to be one of the greatest changes since the introduction of X-ray technology (Osteaux et al 1997).

From the above, it is clear that there are a large number of studies which focus on the different aspects of the introduction of PACS. Few have however tried to view the implementation of PACS in its organizational and social context. We have found no longitudinal study within this field.

4 METHOD OF DATA COLLECTIONS

Kvale (1996) says that "*the best way to get information on how people feel about things it to ask them"*. For this study, the method of data collection selected was interviews. (Jaber 2002).

The reason for this choice of method is based on the purpose of the study, to describe how radiologists and radiographers feel about the change which has occurred with the introduction of PACS. The opinions are the respondents' subjective description over time. The method which would best mirror these subjective opinions was thought to be interviews. Other methods were however considered, e.g. a questionnaire. The advantage of an interview was that it provided an opportunity for the respondent to include information which otherwise might not have been submitted, for example if a questionnaire had been used.

The qualitative interview reminds one of a normal conversation. The researcher sets the thematic context but, at the same time, should not control the conversation too much. In a qualitative interview, standardized questionnaires are not used since the conversation can be too controlled. However, a previously written manual with questions important to the interview may be used. For this study, a manual with a few key themes was used. The themes used during all interviews were: *adaptation, changes in the professional role, changes in the work organization and acceptance of the new technology*. There was also the possibility of complementing the interview with information under the heading *other*.

During the interview, the manual does not need to be followed rigidly; the questions must just be asked in a natural order. While it is important that the interview covers those themes decided on, it can at the same time allow space for new ideas. The purpose of the qualitative interview is to increase the value of information and create a base of deeper and fuller understanding of that which is to be studied (Holme & Solvang, 1991).
For this study, the interviews were carried out in the following way:

- The respondent was invited into a separate room at the clinic in question.

- The time scheduled for the interview was communicated to the respondent in good time. The time allowed for each interview was one hour.

- Before starting the interview, the respondent was given the manual that was to be followed during the interview

- During the interview, notes were made about the answers given by the respondents for each theme

- The interview was concluded with a summary of the contents and a chance for the respondent to correct or add to it

5 METHOD

In the following section, grounded theory is presented, the method which became the starting point for design and computer analysis. The section begins by presenting the scientific theoretical background, followed by a short history, and finishes with a discussion about the criticisms of grounded theory.

Grounded theory is a method of research developed within medical sociology which is today used within many other areas of medicine, e.g. oncology (Madsen, Holm & Riis 2007), gastroenterology (Hall Rubin, Huning & Dougall 2007), medical information methods (Hendy 2007 and Obstfelder Engeseth & Wynn 2007), as well as closely related areas of medicine such as odontology (Newton 2007) The method has also spread within many other areas of research, among them economics (Gustavsson 1998) and pedagogy (Håkansson 2007).
Grounded theory (GT) is a form of empirical research which has realistic observations as its only source of knowledge. Theories are based on empirical research which increases over time.

Knowledge generated within scientific disciplines is often structured in theories Traditionally, a distinction is made between two scientific theoretical traditions, the positivistic and the hermeneutic traditions, and their respective method theories, the quantitative and the qualitative method theories. These method theories are also known as deductive and inductive respectively. Both the scientific traditions describe different kinds of theories. Within the positivistic tradition, the theories constitute clauses which describe connections between different measurable data, while the hermeneutic tradition creates theories on occurrences which are not directly measurable; people's conceptions of reality are studied instead. Those theories created within hermeneutic tradition have as their goal to describe how people see reality.

Grounded theory (GT) falls within the hermeneutic scientific theoretical tradition. The purpose of GT is to describe theories directly derived from empirical data. Unlike many other qualitative methods, how the method is to be used in data collection, in analysis and in describing theories has been carefully described (Glaser & Strauss, 1967). As a result GT is both a scientific tradition and a method. Therefore, in this study GT is used to refer to both theory and method.

As mentioned, the idea of GT is to generate theories. Theories can be described in three levels of abstraction (Hartman 2001). At one end there are theories with a high degree of abstraction; these are intended to provide general explanations. At the other end are smaller work hypotheses, which are intended to describe the connection between a few characteristics. Between these, there are theories which do not provide general

explanations for society at large but do describe relationships between a few characteristics. In this case GT is intended to describe and understand the phenomenon which is common to a group of people. The theories in this case are based on categories and the characteristics of each category. The opinions to be described are those collective opinions at a definite point in time.

The purpose of this study is to describe and understand how one group of people, radiologists and Radiographers, feel their **professional role and work** has been changed with the introduction of a computed image management system at a number of radiology departments.

The reason for this choice of study method is that grounded theory is suitable for studies where earlier research is scarce (Charmaz, 1990), which applies since the study addresses changes which occur in connection with the introduction of a digital image management system within radiology over a five year period. However, studies dealing with computerization of other businesses do exist, see e.g. Gäre (1999, 2003). It may also be logical to choose this method since it can add to the understanding of social processes and shed light on general events, not just individual people (Guvå & Hylander, 2001). Glaser (1978) writes that grounded theory concerns phenomena which are undergoing change in a process.

5.1 GROUNDED THEORY – A SHORT HISTORY

The method was developed in the beginning of the sixties by two American sociologists, Barney Glaser and Anselm Strauss, who together studied people on their deathbed who were being cared for in hospitals. The study was published in 1965 under the title *Awareness of Dying*. Later they wrote the book *The Discovery of Grounded Theory* (Glaser & Strauss, 1967) where the inductive method used in the study is more described in more detail.

Glaser and Strauss had different academic backgrounds, but shared a discontent with the traditional qualitative and quantitative methods. These different academic backgrounds later became the cornerstones of grounded theory (Hartman, 2001).

According to Glaser and Strauss, the problem with the established, deductive methods was a one-sided emphasis on the importance of hypotheses without explaining how these occurred. For the established methods within qualitative research, the problem was that data collection was controlled to a high degree by earlier theory-building and could not be performed in an unbiased way. There was a risk of missing important data since one did not know in advance which data would turn out to be important.

Glaser and Strauss went their separate ways and later interpreted their own method in somewhat different ways. These were described in the books on grounded theory which they later wrote individually (Hartman 2001). Strauss published *Basics of Qualitative Research: Grounded Theory procedures and techniques* in 1990 with Juliet Corbin, and this is probably the most popular book on Grounded Theory.

The similarities between Glaser and Strauss are that the research is divided into three phases; however, the procedures they describe differ during the different phases.

