Radiographers' professional practice
-a Swedish perspective

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ABSTRACT

The general aim of this thesis was to empirically describe the radiographers' professional scope in diagnostic imaging from the viewpoint of the practitioners and investigate how technical development affects the relations and actions in this practice.

Data was collected by interviews and observations to both studies at the same time with two different aims. Eight radiographers (n=8) were interviewed. The interviews were open in character, were recorded with a digital voice recorder, and transcribed verbatim by the interviewer. The interview guide consisted of four interview questions. The observations of radiographers during their work with Computer Tomography (CT) and Magnetic Resonance Imaging (MRI) were conducted in a middle-sized radiology department in the southern part of Sweden. The observations were ten (n=10) in total.

Two different theoretical perspectives were used: phenomenology (Study I) and practice theory perspective (Study II). Data was analysed with a phenomenological method in Study I. In Study II data was firstly analysed inductively, which resulted in seven codes. Secondly, abduction was made by interpretation of these codes from a practice theory perspective. This led to four themes.

The findings in Study I display the main aspect of the radiographers' work with image production. Their general tasks and responsibilities can be viewed as a process with the goal of producing images that can be used for diagnosis purposes. The process has three different phases: planning the examination, production of images, and evaluation of the image quality. The radiographers experience the production of images as their autonomous professional area.

The findings in Study II report how technology development affects the relations between different actors and their actions in the practice of Computer Tomography. Four themes were identified; 1) *Changed materiality makes the practical action easier*. Radiographers' practical work with image production has become easier when working with CT compared to conventional techniques because the CT usually performs the image production in one scan. 2) *Changed machines cause conflict between the arrangements of the work and the patients' needs*. It is difficult to plan the examination individually for each patient because of the arrangements of the CT practice, i.e. they have little information about the patient before the examination. 3) *Changing materiality prefigures learning*. The radiographers describe a need

for constant learning activities because of the changing procedures for image production and new modalities for image production. If not achieved it may affect their relations with the patients. 4) How the connections between different practices lead to times when practical reasoning is required in the radiography process with CT. The connections between the different professions in CT practice mainly occur through material arrangements because physically they work in different areas. The external arrangements in CT practice pre-figure actions for securing accurate radiation level and image quality. But the radiographers, who meet the patients, have to critically judge the intended actions in relation to clinical observed data to ensure patient safety.

Keywords: Radiographer, radiography, practice, technical development, phenomenology, practice theory, patient safety.

INTRODUCTION

This thesis is about radiographers' practice, which is rapidly changing due to medical and technological research. My professional background is as a radiological nurse, i.e. with experience of clinical work as a radiographer and as an educator in radiography. I became interested of this topic around 2006-2007 when there was a national debate in Sweden about radiographers' professional scope and the main subjects for education in this area.

What constitutes the radiographers' professional practice has not only been a topic for debate in Sweden, but in other countries also, and can be seen as mirroring the rapidly changing technology within this field. Internationally there is diversity in the naming of the profession that conducts examinations in medical imaging; radiographers, radiologic technologists, x-ray technicians and medical radiation practitioners (Cowling, 2008). In some countries the radiological nurse is a profession that is responsible for patient care in the radiological ward but is not involved in conduct image production. Swedish radiographers/radiological nurses have a slightly different professional scope compared to other countries. In Sweden the profession is named radiological nurse and the professional scope covers diagnostic imaging and interventional radiology, and also includes care of the patient and conducting image production in medical imaging. In this thesis, 'radiographer' will be used instead of 'radiological nurse' because this is the most accepted international title of the professionals that conduct image production. The main subject for education in this area has been called radiography in Sweden since around 2008, the same as in many other countries.

Worldwide there is diversity in how radiography education is arranged. In some areas, especially North America and Western Europe, the education is at bachelor level with some variations of the professional scope, and combination of diagnostic radiology and radiotherapy is common. Other areas in the world are struggling to attain a regulated education on a basic level (Cowling, 2008). From a European perspective, the required competences of radiographers' have been described on three levels with the aim to tune (standardize) the education across Europe (EFRS, 2012).

The above described diversity in how education is arranged for radiographers internationally reflects that there is no consensus about either the professional scope or education for this professional area. Furthermore, research on how the technological development in the field interacts with the professional practice of radiographers is sparse, and is an important area to

explore in order to understand how to best arrange education for this professional group for the future.

Common themes in former studies about this practice are that it covers both patient care and handling technology (HENRE, 2008; Williams & Berry, 1999; Williams & Berry, 2000; Andersson, Fridlund, Elgán & Axelsson, 2008; Andersson, Christensson, Fridlund & Broström, 2012; Andersson, Christensson, Jakobsson, Fridlund & Broström, 2012; Ahonen, 2008; Ahonen, 2009). But how these aspects merge together in practical work has not been investigated, nor how radiographers experience their professional work. The caring part is emphasized, but not how it is manifested in professional actions.

My overall aim with this thesis was to empirically describe the radiographers' professional scope in diagnostic imaging from the viewpoint of the practitioners and investigate how technical development affects the relations and actions in this practice.

LIST OF PAPERS

This thesis is based upon the following papers, which will be referred to in the text by their roman numerals (I and II).

I: Lundvall L-L, Abrandt Dahlgren M, & Wirell, S. (2014) Professionals' experiences of imaging in the radiography process - A phenomenological approach.

Radiography 20 (1) 48-52.

II: Lundvall L-L, Abrandt Dahlgren M, & Wirell, S How do technical improvements change radiographers practice - a practice theory perspective. Revised manuscript.

BACKGROUND/LITERATURE REVIEW

International perspectives on radiographers' professional scope and education

Cowling (2008), in an overview of radiographers' role, defined a radiographer as a professional practitioner in medical radiation science with the professional scope of radiotherapy and diagnostic radiology. The same professional scope is stated by the European Federation of Radiographers Society (EFRS) to comprise both diagnostic imaging and radiotherapy (EFRS, 2011). Diagnostic imaging may also include ultra sound, magnetic resonance imaging and nuclear medicine in many European countries. EFRS defines a radiographer as a professional that is responsible for the patients' physical and mental wellbeing prior, during and following the radiological examination and radiotherapy. They are also active in the justification and optimization of procedures in medical imaging and radiotherapy and are key persons for ensuring radiation safety (EFRS, 2011).

