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CONSEQUENCES OF OUTSOURCING REFERRALS FOR RADIOLOGICAL EXAMINATIONS

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ABSTRACT

Background: Demands for ever more effective healthcare and care accessibility for all patients continue to increase the workload in diagnostic radiology departments. Along with rapid developments in imaging technology which affect its day-to-day clinical use, these are three important factors for which outsourcing might be a potential solution. Outsourcing radiological examinations increases the need for cooperation between different healthcare units. Outsourcing a radiological examination is accompanied by administrative work. Examinations performed externally change the work flow and create a multifaceted environment that can be reviewed both qualitatively and quantitatively. The impact of outsourcing magnetic resonance (MR) and computed tomography (CT) examinations to external units in a zero-based budgeting healthcare system is unknown. This impact can be studied both from the perspective of healthcare work flow as well as from that of the patient experience.

Aims: The overall aim of this thesis was to describe the outsourcing of radiological examinations such as MR and CT scans from a university hospital in terms of costs, quality, time efficiency, and both the patient's and referring physician's perspectives, and also to investigate the differences when CT examinations are outsourced from a university hospital as part of a contract compared to conditions prior to the contract between the hospital and external radiology unit.

Material and Methods: In Study I, consecutive outsourced MR examinations requested by the Department of Oncology during the first quarters of 2005 and 2006 were selected for investigation. Examinations performed by the University Hospital's Radiology Department (Group A, n = 97) were compared to matched examinations outsourced to external private units (Group B, n = 97). In Study II, structured interviews (oral questionnaires) were held with one group of patients (n = 160) referred for MR examinations. In Study III, qualitative interviews were held with 10 referring physicians from orthopedic and oncology clinics representing clinics with large volumes of radiological referrals. In Study IV, 264 elective CT examinations were randomly selected from four different groups of patients referred from the Departments of Hematology and Oncology during two time periods: one time period had no detailed plan for cooperation (OSnC) and one represented contract-based outsourcing (OsC). Within these time periods, examinations performed in-house (Group HI13; IN14) and outsourced (Group OSnC; OsC) were compared.

Results: In Study I, the time from writing a referral to obtaining the report was significantly longer in Group A (in-house) than in Group B (outsourced). For referrals without a preferred timeframe, the waiting time was shorter for

outsourced examinations than those not outsourced. No significant difference in the number of examinations requiring additional imaging was observed between the two groups. Fewer examinations in Group A needed additional work for reinterpretation of images than in Group B (14% vs. 28%). The average cost for an MR examination in Group A was calculated to be €616.80, and €510.80 in Group B.

In Study Π, 69% of the patients stated that they could neither choose nor influence the location to which their examination was referred. Aspects that influenced the patients' choice of radiology department were: short waiting time 79% (127/160), ease of travelling to the radiology department 68% (110 /160), and short distance to their home or work 58% (93/160). For 40% (60/160) of the patients, a short time in the waiting room was related to a positive response regarding returning for a further MR examination. In study III, all the referring physicians agreed that the quality of outsourced examinations was frequently inferior to that of examinations performed in the University Hospital's Radiology Department and that requests for additional reinterpretation work led to higher costs for their clinics. In Study IV, during 2013, management time for CT examinations which needed no reinterpretation was longer in the outsourced group than in the in-house group, with a statistical significance of 0.002. CT examinations in Group OsC (contract-based outsourcing) were associated with shorter overall processing time, shorter patient waiting time and lower costs compared to group OsC (without a detailed plan for cooperation).

Conclusion:

- Outsourcing magnetic resonance examinations is one potential solution for reducing patient waiting time.
- Outsourced examinations more frequently need reassessment at the University Hospital than examinations that are not outsourced.
- If patients were informed about outsourcing and could also choose where to have their examination, the key factors contributing to patient satisfaction could be met even when MR examinations are outsourced.
- When considering outsourcing, the needs of the patients, of the referring physicians and of the radiology departments must all be considered, to optimize patient care.
- For better planning of radiological services, radiology departments must consider the referring physicians' needs and develop a suitable contract for organizing the practice of outsourcing.
- Using a contract for outsourcing CT examinations may be an effective way of reducing patient waiting time.
- Outsourcing based on a well-founded contract can be cost-effective, compared with outsourcing without a detailed plan for cooperation.

LIST OF PUBLICATIONS

I. Effects of outsourcing magnetic resonance examinations from a public university hospital to a private agent
Tavakol P[1], Labruto F[2], Bergstrand L[2] and Blomqvist L[2]

II. Patients' experiences of outsourcing and care related to magnetic resonance examinations
Tavakol Olofsson P[1], Aspelin P[1], Bergstrand L[2] and Blomqvist L[3]

III. Referring physicians' experiences of outsourcing radiological examinations : A variety of views on the consequences
Tavakol Olofsson P[1], Blomqvist L[2], Fridell K[1] and Aspelin P[1]

IV. The impact of contracts on outsourcing referrals for computed tomography examinations from a public university hospital to a private radiology unit
Tavakol Olofsson P[1], Blomqvist L[2], Aspelin P[1] , Bohlin J[2]and Fridell K[1]

CONTENTS

LIST OF ABBREVIATIONS

MR	Magnetic Resonance
PACS	Picture Archiving and Communication System
RIS	Radiology Information System
HIS	Hospital Information System
ZBB	Zero-Based Budgeting
CT	Computed Tomography
CEA	Cost-Effectiveness Analysis

Disclaimer: Some parts of this thesis are based on the author's thesis at licentiate level, entitled: CONSEQUENCES OF OUTSOURCING REFERRALS FOR MAGNETIC RESONANCE EXAMINATIONS, which was intended as the basis at half-time review.

Parvin Tavakol Olofsson
Stockholm, 2016-09-10

1 INTRODUCTION

Healthcare systems are continually facing the challenge of reducing costs while maintaining quality patient care. Governments have become more cost-conscious and one reason for this is that healthcare expenditures are increasing faster than other sectors of the world economy (1, 2). Much of the rise in healthcare costs can be attributed to advances in medical technology such as that used for diagnostic radiological examinations (3). Diagnostic imaging has become a rate-limiting factor in medical healthcare (4), and, because radiology equipment is expensive, diagnostic imaging has become a target in reviews of medical costs (5). How best to balance public and private sectors in the financing and provision of healthcare services is a major challenge. Patients may have to wait, sometimes for an unacceptably long time, for elective care in the public system and one solution healthcare managers use to address this challenge is outsourcing (4, 6). The national policy of a "healthcare guarantee" enforced in Sweden requires that patients with any kind of illness should be granted specialized hospital care within a maximum of 90 days (7). In this setting, early diagnosis plays a significant role.

Workloads have increased in radiology departments because of the prompt development of imaging technology and the higher demand for access to comprehensive healthcare services.

1.1 DIAGNOSTIC IMAGING: ONE IMPORTANT PART OF THE CONTINUUM OF CARE

About five billion radiological examinations are carried out annually worldwide (8). Part of this growing number of diagnostic examinations is due to continuous improvements in both the high level of imaging quality and the fast delivery of digital information. A Swedish radiology department generally performs between 20,000 and 200,000 radiological examinations and treatments annually (9). The use of radiological services has increased over the past 30 years and, today, very few important decisions concerning patient treatments are taken without the support of radiological examinations. Radiological examinations provide objective data about the human body and its functions and are often more reliable than subjective clinical investigations (10, 11). Any radiological examination consists of at least four major aspects: the assessment of the referral and subsequent preparations for the examination, the examination itself, its interpretation and the communication of the examination results, leading to the treatment decision. The radiology department is responsible for the whole chain of diagnostic examination processes in patient care (12).

1.1.1 The impact of developing technology on radiology departments

The expansion of technology provides more precise and more varied opportunities for diagnosing illnesses. Advances in image quality for demonstrating tissue differentiation have radically increased diagnostic information and in many cases technology is now capable of showing pathology without even requiring a histological reference (13). In the early 1980s, magnetic resonance imaging (MRI) was a new diagnostic technique, which was used to image organs such as the brain, abdomen and spine. Today, the increasing number of indications for MRI has contributed to requests from a far larger number of patients (14). Technological improvements in digital imaging have enabled the images to be post-processed and transferred easily to any location that has access to the corresponding system (15). In order to provide interpretations from radiology coverage during the night and at weekends, many hospitals outsource diagnostic imaging to external units within the country or abroad (16, 17). The concept of teleradiology is that a radiology report is best written by the cheapest well-trained radiologist available. Indeed, teleradiology puts other providers of diagnostic imaging worldwide in competition with the in-house radiologist (10). Due to the speedy transmission of images and reports, teleradiology has become a substantial alternative for delivering diagnostic services (18).

Network communication of diagnostic images between radiologists and clinicians is now a viable option, allowing clinicians to obtain an expert opinion from radiologists through teleradiology services (19). The use of diagnostic imaging technologies also implies that referring physicians can quickly obtain interpretation results and images of radiological examinations. Increased use of the digital imaging Picture Archiving and Communication System (PACS) has reformed conditions within the radiology system. A combination of using computer systems such as the Radiology Information System (RIS), Hospital Information System (HIS) and PACS facilitates the archiving, distribution and transferal of data and images within and across different health organizations (20).

1.2 THE CONCEPT OF OUTSOURCING

In the beginning of industrialism, the entire production process was often handled within a single company, without the involvement of a third party. The essential factors that influenced the development of the outsourcing phenomenon were increased demand and increased competition between the firms that had high demands to reduce production costs (21). The concept of outsourcing is to enhance a business or an organization's efficiency through cheaper, better and faster production. Outsourcing has been around for as long as work specialization has existed and today firms frequently use the outsourcing model to carry out

specific functions, such as billing, payroll and data entry (22). Outsourcing is an old phenomenon with new implications and it triggers different opinions. Outsourcing is also defined as a method or solution for intensified efficiency that leads to increased production or service (23). Outsourcing is a corporate strategy which focuses on a specific mission and how best to accomplish it and achieve a competitive advantage (24). According to Paul Davies (2004), outsourcing can be defined as contracting or subcontracting some portion of a business such as manufacturing, processing, marketing, etc., to outside organizations (25).
However, the concept of outsourcing means that a producer should supply those goods/services that they can deliver most competitively and let other producers create goods/services at which they are more efficient. "*Allocating good production to the most competitive producer will lead to a global economy that is maximally efficient in terms of producing the most goods for the least cost"(26, Page 654).*

1.2.1 Outsourcing of diagnostic medicine

Consumer-driven, global healthcare has opened the market for outsourcing medical care. Limited resources and cost reduction are two main reasons for outsourcing medical care (27). Outsourcing of healthcare in general and radiological services in particular is escalating in today's society (28, 29, 18). This growth of outsourcing may be due to the fact that radiological examinations provide objective data about the human body and its functions, and are often more reliable than subjective clinical investigations (6, 7). About 60 million MR examinations are performed annually worldwide (30) and numbers have increased over recent years. The ability of MRI to provide high soft tissue contrast resolution images without ionizing radiation is important for many diagnoses and this contributes to the modality being highly coveted (31). According to a report on the Census of the Radiology Workforce in the UK in 2008, 18% of radiology clinics outsourced a number of radiological imaging procedures, the median of the requested MR examinations being 49% (32). Use of CT has also increased, particularly in emergency departments. From1995 to 2007, the number of annual CT examinations increased from 2.7 million to 16.2 million with a yearly expansion of about 16.0% (33**).** In short, the overall use of radiological services has increased over recent years. Consequently, workloads have increased in diagnostic radiology departments because of higher demand for comprehensive healthcare services. A shortage of radiologists combined with an exploding demand for radiological examinations force many healthcare organizations to find offshore outsourcing sources even in diagnostic medicine. In conclusion, radiology services are being increasingly outsourced due to technological advancements, shortage of expertise, increasing demand, financial constraints and transitioning radiology from an analog world to a digital one (34). Teleradiology is one result of this change. Teleradiology is the electronic transmission of diagnostic images to various remote places, for the purposes of image interpretation or consultation (35) and it is a customary way of outsourcing

diagnostic imaging. But, outsourcing radiological services can mean various things: it can refer to distant interpretation of the examination and having a report written by an external radiology service; distant performance of the examination with interpretation at the hospital, or outsourcing both the performance and interpretation to an external radiological department (23, 24).
Outsourcing can be considered in two forms, partial or complete. Complete is when an organization moves all functions to an external supplier, while partial outsourcing involves only a part of the organization's function (36). As an example, teleradiology is a partial outsourcing. An example of complete outsourcing is when both examination and interpretation are outsourced to external radiology units (37).
Worldwide, there are many public hospitals that outsource radiological services (38). Outsourcing is a challenge for managers who plan and provide radiological services in public hospitals and the outsourcing itself becomes a crucial task for the healthcare provider (39). Outsourcing radiological services changes the relationship between patients, physicians, referring physicians and radiologists in radiology departments (39, 40, 41). According to Peter Holbrook, "*This is not an issue of whether or not to outsource public services but about how public bodies allow the markets to be shaped and the sort of firms they choose*" (42, Page 1). The decision to outsource radiological examinations requires consideration of several issues such as quality, costs and benefits, because the choice of one external radiology unit over another will not only have an impact on the individual patient's health, but also on healthcare resources for society as a whole (43, 44, 45).