Strauss calls the different phases *open, axial* and *focused coding* while Glaser uses the terms *open, selective and theoretical coding*. In the first phase, the categories appearing in the data are generated. The difference between the researchers in this phase is that Glaser chooses one category which is more important than the others. In the next phase, Strauss finds the relationship between the different categories while Glaser designates his core category instead. In the final phase, Strauss finds his core category while Glaser describes the relationship between the categories.

In short, three differences can be described between Glaser and Strauss. The first and greatest is in which stage the core category, which is the category that can describe large parts of the content of the research, is built. Glaser believes that this should be done in the first phase, while Strauss believes this should be done in the final phase of the research. The other important difference is when the data collection is completed. In Strauss' methodology this is done after the first phase, while Glaser recommends that an initial data collection is performed followed by the analysis of the data according to the three phases and then continuing with further data collection. The third difference between these two is when relationships between categories are created. According to Glaser, this should conclude the research while Strauss recommends an early description of the relationship between the categories.
This study is based on a working principle close to the approach Strauss recommends: first data collection, then analysis and creation of categories and core categories. One reason for this way of working was that data collection had to take place on specific dates.

In this study, the material was analyzed and coded using grounded theory as an *organizational principle* to describe the evolving theory. The principle was to analyze and describe emerging categories and core categories on each measuring occasion (1999, 2000, 2002 and 2005/06. A comparison between the different measuring occasions was then performed and the overall core categories described in the articles were then formed. These categories described those opinions of the changes which could be seen.

The use of GT in this study has influenced the study in different ways. One of these was that the results should be presented in the form of a developed theory, and that this should be empirically based. In addition, GT has been very useful in creating the categories. These were specified from the material analyzed right from the beginning of the analysis. There is some risk of the categories being general and not always being based on the analyzed material. The way the data was analyzed also resulted in a large number of sub-categories, which were useful when the content of the core categories were to be described.

5.2 CRITICISM OF GROUNDED THEORY

In recent years, there has been some criticism of grounded theory. This is primarily directed towards some of the cornerstones of the original methodology: not using existing theory descriptions within the research area and assuming that the researcher is unbiased. Researchers at the University of Linköping have criticized and developed GT. They have developed a new way of working with GT which they describe as a multi-grounded theory (MGT) (Goldkuhl & Cronholm, 2003). In this method, it is self-evident that theories existing within the area should be used. Naturally, with the realization that many scientific theoretical methods of approaches recommend the use of previous knowledge in the form of those theories existing within the area, this was a factor limiting use of the original method of grounded theory for this study.

Others have criticized the expectations that researchers enter the investigation without bias (Seldén, 2005). The researcher, in order to be a researcher, has considerable previous knowledge. This allows everyone to have a pre-understanding of what might influence the investigation. Seldén points out four further weaknesses in grounded theory which must be kept in mind when the method is used.

In a somewhat simplified version, these are approximately as follows (personal note, page 127)

1. Pedantic coding – the technical tail whips the theoretical dog.

2. Losing the connection during coding - only notes, no melody

3. Lack of insight with regards to understanding which causes inability to become a strength

4. Production of general knowledge at a contributing level which opposes theories – trivial knowledge

For this study, the weaknesses of the method can be discussed on the basis of the points described above. The first criticism 1) is directed towards GT's detailed description of how the analysis should be performed in order to create categories and core categories. This can be seen as limiting the scope for freedom and creativity in building these categories. However, this was an advantage for this study, since the material contained a large number of interviews and these extended over a long period of time. Using similar methods for each interview during the years resulted in similar analyses.

The second criticism 2) is directed towards the large number of categories which can be created and that these can lose their context. It is naturally correct that a large number of categories can be created. This was not seen as a problem in this study since the analysis was performed by two researchers, first individually and then together. In addition, the ambition from the beginning was to increase the level of abstraction for the categories created. In the end, the result was based on numerous implemented levels of analyses.

3) Qualitative studies which involve insight and understanding mean that the researcher is participating and present. Naturally the researcher's understanding will then be of importance. In the study, one of the researchers had a background as a radiographers and was well-informed about the context in which the study took place. Radiological activities are complex and a number of different players are involved. Without this previous understanding of the context, it would have been more difficult to derive a deeper meaning from this section of the study. For example, during the third round of interviews (2002) the radiographers discussed extensively the developing apparatus which disappeared when PACS was introduced. It was not hard to understand that this context of the developing apparatus was central, since the developing apparatus symbolized a meeting place for the radiographers during their daily work.

4) The last criticism mentioned can also be understood against the background of the qualitative methodology. It is the researcher who decides when the analysis is complete, and this may result in categories that are too basic in level as the final result. This was counteracted in this study by specifying that the analysis was complete only after a number of levels of analyses had been carried out.

6 MATERIAL

The material used for the study was based on interviews with radiologists and radiographers at six radiology departments in the Region of Skåne. These were then analyzed with the help of grounded theory as an organizing principle.

In the following section, the radiology departments included in the study are presented first, followed by the number of radiologists and radiographers included in the study. The departments can be seen in the tables, as well as how many interviews were performed at each department and which year the interview was carried out.
In 1997, a group was appointed by the management of the Region of Skåne to investigate the possibilities for the introduction of digital image management using PACS. This coincided with the desire to test a system of "pair hospitals", which meant that hospitals within the region collaborated in pairs, as a method to increase availability and effectiveness. This was important in determining which hospitals in the Region of Skåne were to be included in the study. For example, Ystad would be a hospital pair with Simrishamn Hospital and Landskrona Hospital with Lund University Hospital along with the larger healthcare centers in Eslöv and Hörby.
The radiology departments in the Region of Skåne included in the study were: the radiology department at the Lund University Hospital, the hospital in Landskrona, the hospital in Ystad, the hospital in Simrishamn, the radiology department at the healthcare centre in Eslöv and the radiology department at the healthcare centre in Hörby. However, the Hörby radiology department was closed down during the final interview session.
A more detailed presentation of the different departments appears below:

Lund
The university hospital encompasses most medical specialties; it has 1,176 beds and a total of 7,850 full-time employees.
The radiology department consists of different units: Emergency Radiology, Radiology 1, Radiology 2, Neuroradiology and MR. At emergency radiology unit, patients coming to the emergency ward are examined. The activities in Radiology 1 include consultations, patient-related diagnostics and catheterized treatment procedures on inpatients as well as polyclinic patients. Radiology 1's areas of activities involve abdominal organs including oncology, mammography including screening, and conditions of the heart, lungs and arteries. The department also includes a thoracic section which is responsible for both conventional radiology, such as CT (Computerized Tomography) and MR (Magnetic Resonance Tomography), and radiological interventions within the rib cage, except for corona angiography and PCI. The section is also responsible for the venous diagnostics, artery access activities within X-rays as well as CT and MR of the peripheral arteries.