The Higher Education Network of Radiography (HENRE) in Europe has produced a description of required competencies at the first, second and third levels of education in radiography. The aim is to tune the education in radiography to facilitate mobility of both the work force and students across Europe (HENRE, 2008). The first level is suggested to comprise 240 European Credit Transfer System (ECTS) leading to qualifications to practice in diagnostic radiography, nuclear medicine and radiotherapy. The second level, containing 120 ECTS, is suggested to cover research-based clinically knowledge/skills or non-clinically knowledge/skills for example in education, management, informatics, quality assurance or ethics. The second level's competences are generic in character and based on Dublin descriptors. The third level of 180 ECTS is suggested to lead to a doctoral degree but is not described with descriptors in this document (HENRE, 2008). When the HENRE project ended in 2008, the EFRS was given the responsibility for implementing the tuning process in Europe (EFRS, 2012). EFRS decided a benchmarking document for the first level in 2014 (based on the work made by HENRE) with description of base competences for all radiographers and specific competences for diagnostic imaging, radiotherapy and nuclear medicine. The base competencies are in physics, medical subjects, IT/risk management, psychosocial patient care, communication, ethics, inter-professional & teamwork, quality insurance, research, professional aspects and lastly personal & professional development.

Professional scope and education for radiographers in Sweden: a historical perspective

Initially, it was the doctors (radiologists) who performed the radiological examinations. From around 1910 nurses began to work in radiological departments with image production (Dillner, 1968). The first regulated training was as a specialization within nursing education. The nursing program at that time took three or three and a half years and included a specialist part. The specialization in radiology was described in the curriculum of 1939 and covered both medical imaging and radiotherapy. The theoretical content comprised lectures in radio physics, photo techniques, technology and radiology (Svensk Sjuksköterskeförening, 1940).

At the beginning of the 1960s the nursing program was altered to comprise two and a half years, with specialist education afterward. To unburden the nurses some of the responsibilities in the expanding health care organization, other professions were introduced. The education for work in medical imaging was changed into an independent program leading to a profession named radiological assistant. At first, this was a two year program but after a couple of years it was reformed into two and a half year program. A similar education program was arranged for radiotherapy (SOU 1964:45). From the beginning it was proposed that a radiological assistant should mainly conduct image production. Taking care of the medicine and handling sterile procedures in radiological wards should be the nurses' responsibilities (SOU 1962:4). When the program for radiological assistants was prolonged and the specialization for nurses in radiology ended, these responsibilities were also included in the education of radiological assistants (SOU 1966:73).

Around 1980 the education system was reformed. Medical imaging and radiotherapy became two different specializations within nursing education. The initial part of the nursing program was the same for all specializations. Nursing education was for two years and the education in medical imaging was ten weeks longer and led to a license as a radiological nurse (UHÄ, 1981).

The next change was at the beginning of the 1990s due to tuning educations into European educational standard. The nursing education became a three-year education with specialist education afterwards (SFS1993:100). How to educate in medical imaging was not decided. The requirements for this profession were investigated in an official inquiry that first proposed that a possible solution could be to combine clinical physiology (a branch of

laboratory assistant education at that time) and medical imaging into a profession named 'medical assistant' (SOU 1996:138). After suggestions from the Swedish Association for nurses, two other solutions were proposed; a specialized education after nursing education, taking 40-50 weeks or a three-year direct education to become a radiological nurse. The combination of care and technology were emphasized, special because of the Swedish tradition of education in this field (SOU 1996:138). In 2000 it was decided to adopt a three-year direct education to radiological nurse with the professional scope of medical imaging, leading to a special license as a radiological nurse (Högskoleförordningen 1993:100).

Former studies about radiographers' practice

Ahonen (2009), made a concept analysis of radiographers' work from the national context of Finland where the professional scope covered diagnostic radiology and radiotherapy. Three dimensions were presented on an abstract level: technical radiation usage and radiation protection, patient care, and service to the health care sector. Radiographers' actions were explained as based on theoretical and practical-technical expertise. Their work was guided by principles, guidelines and ideologies that could be summarized as respecting the individual, client-orientated and interactive collaboration. This description of radiographers' work was exemplified as performance of individualized examinations or treatments while taking a holistic view of the patient. A working process was described as comprising planning, implementation and evaluation and covered both diagnostic imaging and radiotherapy. The practical actions were described on an abstract level covering: handling equipment, counselling the patient, radiation protection, image production or performance of treatment, and evaluation of images. The study did not report on the practitioners' experiences of their practice.

Niemi et al. 2007, also from Finland, conducted a discourse analysis about how the professional identity was expressed in a national journal for radiographers during 1987-2003. The organization of the education for radiographer in Finland had changed, from being related to nursing to becoming an independent education based on radiography. The study reported three discourses - a technical, a safety and a professional discourse. The professional discourse changed during this time, from discussions about patient care and patient care

methods into discourses about the combination of care and technology in radiographers' practice.

Strudwick (2014) described, from the national context of the UK, the importance of the produced image for radiographers because it is a visible product of their work. The image represented the end product of their work and it was judged and used by both colleagues and other professions. But the image did not show the interaction with the patient, only the diagnostic quality of the images.

Reeves & Decker (2012), also from the UK, explored how radiographers use distancing as a tool for emotional engagement in their practice. The authors reported that it was people who did not want to have a long engagement with patients that initially selected this profession. Instead, they tried to be mentally present in the short patient encounter in the radiological wards. Maybe, because of the short involvement with the patients, there was a use of reductionist language. The image and its quality was central, leading to task-orientated work in producing the images. Introduction of new imaging techniques with short scanning times changed the relations between technical skills versus patient care. Patient care was still important but there was less time for the patient. Instead, there was more work using the equipment. But, being able to handle and establish trust with the patient was still expressed as an important part of the practice.

Studies conducted in Sweden have examined how the radiographers' professional role changed due to the digitalization of image production. They changed from being experts on exposure parameters to specialists handling digital workflows and taking more responsibility for image quality. Judging the image quality of these examinations was the radiologists' professional area in Sweden until the digitalization of image production when new workflows were introduced. To shorten the patients' time in the radiological ward, judging image quality became the radiographers' responsibility. This led to radiographers experiencing a higher degree of independency but also more work by themselves and with the patients and equipment (Larsson et al. 2007; Fridell, Aspelin, Edgren, Lindsköld & Lundberg, 2009). Digital image production was reported as being more deterministic compared to analogue techniques, meaning that the practical tasks had become more steered by the technology (Fridell et al. 2009).

Larsson, Lundberg & Hillergård, (2009), in their study about radiographers' learning strategies, have exemplified some skills and responsibilities, mainly technical and medical orientated ones. The authors give examples of technical preparations of equipment, reading documents like protocols and manuals for image production. The study did not report on caring aspects.