Some studies have demonstrated the undesirable effects that outsourcing has on radiology interpretation, which frequently leads to additional reviewing of the outsourced examinations by the in-house radiologists (46). But outsourcing can also bring benefits for healthcare systems, communities, institutions, departments, individual healthcare practitioners and patients. The advantage of outsourcing radiological examination may be its availability to an expanded network of radiologists and other professionals, by providing easy access to diagnostic images and interpretation (23).

1.3 THE UNIVERSITY HOSPITAL'S ORGANIZATION AND OUTSOURCING RADIOLOGICAL EXAMINATIONS

When resources in a university hospital cannot be balanced with demand, this can lead to an increase in patient waiting times. This is also true when there is an imbalance between radiological resources and the demands placed upon them, despite internal measures taken to make the radiology department more effective. Such measures may include use of the equipment outside office hours, more efficient prioritizing, or the outsourcing of radiological examinations. In this environment, and in an effort to maintain acceptable availability for patients and

an acceptable workload for radiology department staff, some hospitals outsource a percentage of their requested radiological examinations to external private units. The policy of the University Hospital during the study period was that referring clinicians could only send radiological referrals internally within the hospital. Outsourcing implies that the radiology department rather than the referring physician makes the final decision as to where the examination can be performed. The Radiology Department at the University Hospital outsources between 10% and 20% of its referrals to external hospitals or radiology departments, usually private radiology units.

Outsourcing from the university hospital to private units causes additional administrative work. It affects the management of diagnostic images and reports. Figure 1 shows the different phases that a referral in paper format passed through before the digitization of the Radiology Department, while Figure 2 shows these phases for a digital referral seven years after digitization. An essential aspect of efficiency for any organization is its ability to change (47). Usually an organization with a larger sociological network has greater difficulties in convincing and directing all its staff to accept or adopt changes (48). Our University Hospital is a large organization with many activities. The inability to accept change within an organization is most evident when technology changes human professional roles and work practices (47, 49).

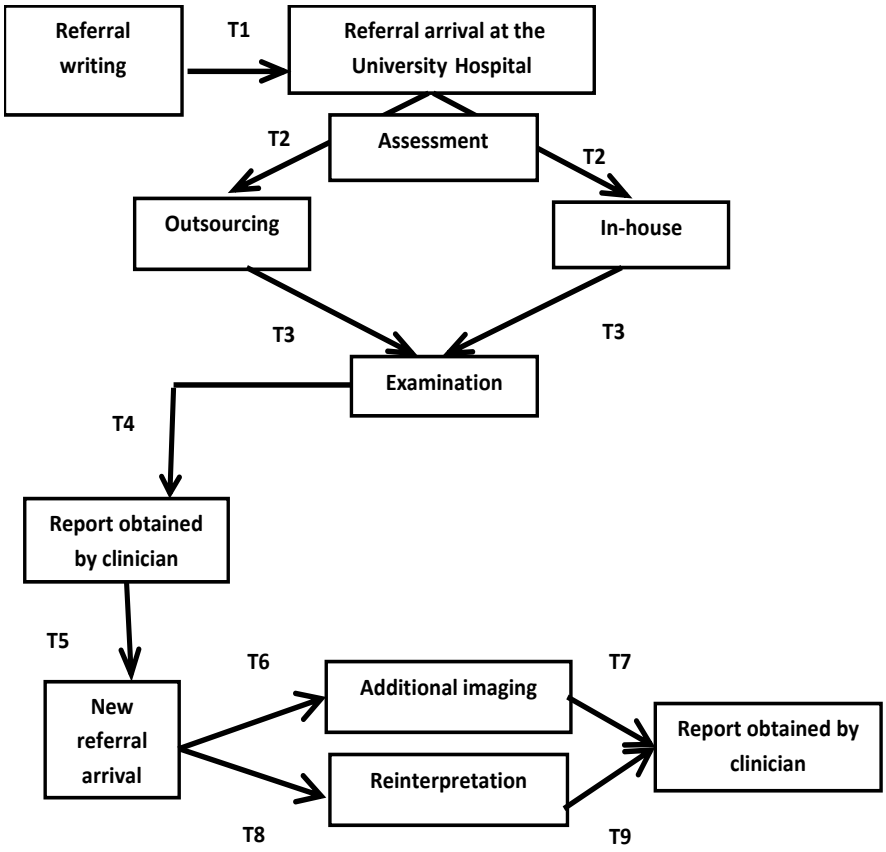

Figure 1. The different stages a radiological examination referral in a paper format passes through, from writing the referral to obtaining the report. In most cases, the process is straightforward, moving from the stage when the referral is written (T1) to the stage when the report is signed by the radiologist (T4). However, in some cases, additional imaging is needed, or the examination must be reassessed. In these cases, the referral must continue through the extra stages of writing a new referral through to obtaining the additional report (T5–T9). This means that it takes a longer time for the clinician to obtain the report (40).

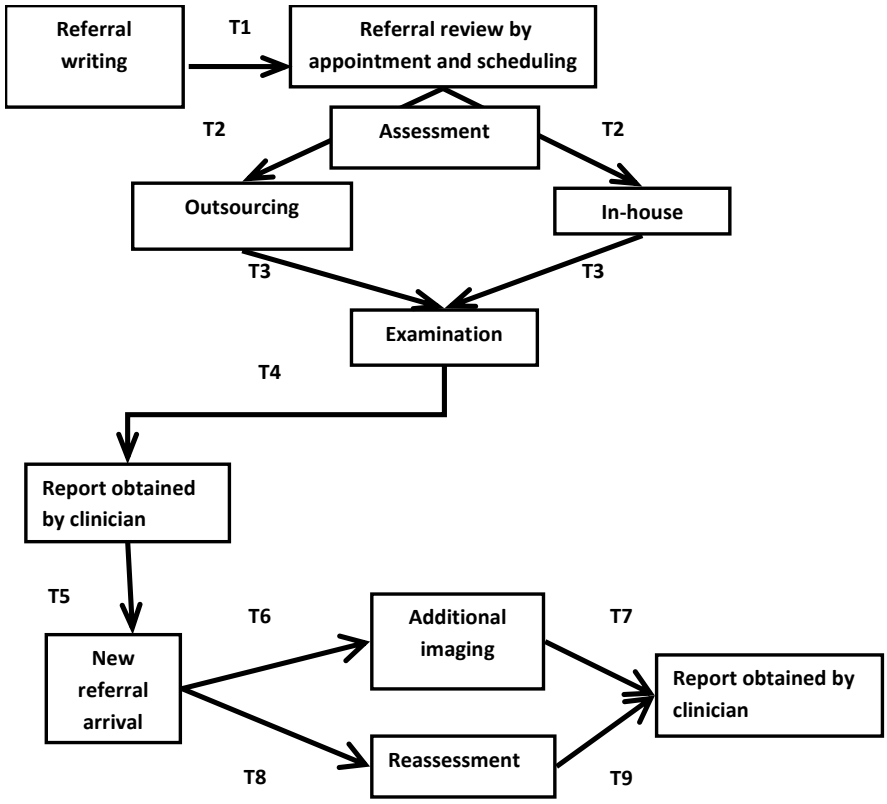

Figure 2. The different stages a digital radiological examination referral passes through, from writing the referral to obtaining the report. In most cases, the process is straightforward, moving from the stage when the referral is written (T1) to the stage when the report is signed by the radiologist (T4). However, in some cases, additional imaging is needed, or the examination must be reassessed. In these cases, the referral must continue through the extra stages of writing a new referral through to obtaining the additional report (T5–T9). This means that it takes a longer time for the clinician to obtain the report.

1.3.1 Outsourcing management approaches in the Department of Radiology

In a previous study (50), we studied the consequences of outsourcing radiological examinations from a university hospital to external units, when this is done without any formalized contract between the sending and receiving departments. Since that study, the University Hospital has initiated a contract for outsourcing CT examination referrals to a private radiology unit. According to this contract, both in-house and outsourced CT examinations should be performed with the same examination protocol and the interpretations made with comparison to any relevant prior imaging.

This contract provides an opportunity to study the impact of a contract for outsourcing between the University Hospital and the external private radiology unit. To the best of our knowledge, no previous studies have been performed to evaluate the effects of organized, contract-based outsourcing on outcomes for

patients and costs, when both the examination and the interpretation of images are outsourced (40).

1.3.1.1 Managing outsourcing by contract

Any manager who uses outsourcing should have a genuine knowledge of what makes outsourcing effective and should carefully study their outsourcing decision in order to identify the impact of different outsourcing management approaches or governance mechanisms, such as a contract and customer - provider cooperation/relational adaptations (51). The definition of a contract according to the business dictionary is as follows: *a voluntary, deliberate, and legally binding agreement between two or more competent parties* (52). The key elements in a contractual relationship are: the proposition, approval of the proposition, and a lawful consideration. Lawful consideration ensures the engaged parties' rights and obligations towards each other (53). It has been shown that the manner in which an organization is safeguarded by a regulated contract and also its relational adaptations influence the effectiveness of outsourcing (54).Some studies suggest that relational adaptation can counterbalance the administration of official contracts (55, 56). There are also studies showing that well-funded contracting has the potential to make outsourcing outcomes extra proficient and reduce the risk of opportunism (57, 58). Contractual governance outsourcing can lead to more control and better collaboration between customer and provider, which may result in higher quality of performance (59). In conclusion, the purpose of both relational adaptation and contractual governance is to increase the preferred outcomes of outsourcing; to make outsourcing effective, and to prevent possible risks from providers' opportunism. In-house investment is another way to circumvent this opportunism. However, a previous study showed that the efficiency of radiology departments can improve when existing devices are used more than simply during office hours (60). In practice, opportunities for doing this are limited because of staff shortages and an inability to recruit staff given the financial restrictions of a zero-based budgeting (ZBB) system, which is the University Hospital's current budgeting system.

1.3.2 Zero-based budgeting

Zero-based budgeting, which is defined as a management tool, was developed in 1969 and promptly found favor in industry, government and hospitals (61). ZBB provides a systematic basis for resource allocation by forcing activities to be ranked according to priority. ZBB is an operating, planning and budgeting process that requires each manager to justify the entire budget request in detail on the basis of purpose and cost-benefit analysis (62). The analysis should cover the profitability of the activity, alternative options for action, performance measurement and the consequences of not performing the activity. This is unlike traditional budgeting in which past expenditures are assumed to continue (63, 64). The gain of ZBB is that it is a valuable tool in terms of efficiency because managers may have detailed information that will highlight redundant activities

or increase efforts within an organization. ZBB facilitates the allocation of resources by focusing attention on the actual resources that are required in order to achieve productivity regardless of the percentage increase or decrease compared to the previous year (65). It also prevents unnecessary bureaucracy and affords a balanced partnership between the finance professionals and the budget holders in the analytical and decision-making processes. The disadvantage of the ZBB method is that managers have limited incentives for making the system more efficient, and this is particularly true for large organizations with various activities and priorities (64).