Radiology 2 consists of consultations, patient-related diagnostics and catheterized treatment procedures on inpatients as well as polyclinic patients. The areas of activities include children and adolescents, skeleton and soft tissue.
The MR unit performs magnetic resonance examinations of the brain, back, the ear, nose and throat region, heart, abdomen, skeleton and soft tissue.
The neuroradiology-odontological section consists of diagnostic examinations, treatment procedures and consultations in the form of rounds and conferences dealing with the cranium, ear, nose and throat and back as well as teeth, jaws, facial skeleton and salivary glands.
A total of 61 radiologists (of which 49 are specialists and 12 are non-specialists) and 107 radiographers work in the radiology department. During the year 2000, 168,000 examinations were performed, and 170,000 examinations during 2006.

Eslöv

The activities consist of consultations and patient-related diagnostics with the help of conventional radiology on polyclinic patients. The most common examinations are radiology of the skeleton and heart/lungs. Mammography screening is also performed here. Three radiographers worked at the beginning of the study at the department, but when the radiology department at Hörby was closed down, the number was increased to five radiographers. The department performs 15,000 examinations per year.

Landskrona

The hospital in Landskrona consists of two medical divisions and two surgery divisions. In addition there is an emergency unit and wards for orthopedics, surgery, urology and ear, nose, and throat conditions.
There are 57 beds available and a total of 340 employees work at the hospital.
The radiology department in Landskrona performs patient-related diagnostics on inpatients as well as polyclinic patients. Conventional X-ray examinations, computed tomography, magnetic resonance tomography and ultrasound as well as mammography screenings are performed for the purpose of diagnosing or treating diseases as well as following the progression of diseases and evaluating results of treatments. The number of radiologists employed is three and the number of radiographers is seven. The division performs 24,000 examinations yearly.

Hörby

The radiology department at Hörby had the same structure as Eslöv. However, the department was closed down during the study in 2005.
Two radiographers worked at the department, and these two radiographers were transferred to Eslöv after the closure.

Ystad

Ystad hospital includes an emergency unit, surgery and medical divisions, a psychiatry division, a geriatric division and an intensive care division. There is also an eye and ear ward. There are a total of 168 beds and the number of employees is 1,300.
The radiology department performs examinations on all organs with the help of conventional radiology, ultrasound, continuous X-ray screening, computed tomography and magnetic resonance tomography.
The radiology department at the hospitals in Trelleborg, Ystad and Simrishamn have since the turn of the year 06/07 been connected during on-call hours and have a common telecommunications link. The new organizational form resulted in an increase from 4 doctors to 15 who share the on-call burden. The radiology department are among the most widely dispersed in Sweden, with examination premises at three hospitals and radiologists living and working in ten cities, with Stockholm and Härnosand (approximately 1050 km) being the furthest apart.

Simrishamn

At the hospital in Simrishamn there are two divisions: medical and rehabilitation. These have 30 beds. There are also a number of special wards. A total of 160 people work at the hospital.
The radiology department performs 11,000 examinations per year, including computed tomography. One radiologist and four radiographers work in the department.

The implementation of PACS at the different radiology departments was carried out *at different points in time* and on the basis of the hospital pair structure. When the study was initially planned during 1998, the Lund University Hospital was paired with Landskrona's hospital, and the healthcare centers at Eslöv and Hörby were also included. In addition, the hospitals at Ystad and Simrishamn were, with time, also included.

6.1 SELECTION PROCESS

A radiographers/administrator located at the Lund University Hospital was engaged as coordinator for the upcoming interviews at the different units. He joined the PACS implementation project at an early stage and was assigned a comprehensive responsibility for training prior to implementation at the different units. Through this role, he became well-acquainted with the radiology departments and their personnel. It was this person who invited the radiologists and radiographers at the Lund University Hospital to participate in the study. It was also this person who contacted the department managers/clinical managers at the other participating departments.
Practically speaking, for this study, this meant that radiologists and radiographers on duty (on a pre-determined day) were asked if they could participate in an interview regarding the implementation of PACS.

Table 1. Number of participating radiologists at the respective hospitals

	1999	2000	2002	2005
Lund	7	5 (3) [1]	7 (3)	5 (3)
Ystad	2	4 (2)	2 (2)	2 (2)
Landskrona	2	2 (2)	2 (2)	2 (2)
Simrishamn	1	1 (1)	1 (1)	1 (1)

The y-axis of the table shows those hospitals participating in the study and the x-axis the occasions on which the interviews were carried out. The table also shows the number of radiologists interviewed at each hospital at a predetermined time. The number of radiologists interviewed throughout the entire study is shown in parenthesis. The total number of radiologists employed totaled 68. Of these 12 were chosen for the study in 1999, 2000 and 2002 and 10 radiologists in 2005. A total of 24 interviews were conducted at the radiology department at Lund University Hospital, 10 interviews at the radiology department at the Ystad hospital, 8 interviews at the Landskrona hospital and 4 interviews at the Simrishamn hospital. All participating radiologists were specialists within radiology; some also had administrative responsibilities. The number of radiologists, which remained unchanged throughout the study, was 3 for Lund, 2 for Ystad, 2 for Landskrona and finally the same radiologist on all occasions during the study at Simrishamn.

Table 2. Number of participating radiographers at the respective hospitals

	1999	2000	2002	2006
Lund	8	14	11	5
Landskrona	2	2	2	2
Hörby	2	2	2	0
Eslöv	2	2	2	2
Ystad	2	3	2	2
Simrishamn	1	1	1	1

The y-axis of the table shows those hospitals participating in the study and the x-axis shows on which occasions the interviews were conducted. The table shows the number of radiographers interviewed at each hospital at a predetermined time

The choice of participating radiographers was made from a total of 133 possible respondents. For the study performed in 1999, 17 radiographers participated, for the study in 2000, 24 radiographers participated, the study in 2002 had 20 respondents and finally for the study in 2006, 12 radiographers participated.

A total of 38 interviews were carried out at the Lund University Hospital, 8 at the hospital in Landskrona, 6 at the radiology department in Hörby, 8 at the radiology department in Eslöv, 9 at the radiology department at Ystad's hospital and finally 4 interviews at the department in Simrishamn.

No interviews were conducted at Hörby in 2006 due to the closure of the unit the previous year.

The participating respondents in the study were selected on the basis of the special method called theoretical sampling used in grounded theory (Strauss & Corbin, 1990;

Folkesson 2005). This method of selection is also mentioned by Robson (1993), who used the term *purposeful sampling.* In this selection procedure, the purpose of the investigation determines the selection of the respondents. It is important that these information sources give an overall view of the area of research and complement each other. Included in this study were different professional groups, different positions, different ages and different units. As a result, the selection of respondents may mirror the total composition of the personnel.

