COST OPTIMIZING IN INTERVENTIONAL OZONE SPINE THERAPY

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ABSTRACT

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Back pain is cost-intensive, as it is often the reason for sick leave and causes high direct and indirect costs. There are no comprehensive and meaningful studies that perform a cost-benefit analysis between MRI-guided and CT-guided interventional spinal O3 nucleolysis from both a medical and economic perspective. This study used a qualitative case method to provide insights into a problem and help develop hypotheses by calculation the real costs of MR-guided and CT-guided O3 interventional spinal neucleolysis. This module must take into account all variable and constant variants (acquisition costs, personnel costs, maintenance costs, etc.) and long term costs because of radiotaion exposure. In this study is the average intervention time for MRI guided interventions was 24.9 ± 6.3 minutes (range: 17 – 36 minutes). Preinterventional patient preparation took an average of 22 minutes, while postinterventional activities took an average of 9 minutes. A CT guided intervention took an average of 19.7 ± 7.9 minutes (range: 5 – 54 minutes) with an average of 20 minutes of preinterventional preparation and 9 minutes of postinterventional activities. The approximated average effective dose for CT-guided interventions was 0.48 ± 0.51 mSv (range: 0.07 – 1.92 mSv). Mean intervention time was 70.8 min (48–90 min) for MR-guided and 60.4 min (52–75 min) for CT-guided treatment. The average total costs per patient were CHF 290.29 for MR-guided and CHF 175.46 for CT-guided interventions. These consisted of (MR/CT guidance) CHF 72/29 for equipment use, CHF 99.47/84.84 for staff and CHF 118.55/61.95 for

disposables. Intradiskal Nucleolysis with O3 using MRI guidance is more expensive as using CT guidance. Given the advantages of no radiation exposure and possible future decrease in prices for MRI devices, MR-guided spinal interventions may become a promising alternative to the CT-guided procedure.

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LIST OF ABBREVIATIONS

MRT	Magnet Resonance Tomography
MRI	Magnet Resonance Imaging
CT	Computer tomography
US	Ultrasound
RG	Radiography
Sv	Sievert
mSv	Millisievert
mGy	Milligray
DALY	disability-adjusted life years
BP	Back pain
BAG	Bundesamt für Gesundheit
SI-unit	Système international d'unités
CHF	Swiss franc
Mio.	Million
Sec.	Second
€	Euro

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creation of value for customers and margin for the firm. The firm's value chain is one link in an industry value chain that links individual firm value chains from upstream suppliers to the end consumer. In this example for the imaging industry, the intermediate products of the various upstream and downstream firms are indicated and used as inputs for the next link in the chain, sequentially adding value to the final outcome, which is sustained or improved patient health (Rubin 2017). 100
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CHAPTER I:

INTRODUCTION

1.1 Introduction

To achieve long term success in the business, pain clinic owners and facilitators need to have a viable and well-detailed financial plan for the outfit. As a buiseiness owner, will have a clearer understanding of how to set pricing if we can classify and define the costs correctly. When a medical institution knows the true costs involved with producing and providing the process or services to customers, it can price both competitively and accurately. Additionally, certain health care area especially image guided minimal invasive interventional pain management is ideal market for pain management business with high rate of competition potential. Using available resources to fulfill the biggest need or, on the other hand, addressing a specific need with the least amount of resources possible are examples of cost-effective behavior. Beginning with this broad interpretation of cost-effectiveness

Essentially, calculational cost-effectiveness—which explains the connection between service revenue and expenditures for every billing period—is reached by taking a closer look at the tools utilized to measure cost-effectiveness. The financing organization for the hospital is responsible for covering the resulting {deficit} because health insurance payments do not cover the whole cost of medical care facilities' services. In light of these conditions, the critical factor is how well any healthcare facility can pay for its own operations. The decision to purchase the new medical imaging equipments (CT scan, MRI scan, etc) exclusively in digital technology (rather than analog) needs to convince medical institution funding body, as it forms a huge investment and must be consider in special investments.

Radiography is a single, but crucial, component in the assessment, diagnosis, and treatment management of the back pain patient. It may also involve neurophysologic testing and the patient's reaction to minimally invasive procedures. Pain and diagnosis using medical imaging

Therapy does not stand alone; it must be understood in the context of the entire evaluation-management process. The capacity of contemporary medical imaging equipment to capture a finely detailed and precise depiction of a patient's anatomy and pathology is frequently seen as having intrinsic value by imaging professionals. Technologically advanced imaging is valuable only insofar as it advances diagnosis, rules out dangerous disease, or points to potential areas for evidence-based therapeutic action, according to the patient and clinician who use it. Imaging is primarily used to diagnose the 5% of back discomfort patients whose pain is actually caused by an undetected underlying condition. Defining and supporting therapy planning in the extremely limited subset of patients with neural compressive disease-associated radiculopathy or radicular pain syndromes that do not respond to conservative treatment and necessitate surgery or minimally invasive intervention is a related imaging aim. As this article explains, imaging is rarely helpful in identifying degenerative disease in patients with back pain and is, at most, of secondary interest.

1.1.1 Statistical Aspects of Back Pain

An ubiquitous indicator is pain. It happens to everyone at a certain time in their existence. It is the way our bodies are capable of alerting us to a problem. There is a trauma, dysfunction, or other issue when we feel pain. It is an uncomfortable feeling that we must get rid of. Given the frequency and urgency of this customer's "need" to be pain-free, businesses should take this into account. It also indicates that there are a lot of prospects in this enormous industry; providing medicaly, technicaly and financialy adequate solutions are good points for a pain therapy business. Like many other elements of life, technology can now be a major factor in delivering improved solutions. Medical science has developed numerous therapy methods in recent years that can have positive effects. Additionally, it was noted that patients frequently find minimally invasive medical technology to be acceptable when it comes to a comfortable therapeutic experience, a low risk of problems and side effects, and long-lasting alleviation. Pain in the back is common in Western societies. In the US, it is the most prevalent and costly cause of job disability (Maus, 2010, p. 726). There is a growing trend in the assessment (diagnosis and treatment) of back discomfort with advanced imaging. According to Medicare utilization statistics, there was a 307% rise in lumbar spine magnetic resonance imaging (MRI) during the 12-year period between 1994 and 2005. There is no proof that patient outcomes have improved in spite of the more thorough review. Instead, a lot of spine imaging is frequently irrational and doesn't improve the patient's assessment in any way. In the United States, there are significant geographical differences in the intensity of spine imaging; according to recognized recommendations, between one-third and two-thirds of spine computed tomography (CT) and MRI scans are deemed unsuitable (Maus, 2010, p. 731). It is important to keep in mind that patients with back or leg discomfort are typically experiencing a relatively benign condition, both in terms of the underlying pathophysiology and the clinical course, while considering the use of advanced imaging technology. The majority of the time, back pain is clinically benign, self-limiting, and not improved by imaging tests or invasive treatments. Von Korff and associates assessed patients who had recently experienced low back discomfort. Seventy-six percent of the patients had no pain at all (21%) or mild discomfort with some impairment, and 14 percent reported considerable impairment with intermediate to severe function limitation six months after the pain began. Another study found that only 35% of patients with acute low back pain reported chronic discomfort after 12 weeks, and only 10% reported persistent pain at 1 year, compared to 70% of patients with acute low back pain who report persistent pain at 4 weeks from beginning (Maus, 2010, p. 726). In an Australian trial with two populations, between 49% and 67% of the participants recovered from low back pain within three months of starting treatment, and between 56% and 71% recovered after a year. Within a year, there was a 7% to 27% relapse rate (Maus, 2010, p. 726).

1.1.2 Medical evaluation

Low back pain that is not specific is a common issue that has significant social and economic ramifications (Maas et al., 2012, p. 5). 85–90% of low back pain diagnoses are classified as non-specific low back pain, which is defined as low back pain that cannot be linked to a distinct, identifiable pathology (such as an infection, tumor, osteoporosis, or fracture) (Maurer et al., 2013, p. 561). Most individuals with low back pain receive effective treatment in primary care; 10–15% of patients will experience symptoms that last longer than three months. The estimated cost of low back pain in Switzerland in 2018 was CHF 8.71

billion (Huber et al., 2018p. 1054). In addition, it is anticipated that in the upcoming years, there will be a rise in the population with back issues due to demographic developments (Maas et al., 2012, p. 4). Effective interventions aimed at the prevention and treatment of persistent low back pain are required due to the significant costs associated with this expanding issue.

The Patient Protection and Affordable Care Act (PPACA) has contributed to the health care system's transition to a value-based delivery model, where the goal is to provide optimal patient outcomes at the lowest possible cost (Goehler et al., 2014, p. 940). This increased emphasis on value is bringing about quick changes that will probably have an impact on payment and delivery models in all medical specialties. Diagnostic radiography as a profession confronts many issues in this shifting environment, and the literature has recently addressed a number of strategies for raising the caliber of interventional radiology services as a way to demonstrate value (Muroff 2013, Dreyer et al. 2013, Enzmann et al. 2013). These strategies involve, among other things, enhanced imaging access, unified submitting reports, and enhanced technologies that are available around-the-clock. While all of these issues are significant to patients and healthcare providers, requests for imaging or interventions should only be justified when they have an obvious effect on medical decision-making and value performance affects outcomes that go beyond the satisfaction of service beneficiaries.

1.1.3 Economic essentials

Rapid advances in medical science and technology, notable gains in health outcomes attributable to medical care, and budget-busting increases in health care spending driven by both state and private insurance have defined the past 60 years of health care in West Europe and the United States. As the country attempts to recover from a protracted financial and economic crisis, politicians and the general public have focused more on those quickly rising health care expenditures. Real per capita health spending increased almost continuously between 1950 and 2009, with the exception of a two-year hiatus in the middle of the 1990s, when the impact of managed care peaked (Fuchs, 2012, p. 976).

In affluent nations, chronic low back pain and radicular pain are quite prevalent and are linked to significant financial burdens from job absence and disability (Gatchel, 2015, p.

838). Under the direction of fluoroscopy or computed tomography (CT), patients with radicular pain who do not have satisfactory pain relief from conservative treatments, such as oral analgesics and physical therapy, can benefit from nerve root infiltration of corticosteroids and anesthetics (Maurer et al., 2014, p. 564). Both guide methods provide good bone-soft tissue contrast and near-real-time monitoring for precise and prompt interventional injection. Still, radiation exposure is a component of fluoroscopic and CT guided procedures. MRI is now a radiation-free alternative imaging method for interventional monitoring thanks to the development of rapid sequences and MR-compatible injection cannulae with appropriate needle artifacts (Ronkainen et al., 2006, p. 2858). Notwithstanding these benefits, there are still a number of barriers preventing this technology from being widely used: Since open MRI systems are not widely accessible, people believe that MRI is more costly since MR-compatible equipment is more expensive, imager utilization is more expensive, and interventions take longer (Alanen et al., 2004, p. 124).

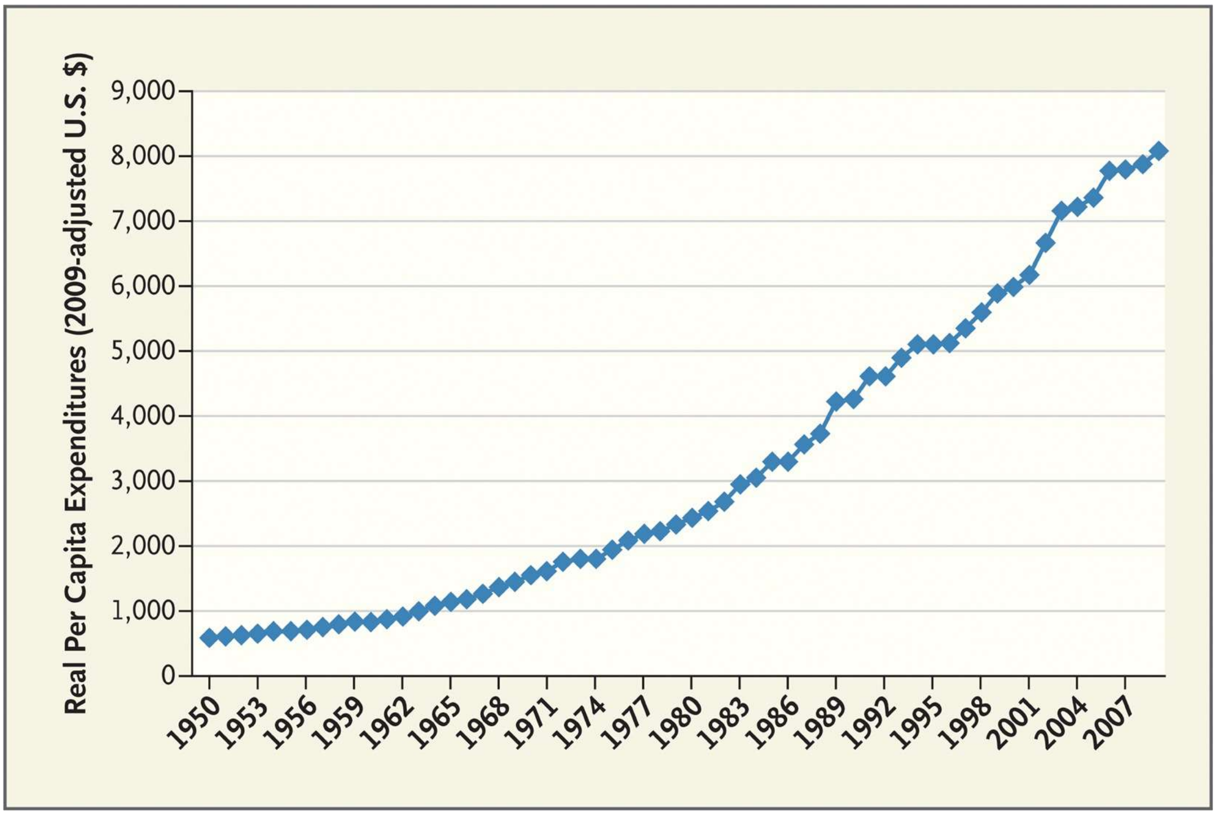

Figure 1.1
U.S. Per Capita Health Expenditures, 1950–2007 (Fuchs, 2012, p. 976)

The cost of MR compatible injectable cannulae and MRI systems has significantly decreased in recent years. Workflow improvements and a significant decrease in total expenses are anticipated with the use of faster MRI sequences and shorter intervention durations. Computed tomography is an imaging procedure that usually produces detailed images of the body region. However, this procedure is accompanied by high-energy ionizing X-rays that can penetrate the body, causing radiation exposure to the patient. Nevertheless, many in the profession have vehemently contested the idea that there might be a drawback in terms of cancer risks (Brenner et al., 2012, p. 330). Compared to people without a history of cancer, cancer survivors used medical services more frequently and spent more money on patient time each year. Our study's objective was to compare the existing costs of MRI-guided spinal ozone infiltration to CT-guided treatment by utilizing and integrating the total short- and long-term expenditures of various modality-guided spine ozone interventions.

Given that ordering imaging studies is often a complex and multifaceted decision, this study will focus on basic concepts in comparative and cost-effectiveness evaluations and value demonstration for interventional spinal neuroradiology in this evolving health care context. In particular, we argue that new applications should only be allowed if they show a significant improvement in treatment planning at the very least and a significant increase in patient outcomes at the most; Furthermore, we argue that the field as a whole will probably need to undergo a significant paradigm shift in order to meet these expectations. Before constructing your case, describe the fundamentals of comparative effectiveness evaluation. Specifically, discuss how comparative and cost-effectiveness studies involving interventional spinal neuroradiology with ozone vary from other types of clinical trials. We conclude by going over a few more topics that are pertinent to the future worth and caliber of clinical radiology.

1.1.4 Early imaging

The first topic covered in recent studies is the value of imaging when a patient has sudden, severe back or leg pain. It is well established that in this patient population, imaging—including radiography and sophisticated imaging—has no role if there is no indication of an underlying systemic disease or any symptoms of neurologic impairment that would require intervention. When Scavone and colleagues analyzed spine radiographs of individuals who had acute low back pain, they discovered that 75% of the tests produced no useful information. In a study done in the UK, patients who had been experiencing back pain for six weeks were randomized to undergo either lumbar radiography or extra clinically guided therapy. Clinical outcomes did not significantly differ during the 9-month follow-up. When a patient first presents with back discomfort, Gilbert and colleagues randomized them to receive advanced imaging (CT or MRI) or imaging only when a clear clinical indication appeared. Patient outcomes were not significantly impacted by early advanced imaging. A meta-analysis of all randomized controlled studies comparing clinically directed therapy with immediate imaging (MRI, CT, and radiography) in acute back pain patients was recently completed by Chou and colleagues. Examining the pooled data from the qualifying trials, there were no appreciable differences in pain or function between imaged and nonimaged patients in the short term (3 months) or long term (6–12 months). Chou and colleagues concluded “lumbar imaging for low back pain without indications of serious underlying conditions does not improve clinical outcomes.” (Chou et al., 2009, p. 466)

1.1.5 Imaging analysis

Not only is early imaging unsuccessful, but it is also expensive. A single day of pain treatment with radiographs taken when back pain initially manifests costs $2000 (1982 USD), according to a cost-effectiveness analysis by Liang and Komaroff. A five-year prospective observational study by Carragee and colleagues expertly shown the inappropriate use of imaging in the emergency. Lumbar spine MRIs were obtained for a large group of asymptomatic people who were deemed to be at risk for back pain caused by physically demanding professions.

This patient group was followed up with periodically over the next five years; among those who saw a doctor for acute back or leg pain, some had a follow-up lumbar MRI examination. Less than 5% of the MRI scans taken at the time of the acute presentation with back/leg pain revealed clinically meaningful new findings; nearly all of the "positive findings" noted on the images at the time of presentation with back/leg pain had been present on the baseline studies obtained when the patient was asymptomatic.

The only imaging data deemed relevant in patients with a comparable radicular pain condition was direct evidence of neural compression. Notably, psychosocial variables were the most accurate indicators of the level of functional impairment brought on by back or leg pain, rather than the anatomical features seen on imaging (Maus, 2010, p. 755). Many professional groups and organizations have released guidelines advising against imaging in the early stages of a clinical pain condition based on such findings. The Agency for Health Care Policy and Research (1994) recommended against imaging patients who have back pain during the first month of a pain syndrome and do not exhibit indications of a systemic illness. In 2007, Bradley updated the practice standards of the American College of Radiology. Imaging is not advised for patients presenting with acute low back pain unless "red flag" features are present (such as recent significant trauma, minor trauma in a patient older than 50 years, weight loss, fever, immunosuppression, history of neoplasm, steroid use or osteoporosis, age greater than 70 years, known intravenous drug abuse, or a progressive neurologic deficit with intractable symptoms). Similarly, for people presenting with nonspecific low back pain, the American College of Physicians and the American Pain Society unanimously advised avoiding imaging. The use of imaging should only be carried out in cases of suspected serious underlying systemic disease or when there are severe or progressive neurologic impairments. Additionally, individuals who exhibit indications of radiculopathy or spinal stenosis ought to have imaging only in cases where they qualify for minimally invasive or surgical interventions (such as epidural steroid injection). These guidelines emphasize even more how important imaging is in identifying underlying systemic diseases, such as neoplasms, infections, or undiagnosed traumatic injuries. (Maus, 2010, p. 746).

1.2 Research problem

A company employs a set of procedures called cost control to keep tabs on its expenses (Niţă et al., 2013, p. 308). Over time, implementing this degree of control can significantly increase earnings. It is often known that throughout the previous ten years, the cost of medical technology has dramatically increased, driving up the overall cost of healthcare (Karapiperis, 2018, p. 2). The goal of this cost control analysis is to improve the overall performance efficiency of the spinal neuroradiology department, not to reduce the amount or quality of services offered to a patient. In order to control costs, cost analysis also helps in evaluating the efficacy and efficiency of each functional component in the manufacturing process (minimally invasive spinal procedures in this example) as well as the implications of those costs (Niţă et al., 2013, p. 308). Healthcare administrators are searching for more advanced instruments to manage expenses without compromising the standard of patient care. Understanding unit cost is necessary to support planning for ongoing budgets as a measure of effectiveness and to enforce service pricing. Though there are many options accessible, the imaging equipment is now more sophisticated due to advancements in technology. The quality and cost control of these expensive investigations—CT and MRI scans, for example—should be a priority because they are vital components of patient care and current imaging technology.

Although there are many ways in which the economy and health are related, the various causal processes that characterize this relationship naturally fall into two groups. The first includes the relationships between growth rate, income distribution, and health. The second relates to the connections between health finance policies, healthcare delivery organizations, and financial results. The main factor driving the increase in actual per capita health costs is the availability of new medical technology and the increased specialization that comes with it. The number of U.S. patents for surgical and pharmacological advances increased by a factor of six alone between 1974 and 2010 (Fuchs, 2012, p. 974). The population's aging accounts for a very little portion of the increase, about 0.1 to 0.2 percentage points every year. It is hard to say how much of the increase in expenditure is due to rising health care prices and how much is due to greater levels of care because the contents of a hospital day or a doctor's visit vary so greatly. Undoubtedly, a portion of the rising costs can be attributed to a rise in the amount of medical care provided, provided that the quantity is corrected to account for gains in care quality. The constantly changing interrelationships between medical ethos, medical professionalism and new, economically oriented incentive structures in the health care system are currently the focus of interest in medical ethics. However, dealing with an increasingly economic working environment has so far rarely been made an explicit subject of medical school courses. Since economic aspects play a significant role in the medical profession, an open and reflected discussion of possible tensions between the "traditional" medical tasks and the "new" economic challenges is desirable from the point of view of medical ethics in order to avoid the uncritical adoption of behavioral patterns and to prevent a fatalism which, in the face of economic constraints perceived as overpowering, sometimes already sets in during studies.

1.2.1 Risk/Benefit analysis

When a patient does not react to conservative treatment or exhibits "red flag" symptoms that indicate a systemic illness, the doctor may decide to begin imaging the patient. Such a choice needs to be based on a logical analysis of risk and reward. Imaging does have certain advantages, for sure. Above all, imaging can point to and help diagnose systemic diseases that were previously unknown. When a patient has radiculopathy or radicular pain syndrome and has not improved with conservative treatment, imaging can provide vital information for the design of minimally invasive or surgical therapies. Additionally, negative imaging should be useful for assuring that no serious illness is present and, in suitable cases, for halting additional testing. Lastly, imaging may help determine the anatomical origin of pain in patients with chronic pain syndromes. Only after a specific source of pain has been identified can a tailored plan of therapeutic action, whether conservative or intrusive, be devised. Risk, the unavoidable counterbalance to benefit, is frequently overlooked when deciding whether to use imaging. Imaging carries certain risks, including labeling impact, radiation exposure, cost, and solicitation of action. The inevitable emergence of degenerative results on any imaging study—the person is suddenly diagnosed with degenerative spine disease and becomes a patient—is known as the "labeling effect." There are only bad associations with the term "degenerative." A 2005 study by Modic and colleagues provides evidence of this negative. Patients who complained of back discomfort got MRIs, and they were randomly assigned to either get the results of the scans and share them with their doctor or not receive them at all. One of the study's conclusions was that, compared to participants whose MRI data was delayed, patients who got the diagnosis of benign degenerative disorders actually felt less well-off. This emphasizes how important it is for specialists to let patients know that the great majority of degenerative signs found on tomography are not significant. If patients are not adequately informed to the contrary, they may perceive this as the start of an unstoppable downward cycle of spine deterioration. This could lead to deconditioning, sadness, and fear avoidance behaviors with decreased activity. Active patient education is beneficial, especially when treating acute low back pain, according to a new Cochrane database study (Omidi et al., 2018, p. 1510). Every patient visit should emphasize the need of maintaining high activity levels and functional strength, as well as the irrelevance of degenerative findings on imaging investigations. Radiation exposure from nuclear medicine research, CT scans, and radiographs increases the chance of neoplasm induction. When serial trials are carried out, this danger becomes especially troublesome. The Sievert (Sv) is a unit of measurement for biologically effective absorbed radiation dosage; The average annual natural background exposure in North America is about 3 mSv. A frontal and lateral chest radiograph is commonly accepted as the gold standard for measuring radiation exposure, with a dosage of around 0.1 mSv. Then, a 3-view lumbar spine radiography series consists of approximately 15 chest radiographs, or 1.5 mSv. It is typical to receive a dose of 6 mSv, or 60 chest radiographs, for a lumbar spine CT scan. In a similar vein, the dose for a technetium bone scan is 6.3 mSv. In this case, the typical cost of a CT scan of the abdomen and pelvis is 14 mSv (Mettler et al., 2008, p. 255). Over the course of a patient's lifetime, all radiation exposure adds up and raises the possibility of radiation-induced cancer. Radiation-using imaging investigations need to be used carefully, taking into account both the potential risks and advantages.

Imaging is expensive. Every year, the medical imaging industry in the US costs society more than $100 billion. Radiographs: $41, noncontrast CT: $264, myelogram: $506, noncontrast MRI: $439, whole body PET/CT: $1183, and single-photon emission CT (SPECT) bone scan: $261.Medicare covered eighteen lumbar spine imaging treatments in 2009.

Usually, nominal fees are three to five times more than Medicare payments. The ease at which imaging expenditures can mount up is apparent. The provocation of intervention is an imaging risk that is less often taken into account. When compared to patients who are not examined, Jarvik and colleagues' 2003 study showed that early access to sophisticated imaging (MRI) during a patient's spine pain syndrome results in higher surgical interventions, even with similar pain and disability profiles. Similarly, Lurie and associates (20) investigated the striking 12-fold geographical heterogeneity in the surgical intervention rate for central canal stenosis. These researchers observed a direct correlation between the intensity of CT and MRI use and the rate of surgical intervention. The temptation is to treat a "abnormality" discovered by sophisticated imaging that may be the cause of a patient's pain. This condition arises in spite of the fact that many of the spine imaging "abnormalities," which are briefly reviewed, have a well-established lack of specificity. Treating the patient—not the image—is crucial.

After weighing the pros and downsides, it's critical to comprehend the sensitivity and specificity constraints that apply to all spine imaging, as well as the reliability of imaging findings. Although the primary purpose of imaging is to detect underlying systemic disease, the low prevalence of systemic disease as a cause of back pain implies that most imaging tests will mostly report degenerative events. Degenerative alterations are common on imaging examinations, rarely the cause of a particular patient's pain syndrome, and frequently mistakenly interpreted as the source of pain, leading to needless, costly procedures. It is not unusual to note that asymptomatic degenerative alterations in the spine are highly prevalent. In 1954, Hult conducted a study on people and found that 87% would have radiographic indications of disc degeneration by the time they are 50 years old (vacuum phenomenon, marginal sclerosis with osteophytes, and disc space narrowing). Hult saw radiographic evidence of disc disease in 56% of respondents aged 40 to 44 and 95% of subjects aged 50 to 59 in a second research using a sample of asymptomatic workers. Despite the development of increasingly advanced spine imaging methods, the specificity of degenerative findings remains low. In their analysis of asymptomatic volunteers' simple myelography, Hitselberger and Witten found that 24% of them had anomalies that would have been deemed relevant in the context of back or leg pain in a clinical setting (Hult, 1954, p. 23). According to a study by Wiesel and colleagues using lumbar spine CT scans on asymptomatic volunteers, 50% of individuals over 40 had "significant" abnormalities. In a similar vein, Boden et al. assessed lumbar spine MRI in asymptomatic volunteers; of those over 60, 57% had anomalies that would have been deemed significant in a suitable clinical situation. Jarvik and colleagues examined a sizable MRI patient sample. Based on this investigation, extrusions, moderate to severe central canal stenosis, and direct observation of neural compression were the only criteria that were likely to be useful in discriminating between patients who experienced pain and volunteers who did not. Findings such as disc protrusions, zygapophysial joint (z-joint) arthropathy, and antero- or retrolisthesis were nearly always asymptomatic. The incidence of degenerative imaging findings in younger populations has been the subject of more recent investigations, mostly conducted in Scandinavia; they are population-based MRI studies that do not take symptomatology into account. In their investigation of 13-year-old children, Kjaer and colleagues discovered a 21% frequency of disc degeneration. Salminen and colleagues observed a 31% prevalence of disc degeneration in 15-year-olds and a 42% prevalence in 18-year-olds in an adolescent study. Takatalo and associates assessed 558 young individuals between the ages of 20 and 22. They found that 47% of these young adults had disc degeneration of grade 3 or higher using the 5-point Pfirrmann disc degeneration classification. Males were more likely to have it (54%) than females (42%). In 17% of cases, multilevel degeneration was found. It is evident that the results of degenerative imaging are not very specific. According to population-based research, the incidence of imaging degenerative results is significantly higher than the prevalence of symptomatic disease. A high frequency of asymptomatic degenerative MRI abnormalities is revealed by studies of cohorts without symptoms. On all imaging studies, degenerative findings will typically be present in one-third to two-thirds of asymptomatic subjects; the frequency of asymptomatic degenerative findings rises with advancing age. Disc protrusions, antero- or retrolisthesis, facet arthropathy, and bulging or retrolisthesis are frequent, mostly asymptomatic conditions whose frequency rises with age. Disc extrusions, significant stenosis in the central canal, and clear indications of neural compression are more likely to be imaging findings that correspond to actual symptoms. Only a definite correlation between imaging and a clinical pain syndrome in a particular patient can imply causality. Even in this situation, provocative or anesthetic testing could be required to enable rational decision-making, especially when therapies with a high potential risk and expense are being considered.

There is usually already at least one standard-of-care technique in place in healthcare settings. New technologies are compared to that typical strategy, which could be a single therapy, test, or more comprehensive method. In order for a new technology to be accepted as a legitimate option, it must, at the very least, be superior to the present standard of care. This makes the comparison of techniques an important endeavor. When many outcomes are taken into account, these comparisons can get more complicated. For instance, a new medical treatment may be somewhat less effective than the existing standard of care, but it may also have significantly fewer or less severe side effects and be more tolerable. To assess the differences between the two alternative treatment options as measured by a common metric, such as the difference in quality-adjusted life-years, in these circumstances, a decision-analytic approach can be helpful in weighing the various properties of the alternative methods by incorporating aspects associated with both clinical efficacy and side effects, such as mortality and quality of life (Caro et al., 2012, p. 667).

It's vital to keep in mind that healthcare, and minimally invasive spine therapy in particular, is frequently a regulated market in many nations when evaluating the potential for a minimally invasive spine therapy business with a good combination of easy access to modern medical technology and competitively priced services. Before a health-related firm may offer its services, there are typically rules to abide by and licenses to obtain.