1.3.3 Patients' impressions of healthcare quality

The patient's impression of healthcare quality is important and valuable in understanding perceived quality in healthcare services. In Sweden, the National Patient Survey measures patients' perceived quality of care annually. The results are used to improve healthcare quality by providing a foundation for improvement plans, where the patient's perspective is a major focus (66). Patients should be evaluators of care: they are the primary source of information on the care provider's performance and their contributions in defining the factors of quality are appreciated (67). It is most important that patients become part of the solution to improve the quality of care (68). One definite way to improve quality of care is to focus on the patient's views on the care they receive and their expectations of it (69, 70). A positive relationship between a patient's satisfaction and their response to medical treatment was reported as early as the 1950s (71). Patient satisfaction involves physical, mental, emotional, cultural and social factors which make it a subjective and complex concept (72). Patient satisfaction is a useful indicator for measuring the quality of healthcare services, and thus many questionnaires have been developed over recent years (73, 74). Patient satisfaction tools that assess patients' perceptions should include the patient's expectations, because expectations are the ideas that patients have about the quality of care they should receive. Expectations are what patients measure their observations against, and for that reason different patients in the same situations and surroundings could experience different levels of satisfaction (75). Outsourcing radiological examinations from a university hospital to external private units affects the patient, who has to attend a different clinic or hospital for the radiological examination. Studies concerning patient satisfaction related to radiological examinations are rare. Although a considerable number of patients undergo MR examinations on a daily basis, the patient's experience of MR examinations is mainly unexplored. Therefore, it is important to study this experience with the aim of improving quality of care based on the patient's needs.

2 AIM OF THE THESIS

The overall aim of this thesis was to examine the consequences of a radiology department's outsourcing of magnetic resonance (MR) and computed tomography (CT) referrals to external private radiology units.

Specific aims:
The aim of Study I was to investigate differences in management/turnaround time, patient waiting time, quality and costs between MR examinations performed in a university hospital and examinations outsourced to private units.

The aim of Study II was to examine the experiences of patients who are sent to private radiology units when their referrals for MR examinations are outsourced from a university hospital, as well as to explore factors which influence patient satisfaction regarding the quality of care related to the MR examination.

The aim of Study III was to explore the experiences of referring physicians when their referrals for radiological examinations are outsourced from a university hospital in Stockholm, Sweden.

The aim of Study IV was to investigate differences when CT examinations are being outsourced from a university hospital as part of a contract compared to conditions prior to the contract between the hospital and external radiology units.

3 MATERIAL AND METHODS

3.1 MATERIALS

3.1.1 Study I

A sample of outsourced MR examinations representative of the years 2005 and 2006 was selected based on the following criteria: all consecutive MR examinations of adult patients requested by the Department of Oncology at the hospital in the first quarters of 2005 and 2006, and delegated by the department to private units (Group B = outsourced). Excluded from the study were referrals marked as "emergency" and all neurological examinations. The groups consisted of 37 examinations for 2005 and 60 examinations for 2006. As a control group, an equal number of MR examinations that were not delegated to external private units, i.e. performed and interpreted within the radiology department, matched for type of examination, was selected (Group A = in-house) (40).

3.1.2 Study II

A group of patients (n=160) referred for MR examinations and either examined at a university hospital or at an external private unit were interviewed. This study was conducted at the two private radiological units that received most outsourced referrals and at a university hospital in Stockholm, Sweden (41).

3.1.3 Study III

Ten referring physicians from orthopedic and oncology departments, representing clinics with large volumes of radiological referrals at a university hospital, were interviewed (76).

3.1.4 Study IV

A total of 264 elective CT examinations from all body CT examinations of adult patients referred from the Departments of Hematology and Oncology, were included in this retrospective study. These examinations were randomly selected from four different groups of patients during two time periods of 12 months each, one being outsourcing without a detailed plan for cooperation (OSnC) and one time period representing contract-based outsourcing (OsC). Examinations performed in-house and those outsourced were compared within these time periods. The study's hypotheses were related to the effectiveness of two outsourcing management approaches. The null and alternative hypotheses were (a) that the two outsourcing management approaches, namely OSnC (outsourcing without a detailed plan for cooperation) and OsC (outsourcing based on contract), are equally cost-effective (H0: OSnC = OsC) and (b) that the two outsourcing management approaches are not equally cost-effective (H1: OSnC ≠ OsC). The

study's other hypothesis was that outsourcing radiological examinations has an effect on processing time, patient waiting time and cost. The null hypothesis of this study was that there are no differences between referrals for CT examinations that the University Hospital's Radiology Department outsources, compared with a control group of CT examinations which were performed by radiology departments within the University Hospital.

3.2.1 DATA COLLECTION METHODS

3.2.1.1 Study I

With the help of the Hospital Information System (HIS) and Radiology Information System (RIS) software available at our hospital, we obtained the management/turnaround time of each examination by calculating the number of days between the date when the referral for the radiological examination was written and the date when the radiological report was completed (40).

All referrals were read and grouped (outsourced and in-house) into two categories: those where a preferred timeframe was specified and those where there was no such timeframe. When a timeframe was indicated in the referral, it was also separately noted if the preferred timeframe was exceeded or not, and by how many days. When no timeframe was indicated, the number of days the patient had to wait for the examination was calculated (40).

The percentage of examinations that had to be re-examined and reinterpreted was used as a surrogate marker for examination quality. This information was obtained from the RIS. The percentage of examinations that the requesting department asked to have reinterpreted/ explained at the University Hospital was chosen as a parameter reflecting the quality of the interpretations.
The cost of each examination was obtained and added to the cost of reassessment (when applicable) for calculating the total costs. The cost of the examination *per se* varied between 2005 and 2006. Moreover, the cost of reinterpretation (explanations) varied from year to year and also according to the type of reinterpretation (demonstration) required (Table 1) (40).
The administrative work for each referral sent from our University Hospital for outsourcing was calculated on the basis of minutes of work dedicated to each referral by three different personnel categories at our institution:

1. Personnel in charge of picture archiving.
2. Personnel in charge of booking the examination.
3. Consultant radiologist needed to make decisions about outsourcing the requested examination.

By multiplying the average salary per minute of each personnel category with the number of minutes dedicated to each referral, we obtained an average cost for administrative work and expressed it in Euro (€) (40).

Table 1.Types of reassessment in both groups A and B. Investigations in Group B required more extensive reassessment. The reassessment is separated into four different categories with increasing cost depending on the complexity of the reassessment and the time needed (40).

Type of reassessment	Number of reassessments Group A	Number of reassessments Group B	Cost
Simple	5	1	€56
Comprehensive	5	21	€112
Review	1	-	€116
Time consumed	2	5	€448
Total cost	**€1852**	**€4648**	

3.2.1.2 Study II

We interviewed 160 patients (Group A, n = 160) who had been referred for MR examinations either to the University Hospital or to private external units. The patient interviews took place in three radiology departments right after the patients had completed their MR examination. This study was conducted at the two private radiology units that received most outsourced referrals and at the University Hospital. The interviews were scheduled on three days per week over a two-week period in each radiology department. Sixty patients at each private unit and 40 patients at the University Hospital were interviewed. The interview was designed as a verbal questionnaire and it consisted of alternative questions and a few open-ended questions. The first step in the development of questions for the structured interview / verbal questionnaire was to investigate what appropriate questions, scale range and alternative answers were available. In addition, questions related to patient satisfaction with their MR examinations had to be formulated. The questions were inspired by and developed from the "Quality of Care from the Patient's Perspective" (QPP) questionnaire (77), because the purpose of the study was to measure patients' satisfaction with quality regarding several aspects of the care that they received in the radiology departments related to their MR examinations, as well as their subjective views on the importance of each aspect. The second step was to select the significant items and relevant questions. The questions were divided into a number of domains (78) which refer to several aspects of care, e.g. the caring attitude of the staff, waiting time, availability and the patient's freedom of choice regarding radiology clinic. Each question regarding these healthcare experiences and related to the MR examination was followed by a question that asked how these particular details were important for the patient (77, 79). The interview questions also included background questions, which sought to obtain patient socio-demographic data, such as age, occupation, education level and physical and psychological well-being. The verbal questionnaire consisted of 34 questions of

which 10 were follow-up questions (41). In total, 20 of the items about patient experiences had a five-point response scale; three had a four-point scale and seven questions had a three-point scale. See Appendix (41). The last step was to validate the questions, which is very important for the collection of significant and accurate information. In order to identify omitted items and also to obtain suggestions for improvements, the questions, range of alternative answers and the wording were pilot-tested several times, before data collection was conducted. The average duration of each interview was 20 minutes.

3.2.1.3 Study III

Ten referring physicians from oncology and orthopedic clinics, representing departments with large volumes of radiological referrals at the University Hospital, were interviewed. A key informant sampling strategy (informants with special expertise) was used in the study. The inclusion criterion was that the informants (referring physicians) should have been working in the oncologic or orthopedic clinics at the University Hospital for a minimum of one year. Interviews with the referring physicians consisted of open-ended questions and follow-up questions to obtain responses potentially covering wider perspectives (76). A qualitative interview is a professional conversation which can include detailed descriptions of the informant´s experiences, work situation and actions (80). The interview questions were separated into two types: "what" questions and "how" questions (81). The first type of questions covered the experience and perception of outsourcing and its effect on professional practice, workflow, patient care, costs, etc., while the second type of questions covered fields like feelings and thoughts about the outsourcing of radiological services. All interviews were voice-recorded (76).

3.2.1.4 Study IV

Data were collected using the Picture Archiving and Communication System (PACS), the Radiology Information System (RIS) and patients' clinical files used in the University Hospital. A total of 264 elective CT examinations were included in this study. Types of examination which were not commonly performed by the radiology units, such as thorax and thorax upper abdomen, were excluded. Table 2 shows detailed information about both the initially excluded and the included CT examinations in this study. After primary exclusion, a randomized block design was used. The data were broken into 12 blocks (Figure 3) with stratification according to referring clinics, radiological examination type and radiology unit for each year (12 blocks, n = 132 for 2013 and 12 blocks, n = 132 for 2014). Randomization was conducted by computer-generated blocks.

Table 2. Total CT examinations referred from the Hematology and Oncology Clinics, those initially excluded as well as the included examinations and the examination type during 2013 and 2014.

Referring Clinic and Year	Total Referrals	Outsourced	Booked In-House	Exclusion	Inclusion	Outsourced After Exclusion	In-House After Exclusion
Hematology and Oncology 2013	7757	3114 (40%)	4643 (60%)	1 canceled 1 wrongly coded 113 canceled 7 patients did not show up 550 thorax and upper abdomen 788 thorax	6296	n=2841 examinations 288 abdomen 2256 abdomen and thorax 297 neck, thorax and abdomen	n=3455 examinations 522abdomen 2402 abdomen and thorax 531 neck, thorax and abdomen
Hematology and Oncology 2014	8202	2537 (31%)	5665 (69%)	157 canceled 18 patients did not show up 638 thorax and upper abdomen 814thorax	6575	n=2280 examinations 162abdomen 1963 abdomen and thorax 155 neck, thorax and abdomen	n=4295 626 abdomen 2918 abdomen and thorax 751 neck, thorax and abdomen

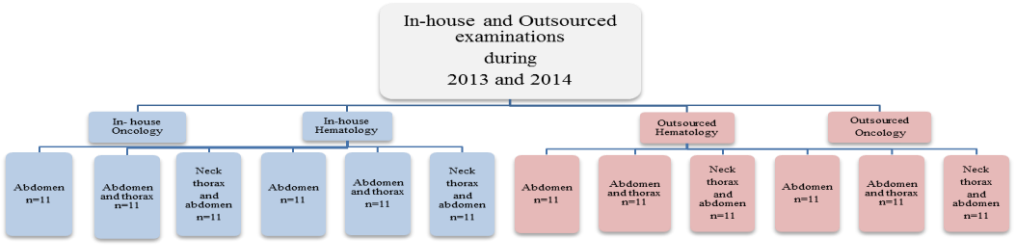

Figure 3. Twelve blocks for different types of CT examinations and the specialty of the referring clinic, which were randomly selected for the years 2013 and 2014, i.e. the year before and after the contract, to compare in-house and outsourced CT examinations.

The last step was to group these examinations into four different groups of patients during two time periods of 12 months each, one being without a detailed plan for cooperation (OSnC) and one time period representing contract-based outsourcing (OsC). Examinations performed in-house (Group IH13; IN14) and outsourced (Group OSnC; OsC) were compared within these time periods (Figure 4).