The study is longitudinal, extending over a period of five years, which means that certain respondents were the same and certain were new. However, the purpose was not to measure the individual opinions, but to describe the different opinions which existed within the change process on a particular occasion.

7 ANALYSIS

In grounded theory, the analysis is called coding,: "…coding represents the operations by which data is broken down, conceptualized, and put together in new ways" (Strauss and Corbin, 1990, p. 57). The coding of data occurs, as previously described, in three steps. The first consists of going through the material and forming categories and sub-categories. The following step involves the description of characteristics that belong to each category, not including respective sub-categories, so that it is possible, in the third and final step, to describe the key category that holds large amounts of the analyzed material. In the first step, going through the material, one makes comparisons and asks questions such as, "*what does this mean…, can it be found elsewhere in the data…?*" Grounded theory is sometimes described in the literature as "*the constant comparative method of analysis*" (Glaser & Strauss, 1967 p. 101-116). Once this part of the analysis has been concluded, one is left with a certain number of categories and sub-categories. These sub-categories will then be used in the next step of the analysis in order to describe the characteristics that belong to the category. Hartman (2001) describes this step from a study on men's view of parenthood. One category from the study is "responsibility". Although one receives no explanation of the category's content, the respective sub-categories can then prove helpful.
The coding process of the material that was gathered in this study resulted in the formation of a number of sub-categories. From these, one or more categories were then formed. Finally, a key category was created from these categories.

Besides the method of analysis used, the results are described in four key categories for every work group, which contain descriptions of their respective categories and descriptions in running text of the characteristics belonging to each category. As usual in qualitative studies, each category contains one or more quotes taken from the interview.

GT is well documented in other studies within the health and hospital fields, usually when describing a phenomenon. One example is the study, Living with dizziness: an explorative study (Mendel 1997). The aim of this study was to describe how patients with dizziness manage their daily life. The analysis resulted in the following categories:

1. Vulnerable reactions, with the sub-categories: feeling exhausted, feeling insecure, feeling a loss of dignity.
2. Affirmation and non-affirmation, with the sub-categories: reactions from healthcare professionals, reactions from others.
3. Ways to carry on daily living, with the sub-categories: planning and adapting, depending on others

4. Expressing the need for health care support, with the sub-categories: needing information, support and teamwork

In grounded theory it is traditionally important that the result stems directly from the data.
In practical terms, the analysis method used in this study was used in the following manner and with reference to how it is described in Strauss and Corbin (1990).

Directly after the interview was finished, a first reading of the material was undertaken in order to provide a general overview. The first step of the analysis was undertaken by the researchers without recourse to one another. The results were then discussed and compared. Afterwards, a careful, line-by-line reading took place, first individually and then in a group. When something in the text cropped up that corresponded to the relevant question, the words would be highlighted and a note made in the margin. This could take the form of a phrase, word or something concrete that indicated the specific phenomenon.
In the next step, comparisons between the annotations were made in order to find similarities. Once similar assertions had been gathered, they were given a name (forming a sub-category). The next step was to gather similar concepts and, from these, give a name to the content (forming a category). The aim is to take these descriptions to an ever higher level of abstraction, eventually resulting in a key category.
For the validation of results, they were presented at a workplace meeting in the radiography clinic in Lund, with other clinics also represented, at a radiology conference in Huddinge hospital, at the yearly conference called Röntgenveckan in two different venues and at the international conference, EuroPACS, also at two different venues. This was also done with the aim of finding more/new suggestions for further progress in the study.

8 RESULTS

How individuals in the organization perceive their work is important for the result of the work, both at the individual and at the organizational level. Figures 1 and 2 below present changes in how radiologists and radiographers perceived their work between 1999 and 2005/06. Changes take place when a new technology is introduced into an organization. How individuals handle these changes represents important information for the understanding of the outcome of the introduction. We have analyzed and compared both these studies in this results section in order to see whether there were any significant events or factors that have affected the process.