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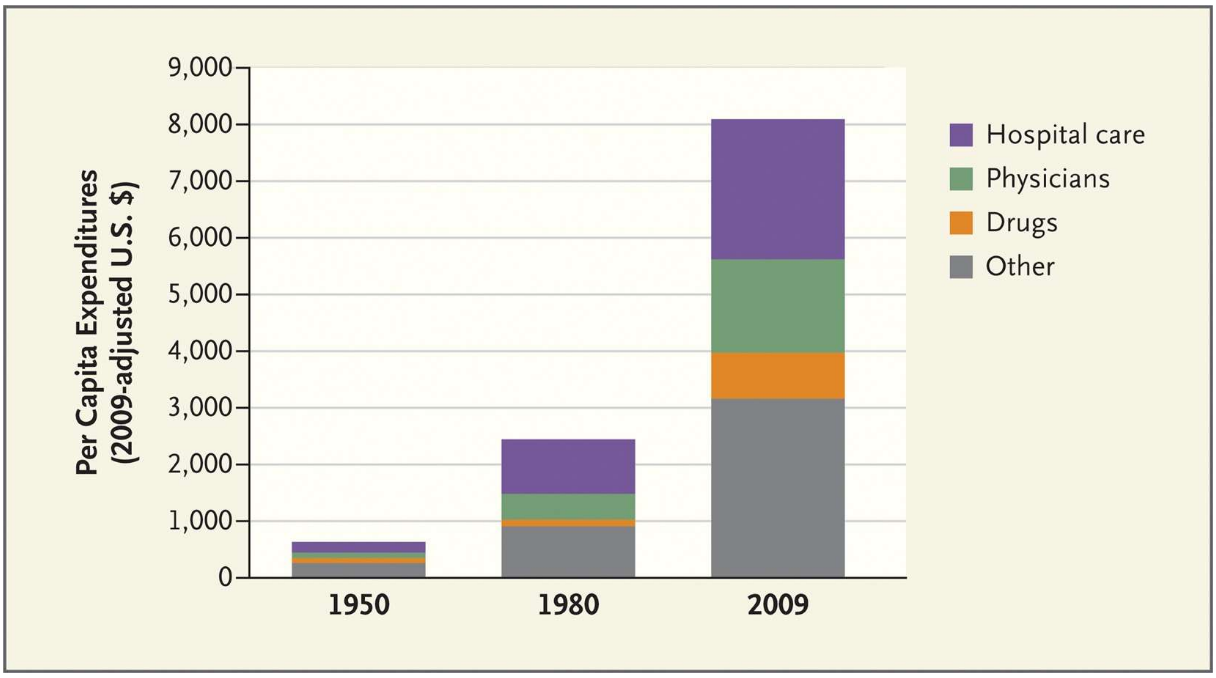


Figure 1.2
Per Capita Health Care Expenditures in 1950, 1980, and 2009, According to Category (Fuchs, 2012, p.978))

Due to the significant number of workdays missed by the tiny fraction of patients who acquire chronic low back pain, low back pain is an expensive burden on society. The main issue of this thesis is to define and find out how high the real costs of CT- and MR-guided spinal interventional pain therapies with ozone are. Invasive pain therapy under computer tomographic image control (periradicular infiltration, epidural infiltration and facet joint infiltration) has been shown and established in recent years to be effective and unavoidable for certain back pain (with or without leg pain). Technically straightforward, the procedure can be used in private practices and small hospitals as long as the necessary equipment is available. The therapy has few complications and is therefore attractive for patients and physicians. The goals of minimally invasive pain therapy are:

- to actively and specially combat pain symptoms and thereby reduce costs of oral medication respectively direct medical expenses,
- to avoid or postpone surgery as a more expensive solution,
- to avoid long-term symptoms, enhance the patient's quality of life, and lower the indirect cost of sick days associated with low back pain.

Healthcare administrators are searching for more advanced instruments to manage expenses without compromising the standard of patient care. Understanding unit cost is necessary to support planning for ongoing budgets as a measure of effectiveness and to enforce service pricing. Though there are many options accessible, the imaging equipment is now more sophisticated due to advancements in technology. The imaging technology of today since MRI s and CT scans are expensive tests yet crucial parts of patient treatment, emphasis shpuld be placed on reducing costs and improving the quality of these tests (Reuschel et al., 2022, p. 4).

An economical option for treating both acute and chronic back pain is image-guided infiltration. Numerous studies suggest that patients experiencing debilitating pain without significant neuromuscular deficits, who do not see improvement after six weeks of conservative treatment, require additional therapy (Ligtenberg et al., 2011, p. 28). Furthermore, there are no definitive treatment strategies for patients who have previously undergone spine surgery for disc herniation and subsequently suffered a disabling relapse. For both groups of patients, the off-label use of periradicular glucocorticoid or ozone injections has shown to be beneficial, particularly in achieving pain relief and restoring functional independence, which are the primary early therapeutic goals (Reuschel et al., 2022, p. 4). This treatment is minimally invasive interventional pain therapy by different materials, which is offered and performed by different specialists (Whynes et al., 2012, p. 2). Spinal ozone therapy is also used worldwide as an important option in minimally invasive therapies. It`s established in Europe, especially in Italy. It can be applied, for example, intradiscally too, analogous to chemical nucleolysis (Omidi Varmezani et al., 2021, p. 737).

However, not every patient experiences periradicular corticoid or ozone injection-induced pain relief to the same degree. On one hand, this is clearly influenced by the timing of the injection, as chronic nerve root lesions tend to respond less favorably to glucocorticoids than those that have been recently injured. However, there are considerable differences amongst clinicians in terms of the technical approach and procedural guidelines for periradicular glucocorticoid or ozone injections. For instance, many percutaneous injections are carried out without the use of imaging guidance, despite the fact that accurate needle placement is essential to getting an adequate amount of the anti-inflammatory drug into the body (Reuschel et al., 2022, p. 2). As a result, because they improve medication distribution and lower the incidence of complications, the use of fluoroscopy, MRI, and computed tomography (CT) in percutaneous spine treatments has significantly expanded (Benson et al., 2010, p. 148). Of those imaging modalities, CT has become the go-to method for guiding percutaneous spinal interventions due to its consistent and user-friendly image quality, which enables extremely accurate needle navigation in all three spatial planes, provides adequate contrast between soft and bony tissue in the area of interest, and precisely predicts the spatial distribution of the pharmaceutical cocktail surrounding the nerve root when a prior contrast medium injection is being performed (Benson et al., 2010, p. 152). Despite best efforts, daily life indicates that not all patients experience enough pain relief following intervention, despite the fact that the majority of treated persons report a favorable outcome. According to a recent study by Reuschel, the distribution pattern of contrast agents is a strong indicator of treatment outcomes. Reuschel et al.'s study looked into the theory that optimal needle placement is required when perineural opacification seems inadequate, and that good clinical efficacy of CT-guided periradicular injections is not only related but causally linked to the specific pattern of contrast agent dispersion at hand. To be more precise, characteristic distribution patterns were examined in relation to each person's experience of pain reduction in order to determine which distribution pattern corresponded to the most successful pain alleviation (Reuschel et al., 2022, p. 4).

Unfortunately, as far as the studies available, no study has proven whether the treatment is economically profitable for the performing entity. An examination of cost-effectiveness and cost-utility will be carried out notwithstanding missing costs and impact data. The fact that a recent publication did not demonstrate consensus regarding the efficacy of minimally invasive techniques for treating low back pain highlights the significance of this investigation (Maas et al., 2012, p. 4). On the other hand, anesthesiologists who lack sufficient imaging control frequently employ minimal interventional techniques. Minimal interventional interventions are advised by the Dutch Society of Anaesthesiologists' recently issued clinical recommendations for a subgroup of individuals with low back pain: individuals suffering from mechanical low back discomfort (Maas et al., 2012, p. 7).

In this study is assumed that CT-guided infiltrations are profitable, and for this reason they are offered in most clinics and practices throughout Europe.

The problem of significant radiation exposure caused by the treatment is unfortunately mostly ignored or neglected. CT units are widely available (even in smaller private practices and hospitals) with clearly lower costs and shorter intervention time (multiple interventions possible in a given time period and therefore financially more attractive). CT is a remarkable modality, frequent scanning confers a significant cancer risk. According to the Swiss Cancer League, around 41,700 people are newly diagnosed with cancer in this country every year, and around 16,900 people die from it every year. Cancer claims nearly 10 million lives annually, but not all cancers are fatal. Total worldwide costs due to cancer is 1`160`000`000`000 US-$ (1,16 billions) (Schult et al., 2020, p. 4). Based on the above data, a reduction in the number of CT examinations, significantly reduces radiation exposure to patients and medical staff.

MRI (Magnetic Resonance Imaging) offers an alternative image producing technology, uses a strong magnetic field and, according to current studies, does not cause any long-term complications in the patients examined. This procedure is a different physical technique in which patients are not exposed to ionizing radiation or X-rays. The limitation of this technique is that no metallic or magnetic objects may be worn. MRI is an advanced and sensible imaging technology with generally higher costs than CT. The increasing intensity of medical technology is one of the main factors behind the rising costs of the healthcare system in Europe. Half of the annual increase in the cost of a hospital day is due to the increasing utility of medical technologies and services (Hillman et al., 2003, p. 1286). As medical costs continue to rise and an increasingly large portion of the already severely constrained federal budget is eliminated, system efficiency becomes critical to preventing more severe rationing of medical resources. This is a gap in the existed medical literature to combine and calculate the whole short and long period costs of different modality guided spine intervention. Thus so far the real costs of these interventions are missing and that is why a comparison between these two modalities with existed literature is not possible. Regular intervention costs (equipment costs, personnel costs, etc.) as well as secondary modality-dependent costs, i.e. direct and indirect costs that induce cancerous diseases as a consequence of computed tomography or (X-ray) radiation exposure, are to be considered.

Cost-effectiveness is currently one of the factors taken into account by organizations like the Institute for Quality and Efficiency in Health Care in Germany and the National Institute for Health and Care Excellence in the United Kingdom when making choices on payment (Goehler et al., 2014, p. 2). There have been particular difficulties in the process of extending diagnostic imaging healthcare. It is often known that on the journey from patient presentation to patient outcomes, diagnostic imaging is frequently a transitional stage. Conventional outcomes like patient morbidity and death may be impacted by a number of extra variables, including the disease's underlying natural history, the selected course of treatment, and the effectiveness of the healthcare system. Furthermore, diagnostic imaging modalities frequently have several uses, and their efficacy is determined by a weighted average of those uses. In 2011, the Radiological Society of North America (RSNA) provided assistance to the Gazelle et al. Working Group on Comparative Effectiveness Research for Imaging, with the aim of to create a framework that would: emphasizes the special qualities of diagnostic imaging technologies and the fact that, depending on the technology's use and varied features, different results are needed to advance imaging technologies from discovery to delivery.

The Working Group expanded a hierarchical list of evidence levels relevant to the evaluation of diagnostic tests, which Fineberg first described in 1978 and Fryback and Thornbury revised in 1991. The Working Group took into consideration the population at risk, the expected clinical impact, and the economic impact associated with the technology (Figure 3).

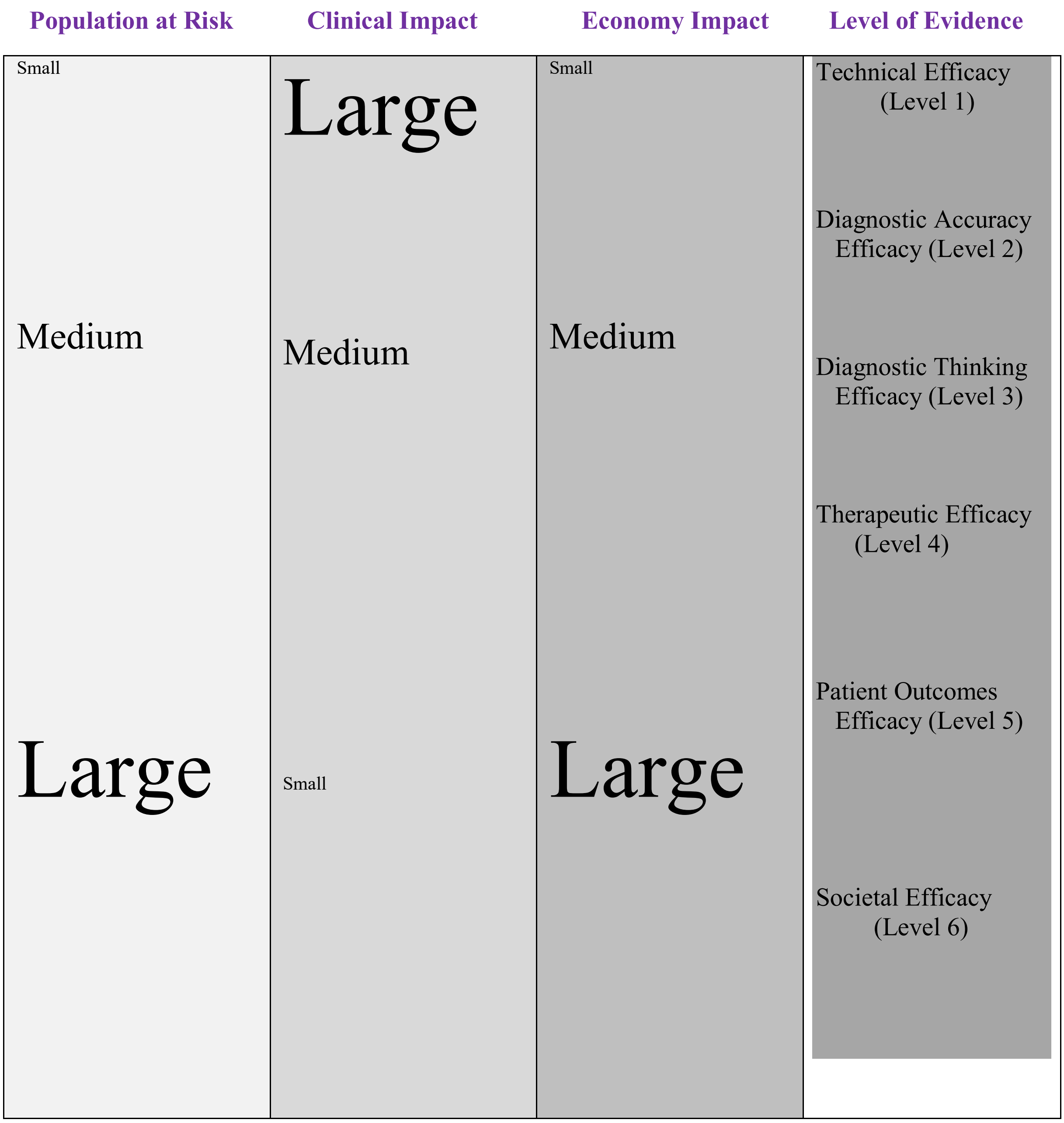


Figure 1.3
Diagram shows efficacy framework: Working Group on Comparative Effectiveness Research for Imaging. (Gazelle et al.,2011: 261:692-698 c)

The result of this framework was a socalled "hierarchical model of efficacy" [Gazelle et al 2011] that can be set up to analyze and comprehend imaging technology investigations. To complement our analysis, we alter each level's definition from Gazelle et al. in the following ways: Technical efficacy (level 1) is concerned with the quality of the photographs, whereas diagnostic accuracy efficacy (level 2) is concerned with the specificity and sensitivity of the picture interpretation. Furthermore, whereas diagnostic thinking efficacy (level 3) inquires as to whether the information from the diagnostic imaging technique influences the referring physician's diagnostic thinking, therapeutic efficacy (level 4) is focused on the influence of this information on the clinical care plan. Last but not least, patient outcomes efficacy (level 5) offers a quantitative examination of the information's influence on patient outcomes, while societal efficacy (level 6) evaluates the costs and benefits of diagnostic imaging technology to society. With this method, it is important to emphasize that efficacy at a lower hierarchy level is necessary but not sufficient for efficacy at a higher level to be established.

1.3 Purpose of research

Even in Switzerland, one of the main impediments to high-quality healthcare is financial constraints. Optimizing the current facilities while utilizing the resources at hand is necessary for quality improvement. Furthermore, within the last ten years, the price of medical services has increased significantly. This has made it crucial to comprehend the true cost of delivering medical services.

One of the most significant economic developments in the western world in the years following World War II has been the quick rise in health care costs. It affects the federal and state governments' capacity to make ends meet financially and has caused wage stagnation in the majority of industry (Fuchs, 2012, p. 4). The second most significant factor contributing to the increase in health expenditures is the expansion of both public and private health insurance, which reduces the impact of health care costs on demand. There is a positive correlation between the growth of health insurance and new technology: the former raises demand for insurance, while the latter does the same for new technology.

We will investigate the cost-effectiveness of this CT / MRI imaging paradigm for interventional spinal pain therapy with Ozone using model-based economic decision analysis. Computer tomography is frequently used to perform interventional spinal pain therapy and to assess the injection as a standard modality (Pengel et al., 2003, p. 323). There is fear that millions of cancers will result from computed tomography (CT) radiation exposure (Schult et al., 2020, p. 7) since a CT scan combines a number of X-ray pictures that were collected at various angles; the CT then utilizes a computer to construct images from these X-rays.

Additionally, because magnetic resonance imaging (MRI) uses radiofrequency waves and a superconducting magnet to penetrate the body, it is safe. Atoms are aligned either in a north or south direction by the magnetic field, with a small number of atoms remaining mismatched and continuing to spin normally. The mismatched atoms spin in the opposite direction when radiofrequency is applied, and they revert to their original position and emit energy when radiofrequency is turned off. The computer receives the energy emitted as a signal and applies mathematical algorithms to transform the signal into an image. An increased risk of cancer could not be proven in connection with electromagnetic fields of MRI. In contrast to other imaging diagnostic methods, MRI is considered harmless, at least as far as the radiation risk is concerned (De Roo et al., 2020, p. 2).

This study's main goal is to present a thorough evaluation of the literature and medical practices about the impact on the healthcare system, the efficacy and cost analysis of a particular modality. In particular, the following sub-objectives are part of the study:

1. Comprehensive review of back pain and its direct and indirect costs;
2. An overview of how back pain affects the medical system generally (with emphasis on Switzerland);
3. Different possibilities for treatment of disease, utilizing different approaches and innovative technologies from the financial perspective;
4. Choice of imaging modality for minimal invasive treatment with ozone and its impact on the treatment costs;
5. The decision's effects on the healthcare system's short- and long-term;

The outcome of this study will be helpful and valuable to healthcare providers such as insurance companies, healthcare investors, hospitals as well as private practices and medical specialists specially pain specialists.

1.4 Significance of the study

Once the physician has evaluated the benefits and drawbacks of imaging and is aware of its sensitivity and specificity limitations, they can proceed with imaging, beginning with radiographs. Usually, this operation is performed when there are growing neurologic deficits, pain that is not improving with conservative therapy, or clinical "red flags." More sophisticated imaging modalities are unable to offer vital information on coronal and sagittal alignment or vertebral enumeration, which is provided from weight-bearing radiographs.

The increasing intensity of medical technology is one of the main factors behind the rising costs of the healthcare system in Europe. Hillman et al reported in 1985; Half of the annual increase in the cost of a hospital day is due to the increasing use of medical technologies and services. Unfortunately, there is evidence that the use of many medical technologies may not be optimal from a scientific or social perspective. The scientific medical societies see Physicians responsible for making needs-based and resource-conscious decisions on the basis of a scientifically founded, individually coordinated indication. However, dealing with an increasingly economic work environment has so far rarely been made an explicit subject of medical staf. Economics has several points of contact with medicine. In the following, four relevant subfields of economics and economic applications in health care are presented. first, the economic subdiscipline called "health economics"; second, economic evaluations and the assessment of the cost-effectiveness of medical services; third, remuneration systems for medical services and the evaluation of the cost-effectiveness of medical services; and fourth, managerial thinking and action, such as the application of management principles among health care providers (Brügger, 2022, p. 777).

As medical costs continue to rise and an increasingly large portion of an already severely constrained federal budget is eliminated, system efficiency becomes critical to prevent more severe rationing of medical resources, with drastic consequences in interventional spinal pain therapy. The relationship between medicine and economics is not a simple one. Medical professionals complain about the "economization" of their field specially for common illnesses like low back pain. This term implies that economics is a disruptive intruder in medicine and that there was the good old time when medicine was free from economic constraints.

Back pain, like cardiovascular disease, is now a widespread and increasingly disease with an increasing incidence with socioeconomic burden. Cost-intensive treatment of chronically ill patients is likely to increase due to demographic change and medical advances (Fischer et al., 2002, p. 1). From a health economic perspective, this means an increasing burden for the health care system. Chronic diseases account for a significant proportion of direct and indirect health care costs (Hillman et al., 1985, p. 1283). In Switzerland, 80% of people suffer from back pain once a year to several times a week. Based on the resident population of Switzerland between 15 and 74 years of age, this amounts to more than 4.6 million women and men, who incur costs of about 1 billion Swiss francs due to musculoskeletal disorders (Gerfin et al., 2011, p. 2). Von Hatvigsen and colleagues were published in 2018 in the renowned scientific journal "The Lancet," back pain was described as the No. 1 cause of physical impairment worldwide. The likelihood of occurrence of treatment-emergent Back pain is estimated to be 80% for low back pain, 48.5% for cervical spine pain, and thoracic spine with 12 % (von Hartvigsen et al., 2018, p. 140).

The management of lower back pain differs from patient to patient because different patients react differently to different forms of treatment, and no single intervention works well for every patient. In order to manage the pain and reduce overall expenses, restricted trials of one or more therapies that are informed by evidence and effectiveness are used (Urits et al 2019). Most people who have an episode of acute low back pain only see a recovery of their symptoms after 4 to 6 weeks, either on their own or with conservative therapy. Regardless of the therapy used, the chance of returning to normal function quickly decreases if symptoms continue (Innuccilli et al., 2013, p. 310). By definition, no evidence of specific causes has been identified as `nonspecific` low back pain, so therapeutic measures can only be symptomatic. Non-drug and drug measures are available. Depending on the stage (acute, subacute, chronic), there are in some cases varying degrees of proof of efficacy and different strengths of recommendation are given. AWMF (program for National Healthcare Guidelines) in 2017 advises using invasive therapeutic measures, when evidence-based noninvasive therapy is unsuccessful. Percutaneous therapy procedures on the spine are increasingly being used. In Switzerland, they are performed by interventional specialists (e.g., orthopedic surgeons, anesthesiologists, neurosurgeons and radiologists). Side effects and complications of the procedures are rare (AWMF, 2017, p. 2).

When a patient has mechanical low back pain, which is characterized as pain that is most likely coming from one source—a facet, disc, sacroiliac joint, or a combination of these—minimum interventional procedures are frequently performed. These minimally invasive methods are usually an essential part of an all-encompassing pain treatment plan. A recent comprehensive research by the Dutch Health Insurance Council raises doubts about the overall value of these operations for patients with chronic low back pain, as well as their potential cost-effectiveness. The study's objective was to determine whether, for patients with persistent mechanical low back pain who did not improve with conservative primary care and were referred to a pain clinic, a multidisciplinary pain program with minimal interventional procedures is more cost-effective than the multidisciplinary pain program alone (Maas et al., 2021, p. 4). On the other hand, anesthesiologists who lack sufficient imaging control frequently employ minimal interventional techniques. However, not every patient experiences periradicular corticoid or ozone injection-induced pain relief to the same degree. As a result, because they improve medication distribution and lower the incidence of complications, the use of fluoroscopy, MRI, and computed tomography (CT) in percutaneous spine treatments has significantly expanded (Benson et al., 2010, p. 150). For percutaneous spinal procedures, CT has become the recommended guiding technique among those imaging modalities (Reuschel et al., 2022, p. 4). The fact that selecting the imaging modality and evaluating its cost-effectiveness (comparing CT and MRI) is a missing piece of information in current research highlights the significance of our investigation.

1.5 Research purpose and question

Modern medicine requires increased demands on the management of patients in the clinic with the demand for a process-oriented view of disease. This approach implies the development of clinical pathways with the inclusion of modern imaging modalities (specially CT and MRI). When compared to MRI, CT offers better imaging of the cortical and trabecular bone. CT has a good contrast resolution and can typically identify root compression lesions such disc herniations. Not only is CT less sensitive than MRI at identifying neoplasms, paraspinal soft tissue lesions, and early viral or inflammatory processes, but it also cannot identify intrathecal pathology. Radiation exposure needs to be considered at all times when utilizing CT. One consequence of CT's recent rapid technological improvement is the paucity of studies comparing MRI and the current generation of multidetector CT scanners in the diagnosis and characterization of disc herniations. In the past 20 years, there has been relatively little advancement in technology; yet, MRI continues to be the most used modality for spine imaging. Because MRI can distinguish between different forms of soft tissue and has a greater contrast resolution, it can detect intrathecal disease and identify minor root compression lesions. When it comes to identifying infections and tumors, MRI has higher sensitivity. Patient acceptance is still a challenge because of the high cost, lengthy imaging periods, and 10% examination failure rate attributed to claustrophobia. Although image quality has suffered greatly as a result of open magnets, patient acceptance has increased. A tiny number of patients cannot undergo an MRI because of implanted equipment such as pacemakers or spinal cord stimulators.

The creation of an activity-based costing system including the radiology cost center is essential for a cost calculation of the treatment paths within health care system. Cost transparency, resource bundling, and the optimum choice of modality within the service centers can help to make optimum use of the revenue framework. Though it comes at a high cost and is sometimes requested as initial screening imaging when a less resource-intensive test will do, magnetic resonance imaging (MRI) is generally considered the most sensitive imaging for diagnosis and intervention. The ultimate goal of the research project is to investigate the true costs of various spinal interventional ozone therapy techniques. It is important to remember to keep the patient and the related health care mandate at the core of the medical self-image, regardless of the state of the economy. This task and the lack of integration of scientifically current evaluated methods due to their cost intensity harbor the danger that specific that specific contents for the professional development and design of clinical pathways, as they are no longer many interventionalists recognize them as economically disadvantageous.

There is a huge scientific gap in existed health economy literature using different modalities in this branch generally and in spinal ozone therapy specifically despite increasing of utility of interventional image guided radiology specially CT and MRI in the last 20 years

(Rautio et al., 2002, p. 1940). This novel therapeutic option for spinal disease—which was previously limited to open surgical procedures—has been made possible by these new instruments. Conversely, this has increased the radiological units' workload and costs. Policy makers and health care organizations are becoming more and more interested in health care expenditures. Despite the rise in the quantity and sophistication of radiological procedures, cost evaluations pertaining to CT or MRI-based spine interventional radiology have not been widely reported (Rautio et al., 2002, p. 1939). Cost-benefit and cost-effectiveness assessments should be performed before introducing a new treatment strategy, but they are most reliable when done in conjunction with a suitable cost accounting. Whatever happens to the incidence and prevalence of low back pain, the number of elderly persons will rise so quickly over the next 20 years that an interventional spine service will have a far heavier caseload.

The purpose of this study was to analyze and compare the costs of the CT and MRI interventional spine radiology unit and to determine the cost factors associated with the various image-based spine intervention activities, such as interventional radiology. The losing part in the medical literature is a combination and calculation the whole short and long period costs of different modality guided spine intervention. Thus, sofar the real costs of these interventions are missing and that is why a comparison between these two modalities with existed literature is not possible.

The asked question e.g. hypothesis is very simple. We assume an image guided interventional pain therapy reliefs the pain of patients with acute or chronic back pain e.g. radiculopathy and the therapy is cost effective; considering the whole (medical and non-medical) direct, indirect, short- and long term costs of these patients, exlusively from the economic perspective is a MRI- guided spinal interventional ozone therapy more attractive (cost effective) or a CT-guided intervention.

CHAPTER II:
REVIEW OF LITERATURE

2.1 Theoretical framework

2.1.1 Epidemiology and economic burden of low back pain

The skyrocketing expense of health care in the United States and Europe in the post-World War II era is one of the most important economic trends. In 1950, the GDP's proportion of health expenditures was a meager 4.6%. In 2009, they accounted for more than 17% of the entire manufacturing, wholesale and retail commerce, banking and insurance, as well as the mining, building, and agricultural industries combined.

The biggest issue to U.S. fiscal policy, according to public finance specialists like Alan Blinder and Alice Rivlin, is controlling health care spending (Fuchs, 2012, p. 976). An universal symptom is pain. It happens to everyone at some point in their lives. It is the body's method of alerting us to a problem. There is an injury, dysfunction, or other issue when we feel pain. It is an uncomfortable feeling that we must get rid of. Given the frequency and urgency of this customer's "need" to be pain-free, businesses should take this into account. It also means that this is a big market with various opportunities; providing medicaly, technicaly and financialy adequate solutions are good points for a pain therapy business. Like many other elements of life, technology has advanced to the point where it can now significantly contribute to improved solutions. Many beneficial therapy techniques have been made available by medical technology in recent years. Furthermore, it was mentioned that the use of minimally invasive medical technology frequently produces long-lasting relief, a comfortable therapeutic experience for the patient, and a low risk of side effects and consequences. Pain in the back is common in Western societies. In the US, it is the most prevalent and costly cause of job disability (Maus, 2010, p. 741).

Since World War II, there has been an epidemic of low back pain—or, more precisely, an epidemic of low back impairment (Konrad et al., 2011, p. 47). Disabilities and pain are not the same thing. Though they are undoubtedly connected, we need to distinguish between them conceptually. In order to gain a fresh viewpoint, a deeper comprehension of the costs associated with low back pain to society, and an evaluation of whether the clinical management of low back pain currently in use complies with evidence-based recommendations while remaining economically feasible, this study will examine research on low back pain with economic ramifications. To do this, a comprehensive search was carried out within the Medline database using pertinent terms. Following the evaluation of 372 abstracts, paper copies of 73 potentially relevant publications were obtained. The specific cost estimates varied depending on the pricing approach utilized, despite the fact that research demonstrated that the cost of treating low back pain illness was substantial and comparable to that of treating other disorders like heart disease, depression, diabetes, and headaches. A small percentage of patients with chronic low back pain bear a large amount of the costs. Although it varies depending on the area and type of provider, excessive and improper usage of diagnostic or therapy services can be noted. Following evidence-based recommendations for management was not always financially advantageous. Low back pain interventions, whether for acute or chronic, showed only minor clinical improvements but no economic benefits, indicating a limited correlation between clinical and economic outcomes.

3227 respondents finished the section on low blood pressure (LBP) in the Monitoring of Trends and Determinants in Cardiovascular Disease Project (MONICA report), a survey that was conducted in Switzerland between 1992 and 1993. According to the survey's findings, men's one-year prevalence rates of lower back pain (LBP) lasting more than seven days were 20.2% in the 25–34 age group and 28.5% in the 65–74 age group. Among women, the corresponding age categories had rates ranging from 31.1% to 38.5% (De Wet, 2003, p. 2). In affluent nations, the lifetime prevalence of non-specific back pain is believed to be between 60 and 70 percent, with an annual incidence of 5 percent in adults (Duthey, 2012, p. 6).