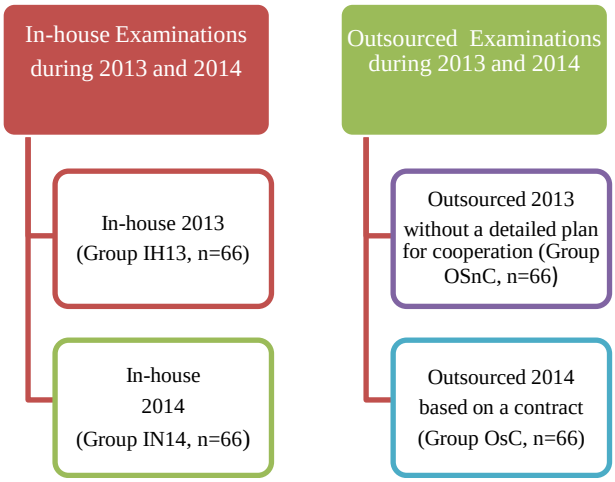

Figure 4. Shows the grouping for two main study groups, In-house and Outsourced, during two time periods (2013 and 2014). The In-house group consisted of CT examinations performed and interpreted within the Department of Radiology at the University Hospital during 2013 and 2014 (Group IH13; Group IN14). The Outsourced group consisted of CT examinations outsourced without a detailed plan for cooperation between the hospital and external units during 2013 (OSnC) and examinations outsourced based on a contract between the hospital and an external unit (OsC).

Management time involves several phases through which a CT examination referral passes (Figure 5). Management time was measured by summation of the time required for each phase.

Referring physicians often require a specific timeframe by which the CT examination must be completed. Therefore the actual examination dates were compared to the requested preferred times and this was used as a parameter indicating the patient waiting time for CT examinations.

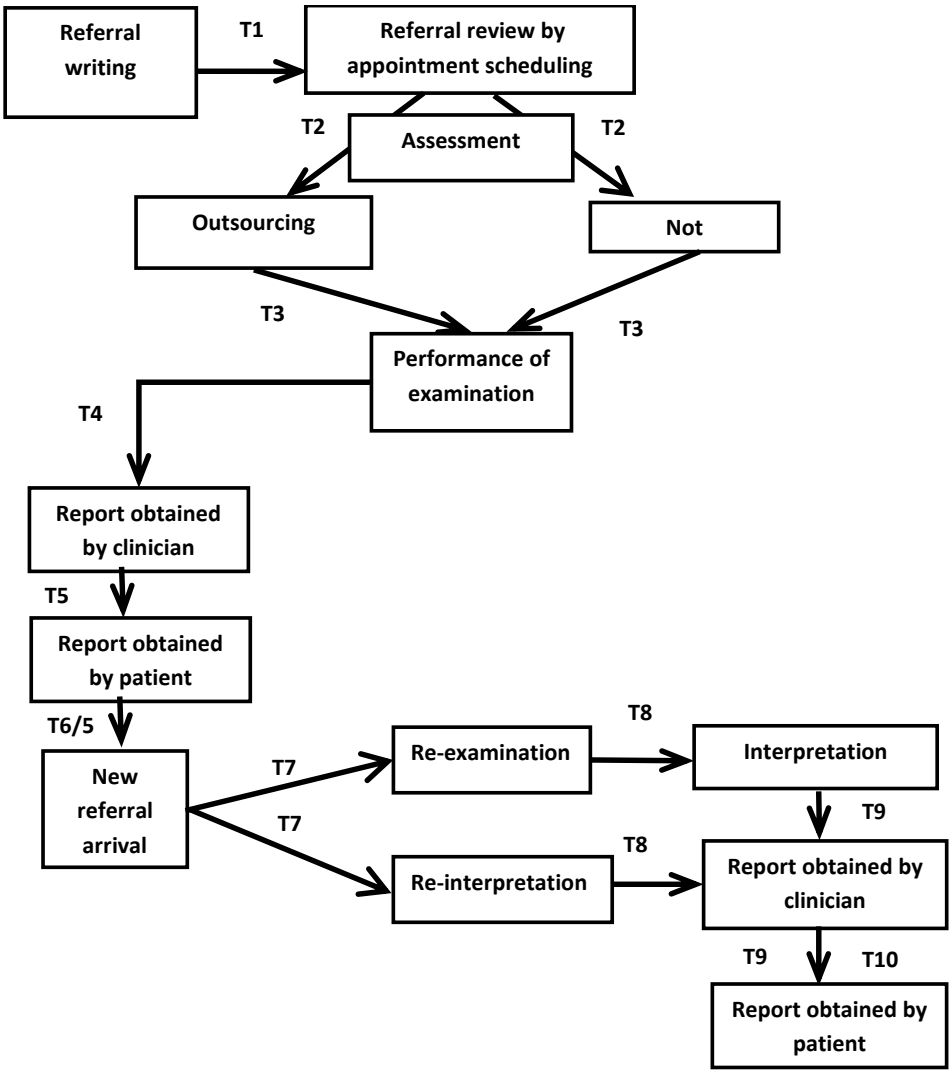

Figure 5. This chart displays the different phases a referral for a CT examination passes through between the writing of the referral and the patient's obtaining the report. Most referrals' journeys start with the writing of the referral and end with Stage 5 when the patient obtains the report. But some examinations need additional imaging and some examinations must be reinterpreted at the University Hospital. Their new journey begins from phase T6/5 and ends at phase T9 or T10 (In these cases, referring physicians often wait to obtain the final interpretation before they inform the patients.).

The calculated cost for each CT examination was the sum of the price charged for each examination and the cost for additional reassessment work. The administrative work for outsourced referrals was calculated on the basis of minutes of work dedicated to each referral by two personnel groups: the radiologists in charge and the appointment and scheduling staff. The average cost per minute of each group was multiplied by the number of minutes consumed by each referral.

In cases where CT examinations needed reinterpretation, the impact of the reinterpretation compared to the original report was measured by consulting two

experienced and independent radiologists. For each reviewed referral the radiologist filled in a dedicated form shown in Table 3.

Table 3. Protocol related to reinterpretation.

Nr.	Questions	No	Yes	It does not change patient's treatment.	It changes patient's treatment.	Comments
	Change in findings?					
	Adding new findings?					
	Adding new interpretation?					
	Are there any changes at all?					

3.2.2 DATA ANALYSIS

3.2.2.1 Study I

Data concerning the management/turnaround times were expressed as median together with 95% confidence intervals and were analyzed using the Mann-Whitney U test. Differences were considered significant for $p < 0.05$.

Statistical analysis of data concerning the patients' waiting times was expressed as mean together with 95% confidence intervals. Those data were analyzed using the unpaired t-test and differences were considered significant for $p < 0.05$.

Numbers of examinations that needed to be re-done or completed, as well as the number of examinations that needed to be reinterpreted, were expressed as absolute value / n and percentage values. Differences were tested with the Fischer test and considered significant for $p < 0.05$. Examination costs were expressed in Euro (40).

3.2.2.2 Study II

The patient's satisfaction with his/her care was calculated by the mean satisfaction scores in each dimension, compared with patient characteristics using Student's t-test and ANOVA to compare differences between dependent and independent variables, as appropriate. Correlations were analyzed using Pearson's test, where satisfaction was defined for $p <0.05$. Statistical analyses were carried out using SPSS software, version 20.

Analysis of the text from open-ended questions was performed as follows. In order to pick up significant information, only those sentences in the responses that were understandable and created context were transcribed. In order to identify themes, each answer was read several times. The second step was to develop coding categories for each answer. The third step was to label each answer with single or several coding categories. The fourth step was to

determine which categories were related to each other and the final step was to identify the common theme (41).

3.2.2.3 Study III

Data were analyzed using the qualitative content analysis method. A qualitative content analysis approach offers a deeper analysis of the numerical data as well as descriptive information, by highlighting significant meanings and gathering them into a set of categories and themes (82, 83). In order to pick up relevant information, sentences in the interviews that created context were transcribed (84). All transcripts were read several times with the purpose of reaching a deeper understanding of the referring physician's responses. Words or phrases (meaning units) which were regarded as significant were highlighted. Subsequently, in a number of meetings between the researchers, the 'meaning units' were condensed into codes and then grouped into varied subcategories. Subcategories of a similar context were grouped into different categories and these categories were gathered into a theme (Figure 6). The categories and theme resulting from this analysis of the referring physicians' comments are shown in Table 4 (76).

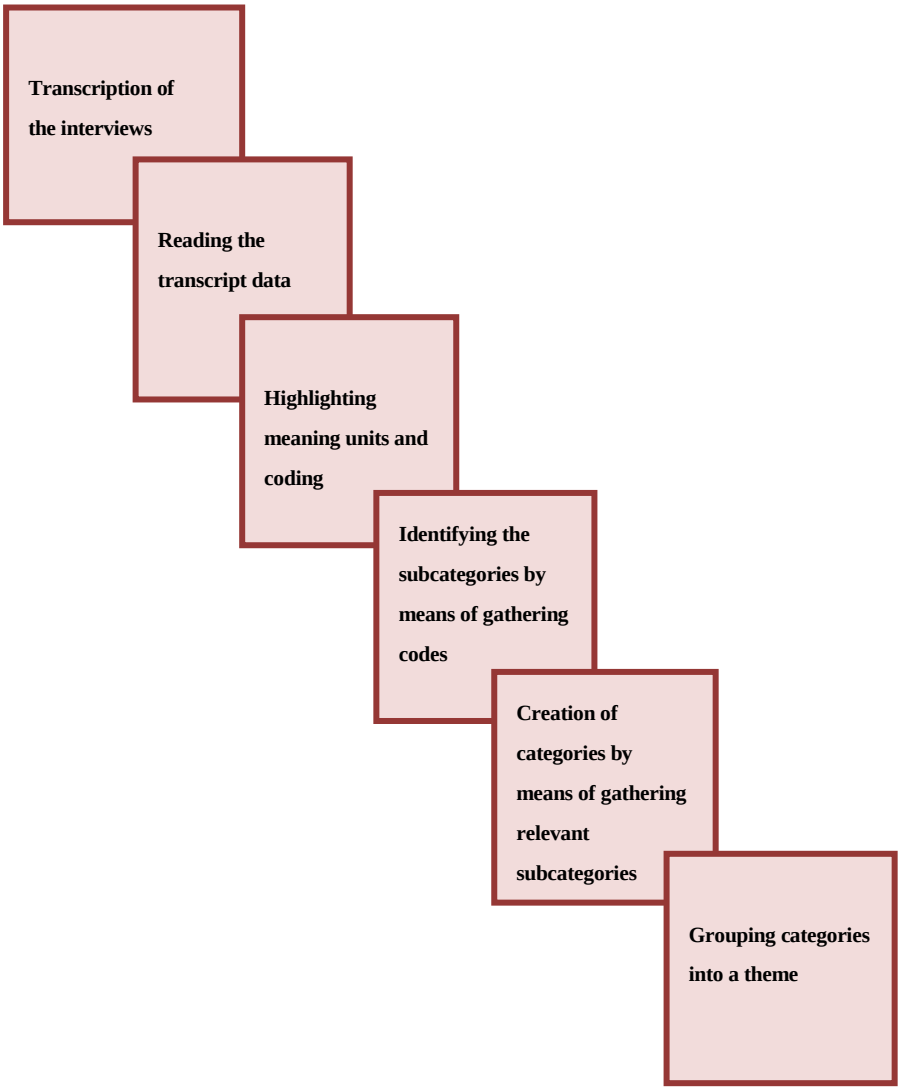

Figure 6. The different phases of interview analysis.

Table 4. Categories and theme that emerged from the referring physician interviews (76).

Categories	Theme
The practical impact	Physicians' experience of outsourcing - a variety of views on the consequences
Referring physicians' considerations with regard to outsourcing	
Radiological services	
Emotional impact	

3.2.2.4 Study IV

Data concerning management times (number of days between the different phases through which a referral passes) were expressed as median along with 95% confidence intervals. The Mann-Whitney U test was used to compare groups and differences were considered significant at $p = 0.05$. Patient waiting times were calculated by the number of days by which the preferred time for carrying out the CT examination was exceeded. This calculation was performed for referrals where the referring physician had specified a time frame for completion of the CT examination. The comparison between groups regarding patient waiting times was analyzed using Student's t-test. Cost-effectiveness analysis (CEA) was used. Cost-effectiveness analysis allows comparison of the costs and outcomes of different management approaches (85, 86, 87). In this study, effectiveness was measured in terms of (a) the number of CT examinations performed within the preferred requested time frame (no patient waiting time); (b) the number of examinations that did not need reinterpretation, i.e. in how many cases the referring physicians needed no new interpretation to enhance their understanding of the initial radiology report, and (c) the number of examinations that needed no additional imaging. Effectiveness was measured by calculating the number of radiology report reinterpretations and the number of additional imaging procedures, i.e. those examinations that hamper diagnosis due to technical shortcomings such as selection of a sub-optimal imaging protocol, inadequate use of contrast media or image artifacts.