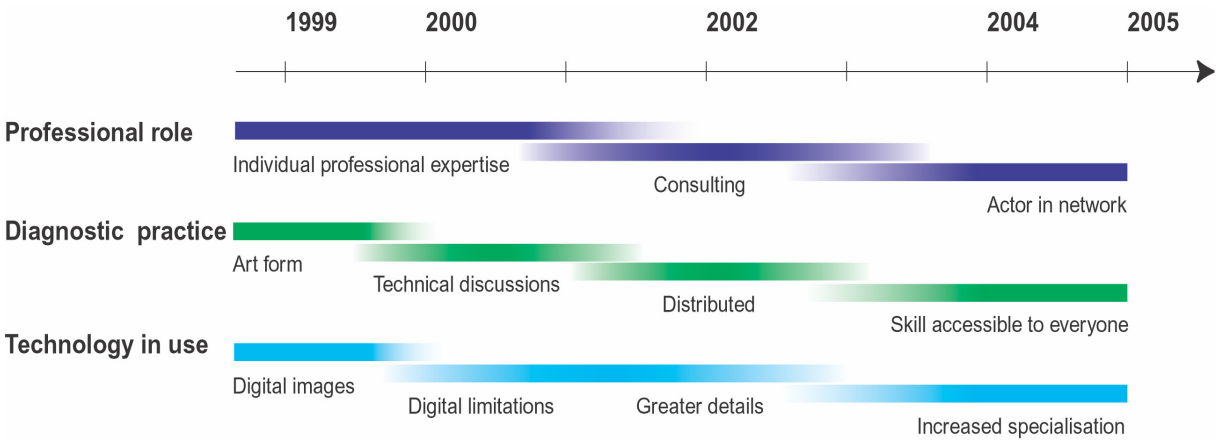

Figure 1 The changes in radiologists' perception of work from 1999 to 2005

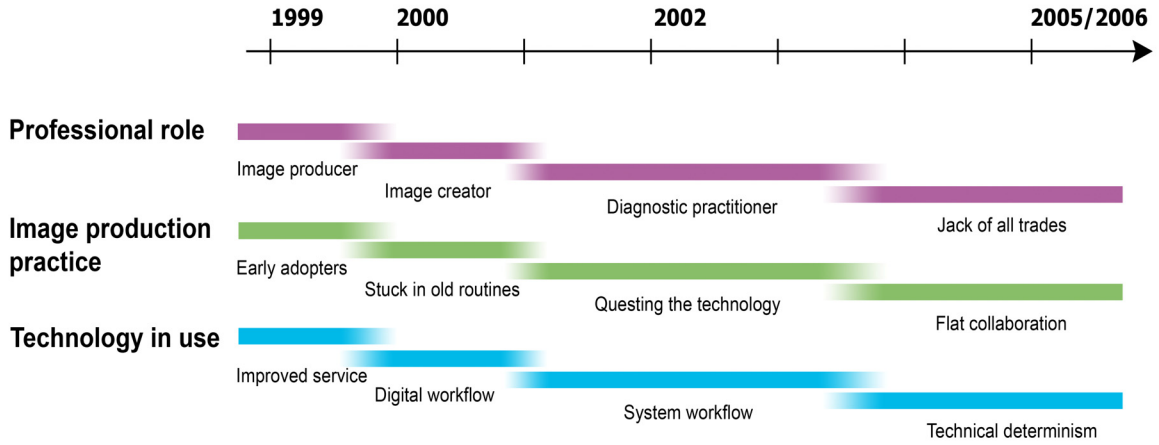

Figure 2 The changes in radiographers' perception of work from 1999 to 2005/2006

The study on which the result is based is longitudinal, lasting from 1999 to 2006. Therefore, an important aspect of the results is that it mirrors the changes that have happened over this period. Through the study's design, we can see that the changes do not happen overnight. This is important information to have when planning the implementation of a new technology (Gell 2006).
This results section is based on two articles (Supplement 1 and Supplement 2). Each article focuses on a workgroup, with Supplement 1 focusing on radiologists whilst Supplement 2 focuses on radiographers. I will give a separate account of each article, with the aim of seeing how the results look per workgroup and year, after which I will list the common themes that are of most interest and discuss them further. The focus for this discussion is what the change has meant to the organization. One can see from the results that both workgroups are relatively similar in their definition of the parts that make up their "Work Practice". Both work categories describe their role and the technology they use. However, they seem to have differences regarding "what I do", with radiologists defining diagnostics, whilst radiographers describe image production.

8.1 RADIOGRAPHERS 1999

The first interviews, from 1999, have radiographers describing their core competencies very clearly. These involve the art of knowing which exposure parameters to use in order to result in a well exposed radiography image, without giving the patient an overly high dose of radiation. This was, however, an ability that was foreseen to have lesser importance in the future.

"*…knowledge of exposure parameters will not be needed in the future …*''.

However, this was not seen in a positive light, as expected, in conjunction with the introduction of PACS. For the job description it was a positive challenge to work with a technique that was seen as new and modern for many radiographers. They foresaw that the new technology could possibly mean that work tasks would be shifted from radiology to radiographers. One conclusion from this reflection was that due to fewer radiography departments, there might not always be a radiologist in place, as one might instead be able to send the images to a larger unit. This would also mean that radiographers, by necessity, would need to diagnose images more carefully before sending them off. Positive changes were also foreseen for the organization. Images were now digital and could be found gathered in an image database (PACS). This should mean that they no longer disappeared, and one would often be able to avoid the lengthy search for the actual physical images. It was also foreseen that the process would be faster, as the images would be easy to access and no longer lost within the organization, which would enable a better patient service.

8.2 RADIOLOGISTS 1999

From the beginning of 1999, radiologists described their core competencies as closely tied to the review process of radiological material diagnosis. This is so central and important that one would be tempted to describe the process as a form of art. One needs to successfully differentiate between the sick and the healthy. This process not only includes the actual diagnosis of images, but also deep knowledge of medical specialties.

”*...some colleagues are able to define 20 possible diagnoses from one patient, but the clinician is only interested in which is the most likely...*”.

The material brought to light differences between older and younger radiologists as regards their outlook on this new technique. Older radiologists were somewhat cautious, whilst younger ones, perhaps due to their previous general computer use, tended to have a more positive outlook. This means that younger radiologists took on the role of teachers for this new technique.

In the analogue world, radiography images were tied to the radiography departments and could be “loaned out” if they were officially requested. The digital world opened up the possibility of allowing radiography images to be accessed by anyone with access to PACS as soon as the images had been exposed. This could cause concern among radiologists, with the risk that clinicians would themselves be able to begin diagnosing radiography image material and thus make radiologists redundant in the long term.

”*…it’s possible we might no longer be needed …*”

It therefore became clear relatively quickly that radiologists belonged to a workgroup that was used to participating in decisions and so used to taking a strategic approach. Besides the possibility of the radiologists’ services no longer being needed, the discussions tended to concentrate around how the profession would develop in a way that was attractive for clinics.

8.3 RADIOGRAPHERS 2000

In the study’s second interview period, radiographers described their core competencies as consisting of two parts. The first was knowledge of exposure parameters needed to produce a well exposed radiography image, whilst the second consisted of knowing how to take a radiography image.

”*…you should know what the image will look like before you even take it …*”.

Both are skills that are difficult to describe and where experience will determine one's level of knowledge. Only a few years after the introduction of PACS and digital images, and as feared by radiographers in 1999, the knowledge of exposure parameters has become less important. In interviews, radiographers instead chose to focus on the technique for taking radiography images as the most important aspect of their competence and toned down the importance of the knowledge of exposure.

"*…you should know what the image will look like before you even take it …*"

The context in which radiographers worked had undergone significant changes. Radiology images were developed faster using a machine. The procedure involved feeding the exposed radiography images manually into a machine to develop them and the developing process only took a few minutes to produce the developed images. These images were then manually shown to the radiologist. Both these activities were undertaken in the radiography departments. Once the context changed, radiographers were no longer necessarily granted natural communication access to their colleagues and radiologists.

" *…we didn't realize what the developing machine meant to us until it was gone …*"

At this second round of interviews, radiographers discussed the policy of consciously keeping up old routines. This could be good, in terms of management, but it quickly became clear that it also made it easy to "become tradition-bound". The smaller units, for example, Hörby and Eslöv, on the other hand, were quick to take up the possibilities created by PACS, principally because they no longer needed to send patients to other units. The radiography images were taken at a health centre, and then sent directly to the specialist radiologist. This meant that the patient could, in many cases, then stay at the health centre for treatment.

8.4 RADIOLOGISTS 2000

In the second round of interviews, in 2000, radiologists did not discuss organizational changes to any significant degree. Instead, their conversations were mainly concerned with the fact that the conditions for diagnosing images had changed. The image diagnosis is of particular importance for radiologists and it is therefore very natural that, should the image diagnosis process change, their discussions would pay special attention to these changes. The main experience was that the focus for radiologists' work had changed from that of diagnosis to technology.