Cervical, thoracic, and lumbar pain syndromes and radiculopathies are common clinical manifestations that result in significant costs to the economy in general and to insurance companies in particular. Many people are affected by back pain at least once during their lifetime. In Switzerland, 16% of adults suffer from moderate to severe chronic pain; the average in Europe is 19%. In Switzerland, the cost of chronic pain was estimated at 5 billion Swiss francs in 2007 and thus occupies a weighty position (Konrad et al., 2011, p. 48). The life-time incidence of LBP was found to be almost 26% in a follow-up research involving 444 adult patients who saw their general practitioner, with a one-year prevalence of roughly 49% (de Wet, 2003, p.4). In the general population between the ages of 30 and 50, a cross-sectional postal survey study (n = 2035) revealed that the one-year prevalence was roughly 50% and the lifetime incidence of low back pain (LBP) ranged from 60% to 65% in both the male and female populations. According to Manchikanti, the prevalence of disabling back pain increased to 162% from 1992 to 2006, an increase from 3.9% to 10.2% (Manchikanti, 2016, p. 10). In the US, musculoskeletal pain is by far the most prevalent type of chronic pain. According to a recent Journal of the American Medical Association publication, back pain is among the nation's most common health issues and causes the greatest number of disabilities each year (Gatchel, 2015, p. 840). According to 2016 hospital health care statistics, musculoskeletal disorders (including back pain) are the most common reason for hospitalization, accounting for approximately 190,000 cases (BfS, 2015).

Back pain is costly, as it is often the reason for sick leave, and incurs high direct and indirect costs. Direct costs refer to outpatient or inpatient medical care with a charge to the health insurance company. Indirect costs are costs that result in absences from work due to pain with sick pay or continued payment of wages. A 1980 retrospective analysis examined all of the documents from 1975 to 1978 from a model family practice located in Vermont, USA. It was shown that 34.8% of patients had reported having LBP (de Wet, 2003, p. 4). Telephone interviews were done between February and April of 1992 as part of another retrospective study carried out in North Carolina. It was discovered that 485 persons, or 11.5% of the sample of 4437 adults, had significant lower back pain in 1991. The duration of LBP was more than three months in 7.6% of the adult patients. In a cross-sectional postal questionnaire study (n=2687) conducted in 1991, the one-year prevalence and lifetime incidence were examined in seven municipalities and one rural district. The results showed that the one-year prevalence of LBP was 36.1% and the lifetime incidence was 58.3% (de Wet, 2003, p. 4). In 19 Tibetan villages, a cross-sectional study (n = 499) revealed that the point and one-year prevalences of low back pain were 34.1% and 41.9%, respectively.

According to this study, LBP is probably a significant issue that goes unrecognized in rural communities like Tibet (de Wet, 2003, p. 4).

Table 2.1
Trend in Physician visit for back pain, USA 1998-2010 (*de Wet, 2003, p.4)*

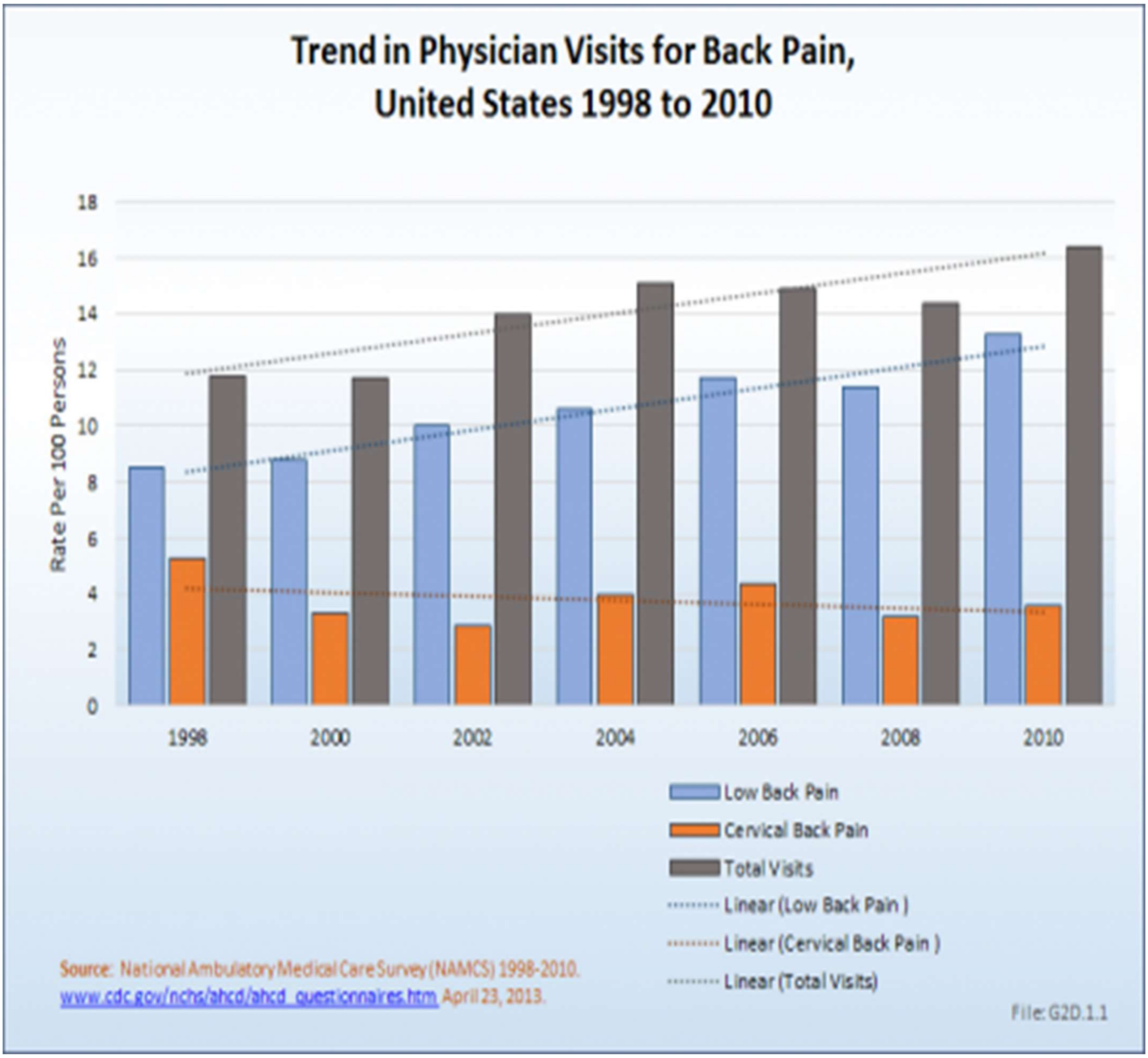


Table 2.2

One-year incidence of low back pain in the general population (Duthey WHO, 2013, p.12)

Citation	Country	Age Range (Years)	Indusion Criteria at Baseline	Case Definition (%)	Incidence (%)	Standard Error (%)	Risk of Bias
Incidence of Number of people who have a first-ever episode							
Biering-Sorensen[21]	Denmark	30-60	Never had low back pain	Low back past over past year	6.3c	0.8	Low
Croft et al. [24]	United Kingdom	18-75	Never had low back pain	Low back past over past year	15.4c	0.9	Moderate
Mustard et al. [30]	Canada	21-34	Never had back pain>1 day	back pain>1 day over past year	7.5c	0.6	High
Incidence of Number of people who have any episode (First-ever or Recurrent)							
Al-Awadhi et al. [28]	Kuwait	15-99	No back pain at baseline	Low back pain over past year	1.5b	0.2	High
Cassidy et al. [23]	Canada	20-69	No low back pain for 6 months	Low back pain over past year	18.9b	2.2	Low
Croft et al. [24]	United Kingdom	18-75	No low back pain at baseline	Low back pain over past year	36.0c	1.2	Moderate
Hestbaek et al. [20]	Denmark	30-50	No low back problems over past year	Low back pain over past year	19.3c	1.7	Low
Jacob et al. [25]	Israel	22-70	No activity-limiting low back pain>1 day over past month	activity-limiting low back pain>1 day over past year	18.4c	2.7	Moderate

a Definition of a new episode of low back pain

b Age and sex- standardized

c Unadjusted

Table 2.3
Summary of Incidence and Prevalence Rates in the Different Countries (de Wet 2003, p.4)

Country	Lifetime Incidence	Six Month Prevalence	One Year Prevalence	Point Prevalence
USA	34.8% (19) 11.5% (8) 60- 80% (3) 80% (1.2)		15- 20% (20)	1 month: 30-40% (3) 15- 30% (3)
Canada	84.1% (14)			28.4% (14)
UK	58.3% (7) 62% (15) 59% (22)		36.1% (7) 48% (15) 41% (22)	16% (15)
Sweden	80% (23)			
Nordic	11%, 20%, 26%, 45%, 54% (24)		2.27% (25)	
Switzerland			20.2 -28.5%, 31.1 - 38.5% (26)	
Nederland			49% (27) 44.4%, 48.2% (17)	26% (27) 26.9% (28)
Japan	60.5% (29)			29.9% (29)
Tibet			41.9% (30)	34.1% (30)
Bulgaria				25.8% (31)

2.2 Functional and social emographic level

Chronic back pain patients are slowly fading into the background in society as they are no longer able to fulfill social obligations with huge financial consequences. In addition, frequent sick leave increases the risk of long-term unemployment. This vicious circle causes a further intensification of the symptoms with psychological conspicuousness up to depression and thus a strong impairment of the quality of life for those affected. Diseases of the musculoskeletal system and especially back pain are among the most common public health problems occurring internationally. In Germany, back pain is the second most common widespread disease (Thielen, 2015, p. 2). From a health economic perspective, a distinction is made between direct costs of illness or medical costs and indirect costs such as costs of incapacity to work, etc.

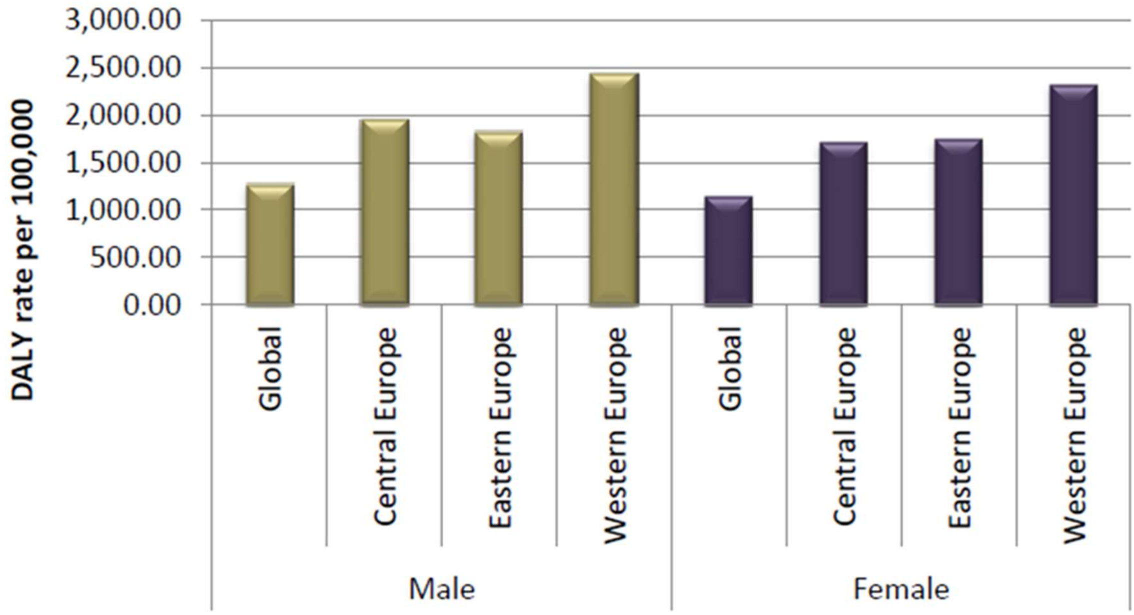


Figure 2.4
DALY- Rate nach europäischer Region und Geschlecht (Duthey, WHO 2013)

In Germany, about 60,000 patients per year undergo surgery for back problems; worldwide, the figure is about one million patients. Back pain is responsible for an annual work incapacity of 2-3 days per insured person on average. In this context, 75 million working days were lost for every 3.7 million cases of incapacity to work (Thielen, 2015, p. 2). In Germany in 1998, over 50% of men and over 60% of women reported having experienced back pain once in the past year (Schmitz, 2004, p. 3).

A large-scale survey (16,634 persons older than 18 years) by the MEM Research Center of the University of Bern revealed a prevalence rate of 24.3 % (Interpharma, 2011, p. 1).

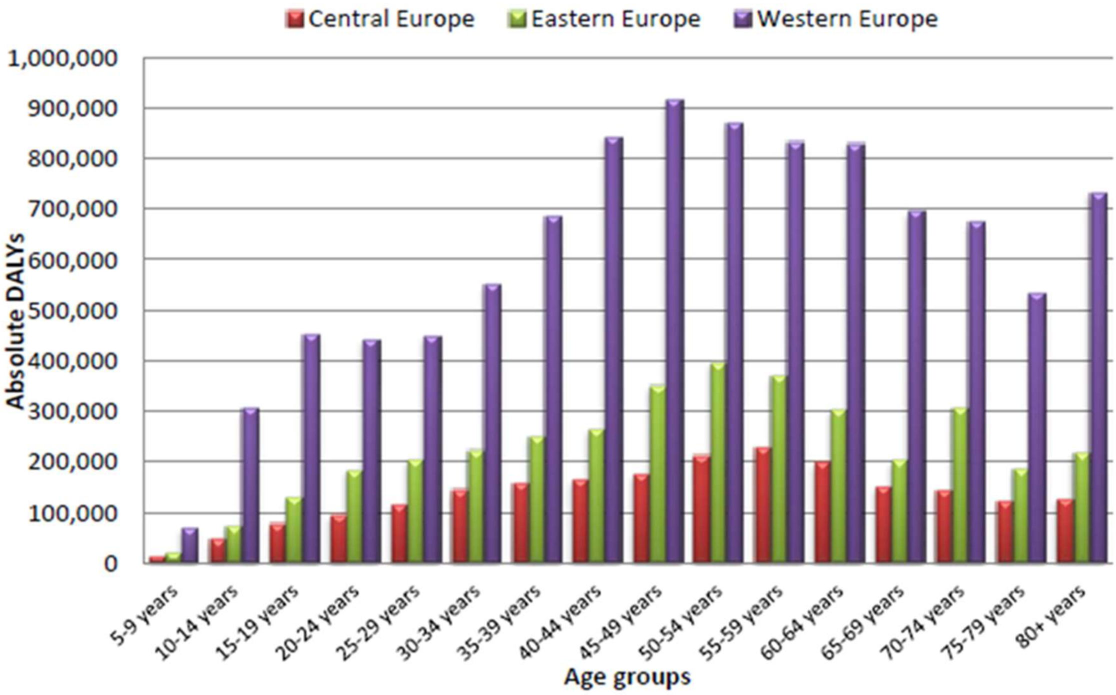


Figure 2.5
Absolute DALYs (disability-adjusted life years) caused by back pain by age group and European region (Duthey 2013).

According to estimates, 60–70% of people in developed nations will experience non-specific back pain in their lives (adult incidence 5% year, one-year prevalence 15–45%). Children and teenagers are becoming more prevalent than adults. It increases and reaches maximum values between the ages of 35 to 55 years. Chronic musculoskeletal syndrome has been reported in approximately 10%, and recurrent pain has been observed in up to 40% of affected individuals (Schindler, 2013, p. 5). According to studies, the third decade has the highest prevalence of back discomfort. Up to the age of 60 or 65, the overall prevalence rises with age and then progressively declines (Duthey, 2013, p. 2). Many people are affected by back pain at least once during their lifetime. In Switzerland, 16% of adults suffer from moderate to severe chronic pain; the average in Europe is 19%. In Switzerland, the costs of chronic pain were estimated at 5 billion Swiss francs in 2007 and thus occupy a weighty position (Konrad et al., 2011, p. 48). In England, between 1958 and 1988, there was an explosive increase in absenteeism from work as a result of back pain; the trend was still upward. This resulted in an average of 1.5 lost working days per inhabitant per year. Lumbar pain and lumboischialgia are responsible for about 30 % of all inpatient rehabilitation measures (Jüni et al., 2021, p. 4). In Switzerland, 80% of people suffer from back pain once a year to several times a week. In relation to the resident population of Switzerland between 15 and 74 years of age, this means more than 4.6 million women and men, who cause operational costs of about 1 billion Swiss francs due to musculoskeletal disorders caused by stressful work situations (Gerfin, 2011, p. 2). According to statistics on health care in the Alps in 2016, illnesses of the musculoskeletal system, including back pain, accounted for over 190,000 hospital admissions (BAG, 2016, p. 4). A survey conducted by the Swiss Rheumatism League in 2020 revealed equally sobering figures on the widespread disease back pain. Here, 88 % of respondents complained of back pain within the last 12 months. 50 % even stated that they back pain several times a week suffer from back pain. All age groups were affected in this survey. In 2011, by comparison, only 39% said they suffered from back pain several times a week. several times a week, with the proportion of patients free of back pain decreased from 7% to 2% (Rheuma Liga Schweiz, 2020, p.6)

Von Hatvigsen and colleagues were published in 2018 in the renowned scientific journal "The Lancet," back pain was described as the No. 1 cause of physical impairment worldwide. The likelihood of occurrence of treatment-emergent Back pain is estimated to be 80% for low back pain, 48.5% for cervical spine pain, and thoracic spine with 12 % (von Hartvigsen et al., 2018, p. 5).

Despite these negative trends, the overall prognosis for back pain is actually favorable with a frequently self-limiting course. In 2019, Langenegger and colleagues calculated the direct medical costs in 2011 for back pain in Switzerland were Switzerland at CHF 3,755 million (Langeneeger et al., 2011, p. 4). Added to this are the indirect costs, such as lost working hours, which Wieser and Kollegen in 2014 amounted to CHF 7,460 million. by Wieser and colleagues in 2014 (Wieser et al., 2014, p. 2).

Table 2.4
The unadjusted prevalence of low back pain in the general population, by age and country (Duthey, 2013, p.2)

Citation	Country	Age Range (Years)	Prevalence (%)	Standard Error (%)	Risk of Bias
Point Prevalence					
Walker et al. [66]	Australia	18-99	25.6	1.00	Low
Skovron	Belgium	15-99	33.00	0.76	Low
Cassidy et al. [68]	Canada	20-69	28.7	1.35	Low
Hoy et al. [13]	China	15-99	34.1	3.00	Low
Biering-Sorensen [21]	Denmark	30-60	13.7	0.87	Low
Bredkjaer	Denmark	16-99	12.0	0.47	Low
Kohlmann et al. [71]	Germany	25-74	39.2	3.41	Low
Mahajan et al. [71]	Indi	15-99	8.4	0.87	Low
Mohseni-Bandpei et al. [72]	Iran	11-14	15.0	0.51	Low
Carmona et al. [73]	Spain	20-99	14.8	0.83	Low
Andersson et al. [74]	Sweden	25-74	23.2	1.05	Low
Harkness et al. [75]	United Kingdom	18-64	18.0	0.88	Low
Hillman et al. [76]	United Kingdom	25-64	19.0	0.69	Low
One Week Prevalence					
Grimmer et al. [77]	Australia	13-13	7.8	1.29	Low
Haq et al [78]	Bangladesh	15-99	20.1	1.11	Low
Davatchi et al. [79]	Iran	15-99	14.8	0.50	Low
Al-Awadhi et al. [80]	Kuwait	15-99	9.5	0.34	Low
Cardiel et al. [81]	Mexico	18-99	6.3	0.49	Low
Chaiamnuay et al. [12]	Thailand	15-99	11.7	0.92	Low
Jones at al. [58]	United Kingdom	10-16	15.611.2	1.62	Low
Minh Hoa et al. [82]	Vietnam	16-99		0.68	Low
One-Month Prevalence					
Heistaro et al. [83]	Finland	30-59	49.5	0.66	Low
Stranjalis et al. [84]	Greece	15-99	31.7	1.47	Low
Kristjansdottir [85]	Iceland	11-16	34.0	1.03	Low

Croft et al. [86]	United Kingdom	18-75	39.0	0.73	Low
Watson et al. [87]	United Kingdom	11-14	24.0	1.15	Low
Three-Month Prevalence					
Miro et al. [88]	Spain	65-99	43.9	2.04	Low
One-Year Prevalence					
Lau et al. [89]	China, Hong Kong	18-99	21.7	2.30	Low
Hestbaek et al. [20]	Denmark	30-50	56.0	1.37	Low
Hestbaek et al. [90]	Denmark	12-22	32.4	0.48	Low
Taimela et al.[91]	Finland	7-16	9.7	1.23	Low
Demyttenaere et al. [92]	Spain	18-99	20.0	1.23	Low
Demyttenaere et al. [92]	Ukraine	18-99	50.3	1.70	Low
Walsh et al.: Demyttenaere et al. (92.93]	United Kingdom	20-59	36.1	0.93	Low

A survey conducted by the Swiss Rheumatism League in 2020 revealed equally sobering figures on the widespread disease back pain. Here, 88 % of respondents complained of back pain within the last 12 months. 50 % even stated that they back pain several times a week suffer from back pain. All age groups were affected in this survey. In 2011, by comparison, only 39% said they suffered from back pain several times a week. several times a week, with the proportion of patients free of back pain decreased from 7% to 2% (Back rapport 2020, rheumatism league Switzerland).

Von Hartvigsen and colleagues were published in 2018 in the renowned scientific journal "The Lancet," back pain was described as the No. 1 cause of physical impairment worldwide. The likelihood of occurrence of treatment-emergent Back pain is estimated to be 80% for low back pain, 48.5% for cervical spine pain, and thoracic spine with 12 % (von Hartvigsen et al., 2018, p. 6).

Despite these negative trends, the overall prognosis for back pain is actually favorable with a frequently self-limiting course. In 2019, Langenegger and colleagues calculated the direct medical costs in 2011 for back pain in Switzerland were Switzerland at CHF 3,755 million (Langeneeger et al., 2011, p.2). Added to this are the indirect costs, such as lost working hours, which Wieser and Kollegen in 2014 amounted to CHF 7,460 million. by Wieser and colleagues in 2014 (Wieser et al., 2014, p. 57). Thus, in socioeconomic terms, back pain already occupies 2nd place among the most expensive diseases in Switzerland, accounting for 13.4 % of the of health care costs. Tendency rising. The inglorious 1st place is still taken by cardiovascular is still claimed by cardiovascular diseases.

Back pain, however, is the most common cause of according to a survey by the Robert Koch Institute 2012, is the main cause of incapacity and rehabilitation (Heine, Raspe, 2012, p. 3). In medical terms, back pain is divided into two large groups, namely specific (15 %) and non-specific (85 %) back pain and the non-specific (85 %) back pain. This means that in only 15 % of the cases a pathology in the area of the spinal column that can be in the spine that is amenable to specific therapy. The large group of non-specific causes includes conditions from other medical specialties, such as abdominal vascular diseases, gynecological or urological clinical pictures, and, last but not least, neurological diseases from the neurological and psychosocial fields.

2.3. Pathophysiology, symptoms and risk factors

In terms of underlying pathophysiology, back or leg pain is overwhelmingly caused by benign disease. A differential diagnosis of low back pain with the associated prevalence of underlying pathologic processes has been compiled by Jarvik and Deyo and is presented in 2002. Their analysis suggests that 95% of low back pain is due to benign processes. In patients presenting to a primary care setting with low back pain, only 0.7% will suffer from undiagnosed metastatic neoplasm. Spine infection, including pyogenic and granulomatous discitis, epidural abscess, or viral processes, will be present in only 0.01% of subjects. Noninfectious inflammatory spondyloarthropathies, such as ankylosing spondylitis, will account for 0.3% of presentations. Osteoporotic compression fractures are the most common systemic pathologic process to present as back pain, accounting for 4% of patients.

Back pain with or without radiation may have a different genesis and pathophysiology: individual characteristics, working conditions such as heavy physical work, uncomfortable static and dynamic postural positions, lifestyle factors, and psychological factors. A small number of back pain cases result from back injuries, osteoporosis, infections, tumors, and bone metastases. The exact cause of back pain is often difficult to identify. Nonspecific pain is therefore a major problem in diagnosis and treatment. Back pain can have various origins:

Muscles, ligamentous apparatus, joints, blood vessels, etc. Under certain stressful situations, these tissues can rapidly generate inflammation by secreting inflammatory chemicals. These inflammatory chemicals stimulate the surrounding nerve fibers and cause pain pulsations.
The primary role of imaging is to identify the approximately 5% of patients with back pain who have undiagnosed systemic disease as the cause of their pain. A related imaging goal is to characterize and assist in therapy planning in the very small percentage of patients who have neural compressive disease resulting in radiculopathy or radicular pain syndromes that fail conservative therapy and require surgical or minimally invasive intervention. Imaging identification of degenerative disease in the patient with back pain is, as this article elaborates, seldom helpful and is at best of secondary concern. Diagnosis of back pain is complicated due to its complex nature and nonstandard medical approach to clinical decision-making. Risk factors for back pain include psychological as well as physical and environmental elements: Lack of exercise, poor posture, age, BMI, smoking, heavy physical labor, lack of balance to daily life and work (stress), conflicts and excessive demands, etc. In most patients with acute or chronic back pain, a variety of radiological changes are observed, including:

- Spinal canal stenosis
- Instability of the spine (listhesis)
- joint arthrosis
- osteochondrosis
- discus hernia
- neuroforaminal stenosis

Table 2.5
Risk factors for the chronification process in back pain (Schindler, 2013, p.3)

Risk Factors for the Chronification Process at Back Pain	
Somatic Factors	**Psychosocial Factors**
Genetic Disposition	Low Education Level
Predisposing Diseases	Low Professional Qualification
Degenerative Changes	Dissatisfaction with the Work Situation
Continuous Exposure to Biomechanical Stressors	Conflicts with Superiors
	Compensation Claim
Workplace Variabilities	Psychosocial Factors
Persistent Hard Work	Cognitive Affective Processing (Maladaptive Coping, Self-Assessment)
Monotonous Exposure to Biomechanical Stressors	Psychic Stressors
	Biographical Stresses
Iatrogenic Effects	**Psychological Factors**
Duration of Sick Leave	Somatization Disorder
Preference passive (regressive) mDowns	Anxiety Disorder
Overestimation of Non-Specific Somatic Findings	Depressive Disorders
Overestimation of Psychosomatic Findings	
Overgiagnostic measures	**Musculoskeletal Disorders**
Preference Invasive therapy	Constitutional Hypermobility
Permanent prescription of non-indicated drugs, in particular addictive drugs	Movement Pattern Disorders
	Complex disturbance Patterns
	Insufficient Depth Stabilization

2.4. Economic level

Back pain is ubiquitous in Western societies. It is the most common and expensive cause of work disability in the United States (Maus, 2010, p. 740).

Cost-intensive treatment of chronically ill patients is likely to increase due to demographic change and medical advances (Fischer et al., 2002, p. 4). From a health economic perspective, this means an increasing burden for the health care system. Chronic diseases account for a significant proportion of direct and indirect health care costs (Schwartzt et al., 1999, p. 6). Pain is one of the main reasons for using the health care system (Andersson et al., 1999, p. 794). In addition, chronically ill patients are permanent and frequent users of the health care system (Fischer et al., 2002, p. 4). Pain accounts for 40% of primary care visits (Mantyselka et al., 2001, p. 2).

The Helmholtz Zentrum München reports that back pain patients in Germany cost approximately 48.9 billion euros per year (van den Heuvel, 2008, p. 2). According to a survey conducted in Lübeck, approximately 53% of respondents had consulted at least one physician for back pain in the past year, of which approximately 11% had not received sufficient conservative treatment (Kohlmann et al., 1995, p. 292). 11% of whom conservative treatment did not appear to be sufficient (Kohlmann et al., 1995, p. 294). The number of annual back herniation surgeries in Germany is 60,000, and most of these patients initially tried invasive pain therapy preoperatively. In Switzerland, 80% of people suffer from back pain once a year to several times a week. Based on the resident population of Switzerland between 15 and 74 years of age, this amounts to more than 4.6 million women and men, who incur costs of about 1 billion Swiss francs due to musculoskeletal disorders (Gerfin et al., 2011, p. 2). The "Nuprin Pain Report" showed that 550 million working days are lost annually in the USA due to pain, although in the USA frequent absence from the workplace leads to dismissal. Converted to Germany, this results in 220 million lost working days per year (Taylor, 1985, p. 5). If one assumes around 130 euros per day for the average earnings of an employee, this results in indirect illness costs of around 28 billion euros per year due to lost working time as a result of pain. According to a WHO study, pain conditions account for about 20% of physician consultations (Guo et al., 1995, p. 592). Patients with a primarily pain-related impairment reported more frequent consultation rates to specialists, higher hospitalization rates, and contacts to emergency rooms (Guo et al., 1995, p. 591). In a survey of the reason for physician visits in Bochum medical practices, 48.8% of men and 50.9% of women reported that they consulted the physician because of acute or chronic pain, respectively (Papageorgiou et al., 1995, p. 1894). The most common contact for chronic pain was with the primary care physician, followed by the physical therapist and specialists in the hospital (Delitto et al., 2012, p. 52). Gender differences indicate that women are treated more frequently compared to men (Foster et al., 2018, p. 2371).

Chronic diseases are not only a frequent cause of premature retirement, but also often lead to incapacity to work. In recent years, there has been a steady decline in the number of days of incapacity to work, and according to AOK data, the average number of days of incapacity to work fell to 4.4% in 2005, which also led to a reduction in sickness benefits of around 8% compared with 2004. Despite this positive development, only 7.7% of the sick accounted for almost half of all days of incapacity to work in 2005. These were patients who were ill for longer than four weeks. Furthermore, people who were unable to work for more than six weeks accounted for 38.5% of absenteeism, although they made up only 4.3% of the insured who were ill. This suggests that long periods of incapacity to work are often due to chronic illnesses (Gopalan, 2005, p. 2).