Numbers of examinations that needed reinterpretation and redoing were expressed as absolute value / n and percentage values. Differences were tested with unpaired Student's t-test and considered significant at $p = 0.05$. Examination costs were expressed in Euro. Changes in diagnoses and patients' treatments were compared using the dedicated form shown in Table 3. To test the level of agreement between radiologists' judgements, a weighted kappa coefficient (≤ 0.00 representing no agreement; 0.00 - 0.30, minor agreement; 0.31 - 0.50, fair agreement; 0.51 - 0.60, moderate agreement; 0.61 - 0.80, good agreement and 0.81 - 1.00, excellent agreement) was used and the accepted level of statistical significance was $p=0.05$. Analyses were performed using Office Excel 2010 11.6560.6568 SP3 software by Microsoft® and SPSS software, version 21.

3.3.1 Ethical considerations

The project was assessed and approved by the local Ethics Committee (Dnr 2006/1128 -31/4; Dnr 2014/2128-31).

3.3.3.1 Human participants

According to ethical principles in Sweden (88), every researcher has a responsibility to protect the participants in an investigation and to consider four

ethical principles. These are the need for the information, informed consent, confidentiality and usefulness. Participation was voluntary and all informants were free to make an independent decision. Each interview began with information about informed consent according to the 17th paragraph of the Ethics Act regarding consent for research (SFS 2003:460). Each patient gave consent verbally before the interview. All participants were verbally informed about the overall purpose of the research and its main features. All participants were ensured confidentiality about their identity as a participant. Tapes and documents which were subject to confidentiality were kept away from outsiders and the statements used as citations do not disclose the informants' identities (88).

Finally all participants were informed that the data gained through the interviews would only be used in this study for the purpose of providing knowledge through understanding their experience. Data were collected by one of the researchers (PTO).

4 RESULTS

4.1 STUDY I

4.1.1 The time between writing the referral and obtaining the report

The median management/turnaround time for in-house examinations (Group A) was 66 days (range 60 – 75) while for outsourced examinations (Group B) it was 33 days (range 29 – 39). The time elapsed before obtaining the report was significantly shorter in Group B than in Group A (Table 5) (40).

Table 5. Management times (in days) for in-house (A) and outsourced (B) examinations (40).

GROUPS	MEDIAN	95% CONFIDENCE INTERVAL	RANGE	SIGNIFICANCE*
A (n=93)	66	60-75	0-187	P < 0.0001
B (n=93)	33	29-39	0-92	

*** Mann-Whitney U test = 1634.5. The two-tailed p-value is < 0.0001.**

4.1.2 Patient waiting time

The referring physician specified a preferred timeframe for the examination in 59/93 (63%) of the referrals in Group A and 65/93 (69%) in Group B. This timeframe was not met in 37 of the cases in Group A and in 34 of the cases in Group B. In these cases the waiting time exceeded the requested time, on average, by 18 days (range 1–77) in Group A and by 22 days (range 1–73) in Group B (P = 0.4). Thus, we observed a difference in the management of examinations with preferred timeframe, but this difference was not statistically significant (Table 6). The referring physician did not specify a preferred timeframe for the examination in 34/93 cases (36%) in Group A or for 28/93 cases (30%) in Group B. The waiting time in these cases amounted to 55 days (range 2–106) for Group A and 36 days (range 15–81) for Group B (P< 0.001). Thus, we observed a significantly shorter waiting time for outsourced examinations, when no preferred timeframe was indicated on the referral, compared to the in-house group (Table 7) (40).

Table 6. Waiting times (in days) for in-house (A) and outsourced (B) examinations with a specified timeframe (40).

Groups	Mean	Standard deviation	Range	P-value
A (N = 37)	18.2	20	1-77	04
B (N = 34)	22.1	21	1-73	

Table 7. Waiting times (days) for in-house (A) and outsourced (B) examinations without a specified preferred timeframe (40).

Groups	Mean	Standard deviation	Range	P-value
A (N = 34)	55	23.3	12-106	<0.001
B (N = 28)	36	14.3	15-81	

4.1.3 Examination costs

The total cost of Group A examinations was €57,979.90, plus €1,852 for reinterpretation, for a total of €59,831.90, giving an average cost of €616.80 per examination. The total cost of Group B examinations was €44,900, plus €4,648 for reassessments, for a total of €49,548, giving an average cost of €510.80 per examination. Examinations in Group B were significantly less costly than examinations in Group A, even when taking into account the increased incidence of reassessments (Figure 7) (40).

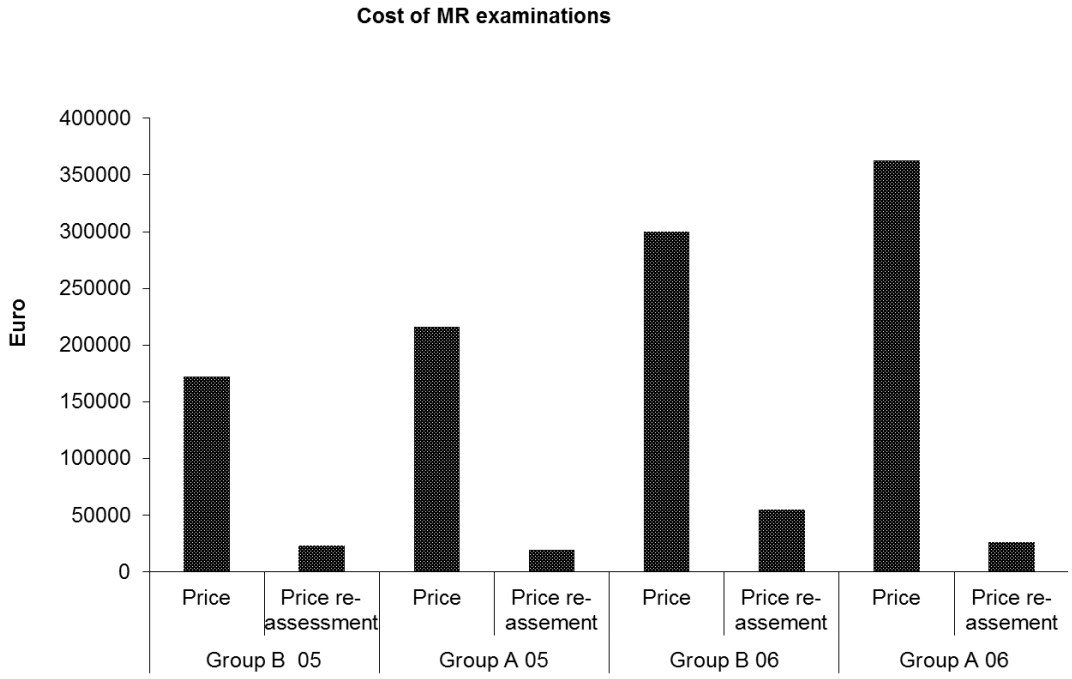

Figure 7. Total costs in Euro for the MR examinations plus costs for reassessment in Group A (In-house) were, on average, higher than those in Group B (Outsourced) during 2005 (05) and 2006 (06) (40).

4.1.4 Administrative costs

The average time dedicated to each request was set to two minutes for picture archiving (average monthly cost €2,628); 24 minutes for scheduling (average monthly cost €3,014) and five minutes for the consultant radiologist (average monthly cost €8,299). An average administrative cost of €13 for each request was obtained (Table 8). The calculated administrative cost for registration and scheduling a subsequent reassessment request was €5 per request (40).

Table 8. Cost of administrative work for each request. All costs are expressed in Euro (40).

	Staff, archiving office	Staff, appointment and scheduling office	Consultant radiologist
Average monthly co	2628	3014	8299
Average cost per minute	0.3	0.3	0.9
Average time dedicated to each request (minutes)	2	24	5
Average cost for eac category	0.5	8	4.5
Total cost	13		

4.1.5 Quality of the examinations

No examination in either group needed to be redone or needed additional imaging. Thus no differences in the quality of the examinations could be found between Group A and Group B (40).

4.1.6 Quality of the interpretations

In Group A, a reassessment request was issued by the referring department in 13 out of 97 examinations (14%): 11 pelvic, one head and neck, and one abdominal examination.
In Group B, such requests involved 27 out of 97 examinations (28%): 17 pelvic, one head and neck, three musculoskeletal, and six abdominal examinations ($p > 0.032$) (40).

4.2 STUDY II

4.2.1 Socio-demographic background

Of the 160 patients who participated in this study, 93 were women and 67 were men, between 18 and 81 years old (median age for women was 61 and for men 43). Table 9 also shows other socio-demographic characteristics of the patients, such as occupational status and education (41).

Table 9. Socio-demographic characteristics of the patients interviewed (41).

Background	n	%
Age Groups		
18-39	44	27.5
40-65	74	46.25
66-81	42	26.25
Gender		
Female	93	58.1
Male	67	41.9
Education		
Primary school	15	9.4
Polytechnic school/ High school	64	40
College education	77	48.1
Other degree	4	2.5
Occupational status		
Student	6	3.8
Employed	78	48.8
Employer	25	15.6
Unemployed	1	0.6
Retired	50	31.2

Two different groups of patients were identified in the analysis: those who had previously had an MR examination (Group A, n=105, 66%) and those who had not (Group B, n=55, 34%). Group A consisted of two smaller subgroups, namely patients who had both their previous and current MR examinations in the one radiology department (Subgroup α^1, n=23, 14%) and patients who had their current and previous MR examinations in different radiology departments (Subgroup α^2, n=82, 51%). See Figure 8 (41).

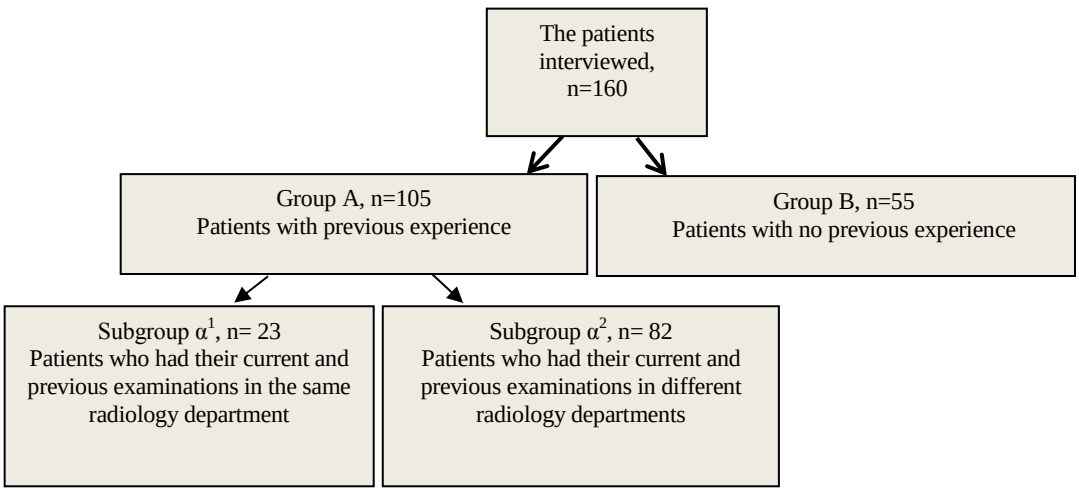

Figure 8. Number of patients interviewed, stratified according to previous experience and radiology department (41).

4.2.2 Patients' satisfaction and the caring attitude of the staff

Patients' satisfaction levels with the four dimensions of care quality (namely, information given by radiology staff, communication between the staff and patients, level of expertise, and caring attitude of the staff) are shown in Table 10 (41).

Table 10. Patients' level of satisfaction within four dimensions of assessment of care quality (41).

Level of satisfaction	Very good		Good		Neither good nor bad		Bad		Cannot judge	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Information given by radiology staff	64	40	54	33.7	4	2.5	19	11.9	19	11.9
Radiographers' communication skills	94	58.8					66	41.2		
Level of expertise	142	88.8	6	3.8	1	0.63	2	1.3	9	5.6
Caring attitude of the staff	145	90.6	15	9.4						

In general the patients were satisfied with the amount of information provided by the radiology staff. This included both oral and written information in 64/160 (40%); radiographers' communication skills in 94/160 (58.8%); perceived level of expertise in 142/160 (88.8%), and the staff's caring attitude in 145/160 (90.6%). Fifty-nine percent (94/160) of the patients responded that the attitude of the staff was of major importance; 40% (64/160) said it was of great importance, and 1% (2/160) of no importance. The majority of patients were very satisfied with their care during their visit to a radiology department. When asked whether patients felt well taken care of by the staff, 91% (146/160) answered that they strongly agreed and 9% (14/160) agreed to a large extent. Fifty-three percent (85/160) found this point of major importance, 44% (70/160) of great importance, 2% (3/160) of no importance and 1% (2/160) could not take a position. When asked about their MR experience, 64% (102/160) of the patients answered that it was very good, 32% (51/160) good, 3% (5/160) bad and 1% (2/160) had no opinion (41).