Andersson et al. (2008, 2012a & 2012b) have investigated the professional competencies of radiographers in a Swedish context. The competencies were analysed from a nursing theory perspective and were divided into two major areas; one directly patient-related and the other indirectly patient-related area. The directly patient-related area covered patient care and performing the examinations. Patient care included giving information, guidance and providing support. Performing the examination comprised; carry out prescriptions, performing medico-technical interventions, radiation protection and adoption of the examination to the patient's need. The indirectly patient-related area included tasks for ensuring quality, handling images, organization and collaboration. The identified competencies have been used for constructing an instrument covering radiographers' competence area. The instrument has been tested and validated in a Swedish context (Andersson et al. 2012a & 2012b).

Studies, mainly from the United Kingdom, have described a role extension for radiographers into new professional areas, mainly tasks and responsibilities formerly belonging to the medical field. This involves interpretation of images and conducting examinations – things that were previously done by the radiologists and which have been included in some radiographers' practice. This development has been facilitated by government policies (Kelly, Hogg & Henwood, 2008; Ford, 2010; Reeves, 2008; Kelly, Piper & Nightingale, 2008; Hardy M & Culpan, 2007).

In medical imaging some of the conventional imaging techniques have been converted into multidimensional imaging techniques instead. This means, in practice, that examinations traditionally carried out by radiologists have now been converted into methods using multidimensional modalities such as Computer Tomography (CT), Magnetic Resonance Imaging (MRI) and Ultrasound. CT and MRI are by tradition carried out by radiographers in Sweden. This means that the majority of radiological examinations in Sweden are carried out by the radiographers, except ultrasound examinations and interventional radiology. It is not

investigated how the switch of imaging techniques affects radiographers' professional actions and responsibilities.

Rationale for this study

Competence descriptions have been used for describing radiographers' professional scope and practice. This perspective is useful for descriptions of different professional areas, for education and for facilitating transferability of work forces between countries (Eraut, 1994). The competence descriptions are usually detailed, sometimes taking the form of a list of required tasks. This perspective focuses on the practitioners' knowledge, both theoretical and practical, in relation to a defined knowledge base and points out required tasks and responsibility areas. However, it does not show how the competencies are used during work, how the competencies may change due to new requirements, and how the practitioners create meaning about their practice. Radiographers' professional scope and practice have been described on an abstract level (Ahonen, 2007; Ahonen 2009) but the practitioners' experiences have not been investigated.

The interaction between humans and technology, and how technical development with multidimensional imaging techniques affects professional actions and responsibilities has not been explored in research so far. Increased knowledge about these topics would be useful for educational purposes in the future but also for developing practice, both for securing patient safety but also for professionalization purposes.

AIMS OF THE STUDIES

I: To explore, from the perspective of the radiographer, the general tasks and responsibilities of their work.

II: To explore how technical development affects the relations between different actors and their actions in the practice of Computer Tomography.

THEORETICAL FRAMEWORK FOR THE STUDIES

Phenomenology (Study I)

Phenomenology is a philosophy concerning peoples' experiences of phenomena in their life-world. Intentionality is central in phenomenology and means that when people experience an object, physical or mental, their mind is directed towards it and gives it meaning. A phenomenon is not the object itself; it is a person's experience of an object. Logical analysis of these experiences leads to a description of the essence of the phenomenon, the characteristic aspects of that specific phenomenon. The aspects that vary in the experiences of the phenomenon are existential and are not part of the true description of the phenomenon. The result of phenomenological analysis is how a phenomenon comes into sights for people in their life-world (Bjurwill, 1995; Husserl, 1995 & Sokolowski, 2000).

Husserl, who developed modern phenomenological philosophy, did not describe a phenomenological research method. Later his philosophy has been used in methods for investigating peoples' experiences of different phenomena. Phenomenology as a research method has different branches. The classical variant, most faithful to Husserl's philosophy, is called descriptive phenomenology. Because Husserl's philosophy was focused on mental experiences concerning the phenomenon, the result of a phenomenological analysis does not take in account the context or the culture where the phenomenon occurs. For interpretation and to develop theory in phenomenological analysis, some phenomenological research methods combine the phenomenological philosophy with existentialism and hermeneutic philosophy (Dowling, 2007).

By using a phenomenological approach in Study I a description of a core, a characteristic part of this practice was attained. But it was not possible from this perspective to investigate how technology and humans interact in practice, nor how technology development affects the practice. Therefore, I added one more perspective for attaining more knowledge about these topics, and a practice theory perspective was used in Study II. Phenomenology explores human experiences of a defined phenomenon but it cannot capture how social and material structures influence the lived world.

Practice theory perspective (Study II)

Gherardi, (2000 & 2009) describe practices as being built up of both social structures and physical things (materiality). In the practice there are both human and non-human (physical things) carrying out different actions. How the practice is arranged socially and materially has an impact on the actions. Knowledge is understood as knowing instead, something changeable and active, meaning that it is not a static element inside people's minds. It cannot easily be measured. Knowledge is developed in a social context and through participating in a practice. Theoretical knowledge combines with the practical doings. Tacit knowledge is understood as when practical doings become routine, so the body does not notice or think about the actions. When something unexpected happens, the theoretical knowledge occurs with reflectively understanding leading to adjustment of the actions. Language is a part of knowing and doing in a practice. Practice provides logic for understanding the practice, necessary for the continuity of the practice, and is learned through participation (Gherardi, 2000 & Gherardi, 2009).

Kemmis' practice theory has a socio-material perspective. It explains practice as being formed by external and internal arrangements. The external arrangements are shaped by discourses, history, tradition, economy and politics and relate to the practice where the actions take place. In the practice there are internal structures formed by the practitioners' habits, rules, general and practical understanding. Teleo-affective structures, which are the common purpose of the actions, accepted end-results, projects and beliefs about that specific work, are also part of the internal structures. The actions are shown in language (sayings), practical doings and relations between the people and between people and physical things (Kemmis, 2005; Kemmis, 2009; Kemmis, 2010; Kemmis & Mutton, 2012; Kemmis, 2012).

METHODS

Study design

Data was collected using open interviews and observations for both studies at the same time.

Data collection by interviews

The interview guide

The data collection started with open interviews. The interview guide was constructed for covering gathering data about: 1) The main aspects of radiographers’ practice, 2) How technical development affects the practice, 3) Experienced professional boundaries to other professions (Table 1). The interview guide was pilot-tested in two interviews which were included in the studies.