2.5. Imaging back pain

Imaging is a single, though integral, part of the evaluation of the patient with back pain. The comprehensive evaluation must include historical data, the physical examination, and may extend to electrophysiologic tests, imaging, and response to minimally invasive interventions. Imaging can only be appropriately interpreted in the context of the totality of the evaluation; it does not stand alone. To an imaging professional, the ability of modern imaging technology to record an exquisite and accurate representation of patient anatomy and pathology is often believed to have inherent worth. To the clinician and patient, the consumers of imaging, technologically sophisticated imaging only provides value where it advances the diagnosis, excludes sinister disease, or identifies opportunities for evidence-based, imaing-guided therapeutic intervention. Imaging has no role in the evaluation of the patient with acute back pain in the absence of signs or symptoms of underlying systemic disease or progressive neurologic deficit. The decision to undertake imaging should be a rational one, balancing risk and benefit, and should be mindful of its well-documented flaws in specificity (asymptomatic degenerative processes) and sensitivity (dynamic lesions). The primary role of imaging remains the detection of undiagnosed systemic disease. Imaging should begin with plain radiographs. Advanced imaging may be undertaken when radiographs are not explanatory and conservative therapy has failed. Degenerative processes can be well demonstrated by imaging, but they obtain significance only in the context of the patient's pain syndrome. Imaging findings of disc degeneration are ubiquitous. In patients suspected of discogenic pain, HIZs in the posterior annulus, Modic type 1 and 2 marrow changes, severe disc space narrowing, and marked T2 signal loss in the disc may predict a positive discogram; there is, however, no true gold standard for the diagnosis of discogenic pain. Disc herniations can be detected by CT, CT myelography, or MRI. The imaged morphology of disc herniations does not predict the degree of disability or the intensity of the pain syndrome. The natural history of disc herniations is resolution. Imaging the structural changes of osteoarthritis in facet or sacroiliac joints does not predict a pain syndrome or response to intra-articular interventions. Imaging the inflammatory response with bone scan or heavily T2-weighted MRI does correlate with response to intra-articular anesthetic injections. In the detection and characterization of systemic disease presenting as spine pain, MRI is the dominant and preferred imaging modality. Imaging will provide the greatest value when there is close communication between the spine clinician and the imaging professional, as all imaging is context driven. To achieve long term success in the business, pain clinic owners and facilitators need to have a viable and well-detailed financial plan for the outfit. As a buiseiness owner, will have a clearer understanding of how to set pricing if we can classify and define the costs correctly. When a medical institution knows the true costs involved with producing and providing the process or services to customers, it can price both competitively and accurately. Additionally, certain health care area especially image guided minimal invasive interventional pain management is ideal market for pain management business with high rate of competition potential. Acting in a cost-effective manner involves using the resources at one`s disposal so satisfy the greatest need possible; or, conversely, meeting a given need with at least possible expenditure of resources. Starting from this general definition of the cost-effectiveness principle, a more detailed consideration of the instruments used for cost-effectiveness leads one to calculational cost-effectiveness, which describes the relationship between proceeds from services and costs for each billing period. Since reimbursements from health insurances do not completely cover the costs of medical care institutions services, the financing body for the hospital must cover the resulting `deficit`. Given these circumstances, the significant parameter is the degree to which the individual health care institution is able to cover their own costs. The decision to purchase the new medical imaging equipments (CT scan, MRI scan, etc) exclusively in digital technology (rather than analog) needs to convince medical institution funding body, as it forms a huge investment and must be consider in special investments.

Imaging is a single, though integral, part of the evaluation, diagnosis and therapy management of the patient with back pain, and may extend to neurophysologic tests and response to minimally invasive interventions. Medical imaging for diagnosis as well as pain therapy can only be appropriately interpreted in the context of the totality of the whole-evaluation-management; it doesn`t stand alone. To an imaging professional, the ability of modern imaging technology to record an exquisite and accurate representation of patient anatomy and pathology is often believed to have inherent worth. To the clinician and patient, the consumers of imaging, technologically sophisticated imaging only provides value where it advances the diagnosis, excludes sinister disease, or identifies opportunities for evidence-based therapeutic intervention. The primary role of imaging is to identify the approximately 5% of patients with back pain who have undiagnosed systemic disease as the cause of their pain. A related imaging goal is to characterize and assist in therapy planning in the very small percentage of patients who have neural compressive disease resulting in radiculopathy or radicular pain syndromes that fail conservative therapy and require surgical or minimally invasive intervention. Imaging identification of degenerative disease in the patient with back pain is, as this article elaborates, seldom helpful and is at best of secondary concern.
The use of sophisticated imaging in the evaluation of back pain is increasing. Lumbar spine magnetic resonance imaging (MRI), as measured by Medicare use statistics, increased by 307% in the 12-year interval from 1994 to 2005 (Maus, 2010, p. 741). Despite the greater intensity of evaluation, there is no evidence that patient outcomes have improved. Rather, much of spine imaging is often unreasoned and adds no value to the patient’s evaluation. There are very large regional variations in the intensity of spine imaging across United States; from onethird to two-thirds of spine computed tomography (CT) and MRI studies are judged to be inappropriate when measured against established guidelines. When considering the use of sophisticated imaging technologies in the patient with back or leg pain, it must be

remembered that this occurs in the context of overwhelmingly benign disease, in terms of both the underlying pathophysiology and the clinical course. Back pain is most commonly clinically benign and self-limiting, and will benefit neither from imaging evaluation nor invasive therapies.

Von Korff and colleagues in 1995 studied patients with a recent history of low back pain; at 6 months from onset, 76% of patients either had no pain (21%) or mild pain and disability, and 14% had significant disability with moderate to severe limitation of function. Another study noted that whereas 70% of patients with acute low back pain have persistent pain at 4 weeks from onset, at 12 weeks only 35% experience persistent discomfort and at 1 year only 10% have persistent pain. In an Australian study consisting of 2 populations, 49% to 67% had recovered from low back pain at 3 months following onset, and at 12 months 56% to 71% had recovered. There was a relapse rate of 7% to 27% within 1 year. Although these recent studies illustrate that the clinical prognosis of low back pain is not as positive as had been thought a generation ago, the vast majority of patients will indeed recover. Many of these patients have musculoskeletal strains or sprains, or suffer from nonspecific degenerative phenomena that may elude a clear diagnosis in up to 85% of patients (Maus, 2010, p. 750).

2.5.1 Early imaging: findings and costs

This study first addresses the utility of imaging in a patient who presents acutely with back or leg pain. It is well established that there is no role for imaging in this patient population in the absence of information that would suggest underlying systemic disease or signs of neurologic impairment which may require intervention; this applies to both radiographs and advanced imaging. A study by Scavone and colleagues6 evaluated spine radiographs in patients who present with acute low back pain; 75% of the studies provided no useful information (Chou et al., 2009, p. 464). A United Kingdom study randomized patients who had experienced back pain for 6 weeks to further clinically guided care or lumbar radiographs.7 At 9 months' follow-up there were no notable variations in the clinical results. When a patient first presents with back pain, Gilbert and colleagues randomized them to receive advanced imaging (CT or MRI) or imaging only when a clear clinical indication appeared. Patient outcomes were not significantly impacted by early advanced imaging. A meta-analysis of all randomized controlled studies comparing clinically directed therapy with immediate imaging (MRI, CT, and radiography) in acute back pain patients was carried out by Chou and colleagues in 2009. Analysis of the pooled data from the six qualifying trials revealed no discernible changes in pain or function over the short term (3 months) or long term (6–12 months) between imaged and nonimaged participants. Chou and colleagues concluded “lumbar imaging for low back pain without indications of serious underlying conditions does not improve clinical outcomes.”

Early imaging is not only costly, but it is also ineffective. According to a 1982 cost-effectiveness analysis by Liang and Komaroff, getting radiographs when back pain initially appears will cost $2000 (1982 USD) in order to provide one day of pain relief. Carragee and associates conducted a 5-year prospective observational research that skillfully illustrated the lack of use of imaging in the acute situation. Lumbar spine MRIs were obtained for a large group of asymptomatic people who were deemed to be at risk for back pain caused by labor-intensive employment. This patient group was followed up with periodically over the next five years; among those who saw a doctor for acute back or leg pain, some had a follow-up lumbar MRI examination. Less than 5% of the MRI scans obtained at the time of acute presentation with back/leg pain showed clinically relevant new findings. Nearly all of the "positive findings" noted on the images at the time of presentation with back/leg pain had been present on the baseline studies obtained when the patient was asymptomatic. The only imaging information that was considered significant in patients with a similar radicular pain condition was direct evidence of neural compression. Notably, psychosocial variables were the most accurate indicators of the level of functional impairment brought on by back or leg pain, rather than the anatomical features seen on imaging (Carrage et al., 2006, p. 626). Many professional groups and organizations have released guidelines advising against imaging in the early stages of a clinical pain condition based on such findings.

The Agency for Health Care Policy and Research (1994) advised against imaging patients who have back pain during the first month of a pain syndrome and do not exhibit indications of a systemic illness. Bradley revised the American College of Radiology practice standards in 2007. Imaging is not advised for patients presenting with acute low back pain unless "red flag" features are present (such as recent significant trauma, minor trauma in a patient older than 50 years old, weight loss, fever, immunosuppression, history of neoplasm, steroid use or osteoporosis, age greater than 70 years old, known intravenous drug abuse, or a progressive neurologic deficit with intractable symptoms). Similarly, the American College of Physicians and the American Pain Society jointly recommended against imaging for individuals presenting with nonspecific low back pain (Maus, 2010, p. 760). Imaging should only be carried out in cases of suspected serious underlying systemic disease or when there are severe or progressive neurologic impairments. Additionally, individuals who exhibit indications of radiculopathy or spinal stenosis ought to have imaging only in cases where they qualify for minimally invasive or surgical interventions (such as epidural steroid injection). These guidelines emphasize even more how important imaging is in identifying underlying systemic diseases, such as neoplasms, infections, or undiagnosed traumatic injuries.

2.5.2 Why measure costs: risk/ benefit analysis

The physician may choose to start imaging a patient who has not responded to conservative treatment or who has "red flag" symptoms that point to an underlying systemic illness. Such a choice needs to be based on a logical analysis of risk and reward. There are undoubtedly advantages to imaging. Above all, imaging can point to and help diagnose systemic diseases that were previously unknown. When a patient has radiculopathy or radicular pain syndrome and has not improved with conservative treatment, imaging can provide vital information for the design of minimally invasive or surgical therapies. Additionally, negative imaging ought to be useful for assuring that no serious illness is present and, as necessary, for halting any testing. Lastly, imaging may help determine the anatomical origin of pain in patients with chronic pain syndromes. Only after a specific source of pain has been identified can a tailored plan of therapeutic action, whether conservative or intrusive, be devised. Risk is often disregarded while weighing the benefits of imaging. Risk is the inevitable counterbalance to benefit. Imaging carries certain risks, including labeling impact, radiation exposure, cost, and solicitation of action. The labeling effect is the term used to describe the unavoidable appearance of degenerative results on imaging studies; the subject is now diagnosed with degenerative spine disease and becomes a patient. There are only unfavorable associations with the term "degenerative." A 2005 study by Modic and colleagues provides evidence of this negative. Patients who complained of back discomfort got MRIs, and they were randomly assigned to either get the results of the scans and share them with their doctor or not receive them at all. Among the study's conclusions was that, in contrast to participants whose MRI data was delayed, individuals who got the diagnosis of benign degenerative phenomena actually felt less well-off. This emphasizes how important it is for doctors to let patients know that the great majority of degenerative signs found on imaging are not significant. If patients are not adequately informed to the contrary, they may perceive this as the start of an unstoppable downward cycle of spine deterioration. This could lead to deconditioning, sadness, and fear avoidance behaviors with decreased activity.

The provocation of intervention is an imaging risk that is less often taken into account. When compared to patients who are not examined, Jarvik and colleagues' findings demonstrate that early access to sophisticated imaging (MRI) during a patient's spinal pain syndrome results in higher surgical interventions, even with similar pain and disability profiles. Similarly, Lurie and associates investigated the striking 12-fold geographical heterogeneity in the surgical intervention rate for central canal stenosis. These researchers found a direct correlation between the frequency of surgical intervention and the degree of CT and MRI utilization. The temptation is to treat a "abnormality" discovered by sophisticated imaging that may be the cause of a patient's pain. This condition arises in spite of the fact that many of the spine imaging "abnormalities," which are briefly reviewed, have a well-established lack of specificity. Treating the patient—not the image—is crucial.

Every patient visit should emphasize the need of maintaining high activity levels and functional strength, as well as the irrelevance of degenerative findings on imaging investigations. Radiation exposure from nuclear medicine research, CT scans, and radiographs increases the chance of neoplasm induction. When serial trials are carried out, this danger becomes especially troublesome. The Sievert (Sv) is a unit of measurement for biologically effective absorbed radiation dosage; in North America, the average yearly natural background exposure is roughly 3 mSv.17 With a dose of about 0.1 mSv, a frontal and lateral chest radiograph is frequently regarded as the standard measure of radiation exposure. Then, a 3-

view lumbar spine radiography series consists of approximately 15 chest radiographs, or 1.5 mSv. It is typical to receive a dose of 6 mSv, or 60 chest radiographs, for a lumbar spine CT scan. In the same way, 6.3 mSv is the dose for a technetium bone scan. In this case, the typical cost of a CT scan of the abdomen and pelvis is 14 mSv (Mettler et al., 2005, p. 255). Over the course of a patient's lifetime, all radiation exposure adds up and raises the possibility of radiation-induced cancer. Radiation-using imaging investigations need to be used carefully, taking into account both the potential risks and advantages. Imaging is expensive. Every year, the medical imaging industry in the US costs society more than $100 billion. Medicare covered the following lumbar spine imaging services in 2009: radiographs: $41, noncontrast CT: $264, myelogram: $506, noncontrast MRI: $439, whole body positron emission tomography (PET)/CT: $1183, and bone scan using single-photon emission CT (SPECT): $261. Nominal fees are typically three to five times the Medicare reimbursements, according to Maus (2010), p. 760. It is easy to see how quickly imaging costs may accumulate.

Organizational overhead is another source of departmental expenses for a radiology department operating within a larger firm. The "service departments," which don't make money, are responsible for most organizational overhead costs. Some of the departments that offer hospital services are contracting, purchasing, revenue cycle, compliance, legal, marketing, accounting, human resources, and general administration. Other departments include housekeeping, security, laundry, pharmacy, information technology and management, human resources, infection control, health and safety, compliance, and social services. Because service departments don't generate revenue, their costs are transferred to "production" centers, which include labs, radiology, surgery, and emergency services, as overhead that can be covered by revenue. In the United States, overhead costs account for between 43% and 45% of total hospital costs (Rubin, 2017, p. 344). Of these costs, 25.3% are specifically attributable to "administrative costs," which do not include costs associated with housekeeping, food, medication, social services, or other general clinical services (Rubin, 2017, p. 345). Outpatient imaging center overhead charges, estimated at 15%–25% of overall costs, are significantly lower than those in a hospital setting (Rubin, 2017, p. 345). Cost is defined by accountants as the monetary worth of resources used, sacrificed, or liabilities incurred in order to accomplish a goal, like producing or acquiring a good or carrying out a task or providing a service (Fasab, 2015, p. 2), which is an imaging examination or intervention that is finished from the standpoint of a radiology department, including initial consultation, scheduling, report completion, picture archiving, and revenue collection. Costs must therefore be assessed internally and analytically; they cannot be ascertained from outside sources.

2.5.3 Specifity, sensitivity, and relability of modern imaging modalities

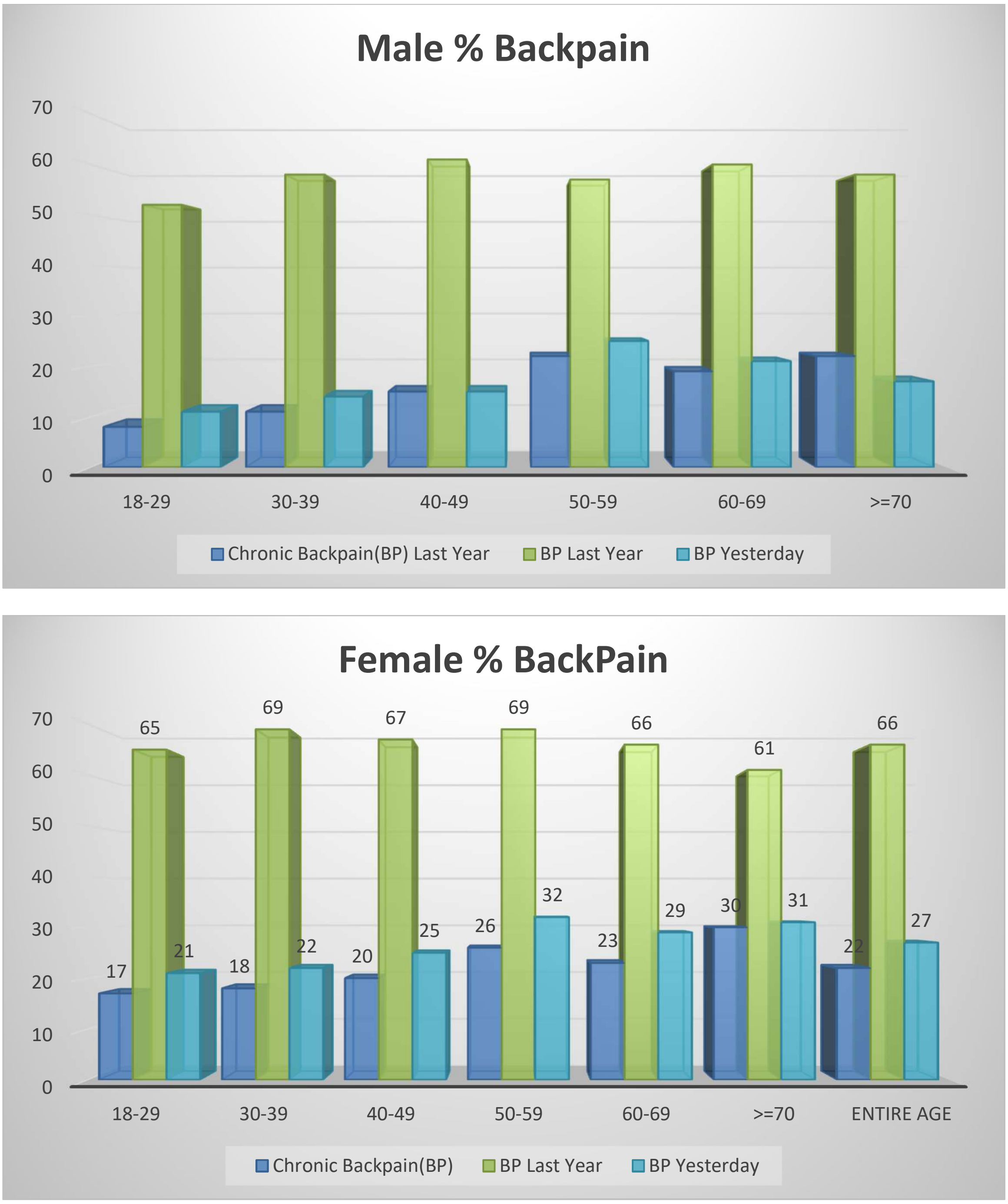
Once the benefits and drawbacks have been considered, it is critical to comprehend the reliability of the imaging results and the sensitivity and specificity problems that impact all spine imaging. Jarvik and Deyo report the estimated accuracy of several imaging modalities for various lumbar spine pathologies. Although the primary purpose of imaging is to detect underlying systemic disease, the low prevalence of systemic disease as a cause of back pain implies that the bulk of imaging investigations will mostly show degenerative processes. Degenerative changes are regularly seen on imaging scans, but they are rarely the reason for a specific patient's pain syndrome. Instead, they are often misinterpreted as the cause of pain, which results in unnecessary operations. It is not new to note that asymptomatic degenerative alterations in the spine are highly prevalent. In a 1954 study, Hult found that 87% of persons will have radiographic indications of disc degeneration by the time they are 50 years old (narrowing of the disc space, marginal sclerosis with osteophytes, vacuum phenomena). Radiographic evidence of disc disease was detected in 56% of participants aged 40 to 44 and 95% of participants aged 50 to 59 in a follow-up research involving a group of asymptomatic workers. Despite the development of increasingly advanced spine imaging methods, the specificity of degenerative findings remains low. In their analysis of asymptomatic volunteers' simple myelography, Hitselberger and Witten23 found that 24% of them had anomalies that would have been deemed relevant in the context of back or leg pain in a clinical setting. According to a study by Wiesel and colleagues using lumbar spine CT scans on asymptomatic volunteers, 50% of individuals over 40 had "significant" abnormalities. Similar to this, Boden et al. evaluated lumbar spine MRI in volunteers who were asymptomatic; of those who were over 60, 57% had abnormalities that would have been considered significant in an appropriate clinical setting. A sizable cohort of MRI patients was investigated by Jarvik and colleagues 26. Based on this investigation, extrusions, moderate to severe central canal stenosis, and direct observation of neural compression were the only criteria that were likely to be useful in discriminating between patients who experienced pain and volunteers who did not. Findings such as disc protrusions, zygapophysial joint (z-joint) arthropathy, and antero- or retrolisthesis were nearly always asymptomatic. The incidence of degenerative imaging findings in younger populations has been the subject of more recent investigations, mostly conducted in Scandinavia; they are population-based MRI studies that do not take symptomatology into account. In their 2005 study, Kjaer and colleagues discovered a 21% frequency of disc degeneration in 13-year-old children. Salminen and colleagues (1999) observed in a study of teenagers that the prevalence of disc degeneration increased from 31% in 15-year-olds to 42% in 18-year-olds. Takatalo et al. (2020) assessed 558 young individuals between the ages of 20 and 22. They found that 47% of these young adults had disc degeneration of grade 3 or higher using the 5-point Pfirrmann disc degeneration classification. Males (54%) had a greater prevalence than females (42%). In 17% of cases, multilevel degeneration was found. It is evident that the results of degenerative imaging are not very specific. According to population-based research, the incidence of imaging degenerative results is significantly higher than the prevalence of symptomatic disease. A high frequency of asymptomatic degenerative MRI abnormalities is revealed by studies of cohorts without symptoms. The likelihood of asymptomatic degenerative findings increases with age. Typically, one-third to two-thirds of asymptomatic people will have degenerative outcomes on all imaging examinations. Antero- or retrolisthesis, facet arthropathy, disc protrusions, and bulging or retrolisthesis are common, generally asymptomatic disorders that become more common as people age. Significant central canal stenosis, disc extrusions, and unmistakable signs of neural compression are more likely to be imaging findings that match clinical symptoms. Causality can only be suggested in cases when there is a clear association in a given patient between imaging and a clinical pain syndrome. Even in this situation, provocative or anesthetic testing could be necessary to enable logical decision-making, especially when therapies with a high potential risk and expense are being considered.

Conversely, there is a fundamental sensitivity issue with spine imaging as well. Numerous studies unequivocally demonstrate that positions involving axial loading and extension exacerbate neuroclaudicatory pain. Schmid and colleagues (1999) demonstrated that the crosssectional area of the lumbar central spinal canal, together with its lateral recesses and neural foramina, all diminish while adopting an axial load (standing vs. recumbent) and moving from neutral to extension posture. Danielson and Willen (2001) looked at both persons with neuroclaudicatory pain syndromes and groups of volunteers who did not exhibit any symptoms. These researchers discovered that axial loading and extension would reduce the cross-sectional dimension of the dural sac in 50% of patients who did not exhibit symptoms; in contrast, this impact would be noted in 76% to 80% of patients who experienced neuroclaudicatory discomfort. The majority of advanced imaging procedures (CT, MRI) are performed with the patient in a supine, relaxed psoas position with the legs slightly elevated for patient comfort and to minimize motion throughout the examination. The detection of dynamic neural compressive lesions is less sensitive when there is no axial strain and when the lumbar lordosis is lost. The literature strongly supports more physiologic imaging, also referred to as upright MRI or P/K (Positional/Kinetic) imaging. We can do both dynamic and weight-bearing testing with current scanners that have a low field strength of 0.6 T. Lower image quality results from a worse signal to noise ratio caused by the decreased magnetic field. Motion artifact results from patients' inability to stay in a position that makes them more uncomfortable. Loading devices that provide a compressive load and place the lumbar extension on conventional high-field MRI or CT scanners are certainly much more financially realistic. Danielson and Willen's research suggests that loading the patient to 50% of their body weight for five minutes and then imaging again is a reasonable way to replicate upright imaging. With these devices, more intricate movements like rotation and side bending are not feasible. Utilizing data from the Spine Patient Outcomes Research Trial (SPORT), the largest and most comprehensive study on the precision of magnetic resonance imaging (MRI) in detecting and characterizing degenerative processes in the lumbar spine has been carried out. Lurie et al. investigated the degree of thecal sac impairment, the grading of nerve root impingement, and the accuracy of MRI in identifying and classifying disc herniations. For disc morphology (herniation), interreader reliability was substantial; for the degree of thecal sac compression, it was moderate; and for nerve route impingement, it was moderate. Later, Carrino and colleagues looked at nondisc contour degenerative findings and discovered that there was good agreement amongst observers when assessing the disc degeneration's degree. There was a moderate level of interobserver agreement in the evaluation of spondylolisthesis, modic endplate changes, z-joint arthropathy, and annular high-intensity zones (HIZ).

In the pursuit of a noninvasive discogenic pain diagnosis, combinations of MRI results were explored by Kang and colleagues in 2009 and O'Neill and colleagues in 2008. Kang et al. combined imaging results into 4 classifications and found that the most valuable finding was the presence of a disc herniation with an HIZ, which resulted in a 46% sensitivity, 98% specificity, and 87% positive predictive value as a predictor of positive discography. Recipient operator characteristic curves were used in a genuine multivariate analysis carried out by O'Neill and colleagues in 2008. All things considered, they came to the conclusion that disc signal abnormality is just as accurate as any other MRI metric or set of parameters. Discography will most likely be positive when there is a significant loss of disc signal and negative when the disc signal is normal. Other parameters can be useful in cases where the disc signal loss is moderate. The best combination of specificity (79%) and sensitivity (80%) was found in cases of moderate disc bulging and disc signal loss. Including results of HIZ presence or disc space height reduction improved specificity at the expense of sensitivity.
A look abroad reveals a similar picture for other industrialized nations (USA, Canada, UK, Switzerland, Netherlands and Sweden): around 56% of the working population stated that they suffered from back pain in the year before the survey. 3% of the working population complained of back pain on more than 31 days. Further epidemiological studies in Western industrialized countries indicate that by the age of 30, almost one in two had experienced a significant back pain episode (Schmidt et al., 2005, p. 292). The age group of 25 to 55 years has the most frequent pain episodes (Linet et al., 2012, p. 78). Chronic back pain develops in 5 to 8% of patients (Segura-Trepichio et al., 2017, p. 7).

Figure 2.6

Prevalence of back pain in Germany (courtesy RKI 2006, p.22)



most frequent pain episodes (de Girolamo, 1991, p. 65). Chronic back pain develops in 5 to 8% of patients (Segura-Trepichio et al., 2017, p. 4).

In Switzerland, the annual (direct) cost of back pain is approximately CHF 10 billion, i.e. CHF 7,400 per patient per year, with total costs (including indirect costs) of approximately CHF 7 billion (Interpharma, 2011, p. 4). Most of the direct costs (approx. 25 %) were caused by the use of medical care, mainly in outpatient settings. Inpatient admission or rehabilitation hospitalization was used by about 9 % of patients. Medication costs account for CHF 30 per patient per year. In addition, a drop in productivity of approximately 30 % was observed in 20 % of the respondents (Interpharma, 2011, p.10).

Table 6
Costs of back pain, data refer to annual costs in CHF 2005 (Interpharma, 2011, p.14)

	Cost per patient in CHF/a	Cost CH in Mio. CHF/a (HKA)	In Percent	Costs CH in MIO.CHF/a(FKA	The total costs in percent
Direct medical expenses	1974	2751	26.7 %	2751	37.3 %
Thereof medication costs	31	42	0.4 %	42	0.6 %
Direct non-medical costs	878	1224	11.9 %	1224	16.6 %
Total direct costs	2851	3975	38.6 %	3975	54.0 %
Informal Care	NA	NA	NA	NA	NA
Productivity loss	4529	6316	61.4 %	3390	46.0 %
Total indirect costs	4529	6316	61.4 %	3390	46.0 %
Total costs	7381	10291	100 %	7365	100.0 %

2.6 Impact on direct and indirect costs

This is not only a new medical challenge, but also an increasing socio-economic challenge. Back pain is a widespread disease which is connected with the known diseases such as e.g. cardiovascular diseases or diabetes diabetes, for example, are now competing for the top places in the frequency statistics. The trend towards new complaints, the need for treatment and the associated costs is rising sharply. Reasons reasons for this are manifold, but certainly also to our aging society. According to current figures from the Federal for Statistics, 1.64 million inhabitants in Switzerland were 65 years and older, in the year 2050 this number is 2050, this figure is expected to rise to 2.67 million. In addition, the Federal Office forecasts a more more than doubling of the number of senior citizens over the age of eighty will more than double from the current 0.46 million to 1.1 million in 2050 (BAS, Federal Office for statistic Switzerland). The number of senior people will increase so rapidly over the next 20 years, regardless of the frequency and prevalence of back pain, that the burden of an interventional service will unavoidably increase. The basis for the economical evaluation and successful utilization of the limited resources in the healthcare system should be solid cost accounting.

Cervical, thoracic, and lumbar pain syndromes and radiculopathies are common clinical manifestations that result in significant costs to the economy in general and to insurance companies in particular. In the U.S., back pain is one of the most common reasons for medical consultation and hospitalization (Parthan, 2005, p. 4).

In 2005, the total economic costs of back pain in Germany amounted to 17 billion euros (approximately 15 % of the gross domestic product) (Schindler, 2013, p. 3). In 1999, 107,390 men and 83,000 women were hospitalized for back pain. The total cost of inpatient admission and treatment of patients with back pain was approximately 1.28 billion euros (Schmitz, 2004, p. 3). In 1994, the total expenditure for back pain in Germany was approximately 10.48 billion euros (Schmitz, 2004, p. 3).

Back pain is cost-intensive, as it is often the reason for sick leave and causes high direct and indirect costs. Direct costs refer to outpatient or inpatient medical care with charges to health insurance companies. Indirect costs are costs resulting from missed work and sick pay or continued payment of wages. Back pain places a significant financial strain on people, families, and the national economy as it is the primary cause of activity limitation and unemployment. Many studies have evaluated the economic consequences of back pain in Europe. An annual loss of 100 million workdays is attributed to back discomfort in England. The number of Swedish workers who missed work because of back pain rose from 7 million in 1980 to 28 million in 1988. In the US, back pain ranks as the second most common cause of disability. It is predicted to cause 149 million lost workdays annually, at a cost of between $100 and $200 billion (Duthey, 2013, p. 15). Most back pain is self-limiting. About 5% of back pain is responsible for 75% of the costs. The direct costs of medical services for back pain in Germany in 2006 were approximately 8.4 billion euros (Thielen, 2015, p. 1). The Helmholtz Zentrum München reports that back pain patients in Germany cost approximately 48.9 billion euros per year (van den Heuvel, 2008, p. 46). On average, back pain costs between 1,322 euros and 7,000 euros per patient per year, consisting of direct and indirect costs (Thielen, 2015, p. 4). Most neurosurgical patients in the U.S. are back pain patients (35%). The rate of physician visits ranged from 11% to orthopedists, 10% to neurologists, and 3% to primary care physicians. Only 2% of patients were directly admitted as inpatients for further treatment (Parthan 2005: 3). In Germany, approximately 16% of all outpatient visits to primary care physicians are back patients. 43% of outpatient orthopedic patients come for back pain (Ossendorf 2008: 2).