Patient satisfaction regarding the radiographers' communication skills were significantly higher according to reports from patients between 45 and 81 years old (mean age = 68) than from patients between 18 and 58 years old (mean age = 35). See Figure 9 (41).

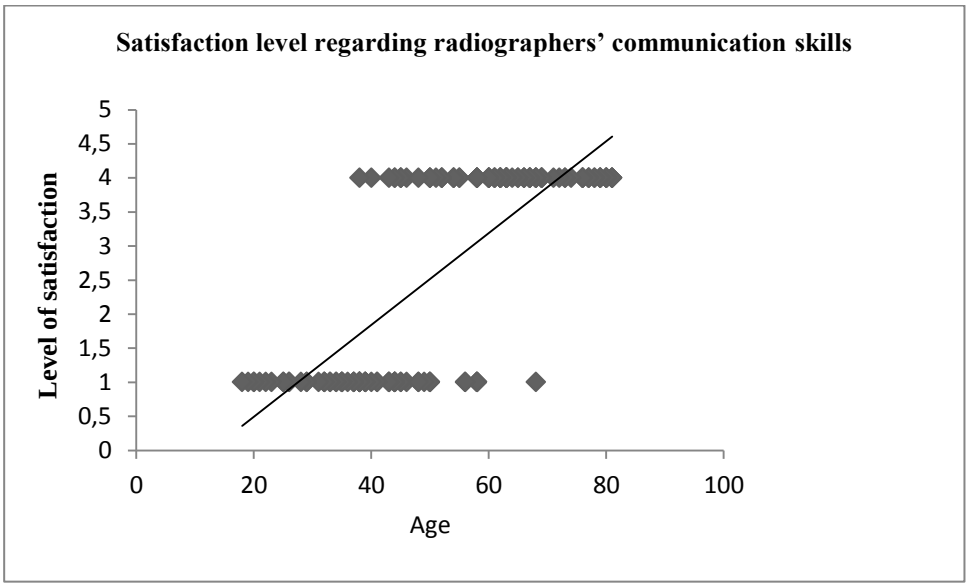

Figure 9. Satisfaction with the radiographers' communication skills and patient age was correlated at the level of about R=0.76 and R2=0.57 (41).

4. 2.3 Waiting time including office waiting time

Twenty-nine percent (46/160) of the patients had waited less than one week between their referral and the MR examination; 60% (96/160) between one and four weeks; 6% (10/160) between one and two months; 2% (3/160) had waited three months or more and 3% (5/160) did not know their waiting time. When patients were asked what an acceptable waiting time for an MR examination would be, 23.1% (37/160) responded less than one week; 64.4% (103/160) one to four weeks; 9.4% (15/160) one to two months, and 3.1% (5/160) did not have an opinion. The less acceptable waiting time reported (between one to four weeks), was significantly ($p < 0.001$) lower among the patients between 18 and 38 years old than among those between 48 and 81 years old. For 64 (40%) of the patients, a short time in the waiting-room was linked to a positive response regarding returning for a further MR examination (41).

4. 2.4 Choice of radiology department and patients' freedom of choice

When patients were asked whether they could choose or influence where their MR examination would be performed, 27.5 % (44/160) of the patients answered Yes; 69.4% (111/160) answered No, and 3.1% (5/160) replied Partly. When patients were asked how important this freedom of choice was, 23.1% (37/160) replied that it was of major importance; 30% (48/160) of great importance; 24.3% (39/160) of little importance; 11.3% (18/160) of no importance, and 11.3% (18/160) had no opinion on the issue. Ninety (56.3%) of the patients who participated in this study, believed that it was their physician who decided where their MR examination should be performed.

Aspects that influenced the patient's choice of radiology unit were: short waiting time 79.4% (127/160); ease of travelling to the radiology department 68.8% (110 /160), and short distance to their home or work 58% (93/160) (41).

4. 2.5 Improving patient satisfaction

When asked whether the staff could have done anything to improve the MR examination, 87% (139/160) said No and 13% (21/160) responded Yes. Those who responded positively commented that they would have liked to have better information about the examination and more instructions during the procedure (41).

4.3 STUDY III

4.3.1 The practical impact

The experience of all the referring physicians interviewed was that it often takes a longer time to manage outsourced examinations and also that many of the outsourced examinations cause additional work because they need to be reassessed by the radiologists in the University Hospital. Their opinions were that examination results were frequently not comprehensive, especially with regard to comparison with previous examinations. Moreover, all the physicians thought that their department had to pay twice for an outsourced radiological examination because reassessment was needed. Five out of ten clinicians had encountered insufficient documentation in the patients' files when MR examinations were outsourced (76).

4.3.2 Referring physicians' considerations with regard to outsourcing

All referring physicians would consider outsourcing if the patient requested it or if the location of the outsourced units was geographically more convenient for the patient. Three physicians would not consider outsourcing if the external units did not share a common patient file system with the hospital. Four of the physicians would consider outsourcing if the external units provided the same quality as in-house examinations (76).

4. 3.3 Radiological services

When referring physicians were asked, "What are your expectations of a radiology department in addition to providing high quality interpretation?" six of them answered that multi-disciplinary conferences provide a mutual, knowledge-enriching forum for improving expertise. Seven of the referring physicians responded that consulting radiologists play a crucial role in enhancing their understanding of the radiological interpretations and images. Five referring physicians answered that they would like unlimited access to the radiological

images. All physicians interviewed were very satisfied with the multi-disciplinary conferences that the University Hospital provided (76).

4.3.4 The emotional impact

All the referring physicians had more faith in radiologists' expertise at the University Hospital and they were upset to observe that it was the lack of resources that forced the Radiology Department to outsource some of their referrals to private units (76).

4.4 STUDY IV

4.4.1 The number of outsourced CT examinations

During 2013 and 2014, the Departments of Hematology and Oncology referred a total of 7,757 and 8,202 CT examinations respectively to the University Hospital. Forty percent of examinations (3,114) were outsourced during 2013, and 31% (2,537) during 2014.

4.4.2 Management time

In three cases a precise management/processing time calculation was not possible because files were missing in the patient journal system.
The total management/processing time was significantly shorter ($p = 0.47$) in Group OsC (37 days, range 9 - 185) compared to Group OSnC (43 days, range 10 - 243). The management time for examinations that did not need reinterpretation was significantly longer ($p = 0.002$) in Group OSnC (43 days, range 10 – 243) than in Group IH13 (19 days, range 0 – 204). The differences in total management time observed during 2014 between Group IN14 (42 days, range 0 - 282) and Group OsC (37 days, range 9 - 185) was not statistically significant ($p = 0.63$).

Time between the writing of the referral and obtaining the report by the referring physician was shorter ($p = 0.55$) in Group OsC (24 days, range 7 - 163) compared to Group OSnC (34 days, range 7 - 235). The processing time for examinations was significantly longer ($p = 0.4$) in Group OSnC (34 days, range 7 - 235) than in Group IH13 (14 days, range 0 –198). The differences observed during 2014 between Group IN14 (28 days, range 0 - 128) and Group OsC (24 days, range 9 - 163) was not statistically significant ($p = 0.61$).

4.4.3 Patient waiting time

In Group IH13 during 2013, the total number of referrals with a specified timeframe was 35/66 (53%) and the University Hospital met referring physicians' requirements in 23 cases. In Group OSnC, the total number of referrals with a specified timeframe was 47/66 (71%) and the external radiology units were able to meet requirements in 28 cases.

In Group IN14 during 2014, the total number of referrals with a requested timeframe was 40/66 (61%) and the University Hospital met referring physicians' requirements in 28 cases. In Group OsC, the total number of referrals with a requested time frame was 44/66 (67%) and the external radiology unit was able to meet requirements in 29 cases.

When a timeframe was specified in the referrals, the waiting time for patients was shorter for Group OsC compared to Group OSnC. This result was not statistically significant (p = 0.956) (Table 11).

Table 11. Patient waiting times in days for Groups BI and BII (outsourced) for CT examinations with specified timeframes.

Groups	Mean	Standard deviation	Range	P value
OSnC (n=19)	6.42	5.79	(1-26)	
OsC (n=15)	6.53	6.05	(0-18)	0.956

4.4.4 Cost

CT examinations in Group IH13 (in-house) during 2013 were significantly cheaper than examinations in Group OSnC (outsourced), even though the price of reinterpretation (p = 0.30) was taken into account. During 2014, total costs for the CT examinations in Group IN14 (in-house) were, on average, higher than those in Group OsC (outsourced) (Figure 10). The differences observed in the cost of CT examinations and the accompanying price of reinterpretations between the groups was statistically significant (p< 00002).

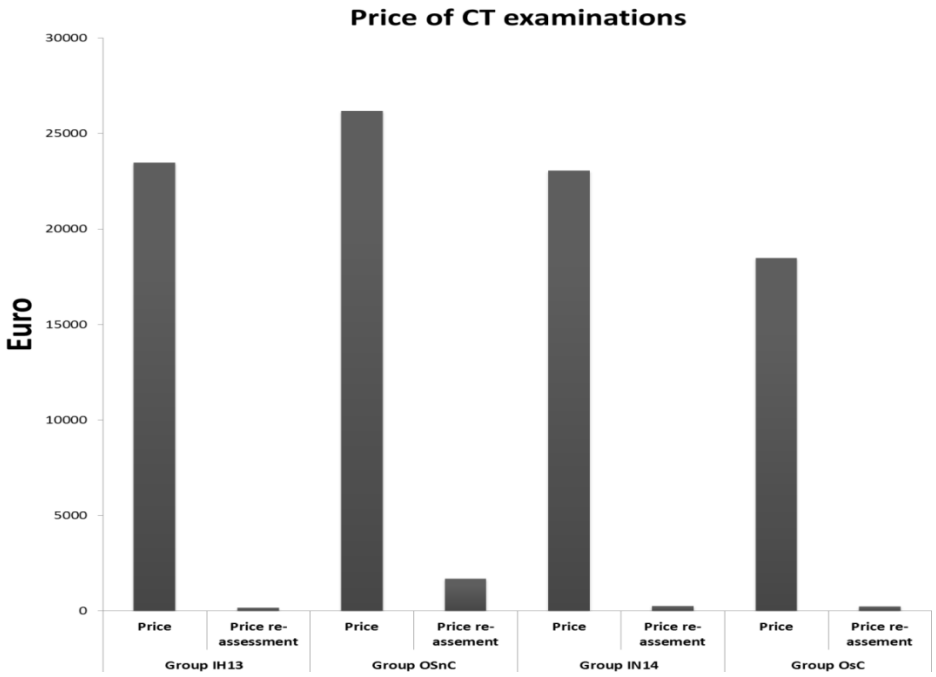

Figure 10. Total costs in Euro for the CT examinations plus costs for reinterpretation in Group OSnC (outsourced without a detailed plan for cooperation) were, on average, higher than those in Group IH13 (in-house) during 2013, while total costs for the CT examinations plus costs for reinterpretation in Group IN14 (in-house) were, on average, higher than those in Group OsC (outsourced based on a contract) during 2014.

4.4.5 Administrative costs for each outsourced CT examination

The cost of administrative work for the in-house referrals is included in the University Hospital's ongoing operating costs, while the cost of the administrative work for each referral outsourced was €7.50.

4.4.6 Redoing of CT examinations

No examination in either group was found to need additional imaging procedures related to the CT examination.

4.4.7 Reinterpretation of CT examinations

A total of four examinations in Group IH13 and IN14 (in-house) had to be reinterpreted during 2013 and 2014 compared to 16 examinations in Group OSnC and OsC (6%, 4/66 vs. 24%, 16/66; p = 0.002). Fewer examinations in OsC needed additional reinterpretation of images than in Group OSnC (3%, 2/66 vs. 21%, 14/66; p = 0. 0008).

4.4.8 Reinterpretation's impact on patient treatment

The results showed that a total of 20 radiology reports out of all CT examinations (n = 264) observed in this study required reinterpretation. Inter-rater agreement is shown in Table 12.