Table 1.The interview guide

Interview questions	Constructed mainly for study
1) Describe an ordinary situation that you have experienced when your knowledge as a radiographer was important.	I
2) Describe a situation when you learned new technology!	II
3) Describe an ordinary situation when your professional knowledge was important for taking care of patients	I
4) What do you know, as a radiographer that other professionals at your place of work (both in your ward but also other professionals you meet during work) do not know?	I (Only partly used in Study I)

The interviewees

A purposeful sampling was used with the aim of recording a variety of experiences from the interviewees (Table 2). All interviewees worked fulltime as radiographers. For the sampling procedure, see method section in the articles (I+II). The informants had diverse formal education in radiography.

Table 2. Description of the interviewees

Age	39 (26-53) Md (Range)
Men/women	3/5
Years of working experience	13,5 (2-29) Md (Range)
Type of clinic (Employment at the time of the interview)	University clinic (N=1) Four (4) interviewees Municipal clinic (N=2) Three (3) interviewees County district hospital (N=1) One (1) interviewee
Specialist field in radiography (Working 50% or more in this field).	Magnetic Resonance Imaging (MRI) (N=1) Computer Tomography (CT) (N=1) Skeletal radiography (N=1) Intervention radiology (N=1)

The interviews

The interviewees chose the place for the interview and all interviews were conducted in undisturbed conditions. The interview guide was sent in advance to seven of the interviewees. The first interviewee did not receive the interview guide in advance. That was the shortest interview (25 min). All interviews were recorded using a digital voice recorder and were transcribed verbatim after each interview. Both the interviewing and transcribing were done by LL. The interviews had a total length of 375 minutes and varied between 25-71 minutes.

Data collection by observation

After a preliminary analysis of the interview data the research team decided that data collection should continue with open observations of radiographers during their work. The aims of the observations were to 1) To identify general tasks and responsibilities in the radiographers' daily work with image production 2) To study how radiographers' professional tasks and responsibilities had changed due to the switch from using conventional imaging techniques to multi-dimensional imaging.

Settings for the observations

A middle-sized clinic in the southern part of Sweden was contacted by telephone by L.L. The supervisor at the clinic was asked for permission for the researchers to conduct observations of radiographers' during their work with MRI and CT. Written information about the study was sent after the first contact with the supervisor. The employees were informed by supervisor about the study before the observations started.

The observations

The observations were open in character and were conducted by L.L. She was dressed as an employee but did not take part in the work. There were ten observations in total and each one lasted between two and four hours. Directly after each observation, field notes were taken. Each set of field notes was organized in the same way; 1) description of what had happened 2) theoretical memos 3) reflection on the focus for the next observation.

Data analysis

Study I

The data analysis was conducted by LL and discussed by the research team and at seminars. The analysis method involved a phenomenological interpretative method with six steps (Colaizzi, 1978 & Szklarski, 2004). The first five steps lead to a description of the phenomenon and the sixth step is verification of the description of the phenomenon. Colaizzi (1978) suggested member-checking in the sixth step and Szklarski (2004) suggested a focus group interview. In Study I, both the interview data and the field notes were used and were analysed in the first five steps described by Colaizzi (1978) and Szklarski (2004).

These five steps comprised: 1) The interviews and the field notes were re-read several times. 2) Data concerning the informants “lived experiences” of the main aspects of the practice were identified as meaningful units and were underlined, and general tasks and responsibilities were identified in the field notes. 3) These meaning units were: a) re-written into the third person b) shortened and written in a more abstract form 4) re-arrangement of each interview and the field notes into a logical disposition for each data-set to show the different identified themes 5) finally, all the themes derived from the interviews and field-notes were compared to find the themes that did not vary (the essence).

Study II

First the data was analysed inductively, inspired by Patton’s description of qualitative analysis work (Patton, 2002). Firstly the researcher has to become familiar with the data; therefore, the data were re-read several times. Meaning units concerning how the technical development affected the practice were identified and underlined in the data. The meaning units were analysed and sorted into different codes. The codes were named based on the content in each code. Seven codes were identified: need of learning, anxiety, easier practical doings, the image, relations during work, changed machines, and time aspect. The inductive analysis led to a description of the meaning in the data.

In the second step abduction was made by analysing the codes from a practice theory perspective in order to attain a deeper understanding about how the technical development had affected the practice. This practically meant that important events in relation to the research questions were identified. These events were then interpreted from a practice theory perspective in order to attain knowledge about the causes of the event. Four themes were identified, each built up of different codes, and that became the final result (Patton, 2002 & Srivastava & Hopwood 2009). The category “the image” was not used in the final result.

ETHICAL CONSIDERATIONS

The study was approved by the research ethics committee in the medical faculty of Linköping University (Dnr 2010/74-31). The studies were conducted in accordance with the Helsinki declaration. All interviewees were contacted by email and asked about their interest in participating in the study. Written information about the study was sent by email after they had agreed to participate. The interviewees were also informed orally before the interview started.

Trustworthiness

Lincoln and Guba (1985) suggest four criteria for quality in qualitative research and describe these criteria in relation to accepted criteria for quantitative research.

Credibility (internal validity) is about the true value of the findings. To ensure credibility, during analysis and the presentation of the findings, the design of the study should take into account multiple views in the data. This can be attained through 1) prolonged involvement in the study context, 2) triangulation of sources, methods and investigators, 3) peer debriefing 4) negative case analysis, and 5) informant feedback in relation to the construction of the design and methods (Lincoln & Guba, 1985).

Transferability can be compared to external validity and generalization. In naturalistic research a smaller group of people are usually studied, making generalization impossible. To achieve transferability, a thick description of how the research has been conducted is important. That makes it possible for other researchers to conduct a similar study (Lincoln & Guba, 1985).

Dependability is similar to reliability in quantitative research. There is no measuring in qualitative research so the focus when judging the quality of the data will be on the design of the study, the sampling, and how data has been collected and handled. The audit trail has to be described to give the reader an opportunity to judge the quality of the data (Lincoln & Guba, 1985).

Conformability is comparable to objectivity. In qualitative research this means that the focus is on the character of the data. What is shown in the findings should be confirmed in data, for example through quotations in the presentation of the results. Methods for ensuring

conformability in the analyses can be made by independent coding/analysis, coding consistency checks, and stakeholder checks (Lincoln & Guba, 1985).