In Germany, back pain causes 17 to 22 billion euros in total economic costs annually (indirect costs of approximately 10 to 15 billion euros or 70% of total costs), which corresponds to approximately 1% of the gross domestic product (Ossendorf, 2019, p. 6). According to an American survey (NHANES II 1976 and 1980), approx. 11.6% of patients underwent surgery. (Parthan, 2005, p. 5) The fact is, however, that surgical procedures are on the rise and vary in frequency depending on where patients live; For instance, compared to other industrialized nations, the United States had a back surgery rate that was almost 40% higher. The number of back surgeries performed per 100,000 persons grew by 55% between 1979 and 1990, from 102 to 158 (Parthan, 2005, p. 5).

2.7 Multimodal diagnostic and therapy

2.7.1. Anatomy of the spine

The intricate arrangement of the spinal nerves and spine permits adequate and regular movement. The 24 vertebrae that make up the spine (7 cervical, 12 thoracic and 5 lumbar). The vertebral bodies have articular processes (facet joints) and thus ensure mobility. The muscles and ligaments are attached to the spinosi and transversi. The ligaments have as a function above all the stabilization with movements and/or a movement limitation. The intervertebral discs (Disci Intervertebralia) function as shock absorbers and consist of a firm outer ring (Anulus fibrosus) and a soft core (Nucleus polposus). The nerve roots originate from the medulla. These emerge between individual vertebral bodies.

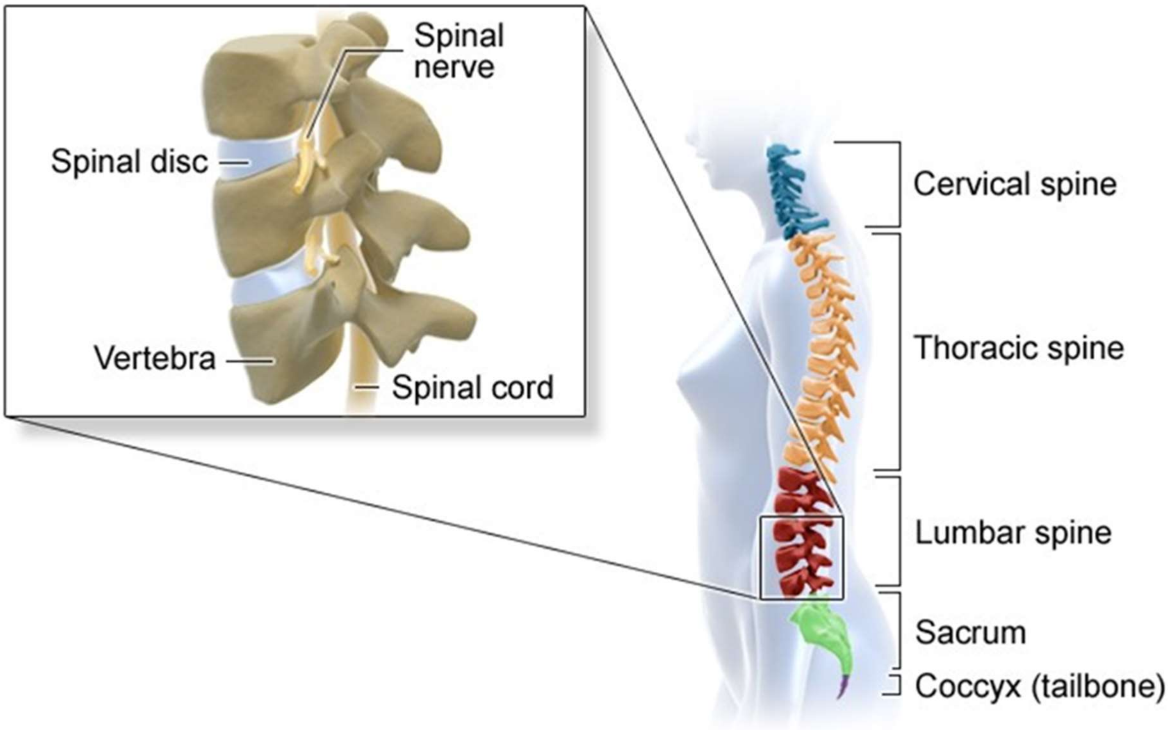


Figure 2.6
Anatomy of Spine

Signal alterations in the cartilaginous endplate and surrounding subchondral marrow that coincide with disc degeneration demonstrate the functional unity of the disc and the endplate. Modic and associates first classified endplate marrow alterations in 1988. The vascularized granulation tissue that has grown into the sub-endplate marrow is represented by the type I alteration, which can be enhanced by gadolinium and shows hypointense and hyperintense T1 and T2 signals on MRI. The type II change indicates fatty infiltration of the sub-endplate marrow and is characterized by increased T1 and T2 signals. Hypointense on T1 and T2, type III alteration is associated with bony sclerosis. Type II changes are more quiescent, whereas type III changes are postinflammatory. Type I changes are assumed to reflect an active inflammatory state. Ohtori et al. (2006) noted that in their cartilaginous endplates, patients with modic changes exhibited increased amounts of tumor necrosis factor (TNF) immunoreactive cells and protein gene product (PGP) 9.5 immunoreactive nerve fibers. The immunoreactive nerve ingrowth was exclusively present in patients with discogenic low back pain. TNF immunoreactive cells were more prevalent in type I endplate changes. Modic endplate adjustments, in particular type I modifications, have been linked to low back pain. Toyone et al. found that 73% of patients with type I alteration had low back discomfort, compared to only 11% of those with type II alteration. Albert and Mannichere also noted that low back discomfort was present in 60% of patients with Modic alterations but not in those without them. Type I change was more strongly correlated with low back discomfort than type II change. Numerous researchers have linked type I and type II endplate modifications to the reaction to provocation discography, including Braithwaite and colleagues, Ito and colleagues, Weishaupt and colleagues, Lei and colleagues, O'Neill and colleagues, and Kang and colleagues (Maus, 2010, p. 740). A modic type I change may also be associated with segmental instability. In 1995, Toyone et al. found that 70% of patients with type I change had segmental hypermobility (>3 mm translation on flexion-extension films). Hypermobility was present in just 16% of patients with type II alterations. In a similar vein, patients who subsequently experienced pseudoarthroses in the post-fusion patients investigated by Butterman and colleagues in 1997 had permanent type I alteration. Patients who have solid fusions are more likely to experience type II change, or resolution of all modic changes.

2.7.2. Imaging technologies and costs

The first step in cost management, which helps ascertain the margin and, ultimately, the value of particular clinical operations or items, is measurement and attribution of expenses to cost objects. For a production department such as neuroradiology, product-level pricing requires the first aggregation of all department traceable expenses, including allocated service department costs. Then, these expenses need to be linked to specific healthcare services or cost items.

Slice pictures of different anatomical structures are produced by both CT and MRI, two diagnostic imaging modalities. Each has a completely different theory underlying it. Whereas MRI makes use of the magnetic qualities of ions in the human body, especially hydrogen ions, CT uses x-rays. In addition to adding unneeded expenses to the healthcare budget, unnecessary imaging exposes patients to ionizing radiation during CT or conventional radiography operations.

After considering the advantages and disadvantages of imaging and realizing its limitations in terms of sensitivity and specificity, the physician can move on with imaging, starting with radiographs. Usually, this operation is performed when there are growing neurologic deficits, pain that is not improving with conservative therapy, or clinical "red flags." More sophisticated modalities are unable to yield the vital information that weight-bearing radiographs do on coronal and sagittal alignment and vertebral enumeration. Vertebral enumeration is not something to take lightly. Anomalies of segmentation (transitional segments) at the lumbosacral junction may affect up to 12% of the general population (Maus, 2010, p. 738). Later advanced imaging and intervention will use vertebral numbering established by radiographs, which reduces the possibility of wrong-level operations. Additionally, radiographs can be used as a low-sensitivity screening method to look for signs of infection, fracture, or malignancy. Degenerative findings such as small degrees of antero- or retrolisthesis, z-joint arthropathy, and disc space narrowing are probably not important and have nothing to do with a patient's pain syndrome. A solitary frontal and lateral standing picture of the lumbar spine is adequate. Oblique views shouldn't be frequently obtained because they double the gonadal radiation dosage. Side bending or flexion-extension views should only be obtained in the context of operational planning. When radiographs fail to reveal an underlying systemic disease or provide an explanation for an ongoing pain condition, advanced imaging (CT, MRI, nuclear medicine) is used. The last ten years have seen a revolution in CT thanks to multidetector technology advancements. It is now possible to get a lumbar spine dataset in a matter of seconds, thereby removing motion artifact and significantly enhancing patient tolerance. After that, this information can be rebuilt in any plane without sacrificing spatial resolution or exposing users to further radiation. When compared to MRI, CT offers better imaging of the cortical and trabecular bone. Because of this, a CT scan can be required to identify primary bone malignancies in the spine. In most situations, CT can detect root compression lesions such disc herniations and has a respectable contrast resolution. Not only is CT less sensitive than MRI at identifying neoplasms, paraspinal soft tissue lesions, and early viral or inflammatory processes, but it also cannot identify intrathecal pathology. Radiation exposure needs to be considered at all times when utilizing CT. The absence of comparative studies between MRI and the current generation of multidetector CT scanners in the literature for the diagnosis and characterization of disc herniations is one effect of the rapid technological advancement of CT in recent years.

Over the past 20 years, magnetic resonance imaging (MRI) has been the most common modality for spine imaging, despite relatively minor advancements in technology. Because MRI can distinguish between different forms of soft tissue and has a greater contrast resolution, it can detect intrathecal disease and identify minor root compression lesions. When it comes to identifying infections and tumors, MRI has higher sensitivity. MRI can identify inflammatory changes by using gadolinium contrast or highly T2-weighted imaging sequences (rapid spin echo T2 sequences with fat saturation or short-tau inversion recovery [STIR]). When determining the chronicity of fractures, it is more specific than CT. MRI can differentiate between scarring and recurrent disc herniation in the postoperative patient with gadolinium enhancement. Cortical bone is not well evaluated by MRI. Patient acceptance is still a challenge because of the high cost, lengthy imaging periods, and 10% examination failure rate attributed to claustrophobia. Open magnets have increased patient acceptance, but image quality has suffered as a result. A tiny number of patients cannot undergo an MRI because of implanted equipment such as pacemakers or spinal cord stimulators. In the lumbar spine, CT myelography continues to play a problem-solving function; in patients who are incompatible with MRI, it will take its place. When compared to MRI, CT myelography offers better spatial resolution, but it is not as good at soft tissue contrast. It can provide an excellent evidence of central canal, lateral recess, and foraminal compromise in addition to root compression lesions when intrathecal contrast material is used. In order to be as beneficial as possible, CT myelography must utilize current CT technology and is costly, operator-dependent, and minimally intrusive. Studies in nuclear medicine are becoming more significant for spine imaging. Accelerated bone metabolic activity can be found with technetium bone scans. Addition of SPECT capabilities allows for the possibility of considerably increased spatial resolution. This type of imaging is helpful in evaluating individuals who have a clinical suspicion of spondylolysis as well as in determining the burden of metastatic disease. Technetium bone scanning can be utilized to assess the chronicity of vertebral fractures in individuals being considered for bone augmentation when magnetic resonance imaging (MRI) is not technically possible. In order to identify pain generators and target these sites for injection, bone scans can detect noninfectious inflammatory illness in the sacroiliac and facet joints. The technetium bone scan combined with the gallium scan provides spondylodiscitis identification with sensitivity comparable to magnetic resonance imaging (MRI). They do, however, offer less anatomical detail, and an MRI might eventually be required to assess the level of central canal damage that could affect the surgical decision. An increasing number of studies use PET or PET/CT scans to determine which lesions should be removed via percutaneous biopsy and to gauge the burden of metastatic disease.

Though the primary goal of imaging in patients with back or leg pain is to discover systemic disease or characterize neural compressive disease that requires intervention, most spine imaging will inevitably be used to assess degenerative disease because these processes are rare. The imaging of degenerative processes is covered in this part first, then imaging results in systemic diseases that might cause leg or back discomfort. A complex process involving genetic, inflammatory, traumatic, and dietary factors all play a role in disc degeneration. A detailed discussion of disc degeneration is outside the purview of this study; nevertheless, there are numerous other articles in this issue that address this topic.

Disc degeneration manifests on plain radiographs as a decrease in the height of the disc space, nitrogen gas inside the disc space (vacuum sign), and marginal osteophytes. An adult's disc space height normally increases from L1 to L4 caudally; the lumbosacral disc, or L5, has a variable height that is usually lower than L4's. Disc degeneration is found on CT images, especially sagittal reconstructions, and is detected with greater sensitivity than on radiography. On T2-weighted MRI images, the typical nuclear compartment of the disc is hyperintense, and the hypointense annulus encircles it. The intranuclear cleft, a horizontal hypointense band that runs through the center of the nucleus, is a characteristic feature of the mature disc. Early disc degeneration results in the loss of the intranuclear cleft and an unclear junction between the low signal annulus and the hyperintense nucleus. This reduced nuclear signal is not just a result of dehydration; rather, it also represents loss of proteoglycans and changes in their hydration status. A later loss of disc space height is possible. Fissuring occurs when the fibrous annulus fails, and this can be seen as an outer annulus focal zone with an increased T2 signal or gadolinium enhancement. It is established that the sinuvertebral nerve provides an afferent supply to the outer part of the annulus, thereby innervating it. Granulation tissue will infiltrate the disc as fissures extend from the annulus to the epidural space, causing unmyelinated C-type nociceptors to proliferate into the inner annulus or nuclear compartment. It is hypothesised that these nociceptors get sensitized to the nuclear biochemical environment, which makes them fire at very low mechanical stress levels, like those experienced in daily activities. This is considered to be the cause of the intolerance for sitting- and standing-related discogenic discomfort. We now discuss potential imaging indicators of discogenic pain. The usefulness of discography as a diagnostic tool is still debatable and has been covered in other articles.

These must be clarified by a specialist and then treated conservatively/medically and, in rare cases, intermittently. Apart from the categorization based on particular and non-specific back pain, a classification based on the duration of symptoms is frequently employed for symptoms beyond 12 weeks. These categories include acute (symptoms lasting up to 6 weeks), subacute (symptoms lasting up to 12 weeks), and chronic. In the group of specific back pains, the most frequent cause of pain is most frequently wear-related diseases of the of the small vertebral joints (facet joint arthrosis), wear of the intervertebral discs with consecutive intervertebral spaces (osteochondrosis), degenerative instabilities (slipped vertebrae), narrowing of the spinal canal (spinal canal stenosis) spinal canal (spinal canal stenosis) and osteoporosis vertebral body fractures caused by osteoporosis. More rare causes are to be found in inflammations and tumor settlements or spinal tumors. Therapeutically, three pillars are available. On the one hand, the conservative/medicinal/physiotherapeutic splint and on the other hand the interventional therapy. Finally, the surgical procedures. This step-by-step scheme is to be applied in most cases. cases. In some cases, such as in the case of severe paralysis, bladder and rectal involvement, pronounced inflammation, tumors or unstable fractures, conservative unstable fractures, conservative therapy is no longer no longer indicated, but only surgical treatment. In the group of conservative therapeutic approaches, the following have been shown to be effective in studies non steroidal anti-inflammatory drugs, opiates, physical therapy, manual/chiropractic therapy, muscle relaxants, heat applications and, above all, activating exercise therapy. Interventionally, the option of infiltration is available. Here, various anatomical anatomical structures, such as the small vertebral joints or the sacroiliac joint, which connects the spine with the pelvis, are infiltrated with a local anesthetic and an additive (cortison, O3). Surgical strategies are based on the underlying pain-causing anatomical structure with the aim of remedying this (causal therapy approach). Depending on the findings, minimally invasive, percutaneous procedures, microsurgical microscopic, endoscopic, but also open corrective procedures are used. General degenerative changes of the spine are the most common cause of complaints. Disc protrusions (with varying degrees and topology), bony narrowing of the spinal canal or neuroforamen, and arthrothic changes of the spondyl joints are the most common degenerative changes. These changes can lead to nerve root or nerve plexus affection with resulting pain symptoms with or without sensory or motor deficits of the extremities. The localization and intensity of the pain are important indicators for further diagnosis and for the therapeutic regimen.

A radicular character of the symptomatology is an irritation or compression of one or more nerve roots involving the exclusive supply area of the affected nerves. The symptoms may be defined in a range from occasional lumboischialgia to severe pain with paresthesias and motor weakness. Worse case scenario is denervation of the affected area with complete motor and/or sensory loss.

Diagnosis and therapy of patients with pain syndrome involve intensive multimodal cooperation and evaluation by a team of different medical specialists (family physicians, general practitioners, orthopedists, neurosurgeons, rheumatologists, neurologists and (neuro-)radiologists. At the next level, physiotherapists, social workers and psychologists are necessary.

The basis of the diagnostic process is a careful and standardized anamnesis with complete and accurate collection of medical history and complaints in combination with physical (neurological / orthopedic) examination. In radiology, a complete precise diagnosis is currently hardly conceivable without imaging procedures. First and foremost, X-ray diagnostics in two planes, computed tomography and MRI are used. MRI has established itself as the golden standard for diagnosing primarily degenerative changes in the spine.
If the patient does not experience relevant relief of pain after the usual conservative measures and non-image-guided injections, the use of image-guided infiltration to control the needle position is necessary. For this purpose, when neurotoxic drugs are applied, the distribution of the drug must also be closely observed.

Wu et al. estimated the cost-effectiveness of MRI in cervical clearance of obtunded blunt trauma in 2021 and discovered that MRI was more costly and provided less health benefit than no follow-up after a normal CT scan finding for spine instability in patients with obtunded blunt cervical spine trauma (Fig. 7). Although the website does not include the exact computations used to arrive at these figures, the expenses are adjusted to reflect 2015 purchasing power. Hence a prior meta-analysis (Malhorta et al., 2017, p. 625) found that further research, including a cost-effectiveness analysis, is required and that the usefulness of MRI in diagnosing unstable cervical injury following a normal CT finding was somewhat restricted.

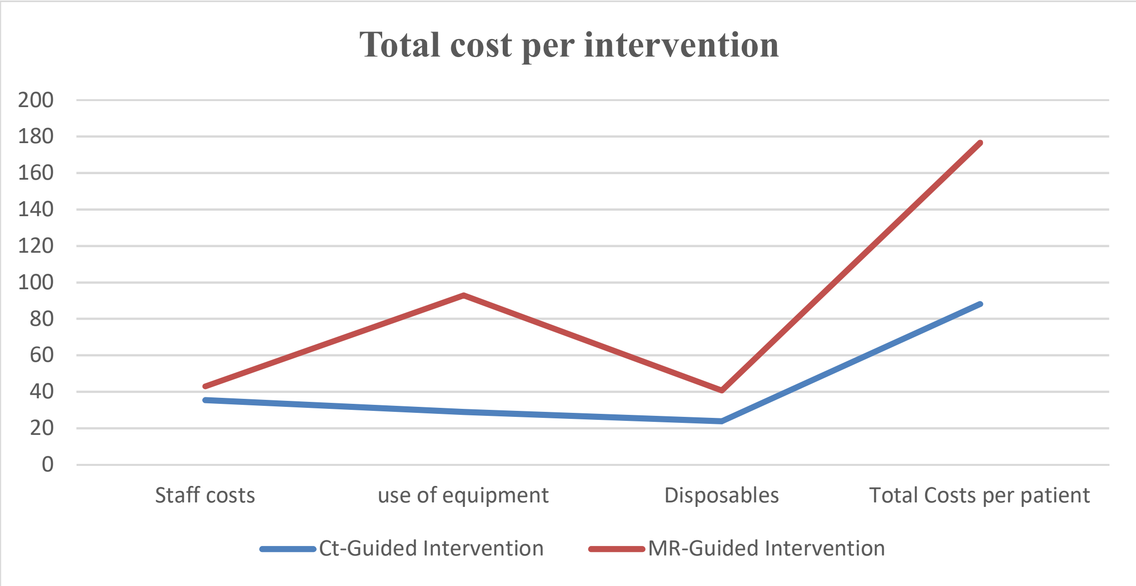


Figure 2.7
Total expenditures (in euros) for each intervention, including personnel, equipment use, disposables, and hospital stays for nerve root infiltration guided by CT and MR. Alternate average total expenses for each patient: Standard 16-row CT scanner: €74; open low-field MR scanner: €121.21

2.8 Cost effective alternative invasive therapy: image-guided interventional pain therapy

Patients who have mechanical low back pain, which is characterized by discomfort that is most likely coming from one source, such as a sacroiliac joint, facet, disc, or a combination of these, frequently get minimally invasive treatments done. These minimally invasive methods are usually an essential part of an all-encompassing pain treatment plan. According to a systematic analysis published by the Dutch Health Insurance Council (CVZ 2011), there is now uncertainty regarding the overall effectiveness and cost-efficiency of these operations for individuals with chronic low back pain (Ligtenberg et al., 211, p. 24).

Cost layering has been suggested as a way to stratify expenses according to their sensitivity to changes in resource use and, consequently, the possibility that their management may result in short-term savings, since the classification of costs as fixed versus variable is dependent on time. Over time, all costs are subject to change. In reality, Kaplan and Porter have argued that the fixed cost conundrum is unfounded and that, with proper attention and openness to the reinvention of long-standing organizational norms, the majority of health care costs—including those related to labor, space, and equipment—could be variable costs (Rubin, 2017, p. 344). They propose, for instance, that these formerly fixed expenditures would become variable costs if surplus space were repurposed, sold, or subleased and unused equipment was sold. Although a thought-provoking concept, this perspective offers less direction for the administration of imaging divisions or complete healthcare systems functioning within the framework of yearly budget cycles and performance standards.

The major objectives of treatment are to control pain, preserve mobility, and avoid exacerbations because, as we all know, these can result in increased direct and indirect medical expenses. Back pain is cost-intensive, as it is often the reason for sick leave and causes high direct and indirect costs. Direct costs refer to outpatient or inpatient medical care with charges to health insurance companies. Indirect costs are costs resulting from absences from work and sick pay or continued payment of wages. In 2005, the total economic costs (direct and indirect) of back pain in Germany amounted to 17 billion euros (approximately 15% of the gross domestic product) (Schindler, 2013, p. 4).

First phase of therapy of back pain starts with analgesics (paracetamol, NSAID, opioids). The problem from long-term oral or intravenous pain therapy is chronicity of pain or possible risk of drug dependence (especially with opioids). In addition, conservative therapy includes musculoskeletal manipulations by various therapists (physical therapy, manual therapy, chiropractors, etc.). Patients suffering from pain are initially treated with low cost conservative oral and physical therapies, i.e. with pain medication in combination with physiotherapy. If conservative therapy does not bring the desired success, minimally invasive pain therapy may additionally be considered. This therapy is very effective and is also recommended for certain back pain (and leg pain) in the guidelines, among others (NVL 2017). The most effective invasive treatment for sciatica brought on by a herniated lumbar disc is still up for dispute. The use of non-surgical techniques like image-guided injections in place of surgical discectomy is not well-supported by data. According to a new UK study, an image guide infiltration should be taken into consideration as a first invasive therapy option for individuals whose sciatica is caused by a herniated lumbar disc. This approach is probably more affordable than surgery (Wilby et al., 2021, p. 347). This study's economic analysis was conducted over a 54-week trial period. Unit costs were acquired using common sources based on prices for 2017 and 2018, with inflation indices adjusted where needed. The difference in the cost per Quality Adjusted Life Year (QALY) between infiltration and surgery was the primary finding of the economic analysis. The uncertainty in the economic outcomes were examined using non-parametric bootstrapping with 10,000 replications of the patient-level data. The outcomes were displayed as cost-effectiveness probability at certain willingness-to-pay thresholds. Koes et al. (1999) evaluated a total of 12 randomized clinical trials and assigned them with points, measured by their methodological quality. He found weaknesses in the respective study in the respective study design. Of his 4 top-rated studies, 2 had a positive outcome and 2 had a negative outcome. Outcome and 2 a negative one. Overall, he said, the effect was short-lived, if it lasted at all. Rozenberg (1998) assessed the same studies in a different way, but came to the same result [73]. In their review, Nelemans et al. (2001) found no convincing evidence for an effect of peridural corticosteroid injections in patients with low back pain and called for further, more detailed studies. A distinction between patients with acute and chronic back pain was not made. Watts and Silagy (1995) summarized the results of the studies that Koes et al. also evaluated. They referred to the odds ratio (OR) and concluded that peridural corticosteroid injections lead to pain relief in patients with lumbar radicular syndrome. They calculated an OR of 2.61 for pain relief for a period of 60 days and an OR of 1.87 for a period of more than 12 months. McQuay et al (1997) referred only to the respective odds ratios (OR) and number needed to treat (NNT) of these studies and were thus able to show that peridural Corticosteroid injections have an analgesic effect [48]. This evaluation showed that 1 in 6 patients who received a peridural corticosteroid injection experienced a short-term Pain relief of greater than 75% in the first 60 days. The NNT for 50% pain relief was less than 3. For long-term (between 12 weeks and 1 year) Pain relief of at least 50%, the NNT was less than 11. In their evaluation, Tonkovich-Quaranta and Winkler (2000) saw a possible effect epidural corticosteroid injections in patients with chronic lumbar radicular syndrome and previous radicular syndrome and previous unsuccessful conservative therapy. Cannon and Aprill (2000) concluded that epidural corticosteroid injections in patients with lumbar radicular syndrome should be used, and that the different results of the study were also due to the uncontrolled application of the corticosteroid in relation to the damaged nerve root. In 2016, Shrivastava et al. conducted a cost analysis of CT scan and MRI at Excel super-speciality hospital in an effort to determine and evaluate the unit cost of these investigations at one general hospital in Ghaziabad. The study's design was derived from staff interviews (both medical and non-medical) along with sample records from the hospital's accounts, maintenance, radiology, stores, and buying departments. The ABC technique, or activity-based costing, has been adhered to by the researchers. They learned about input resource costs and drivers. They then discovered the steps required in every radiological treatment and determined what factors contributed to the overall cost. Cost inputs were first divided into direct and indirect costs, and then into fixed and variable costs. The total cost of each procedure's operation was divided by the total number of operations performed to get the cost per unit procedure. The breakeven volume, or the total number of procedures that must be completed beyond which all marginal contributions (Revenue-Variable Cost) will reflect revenue for the hospital, was then ascertained using breakeven analysis. The break-even point is the output or sales level at which the income generated by the company precisely equals the cost of producing (or selling) the output. The computation is presented as follows:

Sales Income – Variable Expense = Margin of Contribution

This contribution margin helps to cover the fixed costs that are incurred.

The single center study reported after the cost analysis of CT scan the biggest portion of the costs (31.87%) machine depreciation and maintenance followed by wages and salary for staff (21.77%). For MRI scan is the machine depreciation 44%, wages and salary of the staff about 16%. When it comes to MRIs, the direct and indirect costs contribute to the overall cost nearly equally. When it comes to CT scans, direct costs make up 58% of the entire cost, while indirect costs make up 42%.

2.9 Puncture techniques

There are different puncture techniques for lumbar periradicular infiltrations, e.g., puncture in which the needle is placed antero-posterior to the nerve root (so-called safe

triangle). An alternative is retroneural or retrodiscal puncture (Omidi et al., 2018, p. 1508). Lumbar interlaminar infiltration is a technique used primarily for spinal stenosis.
Facet joint infiltrations are used in back pain patients with arthritic changes of the spondyl joints.

In patients in prone position, first a topogram and then an axial scan (slice thickness depends on the CT device and protocol, generally between 2 to 6 mm) is obtained at the level of the affected nerve root. First, the target site is defined, the access route is selected (posterolateral access route), and the puncture site is marked on the skin. After skin disinfection and sterile draping of the puncture site, the skin is punctured with a needle (22-25 G). When advancing or correcting the position of the needle, a control CT is made until the needle is exactly at the target position. This is followed by aspiration and injection of 0.5 ml of radiopaque contrast agent, rechecking with CT scan and assessment of contrast distribution in the perineural or peridural space. Afterwards, a cortisone preparation with or without a short-acting analgesic is applied.

2.10 Frequency of use of image-guided interventional therapy

Unfortunately, no accurate statistical data exist on the number of minimally invasive interventional spinal procedures performed in Europe. It is likely that ESI (epidural spinal injections) are the most commonly performed pain therapies in developed countries (Omidi et al 2018). Medicare data indicate that approximately 2 million of these interventions were performed in the United States alone in 2012 (Omidi et al., 2018, p. 1511) Regarding transforaminal steroid injections, a dramatic increase of circa 609% (per 100,000 service Medicare population) was observed from 2000-2014 (Omidi et al., 2018, p. 1511).
Current studies do not describe the optimal injection frequency of pain management infiltrations (NASS 2012). This causes a rather empirical approach by different specialists, which could lead to unwanted "overtreatment" of patients.

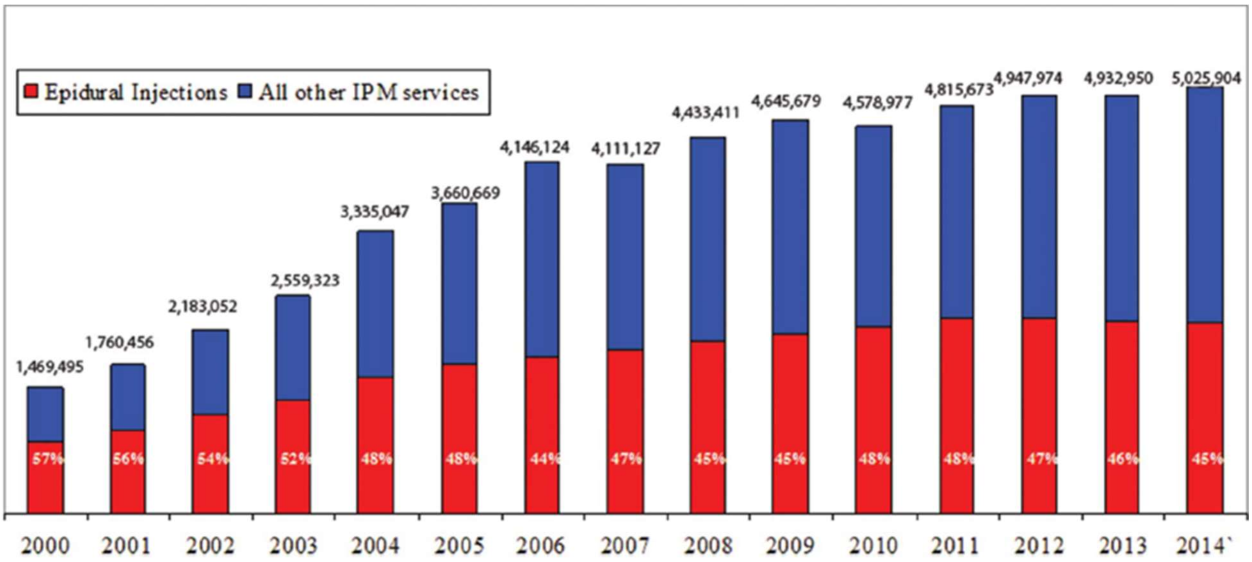


Figure 2.8
Frequency of use of epidural injections and all other interventional pain therapies from 2000 to 2014 in Medicare (Manchikanti, 2016, p.11)

2.11 Radiation exposure

2.11.1 The economic aspects of cancer care

Society has a heavy financial burden due to cancer. Its prevention and control are associated with significant health care expenses. Furthermore, a lot of patients require assistance from friends and family during their treatment or in the latter stages of their illness, and others are unable to return to their occupations. Because of this, estimating the economic impact of cancer in the EU requires not only figuring out how much the disease costs health care systems, but also estimating how much money patients' friends and family must pay for unpaid care when they are unable to work due to illness or early death. The concerns about resources and costs in healthcare are becoming more prevalent. Therefore, it's critical to obtain a precise assessment of the cost of care. Over the course of the analysis period, the economic cost of cancer care more than doubled, from $2.9 billion in 2005 to $7.5 billion in 2012, according to a Canadian study. The majority of expenses went toward hospital care, then physician care, then prescription costs; other expenses were comparable to drug costs and hence not insignificant (de Oliveira et al., 2018, p. 3). According to the study's data, Canada has a larger cost burden associated with cancer treatment than previously believed. The largest and fastest-growing portion of the total burden was accounted for by hospital care. Specifically, the highest growth in costs was seen in chemotherapy and radiation therapy.