In general, the agreement as to how a reinterpretation changes the condition of its previous interpretation (radiology report) was minor between the two reviewers (kappa value = 0.119; p = 0.248) as shown in Table 13. In summary, according to Rater One, in eight cases out of 20 the reinterpretations had changed the diagnoses that were able to influence patient treatment. Rater Two found two such cases.

Table 12. Frequency of changes for Rater One and Rater Two.

	Rater One	
	Frequency	Percent
No changes	7	35.0
Changes in findings, but these do not change patient treatment	0	00.0
Adds new findings, but does not change patient treatment	2	10.0
Adds new interpretation, but does not change patient treatment	3	15.0
Adds new findings and does change patient treatment	2	10.0
Adds new interpretation and does change patient treatment	6	30.0
Total	20	100.0
	Rater Two	
	Frequency	Percent
No changes	12	60.0
Changes in findings, but these do not change patient treatment	2	10.0
Adds new findings, but does not change patient treatment	3	15.0
Adds new interpretation, but does not change patient treatment	1	5.0
Adds new findings and does change patient treatment	0	0.0
Adds new interpretation and does change patient treatment	2	10.0
Total	20	100.0

Table 13. Agreement of changes for Rater One and Rater Two.

Measure of Agreement		Asymptotic Standard Error (Not assuming the null hypothesis)	Asymptotic Standard Error (Assuming the null hypothesis)	Estimated Significance
Kappa	.119	.110	1.156	.248
N	20			

5 DISCUSSION

5.1 MANAGEMENT TIME

The first retrospective study demonstrates that outsourced MR examinations from a university hospital to private radiological units were associated with shorter overall management/turnaround time compared to matched examinations that were conducted in-house. On the other hand, according to the ten referring physicians interviewed, it was felt that it takes a longer time to manage outsourced examinations.

Informant: "We lose so much time sending images [examinations] out [to the private units] and consequently reviewing them again."

The results of Study IV showed that during 2013 the total management time was significantly shorter ($p = 0.472$) in Group OsC (outsourcing based on contract) compared to Group OSnC (outsourcing without a detailed plan for cooperation). There are some theories about the perception of time and a common statement is that temporal and non-temporal variables may have an impact on perception (59). A person's perception of time (duration) can be influenced by non-temporal characteristics of an activity. Whether the person is being passive or active may affect the subjective judgment of duration, active time being perceived as shorter than passive (89). Radiology departments could improve the perceived quality of management time by establishing routines which enhance the involvement (active variable) of the referring clinics regarding outsourcing diagnostic imaging (90, 91). The results showed that management time between the writing of the referral and the referring physician's obtaining the report for MR and CT examinations that were outsourced without a detailed plan for cooperation differ from each other. This result may be due to the fact that time required to perform the examinations are different for these modalities. Future studies in the subject are required.

5.2 PATIENT WAITING TIME, PATIENTS' AUTONOMY AND THEIR EXPERIENCE OF CARE

The first and the fourth studies showed that both MR and CT examinations outsourced from the University Hospital to private radiological units were performed within the requested timeframes as often as those performed in-house. Sixty percent of the patients waited between one to four weeks from the date of their referrals until the MR examinations were performed and 65% of the patients regarded that as acceptable. This indicates that both the radiology departments at the University Hospital and the private radiology units are meeting the patients' expectations fairly well. In order to make optimal use of medical resources, public hospitals should recognize the best opportunities for patients and provide an appropriate, coordinated effort between different caregivers (92, 93).

The results of Study II showed that 69% of the patients believed that they could neither choose nor influence where they would have their MR examination. The

Swedish healthcare system is designed to make patients more involved in making decisions about their own health. According to health professionals, one important dimension of autonomy refers to making decisions and choices freely (94, 95, 96, 97, 98). Fifty-six percent of the patients (89/160) believed that it was their referring physician who decided where the MR examination would be performed, whereas in reality this was a decision made by the Radiology Department. It is natural that the patients, being unaware of the hospital's policy, generally expect the physician to take on the role of decision-maker (99). The physician is the closest link between the patient and the Radiology Department. Patients often believe that the physician interprets their radiology examinations because patients and their diagnostic radiologist never meet. "*Legally, the radiologist is accountable to the patient, but in most cases the patient has had no say in the selection of the radiologist" (100, Page 334).* Either the in-house or external radiologist is supposed to provide the diagnosis. Although radiologists play a crucial role in patients' healthcare, the radiologists and radiology services are invisible to them. The outsourced radiologists are even less connected with the patients and the referring physicians (99).

It appeared from the study results that patients would have liked to have better information about the examination and more instructions during the procedure. Often patients scheduled for an MR examination receive a written invitation that encloses some information about the MR procedure. The advantage of written information is that patients can read the information as many times as they need (13, 101). The advantage of oral information is that it provides an opportunity for communication between the patient and staff that can remove possible misunderstandings (102). Previous studies have shown that communication is a very important aspect of quality patient care (103, 104, 105, 106).

5.3 EXAMINATION COSTS

The results of the quantitative parts of this thesis showed that outsourcing MR examinations without a detailed plan for cooperation and contract-based outsourcing of CT examinations did not increase costs but in fact led to a calculated total decrease in costs. Conversely, outsourcing CT examinations without a detailed plan for cooperation did increase costs and the referring physicians (the qualitative part of this thesis) were of the opinion that outsourced examinations were accompanied by higher overall costs. Healthcare providers, who observe negative outcomes from outsourcing and the consequent difficulties for their institutions, often use the tools of legislation and reimbursement as protection (107). The only protection against the outsourcing of medical services in our digitally globalized world is to offer the maximum quality of care at the minimum cost (108).
The results of our studies must be put into the context of the Swedish healthcare system and the perspective of the Zero-Based Budgeting system in the University Hospital. Within this system, hospital departments have a defined budget where each procedure performed is regarded as a cost. If these budget estimates are

exceeded, the customers/patients become a burden on, rather than an asset to, the Radiology Department. University hospitals are also usually large organizations with a range of administrative, research and educational activities, and costs in such a setting are difficult to calculate and compensate, since the different activities are performed together. On the other hand, private radiological units could be driven by productivity and the number of patients examined. Such organizations are more flexible and might accustom themselves more easily to changes in the need for radiological procedures. It has been shown that when public hospitals have attempted to alter their organizations to adopt changes in the market environment more readily, in many cases they have faced problems with organizational structure (109). In contrast to public healthcare organizations, private caregivers have more flexibility, particularly in adjusting their governance structure to changes in the market (110).

It is important to determine who are the customers or receivers in the context of our study, namely the University Hospital's Radiology Department, the referring clinics, the patients or all of them? It is also important to view the results of our study within the context of the University Hospital's economic policy, where each department has a defined budget. The budget in this policy is judged by means of justifying the previous year's results by using various indicators such as operating and maintenance costs. These indicators work well when the goal is to control costs and the objective is seen as controlling the cost of providing radiological services rather than profit maximization (111, 112, 66). It is important for any organization to separate the roles of customer and provider, and use a contract as a basis for service delivery (113,114). Therefore, the referring clinics can be seen as the Radiology Department's customers; the patients as the referring clinics' customers, and the University Hospital's Radiology Department as the private radiology unit's customer. The referring clinician's finances work well when fewer examinations need additional image reassessment. This situation does not necessarily apply for the University Hospital's Radiology Department, because that department is not using real l finance, as each year's budget is decided in advance. One can argue that in this continuum of care the patient is the true customer, who deserves to receive the best quality of care. However, radiological services play a central role in healthcare operations and are an important element of patients' quality of care. Quality in healthcare is not just an abstract term, but also an extensive and important subject. Indeed, in broad terms, care quality is about patient satisfaction (115, 116).

5.4 QUALITY OF THE INTERPRETATIONS

We observed a statistically significant difference concerning the need for additional interpretation between in-house and outsourced (without a detailed plan for cooperation) MR and CT examinations. All the referring physicians interviewed also experienced lower quality regarding the reports on outsourced examinations. The reason might be that the referring physicians felt more comfortable with the

radiologists at the University Hospital because they work more closely with them than with those in the external units. Examinations in the outsourced group required more extensive reinterpretation. The higher frequency of reinterpretation in this group can be explained by the fact that most of the in-house examinations were discussed for the clinicians at the regular weekly conferences held between them and the radiologists. One disadvantage of the use of internet-based communication systems between the referring physicians and the radiologist might be the increased risk of loss of important patient information, and the reduced opportunities for maintaining a professional bond between both groups (117).

The quality of outsourced reports is a challenge not only for the referring physicians at the University Hospital, who assume that outsourced radiological examinations often need additional imaging, but also for referring radiologists and those radiologists who produce the reports on outsourced examinations. For these radiologists, the amount of available clinical information is sometimes limited, as is access to patient file systems available at the University Hospital.

Outsourced examinations that are reinterpreted at multi-disciplinary conferences may also represent a challenge for in-house radiologists. Outsourced radiological examinations are not necessarily performed to the standards that the hospital uses. On other hand, the results of our study showed that fewer CT examinations in Group OsC (outsourced based on a contract) needed additional reinterpretation of images than in Group OSnC (without a detailed plan for cooperation). This decrease may be due to using the same performance protocol for CT examinations and writing the interpretations with comparison to relevant previous imaging.
The results showed that the experience of outsourcing radiological examinations differs between referring physicians and the patients. The referring physicians' opinions on outsourcing relate to their previous experience of what constitutes quality in a radiological report. Patients' experiences of outsourcing relate to integration of services. Referring radiologists want to maintain acceptable patient waiting times and their experiences regarding outsourcing radiological referrals deserve to be studied. Although outsourcing diagnostic imaging at the University Hospital can be justified by reducing patient waiting time, it may also have a positive impact on the quality of patient care. This is especially true if it focuses on improved access to specialized care that would otherwise be inaccessible, and if it also allows patients to get services from the best provider (48). Outsourcing that is focused on quality may also have other advantages, particularly for patients, and even internal providers may welcome outsourcing that reduces their high workload (23).

With respect to examination quality, we chose the number of examinations reassessed, re-imaged or repeated as surrogate markers. The result of the fourth study showed that in eight cases, according to Rater One, the reinterpretations had changed the diagnoses such that they were able to influence patient treatment. According to Rater Two, there were two such cases. This result indicates that

reinterpretation cannot be a meticulous parameter by which to measure the quality of the radiology report. Direct communication between radiologists and referring physicians can reduce irregularities attributable to ineffective communication of the radiology report (118).

We did not review the radiological examinations to look for specific details in imaging quality. Moreover, these studies did not take into account the impact on diagnostic accuracy of outsourcing radiological services. While the effects on the patients' health by outsourcing radiological examinations may not be relevant in the short term, they could be of major importance in the long term (40).

5.5 RADIOLOGICAL SERVICES

According to seven of the referring physicians, consulting radiologists play a crucial role in enhancing their understanding of radiological interpretations and images, and the fact is that we observed a larger number of requested reassessments in the group of outsourced examinations. This might reflect a need for direct communication between radiologists and referring clinicians at the University Hospital and the departments that take care of outsourced examinations. Direct communication with radiologists at a radiology conference is a service which the private units do not yet provide and there is currently no broad, public healthcare-based, organized system for networking in radiology. Communication of the imaging reports shortly after performing the radiological examinations improves patient care and can even reduce management time and costs (119). The impact of such swift communication of examination results as a factor that influences management time remains to be further studied.
Outsourcing medical care provokes changes in many healthcare organizations, indicating the need to rebuild a new functional structure for medical services (120).

> "...the outsourcing of health care will grow; it will challenge traditional arrangements between patients and both physicians and institutions; it will require rapid and thoughtful development of new ethical, legal, and quality standards; and it will be controversial" (29, p. 665).

The University Hospital Radiology Department's communications plans should include communicating organizational objectives and priorities with diverse units, whether internal or external private units. This would provide internal customer service through identifying referring clinicians' needs/expectations and would allow for a shared, radiologist-clinician decision-making process regarding outsourcing radiological examinations (121).

Radiology departments that support multidisciplinary teamwork with referring clinicians and facilitate communication between radiologist and referring clinicians can improve patient outcomes. Proper communication between healthcare professionals is a basic prerequisite for the delivery of quality patient care (122).