"*…today, we go to technical courses instead of to diagnosis ones …*"

This description shows the extent of the change that radiologists experienced. Much of the work that was previously done manually, for example, arranging images from a patient in a pre-determined manner, used to be undertaken by other work categories. Now, together with the introduction of PACS, this work was expected to be done by actual radiologists. There was also much discussion regarding the quality of the digital images. In many radiologists' experience, digital images lacked the quality of analogue ones in, for example, dissolution, which is decisive for determining the minimum size of details that can be detected in the image.

8.5 RADIOGRAPHERS 2002

Previously, radiographers had identified knowledge of exposure parameters as an important part of their competency. It was quickly realized that the need for this knowledge was about to disappear, as digital images were not dependent on the exposure process. Instead, at the 2002 round of interviews, radiographers chose to describe how they appreciated no longer having to retake images due to wrong exposures, which occasionally happened before. In compensation for the loss of this competence, the new technique, through the speed at which it worked, allowed radiographers to assimilate a whole new competence into the workgroup.

"*…today we began learning preliminary diagnosis of radiography images and it was great…*"

Radiographers were given more responsibility for the preliminary diagnosis of radiography images, enabling them to conclude the investigation of the patient. This decision had previously come from radiologists. This new opportunity for the expansion of competence came in a new context for radiographers. Previously, in the analogue departments, radiographers worked side by side with radiologists, as radiologist needed to approve every patient. This provided plenty of opportunity for discussion and competence development. In the new digital world, the radiologist was removed without the possibility of a speedy return.

"*…nowadays it feels unusual to have the chance of discussing with a radiologist …*"

There were differences between the larger and smaller units. The change continued to be regarded as very positive at the smaller units. One reason for this was that there had previously been talk of closing these units, but in conjunction with PACS, they instead came to be renewed and according to the respondents, become more productive than before. One also noted that patients appreciated that they could be diagnosed at their local health centre, instead of having to travel to a larger clinic.

The suggestions for change that others tried to implement often resulted in failure, as the system was too rigid. What happened instead was that the work processes were forced to adapt to the system.

''…we are experiencing that the PACS system is very rigid …''

One change that was extremely noticeable was that the workflow through the PACS system meant that the short pauses due to waiting times that were previously prevalent, disappeared.

''…we don't get any breaks, like we used to …''

This meant that radiographers experienced increasing levels of stress.

8.6 RADIOLOGISTS 2002

Radiologists' attitudes since the first round of interviews had changed. They were clearly more positive in the interviews undertaken in 2002. There was a shift from worries about the future need for radiologists to thoughts about how to ensure one's development in a manner that would continue to be attractive to inpatient clinics. Radiologists saw the possibility of remaining attractive to these clinics. Their work would take on more of the nature of a consultant's professional role. Modalities such as MR and CT produced more and more image material. Clinicians sought people who could choose relevant images and present them in an understandable manner. This is when the so-called "stacking tools" became very successful. This technique made it possible to present a large amount of image material from CT and MR scans in a three-dimensional presentation.

In radiology, continuous learning is important for both individuals and the profession. With the new technology, radiologists identified great opportunities for the development of knowledge at the smaller units, as the new technique created opportunities for easy access to specialists in order to discuss an image.

This round of interviews saw the winds of change blow over radiologists.

A great change had taken place in the rounds, where radiologists meet clinicians to present their diagnostic results. This had previously taken place with analogue images shown on a backlit screen. The size and format of these images made it difficult for everyone to see them, but with digital images, it was possible to display them using a projector, thus ensuring that everyone was able to see them.

’’…now we are finally understanding what clinicians are actually looking for… we are asked more questions and that means we have to know more …’’

This meant that discussions between clinicians increased, as well as those with radiologists. The radiologist became the person to consult before choosing the inspection modality. Radiologists experienced this change as extremely positive, now that they were included in the patient treatment team.

8.7 RADIOGRAPHERS 2006

By the end of the 2006 round of interviews with radiographers, an exciting change in their competence was revealed. Since the introduction of PACS and digital radiography images, radiographers had anticipated that knowledge of the best way to expose a radiography image would not be necessary in the future. As it turned out, this knowledge became unimportant for a few years. At the 1999 round of interviews radiographers had explained that this knowledge was important to produce a well exposed radiography image. By the last round of interviews, radiographers once again saw a need for knowledge of these parameters, but not for the quality it brought to the radiography image. The importance of this knowledge had shifted to a focus on patients not receiving a stronger dose of radiation than necessary.

"…it is important to know about kV and mAs so that patients don’t receive too much radiation …"

The workgroup had now incorporated new competencies as well as taken up their earlier ones. They were very satisfied with how work competencies had developed during the change that had taken place from 1999. They found that the new work assignments involving diagnostics also necessitated new knowledge. The work was experienced as more lonely due to the loss of contact with colleagues around the developing machine and the contact with radiologists, even though this created the need for new abilities to make the preliminary judgments of the images. However, this also meant that new ways of establishing natural contact with colleagues and developing diagnostic abilities were sought.

’’…we speak more and more often with our colleagues today and work together more’’

The interviews brought to light different aspects of the new technique. One aspect is that the technique today is so invisible and that one does not really understand it. Radiographers are used to the technique and understand that the system can “hang”. What has happened is that the new technique is largely built on digital techniques and

computers, making it invisible to those who use it. Errors that crop up can be difficult to relate to.

''…before, errors also cropped up and things went wrong. But it was easier to understand why the errors occurred and we used to have tricks to correct them… nowadays it just goes wrong …''

8.8 RADIOLOGISTS 2005

When we returned for the last round of interviews they mainly showed very positive aspects, even if they still contained negative points. This did not happen immediately, but took a few years, although now radiologists had become accustomed to the new technology and there were now no differences between junior and senior radiologists. The difference we found in the first years had now levelled off or disappeared. The great difference that had taken place over time was that radiologists were now able to take part as members of the team taking care of the patient, in which the radiologist represented a diagnostic specialization that had grown in importance. Quotes from the interviews include:

''…today the clinician is no longer able to place the patient into observation and see what happens in unclear cases. Instead, they want a quick answer: is the patient ill or can he be sent home …''

Quotes like this one support the development from which radiologists will continue to benefit, in becoming more and more specialized.

Many also saw the positive side, although the possibility that many clinicians would begin to investigate the images themselves had constituted one of their apprehensions at the beginning of the study. This could, in the long term, lead to radiologists gaining greater scope to make a contribution in more difficult cases and allow them to deepen their knowledge and become specialists.

In the interviews, radiologists were able to describe the development as positive for the profession. There were three main reasons for the change: the ease of access to investigation of images, 3D tools, and the possibilities opened up by the Internet.

''…today we are conscious of the possibility of retrieving images over the Internet, although the importance this will have still remains to be seen …''

This comment was made by the head of a clinic who saw the possibilities of distributing images over the Internet and used this opportunity to carry out several radiological tasks.