In 2009, around €126 billion was projected to be the total economic cost of cancer in the European Union by another study (Luengo-Fernandez et al., 2013, p. 5) (Table 7). This research demonstrates national differences: 66% of total expenditures, or €82·9 billion, came from the four EU countries with the greatest populations: Germany, France, Italy, and the UK. Bulgaria, Cyprus, Estonia, Latvia, Lithuania, Luxembourg, and Malta had the lowest overall costs, totaling approximately €1·23 billion (1%). Cancer treatment cost EU health systems €51·0 billion, or 4% of total EU health spending (Table 7). Cancer-related medical expenses for all EU citizens came to €102 per person. various disparities in economic outcomes are probably a reflection of the variations in survival, treatment modalities, and expenses (such as surgery versus radiation) across various malignancies.

2.11.2 Ionizing radiation, definition and risk assessment

Ionizing radiation is high energy radiation divided into alpha, beta and gamma radiation. X-rays are gamma radiation, but with different generation methods. The energy can be completely or partially emitted when passing through a tissue, and the cells can be severely damaged.

Natural radiation exposure is the amount that each person receives from natural sources of radiation (e.g., radon). Radon radiation exposure for the Swiss population is 3.2 mSv per year. Medical diagnostics, especially computed tomography (two thirds of the annual collective radiation dose in radiology), is the largest source of radiation exposure for the Swiss population, with an increasing trend (Figure 5) (BAG, 2018).

The main biological effect of X-rays that matters is ionization. Ionization of water molecules can generate hydroxyl radicals, which can react with DNA to seriously damage it. While the majority of radiation-induced damage is quickly restored, errors in repair can lead to chromosome translocations, gene fusions, and point mutations—all of which are linked to the development of cancer (Lin et al., 2010, p. 11).

Table 2.7
Costs of cancer in the European Union in 2009, by country (Luengo-Fernandez et al, 2013, p.5)

	Cancer-related health-care costs							Productivity losses		Informal care costs	Total costs	
	Primary care	Outpatient care	Accident and emergency	Inpatient care	Drugs	Total	Percentage of total health-care expenditure	Mortality	Morbidity		Total	Percentage of gross domestic product
Austria	33	53	22	750	343	1202	4%	750	136	550	2638	0·95%
Belgium	34	70	9	550	346	1010	3%	1047	604	553	3214	0·94%
Bulgaria	10	12	2	56	44	124	5%	119	26	31	300	0·86%
Cyprus	<1	1	1	12	22	36	4%	53	5	15	109	0·65%
Czech Republic	29	77	14	284	194	598	5%	446	166	122	1331	0·94%
Denmark	4	55	11	299	205	574	2%	1010	380	277	2241	1·00%
Estonia	8	10	7	27	10	61	6%	61	34	17	172	1·25%
Finland	21	145	20	460	157	804	5%	464	77	166	1511	0·88%
France	114	176	19	3716	3025	7051	3%	4990	2299	2543	16 883	0·90%
Germany	710	1689	29	9760	2705	14 893	5%	11 607	2213	6414	35 126	1·48%
Greece	57	126	25	584	453	1244	5%	917	86	348	2596	1·12%
Hungary	26	19	5	121	221	393	5%	416	48	122	980	1·07%
Ireland	32	30	13	417	127	619	4%	603	63	162	1447	0·89%
Italy	487	452	115	4136	1664	6854	5%	3966	143	5491	16 454	1·08%
Latvia	5	7	2	34	11	60	5%	88	20	23	191	1·03%
Lithuania	8	8	4	30	9	59	3%	100	40	29	228	0·85%
Luxembourg	4	7	1	53	26	91	3%	57	18	26	191	0·53%
Malta	1	1	<1	6	7	16	4%	12	1	9	38	0·63%
Netherlands	172	250	13	1351	356	2143	3%	2519	706	983	6350	1·11%
Poland	129	368	15	619	267	1399	6%	1306	386	550	3641	1·17%
Portugal	43	65	28	182	247	564	3%	1118	98	268	2048	1·22%
Romania	19	62	2	133	205	421	6%	643	81	112	1257	1·06%
Slovakia	28	71	3	92	112	306	5%	180	88	53	627	1·00%
Slovenia	3	7	5	82	47	145	4%	147	72	42	406	1·14%
Spain	776	340	208	1275	1515	4114	4%	2838	482	1581	9016	0·86%
Sweden	47	244	40	408	233	971	3%	923	478	397	2769	0·95%
UK	153	1072	44	2916	1054	5241	3%	6186	682	2334	14 442	0·91%
Total for European Union	2954	5419	659	28 357	13 604	50 994	4%	42 565	9431	23 216	126 205	1·07%

Data are millions of euros, unless otherwise stated. No adjustment for price differentials. Totals do not match sum of costs because of rounding.

2.11.3 Radiation-induced malignancy

In the 27 European Union member states in 2008, 2·45 million people received a cancer diagnosis, while 1·23 million people lost their lives to the disease (EU) (Luengo-Fernandez et al., 2013, p. 2). Malignancies, even those caused by radioactive radiation, do not reveal what caused them. In fact, radiation-related diseases can only be calculated by statistical methods. One uses epidemiological studies between two comparable groups, with and without radiation exposure, to determine the prevalence of cancer.

Thus, regrettably, it is impossible to estimate the risk of cancer following radiation exposure in a way that is trustworthy. Based on survivors of high dose radiation, epidemiological studies evaluate the ris. (e.g. atomic bomb etc.).

There is a natural, individual risk of cancer in each person. Age at the time of radiation, gender, and collective radiation dose are factors that influence cancer risk. According to UNSCEAR (2000 and 2006), an increase in cancer risk has been epidemiologically documented for esophagus, skin, mammary, prostate, urinary bladder, CNS, and thyroid (BAS, 2021). Radiation exposure to living cells shows a cumulative property. There is a latency period between exposure and the development of malignant disease. According to the ICRP, the risk of radiation-related cancer in adults is 4.1% per sievert and 5.5% per sievert for the general population after exposure to radiation at low dose rates (such as those experienced in regular daily and occupational life) (BAS, 2021, p.21). The probability of malignancy as a result of radiation exposure is estimated by UNSCEAR (based on epidemiological data) to be between 0.86% and 1.5% at a dose of 100 mSv (for all varieties of cancer including leukemia) (BAS, 2021, p.21). The dose-response relationship for cancer disease can be described as linear. In addition, at a dose of 10 mSv, there is an increased risk to 0.086 to 0.15%.

Radiation risk is determined by radiation dose, radiation type, tissue type affected, and age at exposure. It was found from statistical studies of atomic bomb survivors that approximately 30% of leukemias were attributable to radiation exposure, while only 7% of gastric carcinomas were attributable to the effects of radiation exposure (BAS, 2021, p.22).

Absorbed dose: The absorbed dose (D) is the quotient of released energy and the mass and is the basic unit in dosimetry:

$$D = \frac{dE_D}{dm} = \frac{1}{p} * \frac{dE_D}{dV}$$

The SI unit of absorbed dosage is gray, and one gray is equal to one joule per kilogram.

Equivalent dosage: The absorbed dose is multiplied by q, a dimensionless weighting factor, to obtain the equivalent dose, which is measured in sieverts (1 joule per kilogram).

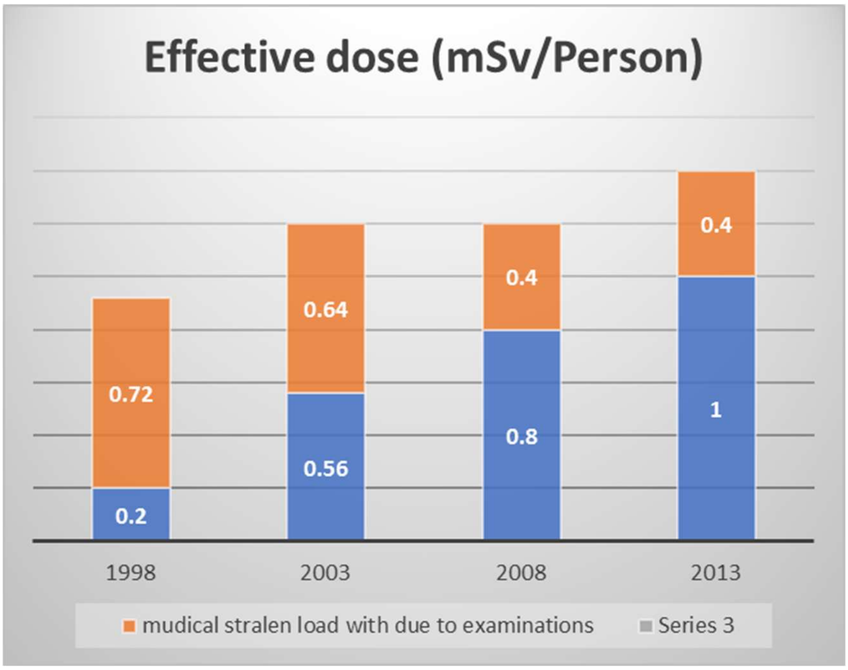


Figure 2.9
Collective medical radiation of the Swiss population (BAG, 2022, p.12)

Table 2.8
Radiation-related proportion of cancer risk for different cancer sites among atomic bomb survivors (Bas, 2021, p.24)

Cancer Localization	Radiation Related Proportion (in %)
Leukemia (without Chronic Lymphatic Leukemia and Adult T-Cell-Leukemia)	30
Chest	27
Lung	15
Intestine	11
Ovary	10
Feeder Tubes	10
Stomach	7

Body dose: Body dose is the average of the equivalent doses to an organ of volume dV.

$$H_r = \sum_R w_R * \overline{D}_{T,R}$$

Effective dose (formerly also effective dose equivalent): This refers to the radiation exposure of a human being. This is calculated by multiplying the determined organ equivalent doses by the respective tissue weighting factor.

$$E = \sum_T \sum_R w_T w_R * \overline{D}_{T,R}$$

The International Commission on Radiological Protection suggests that the nominal probability coefficient for detriment-adjusted cancer risks be 4.1 - 10-2 Sv-1 for adult workers and 5.5 - 10-2 Sv-1 for the general population based on these figures. The detriment-adjusted nominal risk for heritable effects is predicted to be 0.1 - 10-2 Sv-1 for adult workers and 0.2 - 10-2 Sv-1 for the overall population (BAS 2007).

2.11.4 Radiation exposure during intervention

It is feasible to discriminate between two potential radiation effects on the human body: the stochastic effect (genetic damage and cancer induction) and the so-called deterministic effect (such as erythema, tissue necrosis, epilation, hematological or gastrointestinal damage) via a threshold dose. The stochastic effects don't have a specific threshold dose.

Hematopoietic and lymphatic systems are the primary radiation-sensitive tissues; they can react to a single dose as low as 0.5–1 Gy. Doses as low as 0.5 Gy would cause harm to mitotic cell division (Artner 2012: 358).

While skin alterations caused by radiation have been documented at 1000 mGy, radiation dermatitis is created above a threshold of 2000 mGy. Both of ionizing radiation's consequences should worry doctors. Exams and treatments below the threshold dose stop deterministic effects, but cumulative low doses—trials and errors—cause stochastic consequences.

The literature describes a range of radiation exposures to the spine during examinations and interventions, which differ significantly between institutions and settings based on the chosen technique, circumstances, and interventionalists. Leng and colleagues report an effective dose of 9.1 +/- 5.5 mSv, whereas Carlson and colleagues determine a median effective dosage for CT-guided treatments (e.g., 8 biopsy, drainage, etc.) of 738 mGy (approximately 11.07 mSv). A DLP of 199 +/- 101 mGy (or 3.3 mSv) for spinal procedures following the switch from spiral to sequential mode is reported by Shepherd et al. Schmied et al compare infiltrations guided by fluoroscopy and CT, and they determine an effective dose of 0.22 to 0.43 mSv for low dose protocols and 1.51 to 3.53 for conventional protocols (for 4 to 10 scans). A radiation dosage of 3.35 mSv is described by Hoang et al. for CT-guided epidural infiltrations. We use Schmied et al.'s and Artner et al.'s specified radiation dose for our cost calculation.

A definition or estimation of the risk of CT-induced malignancy after CT examination and intervention is not without problems. Richards et al. report a risk rate of 1:3200 for diagnostic scans and 1:200,000 for low dosage procedures (with an effective dose of 0.1 mSv) based on Phanto simulations (Artner, 2012, p. 360). Nevertheless, the dose may differ in actual patients and is mostly depending on the scan mode, scan area size, patient volume, etc. Unfortunately, a lot of doctors underestimate the total radiation dose that patients receiving CT-guided procedures would experience.

2.11.5 CT-guided interventions

The computed tomographic measurements include at least one topogram, one spiral CT and between four to ten scans (at maximum dose reduction). A German study shows a linear increase in effective dose from 4.45 mSv to 10.46 mSv in the range of scans performed. Female organs show a clearly higher radiation exposure (between 4.73 mSv to 11.34 mSv) (Schmitz 2014: 2). In a maximally dose-reduced procedure (low dose CT), a dose increase from 0.5 mSv to 1.18 mSv is shown (Table 10). CT measurements using a standard LS procedure show a linear increase in effective dose between four and ten CT measurements with a dose ranging from 4.45 mSv to 10.46 mSv. (Table 9).

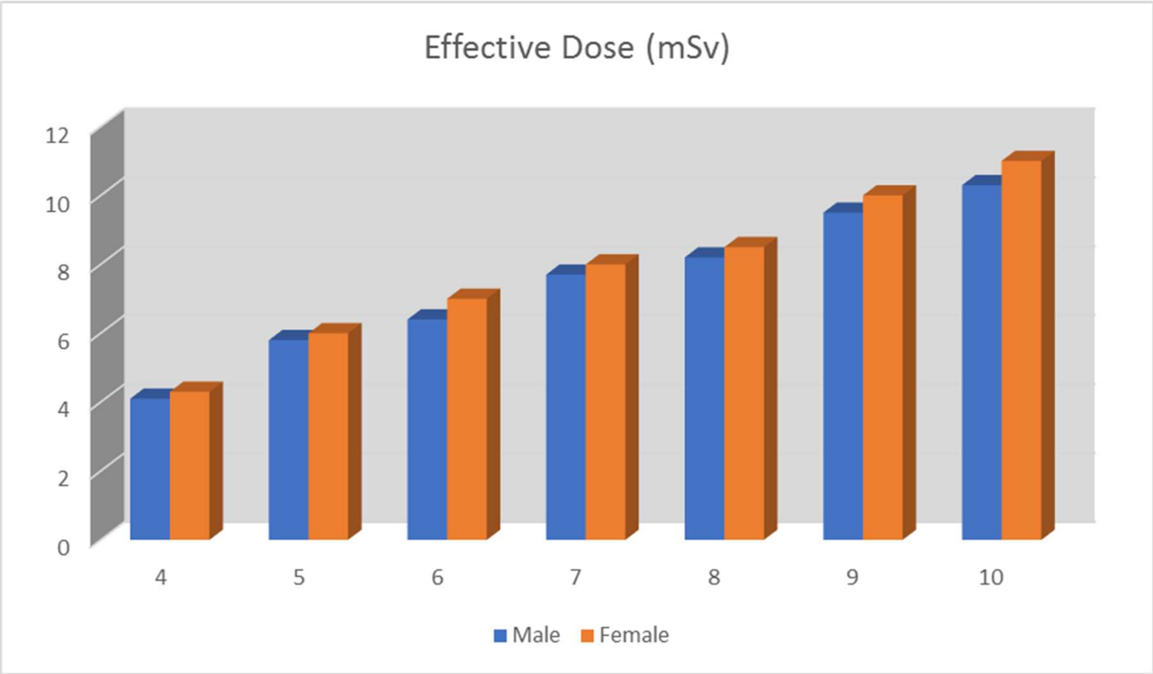


Figure 2.10
Graphical representation of the effective doses in the stand-up lumbar spine CT (Schmitz, 2014, p.4)

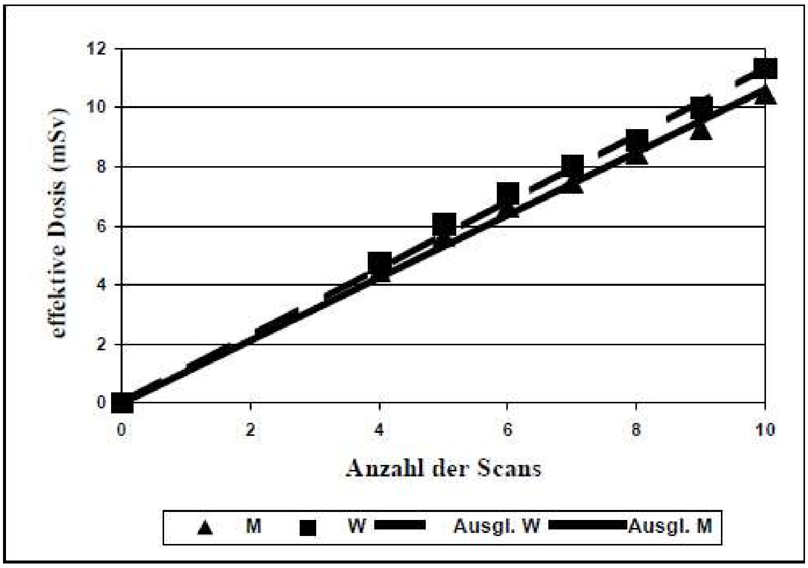


Figure 2.11
Graphical representation of the dose progression in standard lumbar spine CT with the aid of a compensation line (Schmitz, 2014, p.2)

Scan Number	Dose (mSv) Male	Dose (mSv) Female
4	4,45	4,73
5	5,65	6,04
6	6,64	7,11
7	7,46	8,05
8	8,45	8,92
9	9,26	9,98
10	10,46	11,34

Table 2.9. Effective doses in standard lumbar spine CT (Schmitz, 2014, p.2)

Scan Number	Dose (mSv) Male	Dose (mSv) Female
4	0,50	0,54
5	0,57	0,62
6	0,67	0,72
7	0,82	0,89
8	0,93	1,00
9	1,03	1,10
10	1,18	1,26

Table 2.10. Dose profile in maximum dose-reduced CT (Schmitz 2014, p.4)

Scan Number	Dose(mSv) Standard-LWS	Dose(mSv) Max. Dose Reduced	Dose Savings in Percent
4	4,45	0,50	89%
5	5,65	0,57	90%
6	6,64	0,67	90%
7	7,46	0,82	90%
8	8,45	0,93	89%
9	9,26	1,03	89%
10	10,46	1,18	89%
11	11.67	1,41	89%

Table 2.11. Comparison of dose values in standard lumbar spine protocol and low-dose CT (Schmitz, 2014, p.6)

In the comparative study between standard CT mode and low-dose protocol described above, there is a substantial dose reduction of approximately 90% (Schmitz, 2014, p. 5). In this study, the investigators raise organ dose levels from 44 to as high as 102 mSv (with a maximum surface dose of 120 to 301 mSv) for measurements in four to ten scan series (Schmitz, 2014, p.5). The same study describes a maximum 4.15 to 12.13 mSv (maximum surface dose 9.61 to 24.5 mSv) organ dose in the low-dose mode (Schmitz, 2014, p. 6).

2.11.6 Variation in dose between examination types

Each anatomic location has a different mean effective dose (lumbar, thoracic, and cervical spine). In addition, each repetition of the series (depending on the severity of the anatomy and the experience of the interventionalists) results in a higher radiation exposure (Bindman et al., 2009, p. 2078).

The number of interventions/radiation exposure that would result in cancer is highly dependent on gender, age, and intervention (radiation) time (Bindman et al., 2009, p. 24). Variable doses during interventions have been documented in various studies and publications (Schmitz, 2014, p. 7) The effective dose may be much higher than the median amount, depending on where a patient received the intervention and the particular technical parameters that were applied.

The lifelong cancer risk associated with a patient's age, sex, and size varies significantly. After radiation exposure, a 20-year-old woman's lifetime cancer risk is much higher than a 50-year-old man's. According to reports, there can be a 1 in 2000 increase in cancer risk due to CT. For instance, a female patient receiving CT angiography who is 20 years old may be at an elevated risk of 1 in 80 for developing cancer (Bindman et al., 2009, p. 2079). The risks of radiation-associated cancer are particularly important for younger female patients because they diminish significantly with age and are lower in men (Bindman et al., 2009, p. 2084).

Table 2.12
Comparison of organ doses in standard lumbar spine CT and low-dose CT at four and ten scans; organs located in the primary beam are highlighted (Schmitz, 2014, p.12)

Organ	Layer Nr.	Oran Dose Standard-LWS-CT		Organ Dose Lowe Dose-CT	
		4 Scans (mSv)	10 Scans(mSv)	4 Scan (mSv)	10 Scans(mSv)
Bladder	32	1,72	4,02	0,46	0,66
Ovary	31	1,96	5,65	0,30	0,60
RKM Cruciate Leg*	30	2,96	6,70	0,46	0,78
Small Intestine	29	7,56	14,14	1,17	2,11
Colon Sigmoideum	29	7,20	18,62	1,09	2,10
RKM Pelvis*	29	6,18	15,28	0,61	1,25
RKM LWK 4*	**28**	**22,96**	**64,50**	**2,36**	**5,42**
Periosteum 1	**28**	**27,81**	**69,16**	**2,36**	**6,52**
Ascending colon	**28**	**44,67**	**102,13**	**3,90**	**11,76**
Small Intestine 2	**28**	**44,57**	**92,95**	**4,15**	**12,13**
Transversal Colon	27	7,09	15,45	1,15	1,96
Colon (Right Flexure)	25	2,32	5,39	0,41	0,66
Periosteum 2	25	2,68	5,41	0,62	0,94
RKM LWK 2*	25	2,24	4,55	0,59	0,80
Kidney	24	1,39	3,30	0,24	0,44
Abdominal Salivary Gland	23	1,80	2,81	0,68	0,95
Spleen	22	0,90	1,53	0,43	0,48
Liver	21	0,34	0,78	0,09	0,13
Stomach	21	0,42	0,91	0,18	0,21
Esophagus	19	0,19	0,41	0,05	0,08
RKM BWK 10*	19	0,12	0,26	0,04	0,05
Lung	18	0,13	0,31	0,04	0,05
RKM Ribs	16	0,09	0,13	0,03	0,04
RKM Clavicle/Sternum	12	0,04	0,03	0,01	0,01
RKM Scapula*	12	0,03	0,06	0,05	0,01
Skin 1	**28**	**83,56**	**192,47**	**7,81**	**24,25**
Skin 2	**28**	**120,65**	**301,40**	**9,61**	**22,14**
Testes	34	0,60	1,34	0,14	0,20
Mammae	18	0,16	0,38	0,04	0,05

2.11.7 Value of CT-guided spine pain therapy

To the best of my knowledge, there is a dearth of information—especially prospective investigations—about the relationship between distinct contrast agent distribution patterns in CT-guided percutaneous infiltrations of sacral or lumbar nerve roots that are damaged by osteoligamentous degeneration or herniated discs. Furthermore, the distinct subgroup of patients who previously underwent spinal surgery for a severely incapacitating disc herniation and then resurfaced with a similar disease has not yet been included in systematic trials evaluating the efficacy of percutaneous CT-guided infiltrations. Many significant retrospective studies have shown the great value of the minimally invasive treatment for patients suffering from radiating back pain due to lumbosacral neural impingement, even though class I evidence for the superiority of image-guided percutaneous infiltrations over conservative medical treatment for pain management is still needed (Reuchel et al., 2022, p. 787). Consequently, periradicular injections have been widely accepted in routine treatment and are carried out more frequently (Krämer et al., 2008, p.245). There is, however, no agreement on the specifics of the image-guided spinal nerve root therapies; instead, there are numerous, highly disparate regimens. The vast majority of the time, radicular low back pain is a clinical indicator of degenerative spine disease. Even though this group of individuals accounts for most people who present with radicular back pain, more serious underlying disorders such as cancer, infections, fractures, cardiovascular disease, and cauda equina syndrome need to be ruled out before beginning routine treatment. One pain treatment technique that has been tried and studied for a while is interventional pain therapy (Reuschel et al., 2022, p. 787). The indications include back pain that radiates to the extremities with or without an underlying cause, such as foraminal stenosis or spinal stenosis related to osseous or disc hernias, sponylarthrosis, ISG arthrosis, iatrogenic nerve compression following disc hernia surgery, or even unusual persistent back pain. Furthermore, this method is used to confirm a nerve compression diagnosis (preoperatively).

According to those research, patients with incapacitating pain who do not have a significant neuromuscular impairment and whose condition did not improve after six weeks of conservative treatment may benefit from complementary therapies (Juniper et al.2009: 2581). Other than that, patients who have already undergone spine surgery to address a disc herniation and then experienced a debilitating relapse are not offered well-defined treatment strategies. Off-label use of periradicular glucocorticoid injections has been helpful for both patient groups, particularly when pain management and restoring functional independence are prioritized as the most crucial initial treatment objectives (Omidi et al., 2018, p. 1509). However, not every patient experiences periradicular corticoid injection-induced pain relief to the same degree. On the one hand, this is undoubtedly related to when the injection was given, since lesions in the nerve roots that have become chronified naturally react less favorably to glucocorticoids than do nerve roots that have very recently become damaged. On the other hand, different doctors use different procedures and technical approaches when administering periradicular glucocorticoids. For instance, many percutaneous injections are carried out without the use of imaging guidance, despite the fact that accurate needle placement is essential to getting an adequate amount of the anti-inflammatory drug into the body (Reuchel et al., 2022, p. 787). Consequently, because they improve medication distribution and lower the risk of complications, the use of fluoroscopy, ultrasound, and computed tomography (CT) in percutaneous spine treatments has significantly expanded. Of those imaging modalities, CT has become the go-to method for guiding percutaneous spinal interventions due to its consistent and user-friendly image quality, which enables extremely accurate needle navigation in all three spatial planes, provides adequate contrast between soft and bony tissue in the area of interest, and precisely predicts the spatial distribution of the pharmaceutical cocktail surrounding the nerve root when a prior contrast medium injection is being performed (Reuchel et al., 2022, p.788). Despite best efforts, daily life indicates that not all patients experience enough pain relief following intervention, despite the fact that the majority of treated persons report a favorable outcome. Based on our institutional experience, the distribution pattern of contrast agents is a highly reliable indicator of treatment outcome. In a study involving 161 patients, Reuschel et al. 2022 found a strong relationship between pain alleviation following periradicular infiltration and the distribution pattern of the contrast agent, which indicates local medication distribution. Remarkably, several earlier research endeavors were unable to demonstrate a noteworthy association between the caliber of contrast agent dispersion and the therapeutic impact during image-guided percutaneous infiltrations (Lee et al., 2006, p. 1427). Nonetheless, it makes sense that accurate delivery of the medication to the neural impingement location is essential for therapeutic effectiveness, and this is undoubtedly made possible by high-resolution three-dimensional imaging of the anatomical target (Dietrich et al., 2019, p. 752). The findings support this theory by showing a strong, direct relationship between the effectiveness of the treatment and the distribution quality of the contrast agent during CT-guided percutaneous infiltrations. Specifically, a number of studies indicate that a wide and circumferential distribution of contrast agent is recommended for the impact zone between the herniated disc and the afflicted nerve root. This distribution of contrast agents is linked to excellent pain relief and is largely unaffected by long-standing pain or even episodes from previous surgery.

2.12 Epidemiology and financial burden of cancer

2.12.1 Health care utilization

One important public health concern is cancer. In just 2008, 2·45 million individuals in the 27 member states of the European Union (EU) received a cancer diagnosis. The incidence and mortality of cancer have decreased in industrialized nations as a result of various reasons, such as improvements in early detection, diagnostic techniques, and cancer treatment; changes in lifestyle; and the creation of preventive vaccinations for certain malignancies (Luengo-Fernandez et al., 2013, p. 14). However, in the EU in 2008, cancer still claimed the lives of more than 1.2 million people. About half of all new cancer diagnoses and fatalities in this region in 2008 were due to malignancies of the breast, colon, lung, and prostate alone. Cancer has a huge financial cost to society. Its management and prevention come with a significant financial burden (Luengo-Fernandez et al., 2013, p. 14). In addition, many patients depend on friends and family for help throughout treatment or in the final stages of the illness, and others are unable to resume their jobs. Therefore, estimating the financial impact of cancer on the EU's health-care systems is only one aspect of measuring the disease's economic burden; other factors to consider include lost wages resulting from illness or early death, as well as the expenses incurred by patients' friends and family providing unpaid care.

In comparison to people without a history of cancer, cancer survivors had higher annual costs for medical services and patient time, as reported by Yabroff et al. in 2014. Using chi-square statistics, this study evaluated the distribution of descriptive features between people with a history of cancer and those who did not, stratified by age group. They found that 81.4% of cancer survivors and 69.6% of people without a history of the disease had visited a provider in an office setting or at a hospital; in the 65+ age group, the percentages were 95.5% and 90.7%, respectively. Although the differences were not always statistically significant, among those who had received a specific service in the previous year, cancer survivors had greater adjusted frequency of the service or longer length of stay than people without a history of cancer. For instance, patients without a history of cancer had an average of 7.2 trips per year to provider offices or hospitals, while cancer survivors (18–64) had an average of 10.3 visits ($p<0.001$).

According to a 2014 scientific review on the cost of non-communicable diseases in Switzerland, new cases are estimated at 34'956 and the overall prevalence at 387`723 (Table 10) (Wieser et al., 2014, p. 3).