Cho & Trent (2010) describe a more holistic view of validity in qualitative research. Reflective thinking and self-consciousness are emphasized as important for securing validity in quality research. Instead of only relying on different techniques to achieve trustworthiness the authors suggest that the overarching purpose of the research should be directed towards how validity is ensured. Five overarching purposes in quality research are suggested: truth seeking, thick description, development, personal essay and change of praxis/social. The overarching purpose in both Studies I and II is thick description. To achieve this purpose the author gives, as major validity criteria, triangulated, descriptive data and accurate data about daily life.

FINDINGS

Main findings (Study I)

The aim of the study was to explore, from the perspective of the radiographer, the general tasks and responsibilities of their work. The logic for understanding radiographers' practice of image production is presented as a process comprising three different phases: 1) planning, 2) producing the images, 3) evaluation of the quality of examination. The goal of their professional work is to produce images that can be used for diagnosis. Table 3, in the Appendix, shows how the data sources have contributed to the description of the different phases.

The planning phase was as follows:

The information in the referral was critically read and assessed before meeting the patient. During work with conventional imaging techniques the radiographer decided an appropriate method in relation to the description of the patient's medical problem and the question at issue. When working with CT and MRI the radiologist had chosen method in advance. Data about the patient's medical status was gathered during the radiographer's meeting with the patient. If the medical status differed from the description in the referral the radiographer has to judge if the question at issue was appropriate. Observations of the patient's body movements were expressed in the interviews as important because functional impairment and pain might affect the possibilities of attaining visualization of the intended anatomy and pathology. Some of the informants said that they could predict the diagnosis just by looking at the patient.

The informants said that judging the patient's psychological condition in the planning phase was important both for the patient's wellbeing during the examination but also for ensuring good image quality. Many patients had recently undergone a trauma or were worried about diagnosis of a serious disease. Some patients might also be feeling anxiety about going through the examination. These patients had to be recognized, and giving them some extra time for questions or talk eased the co-operation and rapport between the radiographer and patient during image production and could prevent motion artefacts on the images. The patient's communicative capacity was judged. Because of the limited time for each examination, low community capacity was experienced as a challenge that had to be managed. If not taken into account, this might lead to motion artefacts. Medical and radiation

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security risks with the planned method were judged in relation to each patient. These safety aspects comprised radiation risks in relation to children and fertile women and counter indications such as contrast allergy or implants in the body.

Production of the images involved the following process:

The radiographer decided which protocol in the modality was appropriate to use in relation to the selected method, the specific patient's condition, capacity and needs, and identified security risks. The informants explained that their skills lay in being able to choose the appropriate protocol, and described this as knowledge beyond button pressing because they knew how to modify parameters in the modalities when needed. They also said they had responsibility for medical technological preparations such as giving intravenous and oral contrast to the patient. Both in the interviews and in the observations it was noted that before image production, the radiographers checked that the patient was positioned correctly, safely and comfortably in the machine. This was important both to cover the correct anatomical area during image production but also to prevent motion artefacts in the images. The radiographers were responsible for communication with the patient during image production. They gave information before the process started about special breathing procedures for the patient during image production and body sensations that might occur when using intravenous contrast. In the interviews it was explained that the practical tasks varied then comparing conventional imaging technique in relation to CT and MRI technique. Conducting image production with conventional techniques entailed mastering more psycho-motor skills compared to CT and MRI imaging technique; therefore, the radiographers experienced that it involved more work with the machines and choosing the right procedure and protocol. Production of the images was experienced as the autonomous professional part of their work because they had practical knowledge and skills about how to take care of the patient and use the techniques.

Evaluation of the examination comprised:

The radiographers evaluated the images to ensure the correct anatomical area had been covered, the right pathology had been visualized, and the images were of sufficient technical quality. This was expressed in the interviews and then it was seen in the observations how these data were put together before deciding if the quality was good enough in relation to the question at issue, the patient mental and/or medical status and possibilities to co-operate

during the image production. An experienced radiographer knew when the image quality was sufficient, not perfect but enough for diagnosis. They wrote comments to the radiologists if the image quality was poor and explained the conditions. Finally, they concluded the procedure with the patient and clarified the coming phases of the diagnostic process.

Main findings (Study II)

The aim of the study was to explore how technical development affects the relations between different actors and their actions in the practice of Computed Tomography. *The findings are presented in four themes. Table 4, in the Appendix, shows how different data sources have contributed to the categories. Table 5, in the Appendix; show how the different categories have added data to the themes.*

Changed materiality makes the practical action easier.

The machines had been changed to scanners with protocols for image production. When a protocol for scanning was chosen all technical parameters, which were set automatically, and usually no parameter had to be changed. This made their practical actions easier but the exact function of each protocol was sometimes experienced as hidden. The informants expressed responsibility for the radiation doses but it was difficult for them to have control over this because the protocols were set and checked by the physicists. The information to the patient before image production had become simpler when using CT technique instead of conventional imaging technique. The reason was that usually the patient stayed in one body position during the entire image production and the time in the machine for the patient was usually short. The actual image production was easier compared to when using a conventional technique because an entire part of the body was covered in one scan and usually no extra scans were needed. The informants said that image processing into standardized projections after image production was uncomplicated to perform.

New machines cause conflict between the arrangements of the work and the patients' needs.

The relations between the technology and human aspects, i.e. care are seen in this theme. The referral is the only information source about the patient before the patient comes to the radiological department. Some patients suffered from anxiety and pain, and this was difficult for the radiographers to attain information about because the referral was written for

diagnostic purposes. The sparse information about the patient in the radiological ward led to difficulties individualizing the care to each patient.

The time required for the CT to complete the image production was easy to foresee compared to conventional imaging techniques. The reason was that usually only one scan was needed. These circumstances led to tight time schedules. The schedules were planned based on the time for the CT machine to complete image production and then a standard time was added for the practical work with the patient before and after the examination. But the actual time for an examination varied with different patients.

Changing materiality prefigures learning.

The methods for image production and the modalities were often changed. The variety of methods for image production had evolved since conventional techniques were converted into imaging methods on multidimensional modalities instead. These conditions led to learning activities for the radiographer. If the learning did not happen it could cause stress and could affect the relations with and care provided to the patients.

How the connections between different practices lead to times of practical reasoning in the radiography process using CT.

The different professional practices were linked through material arrangements, for example the computers or the machines. Physically, they worked in different areas in the radiological departments. The radiologist decided the appropriate procedure for image production based on the information in the referral, which was the only information source for the radiologist. The choice of procedure was communicated to the radiographer in a few words in the referral note. The radiographer read the referral note and together with his/her own clinically identified medical security risks and consideration of the patient's medical status, this might lead to a modification or change of procedure. These matters were sometimes discussed with colleagues or radiologists.