5.6 CONSEQUENCES OF OUTSOURCING

One limitation with the outsourced examinations is the communication of the results to the clinicians. One way to prevent this problem could be outsourcing the examination but not its interpretation. Another negative consequence of outsourcing is that it may lead to the rarer and more complex types of radiological examinations being performed in-house (3) and only routine examinations being outsourced. This could have a negative impact on external radiologists' and radiographers' professional education and affect their competence. On other hand, this could lead to increased work dissatisfaction amongst in-house radiologists and radiographers, who might come to resent performing only those more complex examinations of critically ill or injured patients. Indeed, these aspects deserve to be studied further. Outsourcing could also limit in-house investment in both apparatus and personnel recruitment in the long term. Reduced investment might reduce future revenues and indicate either a decreased ability to create value or the loss of effectiveness. Investment that might involve capital costs today could well lead to future value creation (123).

Outsourcing is one of the major issues in healthcare today. Two of the issues related to public healthcare outsourcing are concerned firstly with the quality and correctness of the services and secondly with cost-effectiveness (35). It has been shown that cost-effectiveness analysis can also be used to evaluate the outsourcing capacity. The majority of existing studies about cost-effectiveness analyses are based on the perspective of cost-effectiveness to a large community and are thus considered as instruments for public economic policy (124, 125). In our study, we were more interested in cost-effectiveness from the University Hospital's organizational perspective. However, cost-effectiveness analysis as a technique is useful for evaluating an organization's overall efficacy, because it can provide considerable insight into the cost-efficiency of any organization by ensuring that all resources are used and distributed in the best way possible to achieve the maximal favorable outcome (126, 127, 128). Outsourcing MR and CT examinations from the University Hospital's Radiology Department involves the issue of timely diagnosis and treatment for patients. The main desired results from outsourcing are to reduce both patient waiting times and workload pressure on in-house staffs. However, the reality seems to be that outsourcing radiological services is accompanied by administrative work that can make the system less efficient. The referring physicians prefer that the examinations be performed at the University Hospital and not outsourced.

Informant: "We want all the examinations to be performed here [at the University Hospital]."

All ten physicians were aware that lack of resources forces the Radiology Department to outsource its services and argue that the negative results of

outsourcing could have been obviated by directing more resources into the University Hospital.

The results also showed that patients in general had an overall positive experience when being sent to private radiology units. Satisfaction with care usually arises when there is no discrepancy between patients' expectations and the care received (73). It is important to consider whether the benefits of outsourcing can exceed the negative consequences (129). Finding the balance between the consideration of quality patient care and being driven by cost-effectiveness is a major challenge for healthcare.

The complexity of outsourcing requires thorough economic evaluation rather than a superficial cost analysis (130). However, Study I in this thesis did not investigate ways of making the outsourcing of radiological examinations cheaper. In fact, the system for outsourcing radiological services from the University Hospital was developed without any defined criteria and also without any formalized cooperation between the public and private units. One assumption was that the benefits of outsourcing could be improved if such cooperation could be organized within the healthcare system, especially if communication between private units, the referring physicians and the radiology departments could then be improved. In other words, the efficiency of the outsourcing process in the Radiology Department at the University Hospital could be improved by means of developing clear referral pathways between referring physicians and the external radiology units, by identifying outsourcing requirements and by agreeing on effective practice. Only a proper contract can guarantee a gain from outsourcing (131).

5.7 IMPACT OF HAVING A CONTRACT ON OUTSOURCING OUTCOMES

Our results showed that during 2013 the University Hospital outsourced 40% of referrals for CT examinations and 31% during 2014. The reason for the reduced number of outsourced CT examinations could be due to the fact that in 2014 the Radiology Department at the University Hospital initiated a contract for outsourcing CT examination referrals to a private radiology unit. As a result, coordinators for outsourcing CT examinations referred from the Departments of Hematology and Oncology have been employed. These coordinators are responsible for creating a holistic overview of the hospital's ability to meet the referring departments' requests, selecting protocols for the performance of CT examinations, controlling the delivery of outsourced radiological services and communicating with the external radiology unit throughout the contract. As a consequence of having this contract, this holistic approach may have influenced the strategy and decision-making processes for outsourcing (132), resulting in fewer outsourced CT examinations due to more efficient use of internal resources. The results also showed that CT examinations performed internally during 2013 were cheaper than

those outsourced without a detailed plan for cooperation. Good financial management and outsourcing process management are two inseparable components of an organization. Studies have shown that cost-effectiveness is often the main argument for outsourcing radiological services (133).
The result of our fourth study showed cheaper, shorter total management time and patient waiting time for Group OsC (outsourcing based on a contract) compared to Group OSnC (outsourcing without a detailed plan for cooperation). The results indicate a potential benefit in the outsourcing practice when there is a contract. As previously shown, one way to evaluate whether outsourcing can reduce costs, increase quality of service, and improve confidence in quality commitment, is to assess the capacity of the outsourcing contract to protect the customer's interest (134, 135).
The results also showed that fewer examinations in Group OsC needed additional image reinterpretation than in Group OSnC. This decrease may be due to using the same performance protocol for CT examinations and writing the interpretations. This joint practice allows the outsourced radiology report to adopt the same style as the Radiology Department's report at the University Hospital, to which referring physicians are more accustomed (136).

> It is essential that the customer company fully disclose its expectations for quality and service levels, and the means for measuring performance within the outsourcing contract. The outsourcing contract must contain a detailed description of all expectations of vendor performance since service levels for in-house functions are commonly used as the benchmark for outsourced functions (137, Page 1659).

However, an ideal outsourcing contract consists of several key elements: it must have performance and financial parameters, be based on solid principles, and be supported by appropriate human resources (114,138).We did not study the impact of outsourcing radiological examinations on human resources such as the radiologists' and radiographers' workload, work satisfaction and competence.

5.8 OUTSOURCING THEORIES

"*Outsourcing has a very complex structure, which consists of numerous activities and functions giving rise to a series of administrative and managerial dilemmas"* (139, Page 573).

There are several theories concerned with outsourcing, such as transaction cost economics theory, neoclassical economic theory, resource-based theory, core competencies theory, relational and social exchange theories. Each theory has specific recommendations for success factors that can contribute to making outsourcing planning as effective as possible (139). These theories have been studied on the basis of different stages or phases of the outsourcing models. The

five stages that are usually involved in outsourcing models are: preparation, selecting the external supplier, transition, management of relationship and review stages (140,139).

According to the *neoclassical economic theory*, outsourcing is motivated by profit maximization (141). The *transaction cost economics theory* is the most commonly used outsourcing theory. This theory suggests helpful decision-making tools to guide the managers of organizations in determining which of their procedures or actions should be performed internally and which should be outsourced, and how to handle organizational changes that could arise from outsourcing (142,143). *Resource-based theory* focuses on the preparation stage of outsourcing and suggests a model which targets detecting the factors influencing the advantages and disadvantages of outsourcing at the preparation stage (144). The *core competencies theory* is an evolution of resource-based theory and is defined as the general knowledge of an organization with respect to the manner in which to incorporate different methods and skills (145, 146). The *relational theory* focuses on how organizations can obtain and keep a competitive advantage over other organizations (147). This model has been used to study all stages of the outsourcing process. According to Yahnhong (148), the advantages of the outsourcing process are influenced by the quality of the relationship between contracting parties. The *social exchange theory* suggests economic cost-benefit analysis as an obligation for social exchange. The theory assumes that the sharing of resources is an ultimate form of interaction between contracting organizations' human resources. The social exchange theory is considered as a model that focuses on the review stage of the outsourcing process (140,149,150).

Although there are hints of some of the above-mentioned theories within transaction cost economics theory and relational theory, we could unfortunately find no single outsourcing theory to fit our studies. This is firstly because outsourcing radiological examinations from the University Hospital is driven by the need to reduce patient waiting time and lighten workload. Secondly, outsourcing itself as a profit-oriented theory or model is not applicable to the University Hospital's economic structures. Usually, the practice of outsourcing is shaped by the company's type, goals and needs (149). Finally we did not study the University Hospital's outsourcing model and the nature of the contract in Study IV. The outsourcing model, the nature of contract and their impact within the context of outsourcing radiological examinations should be studied further.

5.9 COMMENTS

The studies have some limitations. Firstly, a retrospective method has been used in both Studies I and IV. A constraint of retrospective studies is the researcher's inability to control data. Secondly, a sample of examinations from a two-year period (2005 and 2006) and from one oncology referring department was selected in Study I while in Study IV, we were only able to examine patients who were referred from the Hematology and Oncology Clinics. Therefore, selection biases were introduced

that may affect the generalizability of these studies. The inability to include a larger cohort of patients in Study IV could lead to an overestimation of both the advantages and disadvantages of outsourcing management approaches. Thirdly, it must also be taken into account that the decision to outsource the examination by the radiologist may introduce a bias within the selected examinations. The outsourced referrals may have been those with a preferred, specified, shorter timeframe than those at the hospital. Another limitation of Study I is its focus on the time periods of the first quarters of 2005 and 2006. At that time, the PACS system had only recently been implemented in the hospital. It is likely that the PACS system was not yet used as optimally as in private units with longer experience with PACS. Our study did not investigate these differences, but it hampered our ability to obtain the correct data for our calculations concerning the total cost. Moreover, optimal use of PACS can be a variable to explain the decrease in administrative costs that was shown in Study IV. According to Oreg (151), "routine seeking" is a significant factor of resistance to any change in an organizational setting. Routine seeking is based on the staff's reluctance to adapt to new practices. Resistance to change can also be related to the organizational culture and subcultures. Studies have shown that several subcultures may exist in an organization (152,153, 154). In such organizations, the implementation of new practices takes a longer time (155). The University Hospital is a large organization and it has a mixed cultural profile.

A limitation in Study II is that the interviews may result in a biased sample by attracting only those respondents who could and were willing to participate. The results showed high satisfaction with the patient care, which could be caused by the fact that displeased patients did not participate (156). For this reason, we may not be able to generalize the results. Another limitation in this study is that we studied those dimensions of care quality during MR examinations, which were most closely related to patient nursing. However, the quality of care related to MR examinations involves other factors, such as the radiologist's level of expertise, work experience, knowledge, workload pressure, as well as work satisfaction, all of which may have a major impact on the quality of the interpretation. Indeed, these factors should be studied further. Patients undergoing MR examinations usually come into contact with radiographers, but they seldom have direct contact with radiologists (76).

Limitations in Study III are as follows. First, we achieved 'data saturation', i.e. no more new information (codes) emerged during the analysis (157,158), after interviews with a small number of referring physicians. A second limitation is that this study assessed the outsourcing experience and it is possible that personal views influenced that experience (41). How different people perceive outsourcing depends on their subjective interpretation of the phenomenon. Another limitation is that the analysis may represent an insider perspective (159,160), because all the authors work in the Radiology Department of the University Hospital.

Finally, since October 2014, the private radiology unit has begun to provide internet-based, multi-disciplinary conferences on a weekly basis for referring

physicians, but we did not study the impact of internet-based, multi-disciplinary conferences on requests for reinterpretation in Study IV.

Even if the results of our studies are not generalizable, we believe that these studies could be of interest to other public hospitals which choose outsourcing as one solution for improving the efficiency of their departments.

6 CONCLUSION

Outsourcing magnetic resonance examinations is one potential solution for reducing patient waiting times. Outsourced examinations need more frequent reinterpretation. The discrepancy between patients and referring physicians indicates that there is insufficient communication between referring physicians and the radiology departments. When considering outsourcing, the needs of the patients, of the referring physicians, as well as those of the radiology departments must all be considered, to optimize patient care. For better utilization of radiological services, radiology departments must consider the customers' needs and safeguard them through a proper contract. Using a contract for outsourcing examinations may be an effective way of reducing patient waiting times. Outsourcing based on a well-founded contract can be cost-effective, compared with outsourcing without a detailed plan for cooperation. The impact of outsourcing radiological examinations on radiologists' and radiographers' competence should be studied further.

7 MAIN RESULTS

In summary, the results of the studies showed that outsourcing MR examinations from a public University Hospital to private radiology units was associated with shorter overall patient waiting times compared to in-house examinations. Outsourced examinations were more frequently reassessed at the University Hospital, indicating a lower quality of the interpretation of the outsourced examinations and/or a need for conference communication regarding the report. However, with everything taken into account, outsourcing the examinations led to an overall decrease in costs. The patients interviewed in this study had a generally positive experience when being sent to private radiology units. The key factors of care quality that have positive impacts on patients who undergo MR examinations are: adequate information concerning the MR examination, more instructions during the procedure, the staff's attitude and their level of expertise. The referring physicians interviewed had negative opinions about outsourcing. Contract-based outsourcing was associated with shorter overall management time, shorter patient waiting time and lower costs compared to outsourced examinations without a detailed plan for cooperation and those performed within the Radiology Department at the University Hospital.

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