Luengo-Fernandez et al. estimated in 2009 that the cost of cancer to the European Union surpassed €126 billion. Germany, France, Italy, and the United Kingdom were the four EU nations with the highest population shares, accounting for sixty-six percent of the overall costs. Bulgaria, Cyprus, Estonia, Latvia, Lithuania, Luxembourg, and Malta had the lowest overall costs, totaling approximately €1·23 billion (1%). The sensitivity tests' findings indicated that the biggest impacts on overall expenses were from adjustments to the discount rate and a 20% variance in wages, which were utilized to evaluate informal care, morbidity, and mortality losses. Luengo-Fernandez states that the human capital strategy is to blame for the overall increase in cancer expenses, which went from €126 billion (friction-adjusted costs) to €133 billion.

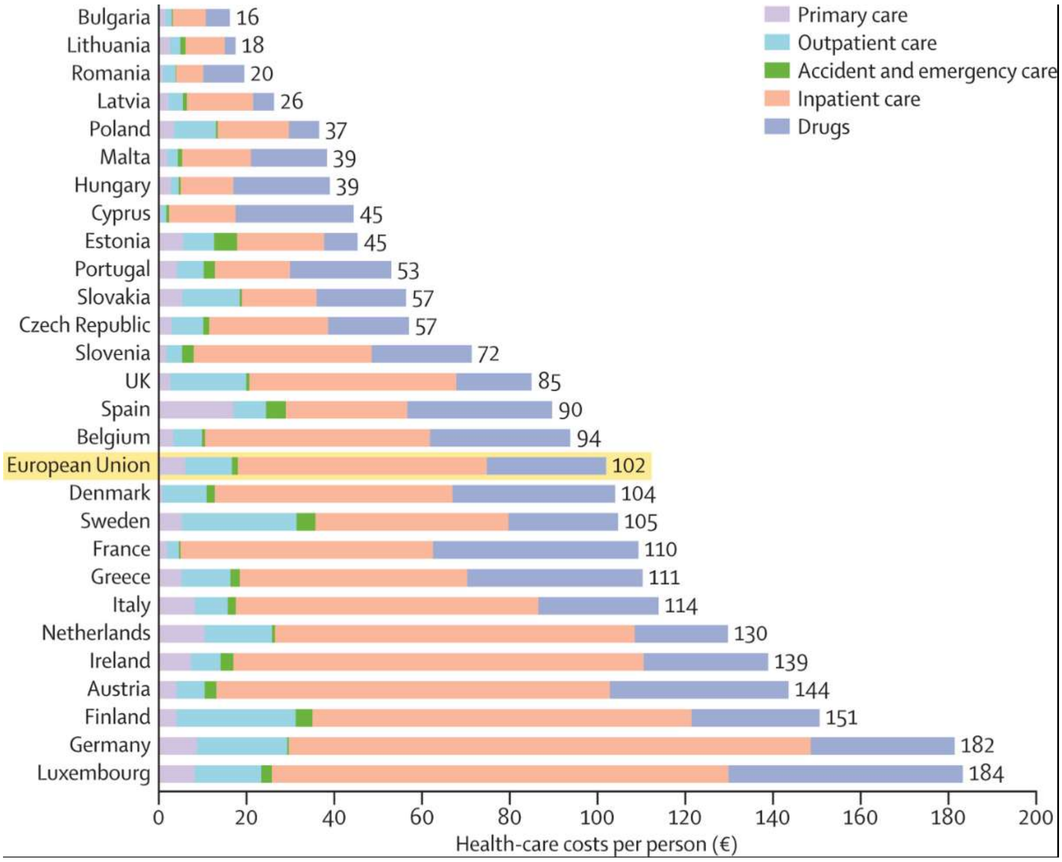


Figure 2.12
Prostate, lung, colorectal, and breast cancer medical expenses per person in the member states of the European Union in 2009, broken down by type of medical service Information not corrected for price differences

2.12.2 Patient time costs

According to a US research team, the yearly patient duration for people who have survived cancer and those who have never had cancer was 30.2 hours and 13.6 hours, respectively. The yearly patient time for the elder group was 36.6 hours and 55.1 hours, respectively. Days spent in an inpatient hospital contributed the most to the time estimations of all the service kinds. According to this study, annual patient time costs were greater in cancer survivors than in people without a history of cancer in the 18–64 ($500 vs. $226) and 65+ ($913 vs. $607) age groups in the base case analysis using the median US wage rate to evaluate time (Yabroff et al., 2014, p. 594). This research concludes Compared to people without a history of cancer, cancer survivors had annual patient time costs of approximately $300 more. This study's capacity to evaluate time expenses in adult populations with and without a history of cancer in the 18–64 and 65+ age categories is a significant strength.

Unfortunately, a comprehensive international or national cost study for cancer does not exist. Several cancer-specific data are available for specific years (e.g. Delco et al on colorectal cancer for Switzerland for 1997/98, Mariotto et al for the USA, Morris et al for the UK, and Reois et al for Germany) (Wieser et al., 2014, p. 1055).

Table 2.13
Epidemiological data and estimates on cancer in Switzerland in 2011 (Wieser et al., 2014, p.1054)

Cancer Type	**New Patients (After NICR)**			**Partial Estimation of the Prevalent Trap (based on NICER and Marriott et al. (36)**			**Deaths (According to Cancer Mortality Statistic of the BFS) (43)**			**Estimation of the Total Prevalence (Sum of the Columns 1-3)**		
	Female	**Male**	**Total**	**Female**	**Male**	**Total**	**Female**	**Male**	**Total**	**Female**	**Male**	**Tota**
Oral Cavity, Pharynx & Larynx	357	1'060	**1'417**	3'558	10'448	**14'006**	117	373	**490**	4'032	11'881	**15'91**
Esophagus	140	418	**557**	442	1'317	**1'759**	107	347	**454**	689	2'082	**2'77**
Stomach	322	527	**849**	1'822	2'950	**4'772**	215	332	**547**	2'359	3'809	**6'16**
Colon/Rectum	1'875	2'487	**4'362**	18'631	24'454	**43'085**	771	979	**1'750**	21'277	27'920	**49'1**
Liver	192	560	**752**	-	-	**-**	195	469	**664**	387	1'029	**1'41**
Pancreas	585	580	**1'164**	325	387	**712**	578	546	**1'124**	1'488	1'513	**3'00**
Lung	1'495	2'662	**4'158**	4'328	7839	**12'167**	1'071	2'174	**3'245**	6'894	12'675	**19'5**
Melanoma	1'145	1'222	**2'367**	15'366	16'872	**32'238**	130	188	**318**	16'641	18'282	**34'9**
Chest	5'660	-	**5'660**	77'537	-	**77'537**	1'440	-	**1'440**	84'637	-	**84'6**
Cervix	258	-	**258**	8'121	-	**8'121**	85	-	**85**	8'464	-	**8'46**
Uterus	904	-	**904**	14'847	-	**14'847**	221	-	**221**	15'972	-	**15'9**
Ovary	600	-	**600**	7934	-	**7'934**	452	-	**452**	8'986	-	**8'98**
Prostate	-	6'451	**6'451**	-	64'215	**64'215**	-	1'433	**1'433**	-	72'099	**72'0**
Kidney	297	581	**879**	3'105	5'983	**9'088**	123	197	**320**	3'525	6'761	**10'2**
Blow	283	899	**1'182**	2'849	9'045	**11'849**	155	371	**527**	3'287	10'315	**13'6**
Brain	264	357	**621**	2'777	3'868	**6'645**	212	283	**495**	3'253	4'508	**7'76**
Hodgkin lymphoma	105	145	**250**	1'274	1'782	**3'055**	15	20	**20**	1'394	1'947	**3'32**
Non-Hodgkin lymphoma	706	842	**1'549**	7'639	9'290	**16'928**	247	280	**280**	8'592	10'412	**18'7**
Leukemia	414	559	**973**	4'079	5'574	**9'652**	249	316	**316**	4'742	6'449	**11'1**
Total	**15'602**	**19'353**	**34'956**	**174'634**	**164'024**	**338'655**	**6'383**	**8'308**	**14'112**	**196'619**	**191'685**	**387'**

Direct medical costs are in principle treatment costs, e.g. due to doctor or hospital visits, medication, nursing services.

Indirect costs arise from productivity losses (due to illness), early retirements. These costs are not direct expenditures, but are a burden on gross national income.

The direct medical costs of cancer patients for 2011 were determined from a cost study and then extrapolated to account for the epidemiologic population using the study by Mariotto et al (Wiese et al., 2014, p. 1054) (Table 15). Table 12 summarizes the costs of different types of cancer in men and women. According to rough calculations, the costs caused by cancer were CHF 5018 million in 2011, which is approximately 6.6% of the total health care costs. The most expensive type of cancer in men is colon cancer (CHF 410 million), and in women breast cancer (CHF 422 million) (Wieser et al 2014). The total indirect costs of cancer in Switzerland range from CHF 3912 to 5849 million (Table 14). Figure 13 shows a comparison of the seven most important non-communicable diseases. Cancer costs take fourth place with CHF 4,005 million.

Table 2.14
Indirect costs of cancer, 2011(BAG, 2016, p.1)

	According to Lwengo et al. (41)	
	Per Patient (CHF)	**Switzerland (Mio. CHF)**
Morbidity	NA	1’406
Mortality	NA	2’861
Informal Care	NA	1’581
Indirect Expenses	**NA**	**5’849**

Table 2.15
Direct medical costs of cancer in Switzerland in 2011 (Achtermann, 2016, p.2)

Krebsart	**Frauen** (Mio. CHF)	**Männer** (Mio. CHF)	**Total** (Mio. CHF)	**Hauptquelle**
Mundhöhle, Pharynx und Larynx	46	126	172	Mariotto et al. [36]
Ösophagus	28	87	114	Mariotto et al. [36]
Magen	59	93	152	Delco et al. [35]
Kolon/Rektum	410	535	945	Lang et al. [39]
Leber	7	20	27	Mariotto et al. [36]
Pankreas	129	134	263	Mariotto et al. [36]
Lungen	250	471	721	Mariotto et al. [36]
Melanom	77	144	221	Morris et al. [37]
Brust	422	-	422	Mariotto et al. [36]
Zervix	33	-	33	Mariotto et al. [36]
Uterus	66	-	66	Mariotto et al. [36]
Eierstock	172	-	172	Mariotto et al. [36]
Prostata	-	433	433	Mariotto et al. [36]
Nieren	41	78	119	Mariotto et al. [36]
Blasen	30	92	122	Mariotto et al. [36]
Hirn	93	131	224	Mariotto et al. [36]
Hodgkin Lymphom	4	5	9	Reis et al. [38]
Non-Hodgkin Lymphom	48	56	104	Reis et al. [38]
Leukämie	85	126	211	Mariotto et al. [36]
Subtotal	**2'000**	**2'531**	**4'530**	
Andere	257	229	486	~10% aller Kosten
Total	**2'257**	**2'761**	**5'018**	

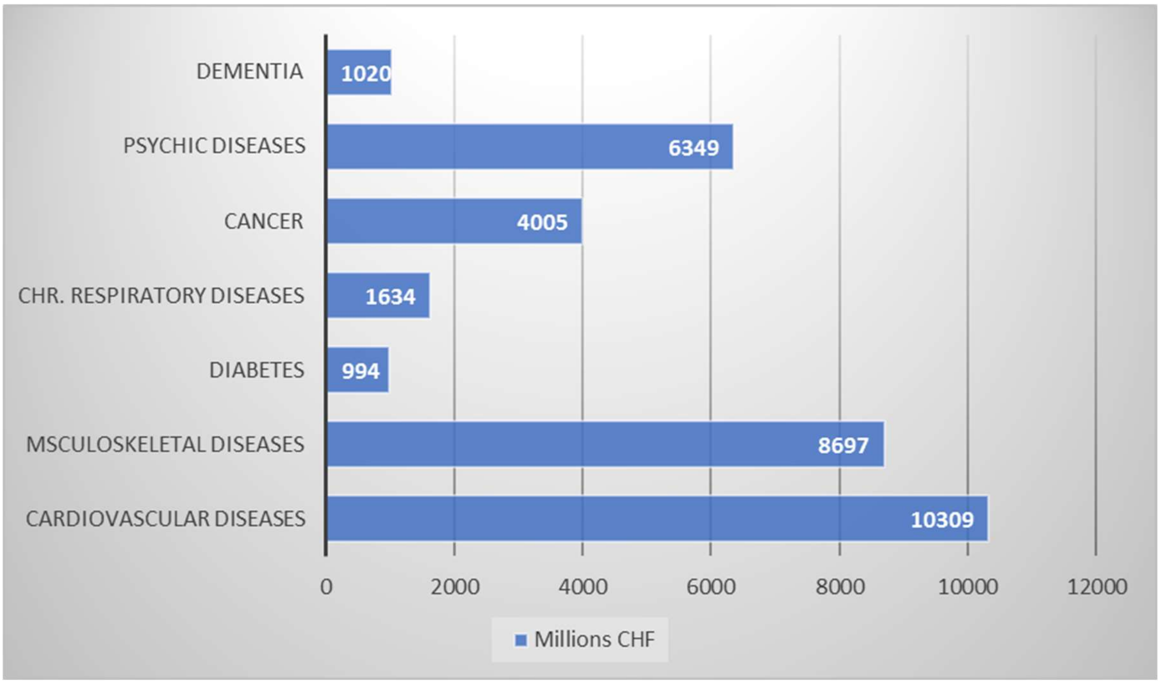


Figure 2.13
Direct costs of the 7 NCD groups in 2011 (data-driven calculation) (Achtermann, 2016, p.3)

2.13 CT- versus MRI- guided intervention

Slice cross-sectional pictures of different anatomical organs are produced by the diagnostic imaging modalities of magnetic resonance imaging (MRI) and computed tomography (CT or CAT scan). A CT scanner has a donut-shaped circular aperture that rotates around the body of the patient. It uses a thin x-ray tube that is placed directly across from a digital x-ray detector. An advanced computer system and a strong magnetic field are combined in the MRI. Compared to other imaging modalities that make use of x-ray technologies, such as radiography and CT scan, it is less harmful because it does not carry a radiation risk. The only things that make magnetic resonance imaging (MRI) feasible are extremely sophisticated technology and the expertise of some highly qualified professionals. For example, an MRI is far more complex than an X-ray or CT scan, and there are several inherent reasons why MRIs will always cost more than other imaging methods. The price of an MRI scan includes the cost of the equipment itself, which can run up to $1 million for new high-field units; the cost of the "buildout," which typically entails installing and rigging these massive machines (which typically involves demolishing and rebuilding exterior walls), and the electricity required to run the MRI machine and its cooling equipment (which can easily run up to $5,000 per month depending on the MRI's field strength), the price of the engineers who runs the machine, the yearly checkups required to keep it "tuned" and in working order (usually two to three percent of the machine's cost; for a million-dollar machine, this equates to about $20,000 annually), the time and experience required of the physician who interprets the scan, the cost of the physicist who is required to periodically inspect and test the machine, and numerous other factors. Many managed care plans do not even come close to paying these costs with the payment they offer, let alone providing a profit margin.

Historically, infiltrations were performed under the guidance of computed tomography or fluoroscopy to increase accuracy and therapeutic outcomes. This is mainly due to the availability of these devices on the one hand and the relatively low costs on the other. The patient's radiation exposure and the requirement for medical personnel are drawbacks, though. The number of interventional back pain therapies has increased dramatically during the past several years (Figure 4). Demographically, patients are getting younger and have been exposed to radiation several times because the symptomatology showed a recurrent character. At the time of the initial computed tomography image-guided intervention, a cumulative individual radiation exposure is more likely to be seen in younger patients. This is because recurrent back disease requiring therapy can be expected over the course of a lifetime (Krämer et al.2008: 596). This makes regular image monitoring during interventions problematic. By law, patients must be fully and adequately informed pre-interventionally about the cumulative radiation exposure with the resulting increased risk of leukemia and carcinoma. Therefore, in younger patients, MR-guided pain therapy is an extremely attractive and reasonable alternative in view of the repeated need for interventional therapy. Magnetic resonance imaging (MRI or MR) is a recently developed radiological method. Interventional MRI is technically available in most hospitals and practices and offers a new, accurate modality for navigation and intervention monitoring.

The last few years have seen the emergence of MR-guided pain therapy interventions in soft tissues. The development of MR devices and compatible MR sequences and MR-ready interventional material also allows pain therapy under MR control. Multiplanar imaging provides the interventionalist with an excellent anatomic/pathologic overview with precise planning of the access route. Furthermore, medication distribution is monitored without the need for ionic or paramagnetic contrast agents (Fritz et al., 2007, p. 161). Patients who have a history of allergic reactions will find this aspect especially appealing. A strong, uniform magnetic field is used to create the sequences for magnetic resonance imaging. This field is briefly exposed to radiation through a transmitting antenna. In this procedure, a highly particular magnetic field intensity is correlated with the hydrogen molecule's excitation frequency. The molecule first absorbs energy as a result of the excitation, which it then releases again shortly after. By means of an antenna, the emitted frequencies can be observed. The lack of radiation exposure makes MRI ideal for treating children and for serial injection therapy (Fritz et al., 2007, p. 162). Selective T1 or T2 weighting with or without fat suppression allows tissue characterization combined with visualization of blood vessels and any inflammatory altered environmental responses.

Despite these advantages, MRI-guided pain management has not been able to gain widespread acceptance to date, partly because of the lower availability of MRI systems compared with CT and DL and partly because MR imaging causes longer procedure times and MR-compatible equipment inevitably incurs higher costs. Nonetheless, there has been a noticeable decrease in the cost of MR-compatible injectable cannulas in recent years. Furthermore, a decrease in scan and operation times has been facilitated by the creation of rapid MRI sequences. It is possible to foresee a large decrease in overall expenses with significant workflow optimization.

CHAPTER III:
METHODOLOGY

3.1 Overview of the research problem

Decisions on the daily use of imaging modalities in patient care are influenced by costs. However, a lot of interventional spine neuroradiologists find it difficult to fully utilize cost management and monitoring as a vital step in proving their worth to patients. Neuroradiologists face losing control over the delivery and support of imaging when they are unable to clearly communicate the value they provide. Quantifying the expenses of providing certain imaging services and comprehending imaging costs at a procedural level are essential to controlling imaging costs. A bottom-up strategy is necessary for effective product-level costing, and recent advancements in time-dependent activity-based costing have reinforced this need. If the expenses are understood, they can be managed. The ramifications of mismatched top-down cost management techniques in the high overhead and fixed cost environment of health care provider companies must be understood by stakeholders. These methods have the ability to paradoxically transfer effort from less costly workers to more expensive specialists while also allocating overhead expenditures in an inefficient manner. Radiology specialists have a significant opportunity to lead their healthcare organizations in boosting value and margin through ethical and effective cost management, as spine neuroradiology covers a wide spectrum of treatments.

The increasing intensity of medical technology is one of the main factors behind the rising costs of the healthcare system in Europe. Half of the annual increase in the cost of a hospital day is due to the increasing use of medical technologies and services (Hillman et al., 1985, p. 1290). Unfortunately, there is evidence that the use of many medical technologies may not be optimal from a scientific or social perspective. As medical costs continue to rise and an increasingly large portion of an already severely constrained federal budget is eliminated, system efficiency becomes critical to prevent more severe rationing of medical resources. Understanding the factors that influence the diffusion of medical innovations and examining the impact of past health policies on that diffusion are prerequisites for developing public policies that promote more thoughtful evaluation and adoption of technologies. Such knowledge could also make it easier to allocate resources for healthcare in the future in an effective manner. This paper addresses how cost management techniques may support or undermine high-value healthcare, offers standard and enhanced methods for assessing health care costs, and contextualizes costs from the viewpoints of many stakeholders (relativity). It also discusses the fundamental ideas behind how costs are classified (rudiments).

Conventional computed tomography has historically been used by radiologists when performing a percutaneous spinal intervention. CT, nuclear, and x-ray scans expose you to ionizing radiation, which is created by high-energy wavelengths or particles that puncture tissue to show the body's interior organs and systems. Ionizing radiation may damage DNA. Although your cells can usually repair most of the damage, there are times when they can't, leaving minute gaps in the repair process. This can lead to DNA mutations that can cause cancer years down the line (Lin et al., 2010, p. 1142). In the United States, more than 80 million CT scans are done annually, up from just three million in 1980 (Lin et al., 2010, p. 1142). The younger the patient is at the time of the first image-guided intervention with computed tomography, the more likely a cumulative individual radiation exposure appears. This is because recurrent back diseases requiring therapy are to be expected in the course of life (Krämer et al., 2008, p. 596). Cancer has an economic impact on individuals, healthcare systems, and whole countries due to treatment expenses, missed work due to illness, and early mortality. Economic analyses can have an impact on resource allocation and investments in cancer control programs. The significant variations in cancer expenses among European countries can be attributed to a number of factors, including differences in the incidence and mortality rates of cancer, as well as differences in population size, age distribution, healthcare delivery systems, work patterns, and salaries. In nations that are members of the European Union, the financial burden of cancer-related morbidity and early mortality accounts for around 60% of the entire economic burden of the disease (Reedy et al., 2015, p. 2).

With increasingly widespread use of MR equipment and the development of therapeutic materials suitable for MRI, there is the potential to perform nearly all percutaneous pain therapies in an MR-guided manner. Interventional MRI, by using powerful magnets rather than ionizing (carcinogenic) radiation, is particularly appropriate for treating adolescents and young adults.

There are no comprehensive and conclusive studies that perform a cost analysis between MR-guided and CT-guided infiltration from both a medical and economic perspective. Unfortunately, accurate statistics on the number of invasive pain therapies in Europe do not exist.

3.2 Research purpose and questions

What could be more irrelevant and unimportant to a doctor more concerned with the well-being of his or her patients than cost accounting? When you mention the term "cost," jokes about bean counters, accountants, and bureaucrats fill your head. If we dig a little deeper, we can see right into the core values and core beliefs of an organization. For spine neuroradiologists seeking to better understand their role within a healthcare system, the organization's approach to cost accounting and management reflects both intentional decision-making and a callous disregard for consequences. These traits speak to the organization's psychology and demonstrate its commitment to achieving its goals, honoring its stakeholders, and optimizing performance. Spine radiologists have two fundamental perspectives on costs: their own and those forced upon them. Since medical expenses are the primary cause of personal bankruptcy and because up to one-third of medical testing and treatment does not improve health, physicians have an impact on patients' well-being that is impacted by both their financial situation and physical health. Value, which expresses a balance between health outcomes and costs from the viewpoint of the patient, has therefore emerged as a fundamental indicator of the efficacy of health care across a variety of conceptual frameworks for defining health outcomes (Rubin, 2017, p. 342). Effective and efficient delivery of healthcare is dependent on financially viable health care organizations and their operating units, even as the research and control of patients' costs is a significant responsibility due to physicians' professional responsibilities and societal interests.

Costs guide choices that affect how well medical treatments work in the day-to-day treatment of patients. However, a lot of interventionists find it difficult to fully utilize cost management and measurement as a vital step in proving their worth in the patient care.

Interventional radiologists run the danger of losing control over the provision and support of imaging when they are unable to effectively communicate their worth. Quantifying the expenses of providing certain imaging guided interventional therapies and comprehending imaging costs at a procedural level are essential to controlling imaging costs. A bottom-up strategy is necessary for effective product-level costing, and recent advancements in time-dependent activity-based costing have reinforced this need. What could be more peripheral and unimportant to a doctor more concerned with the well-being of his or her patients than cost accounting? Why are interventional radiologists involved in this? When compared to other departments, should the interventional radiology department accept an overhead rate that is significantly higher? Examining through the cost lens will reveal how and why healthcare systems and medical facilities make decisions.

This thesis does intend to find out the real costs of CT- and MR-guided interventional pain therapies. Regular intervention costs (equipment costs, personnel costs, etc.) as well as secondary modality-dependent costs, i.e. direct and indirect costs that induce cancer as a consequence of CT or (X-ray) radiation exposure, are to be considered. It is important to understand that the cost of imaging is not a fixed amount and is primarily determined by the viewpoint of the organization that will be paying for it.

3.3 Research essentials

Cost containment is the aim of healthcare systems and institutions. Beyond just cutting costs, healthcare leaders are striving for financial stability in an unstable market. Additionally, there is a thin line separating delivering top-notch patient care from controlling expenses. While searching for methods to save costs, cost-reduction strategies must prioritize the health of the patients. Healthcare systems with cost-sharing arrangements have a higher chance of success than those without. Harvard Business Review claims that cutting costs in areas like personnel, supplies, and equipment alone might make it more difficult for a hospital to provide a first-rate patient experience (Kaplan et al., 2014, p. 5).

When we discuss `Strategic Cost Reduction`, we mean: what cost-cutting measures should executives in the healthcare industry look at to lower costs without compromising patient care? Back pain individuals in our study. Using a range of cost-reduction strategies, healthcare costs may be decreased without compromising medical outcomes or patient happiness.

Special aims:

- In addition to raising the caliber and effectiveness of interventional back pain treatments, controlling costs is necessary to optimize the value of imaging..
- Strategic Cost Reduction: notably in the interventional image-guided treatment of low back pain, What cost-cutting measures (due to the use of the imaging modality) should medical executives look into to save costs without compromising patient care??

3.4 Research design

3.4.1 The relativity of costs

We learn from classical relativity of moving objects that there is no such thing as "absolute motion" or "absolute rest." When a ball is thrown between two boys on a speeding train, the speed will vary depending on who is measuring it—those on the train, those by the side of the tracks, and those looking down from space using a telescope to watch Earth's orbit and spin. Despite the claim that costing is not complicated, it is important to understand that, like to the universe, costs are subject to relativity. It is possible to develop reference points for costing in relation to the value chain of a business that operates within the industry (Fig. 15). Similar to how the estimated speed of the traveling ball depends on its placement, the costs of each entity in the value system are different. Value chain analysis has been used to strategically plan the growth of radiology's business model and has aided strategic cost control across a range of sectors (Rubin, 2017, p. 344) and its value proposition.

Given that estimates of pain prevalence range from 8 to over 60%, there is a great deal of clinical, societal, and financial concern around pain. The cost of back pain alone is comparable to more than a fifth of a country's entire health expenditures and 1.5% of its yearly gross domestic product; in another, it is three times the total cost of all cancer kinds. The impact of pain on economies is immense (Phillips, 2006, p. 591). Still, decision makers have focused on a relatively small portion of the cost burden—prescription expenses, which account for 1% of the entire cost burden in the case of back pain, according to Philips.

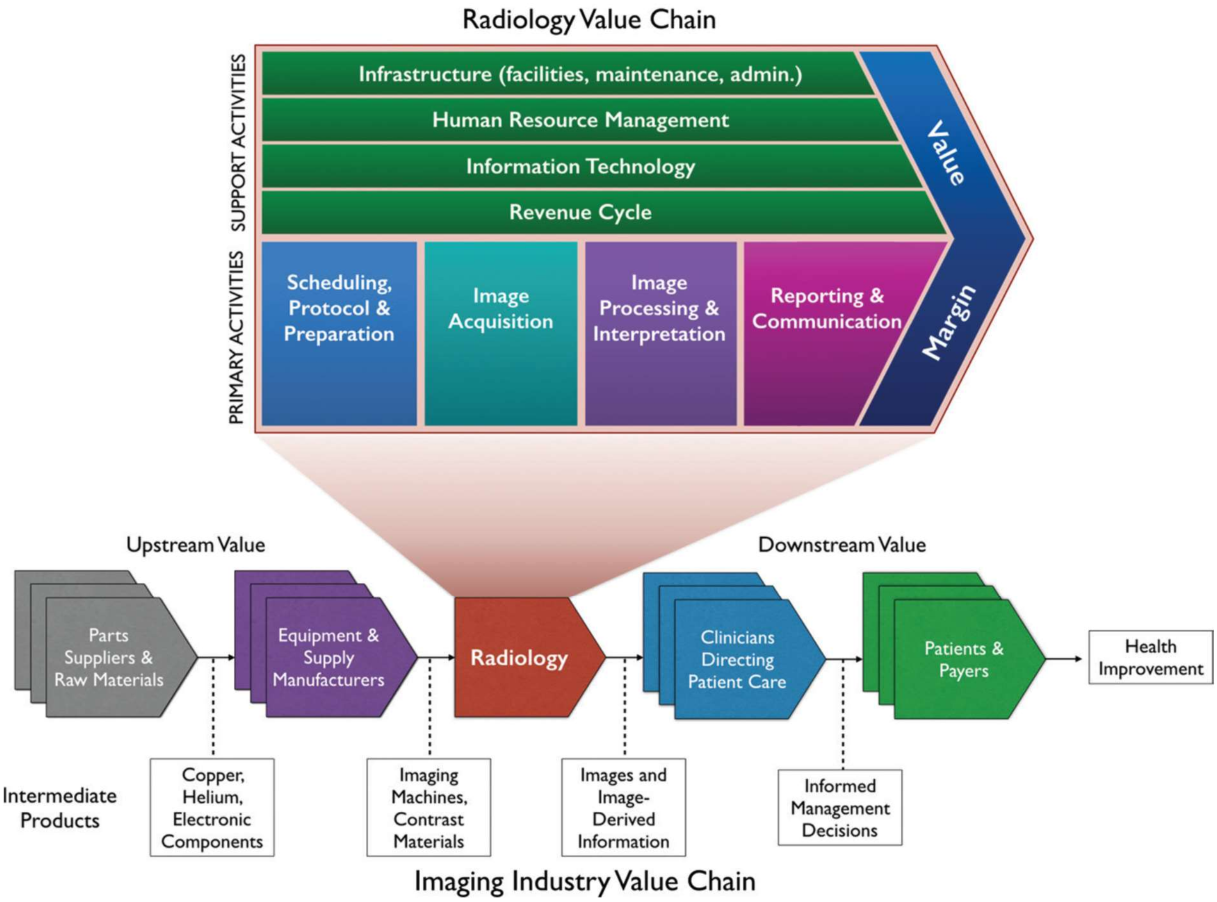


Figure 3.14
An illustration of the industry and company value chains for the imaging (bottom) and radiology (top) sectors, respectively. The main activities of the company that gradually add value to the finished good or service are listed in the firm value chain, along with the important indirect or support activities that are relevant to all stages of the firm value chain. In radiography, the outcome of the activities is the generation of pictures and information derived from images, which creates value for customers and profit for the business. The firm's value chain is a single link in an industry-wide value chain that connects several company value chains, ranging from upstream suppliers to the end user. The intermediate products of the numerous upstream and downstream companies are highlighted in this example for the imaging business and are utilized as inputs for the subsequent link in the chain, gradually adding value to the end result, which is maintained or enhanced patient health (Rubin, 2017, p.344).

Based on a literature search in existing databases (both medical database Pubmed and general databases Google Scholar, data from European and US professional societies, data from statistical and health federal offices Switzerland, Germany and USA etc.) the most recent scientific data / figures and recommendations as well as publications of large controlled trials on radiation protection and image guided interventional therapy were searched. In addition, statistical data from US fee-for-service Medicare population from 2000 to 2014 were considered when European statistics were not sufficiently detailed with regard to interventional therapies.