The connection between the physicists and the radiographers went through the protocols. The parameters and the radiation doses in each protocol were determined by the physicist but the radiographer's choice of protocol in relation to each patient was critical for the radiation dose to the patient.

Patient safety aspects in relation to radiation doses and image quality were a part of the teleo-affective structures in CT practice. These structures were visible in the construction of the machine and the written instructions about intended actions of the radiographers for image production. This made radiographers' actions easy if the intended actions could be followed. But the sparse information about the patient led to difficulties to meet each patient's individual needs and to take the patient's medical and/or mental status into account. This arrangement of the practice led to times when practical reasoning was important from a patient safety perspective.

DISCUSSION OF FINDINGS AND THEORETICAL BACKGROUND

The results of Study I report a common purpose of radiographers' practice in image production - to produce images that can be used for diagnosis. The description of the radiography process shows the logic of the practical doings and responsibilities for achieving this goal. This result is in accordance with Strudwick's study (2014) that emphasises the importance of the images, which are seen as a result of the radiographers' professional work.

Ahonen (2009) has also described a working process with three phases intended to cover both radiotherapy and diagnostic imaging in accordance with the professional scope in Finland. The tasks described by Ahonen (2009) are similar to the practical actions described in Study I. What Study I has added is radiographers' lived experiences about general tasks and responsibilities linked to an intended goal. The practical tasks and judgements, shown in Study I and the description of required specific competencies (EFRS, 2012; Andersson et al. 2008; Andersson et al. 2012; Andersson et al. 2012) are comparable but how the competencies are used together in practice is illustrated by the findings (Study I).

The radiography process (Study I) includes technical, caring and medical aspects. The medical aspect, as described in Study I, is visible in clarification of the question at issue in the referral and in relation to the patient's functional status and the evaluation of the images. In the European competence descriptions (HENRE, 2008 & EFRS, 2012) these tasks and responsibilities are seen in the specific competences, but in the Swedish competence description it is only the judging of the referral that has been emphasized (Andersson et al. 2008, 2012a & 2012b).

The caring part is described in Study I as an important aspect, both from the viewpoint of the patient's wellbeing during the examination and also for ensuring image quality. This is also emphasized in the European competence descriptions (HENRE, 2008 & EFRS, 2014) and Ahonen (2009) has reported that patient counselling is part of radiographers' professional responsibilities. The findings (Study II) indicate that the arrangement of the practice makes individual planned care difficult to realize even though it is recognized as a professional responsibility. Reeves & Decker (2012) reported that the changed techniques with short scanning times give less time for patient care. Seeing this from a practice theory perspective,

the arrangements of the practice have to be changed, with better connection between different practices for achieving individualized planned care. Information about the patient before they come to the radiological ward mainly comes from the referral written for diagnostic purposes. Clinical information about the patient's actual physical and psychological status is missing for the radiographers. This information must be gathered by the radiographer before the examination for ensure properly planned care for the individual. No studies have been found about how this clinical assessment is made by radiographers.

Study II reports that the arrangements in CT practice lead to actions to ensure accurate levels of radiation and image quality. Diagnostic quality is ensured by the radiologist's choice of appropriate method for image production. The radiologists and radiographers work independently of each other, on separate tasks. Judging the question at issue and making the choice of procedure is the radiologist's professional responsibility in the CT practice. But because they do not meet the patient, the radiographers have to critically judge identified security risks in relation to the planned method in their meeting with the patient. Seeing this from the practice theory, the arrangement prefigures specific actions, but for ensuring patient safety, there is still a need for times of practical reasoning. This means that the planning phase in the radiography process has become more critical for ensuring patient safety and should be emphasized in radiography education.

The Computer Tomography imaging technique, compared to conventional techniques, makes the practical task of actual image production easier because the CT machine does most of the image production. With conventional techniques, image production requires use of radiographers' professional talent to visualize the correct anatomy and pathology in relation to each patient's individual anatomy, pathology and capacity. Reeves & Decker (2012) has also described these changed skills as leading to more work with the equipment instead of work with the patients. From a practice theory perspective, the changed material arrangements form new actions in the practice; the need to master practical psycho-motor skills has changed to a need to have a general understanding about how different medical and radiation security risks impact on the choice of procedures and protocol. Being able to handle the machines was still important but the choice of technical parameters was prepared in the protocols. There might be new expert knowledge about the technical aspect of radiographers' practice with CT that was not identified in these studies because of the sample of interviewees. To investigate this topic, radiographers who are experts on CT practice should be studied.

The constantly changing techniques, both concern the methods of image production and also the applications of the machines i.e. how to handle the machines correctly, lead to learning activities for the practitioners. From a practice theory perspective, the constantly changing material arrangements lead to actions in the practice. To learn technology is important both from a patient security perspective and also to ensure the patient is properly cared for during the examination. Not being able to handle the technology correctly might cause stress and affect relations with the patient.

The phenomenological perspective was useful for gaining an inner perspective on this practice. The findings indicate main tasks and responsibilities as experienced from the practice itself. However, the phenomenological perspective does not capture what influences and forms the actions because phenomenology investigates peoples' experiences, not the context. Therefore, a practice theory perspective was useful for attaining knowledge about how the technology development affects the practice (Study II). This perspective focuses on the relations between external arrangements and the actions in the practice, and this made it possible to study the interactions between different actors, both human and non-human.

Methodological considerations

Credibility, the true value of the findings, has been strengthened by using two different data sources. The data collection started with interviews. The interview guide was pilot-tested and after a minor revision of it the data collection continued. The interviewees spoke in response to the questions in the interview guide. The majority of the interviewees received the interview guide in advance and most had made notes before the interview. That led to data from reflections on experience concerning the research topics. Afterward, when critically judging the interview questions, it might have been better to formulate the first interview question without mentioning knowledge. In some minor parts of the interviews there is a slight "feeling" that the interviewees answered as they were supposed to answer. An alternative interview question could instead have been formulated, "If you were telling somebody that never had attended a radiological ward, what you do during your work, what would you tell them about?" Because the aim was to explore their practice, to catch the essence of their daily practical doings and responsibilities, maybe data from this more open-ended question would have attained better creditability. To catch the changing technology, another interview question instead of interview question two, could had been "If a

radiographer that had not worked for many years as a radiographer started work again, how should you explain to that person how radiographers' work has altered?"