9 DISCUSSION - CHANGE OF RADIOLOGY WORK AND ORGANIZATION

Several studies published previously regarding the introduction of PACS have focused on the technique (see Bibliography). For a long time the introduction of PACS was seen as a technical project. This study shows, however, that the introduction of PACS today is understood to be an organizational process. One of the quotes given at an interview demonstrates this very well: *''…PACS is not a product, PACS is a process''*

The organizational process is very complex. It travels both horizontally over the operation's boundaries and vertically, as it includes the smallest details of an activity. The starting point of this study was to focus on how radiographers and radiologists understood social aspects of what it meant to introduce PACS.

When new technology is introduced there is always a discussion about which problems it is meant to solve and how (Obstfelder et al, 2007). One factor for the result of the implementation can be to understand how the players involved perceive the changes that occur or will take place. By comparing both articles, we found occurrences over the time of the study that may have been of importance to the continued development. These have come to be called "**accelerators**" and "**decelerators**". The effects of computerizing are often not the expected and foreseen ones (Gäre, 1999). Unexpected side effects can be explained by, among other things, the fact that the introduction requires knowledge and abilities in a variety of fields, such as operations development, change work, economics and psychology (ibid.). They can also be explained by the fact that one can never be sure in advance how a user will make use of a technique in practice (Lundberg, 2000; Hanseth & Lundberg, 2001). Other explanations of unexpected side effects can be that the introduction is viewed as a rational process, which has been shown to not always be the case (Andersson, 1989). Another surprising result can be that there is resistance to change within organizations (Bruzelius & Skärvad, 2000).
This study revealed an initial resistance among some radiologists to the implementation of PACS. One reason for this could be that the technology made changes to the group's professional development and profession. For example, it took longer for the senior radiologists to adapt to the new technique, whilst junior radiologists were quicker at getting up to speed with the new technique.

Change always includes a learning process. It can be about learning new work tasks, formal competencies development, but also changes to professional roles or new attitudes (Thor & Södergren, 2002).

How radiologists and radiographers understand that their professional role, practice and technology in use have changed with the implementation of PACS will be described below from the point of view of three themes. The first focuses on the differences regarding accelerators and decelerators between both small and large radiography departments. The second focuses on differences between radiologists and radiographers, whilst the third focuses on differences depending on management strategy with regard to the introduction of PACS.

9.1 SMALL VS. LARGE RADIOGRAPHY DEPARTMENTS

The study shows significant differences in the inclination to change between small and large departments. This can be explained by the fact that small departments have been threatened with closure for a longer time. The introduction of PACS enabled them to continue operating. The reason behind this was that distributed radiology allowed for the diagnosis, and even specialized diagnosis, of radiography images. Through the introduction of PACS the work organization could operate without the physical presence of radiologists on a daily basis. This allowed for a very fast organizational change and, according to them, increased productivity.
The threat of closure that was hanging over the small departments can even be viewed as an “accelerator” for the implementation of PACS. Distributed radiology, with the help of PACS, helped to make it possible to dissolve the previous organization structure. For the small departments, there was even a “decelerator” in the form of a possibly impaired diagnostic service in the long term. The background to this “decelerator” was that the radiographer did not have the radiologist’s anatomical competence and was therefore unable to make the same judgments regarding which investigations should be selected for a patient. The possibility that one would miss an area for investigation would arise. What one has not taken images of, one cannot diagnose, and there is a risk of an incorrect diagnosis resulting from inadequate investigation. Distributed radiology therefore requires more proficient investigators. The answer will never be better than the foundation from which it comes and, if the foundation is weakened because of the lack of access to a radiologist, the end result can be worse in the long run. By taking into consideration that it is not a radiologist who will lead the investigation, one can limit adverse effects from this “decelerator” by only allowing simpler skeletal investigations at these departments.

The larger departments’ strategy for the introduction of PACS was both to ensure that the organization did not change and that the new technique could be incorporated into the existing routines and processes. As PACS did not have the same characteristics as analogue film, ***digital limitations***, it did not fit in with the existing routines for film and processes became decelerators for the introduction process. In practice, radiographers were given more responsibility in certain respects and radiologists more work in others. Both workgroups and their individual members had to change their work in order to fit

the new technique into their existing routines; they were adapted to a ***system workflow***. The fact that the change process was tied to increased responsibility for radiographers was an “accelerator”, whilst the upward delegation of work responsibility for radiologists was a “decelerator”. If, at the time, it had been possible for radiologists to work from home, this might have acted as an “accelerator” and not as the ***technical deterministic*** system, as it was viewed by many.

9.2 CHANGES IN PROFESSIONAL ROLES

The findings of the study are based on a total of 46 interviews with radiologists and a total of 73 with radiographers. The selection of respondents for the interviews was designed to enable wide-ranging exploration of the issue. It is important to note that no general conclusions will be drawn, but the results give substance to the conceptions that were described during the interviews and how these conceptions change over time. The result covers respondents from different areas; although many of them worked in more general areas, there are respondents from a variety of specialized and management positions as well. One of the strengths in the design of the study is that it is longitudinal and changes take time.

Radiographers stated that they had not felt a threat to the continued existence of their profession resulting from the implementation of PACS. This meant that they had a positive base position and can be viewed as an “accelerator”. They understood that they would always be included in the operation, as their services could not be transferred to other workgroups. One can imagine that secretaries saw it differently, as there is a general discussion regarding their presence, or absence, in the digital health ward. Radiographers understood that, as ***image producers***, they had an ability and that there were guidelines regarding radiation that meant they were the only ones who could undertake these tasks. In this respect, the radiographers, as well as younger radiologists, were early adopters. One can notice that the radiographers relate the areas of questioning more to digital images than to PACS. This may be because digital images are seen to have greater significance for any possible changes in work practice for the radiographers. When radiographers describe their work, one of the aspects they mention is image production practice. The radiologists instead use diagnostic practice. This shows that one important component for the radiographers is to produce images. The radiographers' positive attitude towards impending changes made them "early adopters". The junior radiologists also saw positive effects of the possibilities offered by PACS and this could have made it easier for them, too, to be "early adopters". Early adopters trigger commitment, which in itself has a positive effect on the introduction and is therefore an “accelerator” for the introduction process. It is therefore important to identify early adopters in a change process and allow them to develop; in other

words, give them the authority to take up new work tasks with increased responsibility (Rogers, 2003).

The new technique became an “accelerator” for radiographers in that it placed quality examination of radiography investigations, especially skeletal investigations, which had previously been in the hands of radiologists, into their field of responsibility.
This study does not provide evidence of the extent to which these findings also reflect changes in diagnostic practice from other specialities or modalities. Those radiographers who made this expended change in competence developed a very positive attitude to these new opportunities.
One can discuss the long-term effects on the diagnostic quality when there is no radiologist present when the examination is done. The communication between the interpreting radiologist and the radiographer performing the examination is vital. The findings show that the radiographers miss their former close contact with the radiologist. If a new working practice is to develop, it is very important that the radiographer receives appropriate education and training. Future research will show how these changes have affected both individuals and the organization.

Change always includes a learning process. It may involve learning new work tasks, formal competencies development, but also changes to professional roles or new attitudes (Thor & Södergren, 2002).

Radiologists described a greater preoccupation with the introduction of PACS. They understood that radiography images would be accessible by all, including clinicians, as soon as they were exposed. Previously, radiography images could only be found at the radiography department and could not be sent out from the department without authorisation by the radiologist. There was a strong feeling of ***individual professional expertise*** among radiologists. When this foundation was changed, a certain preoccupation regarding the future need for their services arose. Those who felt threatened by the new technique or other changes became a “decelerator” in the actual process of introduction and use of the new technique. Groups opposing the use of the new technique were formed among some senior radiologists. It is important to identify how they could strengthen their roles or facilitate a factor in their work.

Radiologists found that the “material” used for diagnosis had changed. It can take time to reverse mental barriers and this, too, became a “decelerator”. This has been described by several authors, for example, Reger, Mullane,Gustavsson & De Marie (1994). Reger et al (1994) aptly described how mental barriers can make adjustment more difficult. Normann and Ramirez (1995) use the term reconfiguration when discussing the development of new attitudes and concepts. The issue here is a significant reformation of occupational practice, which is not easy to describe.

It took some time before radiologists fully accepted the new technique. What changed radiologists' view of PACS was the possibility of explaining the radiological investigation material on the clinical meetings. The new technique made it possible to show the images in an enlarged format, which enabled those on the round to see the images. This meant that discussions increased, first between clinicians, but then between clinicians and radiologists. With PACS came the possibility to reconstruct images in 3 dimensions instead of two, making the examination easier for the clinicians to understand. Future research may reveal the implications of this for the different radiological specialties. In specialties such as gastro-enterology and orthopedics, clinicians appreciated this new way of interpreting the images in an examination when the question was very specific. The study, however, shows that radiologists reclaimed their role as experts and could take part in discussions, being able to become one of the team serving the patient. This clearly became an "accelerator" for the radiologists' continued development.

9.3 MANAGEMENT STRATEGY

When introducing a new technology, the management can follow a variety of strategies. Normally, these are described in literature as either top-bottom or bottom-top (Gell, 2006). This dictates how management takes the initiative for the process. In the case in question several perspectives were chosen. At larger departments, management chose to implement the introduction without instigating changes to the workflow. At the smaller departments implementation was undertaken with a strategy for work organizational changes from the beginning. The strategy chosen became a "decelerator" for the larger departments as it focused on the success of the technique. In hindsight, one can understand the choice made by management as the project had only recently been devised and there were no other studies of work organization change due to PACS implementation from which to learn.

A general problem was that management was not fully successful in communicating the goal of the change that was to take place. This led to the personnel interviewed often stating that they were unsure about why the change was taking place and were of the opinion that "***it was working fine as it was...***". Had management been more keenly aware earlier on, then perhaps it would have been understood that this was not solely a technical project. It would have been possible to implement the project in a different manner. The management's process-oriented point of view can, in itself, be an "accelerator" as it makes it possible for the personnel to share their experiences and ideas in a broader manner. By sharing information one can identify how processes develop on several levels. One can discuss and present how orders emerge and in these discussions it is possible to create feedback processes that are able to create positive changes. In summary, the sharing of information regarding the development of

organizational processes can, in itself, create attractive new ways of working. The management strategy of maintaining old routines could be responsible for less inclination to change and could hinder the optimization of PACS use.

In the study, the system for the larger departments had to be adapted to the organization's existing workflows. As the PACS system was limited and rigid, problems arose in the adaptation of the system. Energy was expended on finding ways to come up with "work-around" solutions that would make the system function in the same way as the previous analogue one. The fact that the system was rigid and determined how the work should be organized made it a "decelerator" in practice. If the focus had been on the optimization of the work organization based on the system's characteristics and possibilities, that is to say, an openness to change ideas, it is possible that the implementation would instead have constituted an "accelerator".

10 CONCLUSION

The study shows that the introduction of PACS was not solely a technical project. It bears all the hallmarks of a so-called change project. This means that on implementation it is important to have the knowledge regarding the dynamic between the technique, organization, workgroups and individuals.

The radiologists perceived a change in professional role that went from a more individual-centered competency, via a consultant role, to becoming an active part of the patient diagnosis and treatment as an actor in a network.
The diagnostic work went from being an ***art form***, at the beginning of the study, which was dependent on individuals, to being ***distributed*** and therefore enabling more people to take part. The ***digital image*** technique opened up new diagnostic possibilities. Based on this, it was easier to present them on the rounds and the discovery of the 3D tool led, over time, to the need for more and more ***increased specialization*** of radiologists.

Radiographers changed their professional role from being focused on ***image production***, to a focus on how the images are taken and, by the end of the study, had incorporated this and furthermore, diagnostic knowledge in their ***jack of all trades*** professional role. With regards to the context in which radiographers worked, they quickly became positive regarding the new technology and so were ***early adopters*** who came to support the technique and the changes that could be effected over time. They came to lose touch with radiologists but showed, by the end of the study, the beginning of a new way of interacting with colleagues in a ***flat collaboration***. At the start of the study, the new technology allowed for radiographers to have ***visions*** of a new way of working for a better service. However, over time the system instead determined how working routines should build up ***technical determinism***.
The implementation of new technology does not automatically change the organization. The organization can change if this is the management's strategy. However, it may be postulated that individuals always change when technology changes.

11 FUTURE RESEARCH

The successful implementation of IT is no simple process. Many of these implementations fail or fail to meet expectations (Obstfelder et al 2007). The findings of this study show that the introduction of PACS does not follow previous models of the introduction of a new technology. For example, the study by Rogers (1983) shows that the introduction follows a relatively static process with intervention, diffusion and routine. New technology, on its own, does not cause change. It is the relationship between new technology, social factors and organizational aspects that causes change to occur.

It can, therefore, be of great interest to direct research into the adaptation process between technology, individuals, organizations, clinical challenges and outcomes. The overall aim will then be to develop a method for change management for this and similar types of change processes

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- Precis innan…, svarade Nalle Phu

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