The data analyses were discussed at seminars but for strengthen trustworthiness independent coding/analysis or coding consistency checks could have been useful. The sixth step in the phenomenological analysis was not taken. In this study a focus group interview was an alternative for verification. This alternative was not used because the informants worked in different clinics, and practically it may have been difficult to find a time and place for a focus group interview with all the interviewees. Therefore, the research team decided to first do the analyses in the first five steps, and after that it was decided not to continue with further analysis.

Thick descriptions in the method sections have been given to ensure transferability. Dependability is both about the design of the study and the handling of data. The focus in these two studies is on the practice, the radiographers' practical doings, and their judgments. It might have been better to start with open observation first and then make the interview guide based on the findings from the observations. The practical doings are visible in the actions, and the thoughts about responsibility are better explored in an interview study. The audit trail, i.e. how the studies were conducted, are reported so the reader can judge the quality of the studies. Conformability is about objectivity. LL's pre understanding might be seen as a bias. Memo writing was done throughout the work on the studies to attain reflexivity. In Study I, LL wrote down her pre-understanding before the study started and these notes were not read again until the study was published. In the findings, raw data are presented through quotations.

CONCLUSIONS

Radiographers' professional tasks and responsibilities with image production can be viewed as a process including three phases: planning, image production and evaluation of image quality. The experienced goal of this process is production of images that can be used for diagnosis purposes. The experienced autonomous professional area is the image production phase.

The technical development of the Computed Tomography technique has changed radiographers' practical work; it now involves more work with the machines and on planning the examinations. Their required professional skills have changed from an ability to master different psycho-motor skills in conducting image production into becoming experts on identifying patient security risks in relation to the examination, preparing the patient before scanning and learning constantly appearing new technical applications and machines.

FUTURE STUDIES

Future studies should investigate other perspectives of the technical development in medical imaging, for example from the radiologists' and physicians' perspective.

How radiographers make clinical judgments, what they judge, and how they use this in their work with image production.

Topic for future studies is former students of radiography education and their experiences of how their education in radiography has prepared them for professional work in this practice.

Investigation of the professional boundaries between the different professions in medical imaging, how they change and what initiates these changes.

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SUMMARY IN SWEDISH

Röntgensjuksköterskor arbetar inom ett område som utvecklas snabbt på grund av tekniska och medicinska framsteg. Det finns få studier om vad yrkesutövarna upplever som karakteristiskt för deras yrkesutövning samt hur den tekniska utvecklingen med övergång till flerdimensionella undersökningsmetoder påverkar deras praktiska handlingar och ansvarsområde. Utökad kunskap behövs för utbildning inom området, professionalisering samt verksamhetsutveckling.

Övergripande syfte var att empiriskt undersöka röntgensjuksköterskors professionella verksamhetsområde utifrån yrkesutövarnas perspektiv samt hur teknikutvecklingen påverkar relationer och handlingar i praktiken.

Metod: Designen var intervju- och observationsstudie. Data samlades in samtidigt för båda studierna med två olika syften. Åtta röntgensjuksköterskor intervjuades. Urval av informanter gjordes för att erhålla variation av de intervjuades yrkeserfarenheter. Intervjuguiden bestod av fyra öppna frågor. Åtta intervjuer (N=8) gjordes och spelades in med en digital bandspelare samt transkriberades direkt efter intervju tillfället av intervjuaren. Efter en preliminär analys av intervjudata gjordes öppna observationer av röntgensjuksköterskor under deras arbete med Magnetisk Resonanstomografi (MR) och Dator Tomografi (DT). Observationerna genomfördes på en medelstor klinik i södra Sverige under en vecka. Det var totalt tio (N=10) observationer som varade mellan två till fyra timmar per observationstillfälle. Fältanteckningar skrevs i direkt anslutning till varje observation.

Data analys: Studie I analyserades med en tolkande fenomenologisk metod. Studie II analyserades först med en induktiv data analys. Sju kategorier identifierades som namngavs utifrån innehållet i kategorierna. Därefter tolkades innehållet i kategorierna utifrån ett praktik teoretiskt perspektiv vilket resulterade i fyra teman. Både intervju- och observationsdata har används i båda studierna.

Fynd: Studie I; centrala aspekter i röntgensjuksköterskans praktik kan ses som en process där målet är att producera medicinska bilder som är användbara för diagnostik. Processen omfattar tre faser. Första fasen) Planering då en bedömning sker av; a) remissens innehåll b)frågeställning i förhållande till patientens aktuella kliniska status samt bedömning av

patientens rörlighet, kommunikativa förmåga och psykologiska tillstånd c) bedömning av säkerhetsrisker för patienten med undersökningen.

Andra fasen) Genomförande av bildtagningen då val av protokoll och tekniska parametrar anpassas individuellt till patienten, patienten positioneras korrekt i maskinen inför bildtagning. Innan bildtagningen påbörjas säkerställs att kontakt och samarbete är etablerat med patienten för att möjliggöra samarbete under bildtagningen. Kunskap om och praktisk förmåga att genomföra bildtagning upplevs som röntgensjuksköterskornas egna autonoma professionella område.

Tredje fasen) Undersökningsresultatet (bilderna) utvärderas utifrån att; a) rätt anatomiskt område är med på bilderna b) korrekt patofysiologi är visualiserad c) god teknisk kvalitet på bilderna d) samt hur patientens individuella behov och förutsättningar till samverkan under bildtagningen har påverkat undersökningsresultatet. En erfaren röntgensjuksköterska vet när undersökningsresultatet har tillräckligt bra kvalitet för diagnostik i förhållande till de förutsättningar som förelåg vid bildtagningen.

I Studie II identifierades fyra teman som illustrerar hur röntgensjuksköterskans arbete med bildgivande undersökningsmetoder förändras när konventionella undersökningsmetoder konverteras till undersökningsmetoder med Datortomografi.

Tema ett) De förändrade materiella förutsättningarna med annan teknik gör deras praktiska handlingar lättare. De tekniska parametrarna finns förprogrammerade i apparaten vilket innebär en förenkling men också en osynlighet av de parametrar som styr bildtagningen. Maskinen utför oftast bildtagningen i en seans och täcker då in ett valt område av kroppen. Data från den bildtagningen bildbearbetas efteråt till olika projektioner av det undersökta området. Datortomografi undersökningar är oftast lätta för patienten att genomgå eftersom undersökningstiden är kort och patienten kan oftast vara positionerad i samma kroppsläge under hela undersökningen. Det underlättar patientinformation och kommunikationen i samband med undersökningen.

Tema två) De förändrade materiella förutsättningarna skapar en konflikt mellan arrangemanget av praktiken och patientens behov. Information om varje enskild patient medicinska status och individuella behov saknas för röntgensjuksköterskan eftersom informationen om patienten endast kommer via röntgenremissen. Den är skriven från klinikern till radiologen i ett diagnostiskt syfte. Det leder till svårigheter att ge individuellt

planerad vård. Tiden för själva bildtagningen är kortare med DT teknik och är enklare att förutsäga jämfört med konventionella metoder vilket leder till kortare inplanerad undersökningstid för patienterna. Patienterna har dock olika individuella behov vilket leder till i praktiken varierad undersökningstid för patienterna.

Tema tre) Den föränderliga praktiken med ständigt nya metoder för bildproduktion och nya modaliteter konstituerar lärande aktiviteter för yrkesutövarna. Om det lärandet inte sker kan det påverka relationen med patienterna eftersom det skapar stress och osäkerhet i arbetet.

Tema fyra) De olika professionerna i CT praktiken, läkare, sjukhusfysiker och röntgensjuksköterskor sammankopplas via materiella arrangemang. Praktiken är arrangerad för handlingar för att åstadkomma hög diagnostisk kvalitet och patientsäkerhet i förhållande till stråldoser och medicinska risker. Undersökningarna planeras för diagnostisk kvalitet av läkaren utifrån informationen i remissen. Optimering och kontroll av stråldosnivåer i protokollen görs av sjukhusfysiker. Röntgensjuksköterskorna som möter patienterna måste kontrollera att det är rätt val av undersökning och protokoll i förhållande till deras kliniska observationer av patientens status samt deras identifierade säkerhetsrisker utifrån varje patient. Det här innebär att planeringsfasen i deras arbetsprocess har blivit viktig.

Konklusion:

Målet med röntgensjuksköterskans arbete är med bildtagning att skapa medicinska bilder som är användbara för diagnosticering. Centrala aspekter i röntgensjuksköterskans yrkesutövning är att planera, utföra bildtagning samt utvärdera undersökningskvalité. Bildtagningsfasen upplevs som det egna professionella området eftersom det innebär både kunskap om hantering av apparaterna i kombination med omhändertagande av patienterna. När konventionella metoder konverteras till datortomografi undersökningar blir deras praktiska arbete med själva bildtagningen förenklat däremot blir bedömningen av säkerhetsrisker med undersökningen viktigare eftersom de är den profession som möter patienten på den radiologiska avdelningen. De olika professionerna vistas i fysiskt skilda områden och knyts samman via materiella arrangemang. Praktiken är främst arrangerad utifrån ett tekniskt och medicinskt perspektiv. Individuell planering av undersökningar utifrån patientens behov är svårt att göra på grund av brist på information innan patienten kommer till den radiologiska avdelningen.

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APPENDIX

Table 3. Description of how different data sources have contributed to the findings (Study I).

Categories	Interview questions	Data sources (Number)
Planning phase	1) Describe an ordinary situation that you have experienced when your knowledge as a radiographer was important.	(N=7)
	2) Describe a situation when you learned new technology	(N=4)
	3) Describe an ordinary situation when your professional knowledge was important for taking care of patients	(N=8)
	4) What do you know, as a radiographer that other professionals at your place of work (both in your ward but also other professionals you meet during work) do not know?	(N=6)
	Observation aim one- to identify general tasks and responsibilities in their daily work with image production	(N=9)
Producing the images	1) Describe an ordinary situation that you have experienced when your knowledge as a radiographer was important.	(N=6)
	2) Describe a situation when you learned new technology!	(N=7)
	3) Describe an ordinary situation when your professional knowledge was important for taking care of patients	(N=3)
	4) What do you know, as a radiographer that other professionals at your place of work (both in your ward but also other professionals you meet during work) do not know?	(N=7)
	Observation aim one- to identify general tasks and responsibilities in their daily work with image production	(N=3)
Evaluating the examination	1) Describe an ordinary situation that you have experienced when your knowledge as a radiographer was important.	(N=3)
	2) Describe a situation when you learned new technology	(N=1)
	3) Describe an ordinary situation when your professional knowledge was important for taking care of patients	(N=3)
	4) What do you know, as a radiographer that other professionals at your place of work (both in your ward but also other professionals you meet during work) do not know?	(N=3)
	Observation aim one- to identify general tasks and responsibilities in their daily work with image production	(N=3)

Table 4. Description of how the data sources have contributed to each category (Study II).

Categories	Data sources	Number(N)
Anxiety	Interview question 1) Describe an ordinary situation that you have experienced when your knowledge as a radiographer was important.	(N=1)
	Interview question 3) Describe an ordinary situation when your professional knowledge was important for taking care of patients	(N=3)
Need of learning	Interview question 2) Describe a situation when you learned new technology!	(N=4)
Easier practical doings	Interview question 2) Describe a situation when you learned new technology!	(N=6)
The image	Interview question 2) Describe a situation when you learned new technology!	(N=2)
Relations during work	Interview question 2) Describe a situation when you learned new technology!	(N=3)
	Interview question 4) What do you know, as a radiographer that other professionals at your place of work (both in your ward but also other professionals you meet during work) do not know?	(N=1)
	Observation aim two- to study how radiographers' professional tasks and responsibilities has changed due the change from conventional imaging technique to multi dimensional imaging	(N=7)
Changed machines	Interview question 2) Describe a situation when you learned new technology!	(N=7)
	Interview question 4) What do you know, as a radiographer that other professionals at your place of work (both in your ward but also other professionals you meet during work) do not know?	(N=2)
	Observation aim two- to study how radiographers' professional tasks and responsibilities has changed due the change from conventional imaging technique to multi dimensional imaging	(N=3)
Time aspect	Interview question 2) Describe a situation when you learned new technology!	(N=4)
	Interview question 4) What do you know, as a radiographer that other professionals at your place of work (both in your ward but also other professionals you meet during work) do not know?	(N=2)
	Observation aim two- to study how radiographers' professional tasks and responsibilities has changed due the change from conventional imaging technique to multi dimensional imaging	(N=5)

Table 5. Description of how different categories have contributed to each theme (Study II).

Categories	Themes
Changed machines Easier practical doings	<i>Changed materiality makes the practical action easier</i>
Changed machines Easier practical doings Anxiety Time aspect	New machines cause conflict between the arrangements of the work and the patients' needs
Changed machines Learning Relations during work	Changing materiality prefigures learning
Changed machines Learning Relations during work	How the connections between different practices lead to moments of practical reasoning in the radiography process with CT

Papers

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