With the exception of US studies by Laxmaiah Manchikanti, large European studies contrasting individual pain management or cost procedures are few. Because technical innovations are introduced differently and very quickly, radiation exposures from CT or sequence times from MRI are very dependent on the available device (hardware), modules (software) and the skill of interventionalist. From this point of view, a comparison of radiation-exposing techniques in the context of classical studies is not legitimate. These factors play an enormous rol in end medical finances. The doctor plays a key role in this case: he makes the diagnosis and suggests eg performs medical interventions. Very often medical professionals complain about the "economization" of their field. This term implies that economics is a disruptive intruder in medicine and that there was the good old time when medicine was free of economic constraints. Well, things are not quite that simple the matter is not. The buyer of products and services is the only party that can profit from that purchase in the majority of sectors. The seller's income is determined by the buyer's willingness to pay a particular price. This, in turn, caps the seller's costs at a level that maintains the seller's margin.

As soon as a fee is charged for medical services, such as consultations, hospital stays or intervention, medicine is economized. We now require actions for resource-conscious, patient-centered, and scientifically grounded care. A significantly more complicated set of dynamics surface when the value chain for spine neuroradiology is mapped within the health care value system. These entities buy, use, and have an impact on the price of radiology's main product: pictures and information based on images.

First, a separate cost calculation and cost analysis of the whole intervention process for both CT-guided intervention and MRI-guided intervention by ozone was mapped, taking into account all material and personnel costs. The impacted persons (patients) were then subjected to a risk analysis only in terms of their radiation-indexed risk of acquiring cancer using descriptive statistical scientific data. This study shows a road map to calculate the real costs of

MRI-guided and CT-guided infiltration with ozone to allow an accurate comparison. This module must consider all variable and constant expenses (acquisition costs, personnel costs, maintenance costs, etc.). As an example, we take the walk-in practice Limmatfeld, a branch of the Cantonal Hospital Baden in the Canton of Zurich, which opened in 2015. The walk-in practice of the Limmatfeld medical center covers a wide range of general medical services. Also integrated are a radiology institute, physiotherapy, nutritional counseling, and surgical, rheumatological and angiological specialty consultations. The Institute of Radiology at the Walk-in Practice Limmatfeld in Dietikon (Zurich, Switzerland) is equipped with a modern multi-slice spiral CT scanner (Siemens Somatom Definition 64 Slice Dual-Source), which is used for interventional pain therapy, and an MRI scanner (Siemens Magnetom Aera 1.5 Tesla. To calculate the cost per operation, the total cost of operating each procedure was divided by the total number of procedures carried out. The breakeven volume, or the total number of procedures that must be completed beyond which all marginal contributions (Revenue-Variable Cost) will reflect revenue for the hospital, was then ascertained using breakeven analysis. The break-even point is the output or sales level at which the income generated by the company precisely matches the cost of producing (or selling) the output. The following is the formula: Sales Revenue - Variable Cost - Contribution Margin.This contribution margin helps to cover the fixed costs that are incurred.

The important point ist that in a healthcare system financed on the basis of solidarity an appropriate, efficient and equitable use of the funds made available is also required. In this respect, medicine and economics cannot be separated. However, economic interests must not unduly influence medical decisions. Going back to our initial purpose of measuring margin and value, we need to consider the cost term that is shared by both definitions from two very distinct angles. Value must be defined in terms of the patient's perspective, just like its cost word. On the other hand, while margin is a firm's internal attribute, its cost word needs to be defined from the standpoint of the supplier. The rest of this manuscript will center on this latter viewpoint.

3.4.2 Technique of intervention, MR-guided intervention

Every patient was positioned on the MRI table in the lateral position, with the side that required treatment facing up. A multifunction surface coil coil was positioned over the patient's target region orthogonal to the main B0 magnetic field in order to obtain the greatest MRI signal feasible. Anatomically targeted PDw fast spin echo (FSE) sequence (TE/TR 10/600) that was almost real-time interactive directed the injection needle. For local anesthesia, about 10 milliliters of Rapidocain 1% (lidocaine HCl 1% Sintetica S.A., Mendrisio, Switzerland) were given subcutaneously. Under MRI guidance, a dorsolaterally inserted 25G injection cannula that was compatible with magnetic resonance imaging (MRI) was placed through the soft tissue until the tip could be properly positioned in the disc material or lateral to the nerve root (Fig. 1). An intradiscal provocation test with manual application of carbosthesion 0.5% monolaterally or bilaterally (for intradiscal chemonucleolysis) is carried out following a position check and, if necessary, position adjustment. If the test is positive, only then was the chemonucleolysis carried out. The correct distribution of the injected material was confirmed using a strong T2w fat-saturated FSE (SPIR, spectral presaturation with inversion recovery) in axial layer orientation. Technical success for infiltration was achieved when the injection substance was precisely placed in the periradicular space. The injection site was wrapped with adhesive tape once the cannula was removed. The patients were monitored for thirty minutes following the nerve root operation and six hours following intradiscal chemonucleolysis.

3.4.3 Technique of intervention, CT-guided intervention

On the CT table, patients were positioned supine with their heads facing the gantry. To facilitate the planning of treatment, a lateral overview image of the lumbar spine was obtained. Then, taking into account the CT scout, individual CT scans (or a quick spiral scan in individual patients) were carried out to determine the exact height of the disc or nerve root that required treatment on the z-axis. The CT scan's positioning laser will be used as a reference to establish the location of the puncture in the xy plane. Using a felt-tip pen, the skin was marked at the likely correct injection site. Following the application of sterile dressing and skin cleaning, a local anesthetic was administered to the intended injection location. 10 milliliters of 1% Rapidocain (lidocaine HCl, Sintetica S.A., Mendrisio, Switzerland) is the local anesthetic that is intended to be injected. The tip of a 25-gauge injection chiba cannula (HS Hospital services, Italy) was advanced to the associated lumbar nerve root just anterior to the corresponding facet or to the disc during the CT fluoroscopy procedure. After removal of the interior trocar, a provocation test is for intradiscal nucleolysis a provocation test with abouit 5 ml Bupivacain 0.5% performed. Nerve root infilttration patients do not needs this step, they have got directly 2 ml Bupivacain 0.5% in combination of O3-O2-mixture (15-25 µg/ml). Administration of contrast agent is not necessary, because O3 is very well to see on computertomography scan.

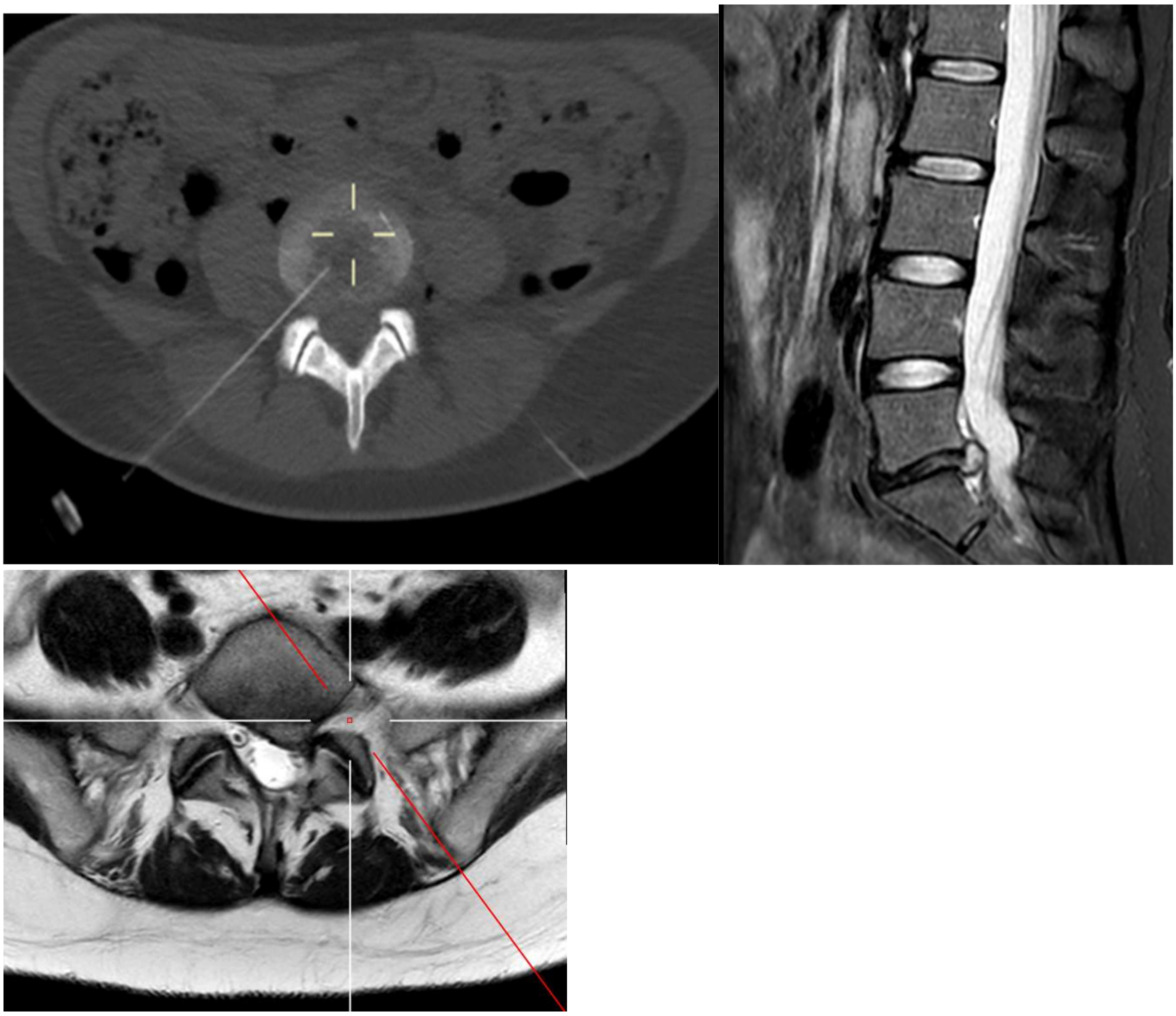


Figure 3.15
Example of MRI-guided and CT-guided intradiskal pain therapy by chemonucleolysis using Ozone: intervertebral disc protrusion L5/S1 with displacement of the left S1 root A; sagital

PDw-FSE sequence shows a subligamentary lumbar disc herniation B; a strongly T2w-FSE sequence planning the final needle positioning laterally extraforaminal near the left L5 root C; shows intradiscal chemonucleolysis usion computertomograph.

3.5 Definition and calculation of costs

3.5.1 Activity-based cost analysis in interventional radiology

Over the past 20 years, interventional radiology has seen a significant increase in applicability. Numerous innovative tactics have surfaced. Diseases that were previously solely treated by open surgical procedures now have additional treatment choices because to these new instruments. Conversely, this has increased the radiological units' workload and costs. The cost of healthcare is a topic that policymakers and health care organizations are becoming more interested in. Numerous cost-benefit and cost-effectiveness assessments that may be found in the medical literature attest to this (Rautio et al., 2002, p. 1937). Despite the rise in the quantity and sophistication of radiological procedures, analyses pertaining to interventional radiology have not been widely published. Many service organizations have found great benefits in using activity-based cost analysis (ABC) for budgetary planning. This is because ABC allows costs to be more accurately allocated to resources and allows for the evaluation of the cost factors of the activities that make up the product (Rautio et al., 2002, p. 1937). We are not aware of any reports of comprehensive ABC analysis in an interventional radiologic facility. Cost-benefit and cost-effectiveness assessments should be performed before introducing a new treatment strategy, but they are most reliable when done in conjunction with a suitable cost accounting.

From the standpoint of the interventional unit, all expenses directly associated with interventions in radiology were totaled. The overhead costs for the radiology unit and the hospital were omitted. They accounted for barely 5 percent of the total spending. Premedication for patients, general anesthesia, and ward pre- or post-care were not included because these expenses were paid for straight out of the ward budgets (Geoffrey et al, 2017, p. 342). The cost and consumption data was obtained from inventory files and the hospital accounting department. A budget of around 1.8 million euros was reported by Rautio et al. in 2002 for the entire interventional unit (endovascular and non-endovascular). Of this, 67% (1,252,070 euros) went toward material costs, 17% (309,466 euros) went toward labor expenses, 14% (254,624 euros) went toward equipment expenditures, and 2% (28,256 euros) went toward premises costs. Radiologists spent 148,005 euros on staff, radiographic technicians spent 141,278 euros, and other personnel spent 20,183 euros. He comes to the conclusion that 89% of the interventional radiology's overall expenses came from the activities.

To calculate the total cost of CT- and MRI-guided pain therapy, worker, material, and equipment utilization expenses were divided into three groups. For equipment with an 8-year useful life and a straight-line life, the expenses of acquisition, depreciation, and maintenance are included in the consumption costs. Depreciation is calculated in accordance with Swiss tax law. Regular intervention costs (equipment costs, personnel costs, etc.) as well as secondary modality-dependent costs, i.e. direct and indirect costs that induce cancerous diseases as a consequence of computed tomography or (X-ray) radiation exposure, are to be considered.

The average useful life of each modality in relation to the total annual usage time was calculated, accounting to calculate the equipment usage costs per procedure for the open MRI system and CT device, maintenance expenses and energy costs per minute of use are necessary.

Table 3.16
Calculation Assumptions

Working Daye / Year	**260**	**Days**
Working Minutes Physician / Year	149'760	Minutes
Working Minutes **MRT** /Year	131'040	Minutes
Device Usage (in Minutes) / Day	540	Minutes
Usage in Minutes / Minutes	140'400	Minutes
Acquisition Costs CT	812'000	CHF
Total CT Maintenance Costs	96'880	CHF
Acquisition Costs MRI	1'718'000	CHF
Total MRI Maintenance Costs	109'715	CHF
Depreciable Life of Equipment	8	Year
Physician Fee / Year	224'640	CHF
Physician Fee / Minutes	1.50	CHF
MTRA Fee / Year	99'840	CHF
MTRA Fee / Minutes	1.31	CHF

The Hospital's purchasing department assessed the cost of disposable items (e.g., drapes, MRI-compatible injection kannulae) (Table 1). Process models were developed for both treatment methods, including each step individually, in order to determine the personnel costs for physicians and radiographers (Table 2). Each modality and patient had a designated number of persons (radiographer and interventionist) who were required to complete the intervention and put in time units. The initial scout picture, the last CT fluoroscopy image, and the T2w FSE SPIR sequence may all be used to retrospectively estimate the average intervention time from the DICOM header of the MRI or CT image series. Using data from five MRI-guided and five CT-guided interventions, it is possible to estimate prospectively the average amount of time needed for pre- and post-intervention activities. Subtracting absences for vacation, illness, and training from the average monthly wages of physicians and radiographers based on their specific engagement periods, as stipulated by the civil service wage agreements, yielded the expenses for personnel minutes. The equipment usage costs, human charges, and costs for disposable items added up to the overall costs. Further cost types, including as room usage and cleaning expenses and building costs, were not taken into consideration for the purpose of simplification since they could not be consistently connected to individual therapies in our treated patient collective.

3.5.2 Data management

Technically, every MRI fluoroscopy and CT fluoroscopy-guided intervention was executed successfully. The entire cost of operating each procedure was divided by the total number of operations performed to get the cost per procedure. The breakeven volume, or the total number of procedures that must be completed beyond which all marginal contributions (Revenue-Variable Cost) will reflect revenue for the hospital, was then ascertained using breakeven analysis. The break-even point is the output or sales level at which the income generated by the company precisely matches the cost of producing (or selling) the output. The formula is as follows: Contribution Margin – Variable Cost – Sales Revenue. This contribution margin helps to cover the fixed costs that are incurred.

For MRI guided interventions, the mean intervention duration was 24.9 ± 6.3 minutes, with a range of 17 to 36 minutes. The average time for preinterventional patient preparation was 22 minutes, whereas the average time for postinterventional activities was 9 minutes. A CT guided intervention took an average of 19.7 ± 7.9 minutes (range: 5 – 54 minutes) after 20 minutes of preinterventional preparation and 9 minutes of postinterventional activity. An estimated average effective dose of 0.48 ± 0.51 mSv (range: 0.07 – 1.92 mSv) was obtained from CT-guided treatments. In order to better localize the nerve root and arrange the access, a brief CT spiral was required. The patient group's estimated average effective dosage, which ranged from 0.34 to 1.93 mSv, was 0.85 ± 0.48 mSv, which was considerably greater than the subgroup that did not have a planning scan (t-test, $p < 0.001$). The average time of the intervention was 20.7 minutes, however there was no statistically significant increase in comparison to the patient group that did not obtain the necessary preparatory scan.

The average usable life of each modality, accounting for maintenance and energy costs per minute of usage, was computed as a percentage of the total yearly useful life to determine the equipment cost per operation for the MRI and CT machines. The acquisition cost of the MRI device is CHF 1,718,000, CHF 109,715 maintenance costs exclusive. The CT device costs CHF 812,000 excluding annual maintenance costs of CHF 96,880. The devices are used for a total of 540 minutes per day (140,400 minutes per year) (Table 16).

The costs of disposable injection cannulas and the other material costs or administered drugs are shown in Table 17.

A process flow with the necessary time was constructed for both treatment approaches in order to determine the human expenses for doctors and radiologists (Table 18). The collective agreements for doctors and staff at Swiss cantonal hospitals state (Canton Aarau), the personnel costs per hour are 90 CHF for the radiologist and 40 CHF for the radiographer. For this cost calculation we assumed 260 working days per year with 149'760 minutes for physicians and 131'040 minutes for radiographer (with a 48-hour working week for physicians and a 42-hour working week for radiographer). Accordingly, a physician / minute costs 1.50 CHF (annual cost 224,640 CHF) and an MTRA 1.31 CHF per minute (99,840 CHF per year) (Table 18).

Table 3.17

Cost of Materials for CT- and MRI- Controlled Infiltration

Material	**Manufacturer**	**Price (CHF) / MRT**	**Price (CHF) / CT**
20 G MRI – Suitable COMPLETE-CHIBA Needle	Styrilab, Mialn, Italy	84.95	
25 G CHIBA Needle (CT)	Styrilab, Mialn, Italy		28.35
Kenakort-A Solubile 40 mg/ 1 ml	Derma pharm AG, Switzerland	9.00	9.00
Lopamiro 300	Bracco, Switzerland	11.00	11.00
Bupivacaine 0.5% 5mg/ml	Sintetica, Switzerland	4.50	4.50
Sterile Kit	Vascular Medical, Cardiva, Spain	5.10	5.10
Sterile Gloves	Sempermed, Supreme, UK	4.00	4.00
Per Examination (CHF)		**118.55**	**61.95**

The personnel expenses for an MRI-guided intervention were CHF 99.47, and for a CT-guided intervention, they were CHF 84.84, taking into account the duration of both intervention types' doctor and X-ray assistant engagement (Table 2). For disposables, costs of CHF 61.95 for CT guidance and CHF 118.15 for MRI guidance were determined (Table 19). The cost of the equipment is CHF 29 for a CT-guided intervention and CHF 72 for an MRI-guided intervention per patient. The average total cost per patient is 290.29 CHF for an MRI-guided intervention and 175.46 CHF for a CT-guided intervention. To calculate the costs of the overall process of a pain therapy (MRI- and CT-guided), 260 working days per year were assumed with a 48-hour working week for physicians and with a 42-hour working week for radiographer. Salary levels were calculated on the basis of collective agreements (cantonal hospitals) in the canton of Aargau at 99,840 CHF for an radiographer and 224,640 CHF for a physician (specialist competence) (Table 15).

Table 3.18
Personnel Cost at CT- & MR-Controlled Infiltrations (Wage Radiographer: 40 CHF per hour, physician: 90 CHF per hour).

Personnel	**Qualification Personnel**	**Number of Minutes/Examination MRT**	**Number of Minutes/Examination CT**	**Cost Personnel/Minute**	**Cost Personnel/Examination MRT**	**Cost Personnel/Examination CT**
Patien Registration	MTRA	3	3	1.31	3.94	3.94
Clarification	Arzt	5	5	1.50	7.50	7.50
Material Preparation	MTRA	5	5	1.3125	6.56	6.56
					0.00	0.00
Intervention	Arzt	24.9	19.7	1.50	37.35	29.55
	MTRA	24.9	19.7	1.3125	32.68	25.86
Overlay of Pat.	MTRA	2	2	1.3125	2.63	2.63
Images Analysis &Transmission	MTRA	1	1	1.3125	1.31	1.31
Findings	Arzt	5	5	1.50	7.50	7.50
Per Examination		**70.8**	**60.4**		**99.47**	**84.84**

For personnel costs, the average times of CT-guided pain therapy and MRI-guided pain therapy are divided into different subgroupings with corresponding times and costs per unit (Table 18). Here, higher costs of MR-guided pain therapy in the amount of 14.63 CHF can be derived, caused by longer lasting sequences with MRI than with CT.

Table 3.19

Equipment Usage Costs per Intervention Assuming an 8-Year Useful life

Devices Cost	**MRI Magneton Area Siemens**	**CT Somatom Definition AS+ Siemens**
Acquisition Costs	1’718'000.00	812’000.00
Maintenance Costs	109’715.00	96’880.00
Daily Usage (Minute)	540.00	540.00
Electricity Costs (Per Intervention)	5.55	1.15
Average Intervention Time (Minute)	41.00	34.00
Per Examination* (CHF)	**72.00**	**29.00**

Table 3.20

Total Costs of CT-Guided Spinal Pain Therapy Versus MRI-Guided Therapy

	MRI Magneton Area Siemens	**CT Somatom Definition AS+ Siemens**
Total Cost per Examination (CHF)	**290.29**	**175.46**

3.5.3. Quality management of data

Overall, high reliability and objectivity can be assumed for the patient data,

- because a pretest was carried out for the data
- an intensive follow-up interview was conducted with the doctor(s) in the event of missing data, and
- the interviews were conducted by trained employees of the Institute

In addition, plausibility checks were performed for approximately 10% of the data entered in order to minimize the error rate during data entry.

3.5.4 Cost rates for the direct and indirect costs

If we can accurately define and classify the costs, as business owners, we will have a better grasp of how to determine price. An hospital may set prices that are both competitive and correct if it is aware of the full costs associated with creating and offering the procedure or services to clients. Furthermore, keeping accurate records of both direct and indirect expenses will help optimize tax deductions because some costs are also deductible.

Direct, indirect, and intangible costs are the three main cost components that health economics often separates out. The use of resources directly associated with the application or performance of nursing, medical, and therapeutic treatment is included in the direct expenses. For the calculation indirect costs are usually calculated the so-called human capital approach. The name of the approach assumes that, from an economic point of view, health care expenditures in the preservation of the ability of patients to of patients, i.e. in human capital. The indirect costs of an illness are thus as great as the loss of labor potential, of a national economy due to absenteeism or reduced absences or reduced performance at the workplace. On the third dimension, intangible costs, health economists are generally not in a position to make any statements to make any statements. The intangible costs include feelings such as fear and pain. Cost studies on the direct and indirect costs of chronic pain are rather rare, for Switzerland almost non-existent. On the basis of the "Pain in Europe" study the German results are the most likely to be applicable to the Swiss and, secondarily, the British results for further discussion. When setting the price for the good or service, it's critical to distinguish between direct and indirect expenses. Indirect costs are those associated with upkeep and operation of the facilities, whereas direct costs are those that may be linked to a specific product, such as power consumption, machine technician yearly cost, depreciation, and equipment maintenance and insurance (facility area, wages and salary and other overhead cost per scan).

This approach can be justified by the fact that according to the "Pain in Europe" study, Germany and then and then, along with Austria, Great Britain are closest to the Swiss results (Oggier, 2007, p. 29). problem to be overestimated rather than underestimated, because in the same study Austria shows above-average above the average in the same study, while Great Britain on the other hand, is below average.

Furthermore, the data situation in Austria's healthcare system is as dire, and the country's healthcare system is just as insufficient as Switzerland's. Of the available studies mentioned above the case of Great Britain, the study by Maniadakis and of Maniadakis and Gray can be consulted, to which the statements of Schug also refer (Oggier, 2007, p. 28). However, this work is limited to the economic costs of chronic back pain.

3.6 Data analysis

Data analysis is the methodical use of statistical and logical techniques to characterize the scope of the data, modularize the data structure, condense the data representation, illustrate using pictures, tables, and graphs, assess statistical inclinations, probability data, and draw meaningful conclusions (Arora, 2022, p. 7). These analytical methods enable us to get the fundamental conclusion from the data by eliminating the superfluous clutter that the remaining portion of the data generates. Data analysis is a continual, iterative process that involves contemporaneous data gathering and analysis, as the creation of data is a continuous activity. Ensuring data integrity is one of the most important aspects of data analysis. Descriptive analyses (frequency distributions) were performed to describe the sociodemographic parameters, such as age, gender, education, income, etc. The results of these analyses were used to calculate the costs of health care services. The diagnostic analysis is used as a step beyond the statistical analysis to give a more comprehensive research to address the questions. Predictive analysis is crucial in this case. A machine learning model is trained with historical data to find significant patterns and trends. The model is used with the given data to predict future events. Because of its numerous advantages—which include handling massive volumes of data of any sort, faster and more reasonably priced computers, easy-to-use software, tighter financial circumstances, and the need for competitive differentiation—many firms find it appealing. In order to calculate the costs of treatment, the indicated reimbursement prices for health services were multiplied by the average resource consumption of all patients and the mean value, standard deviation and total costs calculated. The entire cost of operating each procedure was divided by the total number of operations performed to get the cost per procedure. The breakeven volume, or the total number of procedures that must be completed beyond which all marginal contributions (Revenue-Variable Cost) will reflect revenue for the hospital, was then ascertained using breakeven analysis. The break-even point is the output or sales level at which the income generated by the company precisely matches the cost of producing (or selling) the output. The computation is presented as follows:

Sales Income – Variable Expense = Margin of Contribution

This contribution margin helps to cover the fixed costs that are incurred.

3.6.1 Radiation analysis

Technical success rates for both MRI- and CT-guided cervical root infiltration with cortison have been reported as 100% by Maurer et al (Maurer et al, 2014, p. 564). All MRI- and CT-guided interventions were technically correct. An MRI-guided intervention took an average of 24.9 +/-6.3 minutes (range: 17-36 minutes) to complete. The postinterventional activities took around nine minutes, while the patient preparation time before the intervention was twenty-two minutes. An average of 19.7 minutes +/- 7.9 minutes (range: 5-54 min) was spent on CT-guided pain treatment; this comprised 20 minutes for preinterventional planning and 9 minutes for postinterventional chores. For CT-guided treatments, the average effective dosage in the cervical area was 0.85 +/-0.48 mSv (range: 0.34-1.93 mSv), while in the lumbar region, it was as high as 2.9 mSv (Maurer et al, 2014:560). The scan length for typical CT infiltrations extended to approximately 6 cm (one floor). For each disc herniation with resulting nerve compression, one can expect up to ten CT-guided spinal injections and possible repetition at the same site approximately every two years, depending on the clinic (Krämer et al., 2008, p. 598). This results in an effective individual annual dose of 6.5 mSv for five CT-guided interventional therapies. Even with low-dose protocols, cumulative radiation exposure must be expected with repeated interventions over the years (Krämer et al., 2008, p. 598). The relevant bodies in the field of radiation protection regularly compile estimates of the individual increase in risk for malignancy as a result of radiation exposure. However, no statistics are available for the present problem case. The additional number of solid tumors for individuals exposed to 10 mGy annually between the ages of 18 and 65 years is estimated to be 2600 (95% confidence interval (CI: 1250-5410) per 100,000 for men and 4030 per 100,000 women (95% CI: 2070-7840) (Krämer et al, 2008, p. 598).

High-frequency radio waves are used in magnetic resonance imaging (MRI) to break up hydrogen atom nuclei, which are prevalent in tissue. Strong magnets map the areas of the tissues containing hydrogen and detect the hydrogen reaction. No ionizing radiation is used. Thus, the effective radiation dose for MRI-guided interventions is zero.

Table 3.21
overview of radiation calculations

Interventions -Rate 2014:	Medicare Insured (16,8 % US-Population) Have a Total of 5025’904 WS-Get Infiltrations (4,5 % der Total Insured)						
Population Switzerland:	8’500’000	4.50%					
Infiltration / Year	382’500						
Dose:	100 mSv = Risk Increase g um 1,5%						
		Normal CT		Low Dose CT		DL	
		min. CT Dose (4 Scans)	max. CT Dose (10 Scans)	Min. Dose (4 Scans)	max. Dose (10 Scans)	1 Min.	3 Min.
	Unit mSv	4.45	10.43	0.5	1.18	0.67	2.03
	Increased Risk /mSv	0.07	0.16	0.008	0.02	0.01	0.03
	Extra Cancer Patients / Year	268	612	31	77	38	115
	extra Direct Cancer Costs /	3’484’000	7’956’000	403’000	1’001’000	494’000	1’495’000

	Person/ Year = 13’000						
	Extra Indirect Cancer Costs / Person / Year =12’000	3’216’000	7’344’000	372’000	924’000	456’000	1’380’000
	extra direct + indirect Cancer Costs / Year	6’700’000	15’300’000	775’000	1’925’000	950’000	2’875’000

3.6.2 Radiation risk and cost analysis

In MRI-guided interventions, patients were not exposed to ionizing radiation and no iodine-containing contrast medium was used. These advantages are very important especially because of the tremendous increase in the number of CT-guided infiltrations and because of the ever-younger patients who receive multiple treatments during their lifetime. Multiple treatments by CT mean a cumulative increase in radiation dose in a large population with increasing risk of developing malignancy at some point. Radiation dose in medical imaging, especially the increased risk of cancer in computed tomography, has been the subject of much discussion recently. An American study from 2007 proves that approximately 2% of diagnosed malignancies in the USA can be attributed to the consequences of these medical examinations. This is comparable to other studies that conclude a 1.5 to 2% cancer prevalence as a consequence of medical examinations (Lin et al., 2010, p. 1145). A radiation dose of 10 mSv is estimated to cause an increased risk of cancer of 0.05%, i.e., the risk of developing a fatal malignancy is 1 in 2000.

The chance of cancer is increased to 1 in 2000 with a CT scan at an effective dosage of 10 mSv; nevertheless, this risk is far lower than the risk of acquiring a malignancy on its own (in the U.S., 1 in 5 or 400 in 2000). Put otherwise, the inherent risk of cancer for any given person is far larger than the chance of cancer brought on by radiation. When all hazards are taken into account, the total lifetime risk of cancer rises from 400 to 401 by 2000. Even though an individual's increased risk of radiation-associated cancer may appear negligible at first, if CT examinations or other treatments grow dramatically, this might pose a "public health risk" (FDA, 2015).

Assume we want to apply our case to a population of 8'500'000'000 people in Switzerland. Let us assume that 4.5% of the population would have to undergo such pain therapy, which would correspond to 382,500 / people / year. If these patients opt for a CT-guided intervention instead of an MRI-guided one, this saves money. For example, if a CT costs CHF 175.46 (cost for all patients: CHF 67,320,000) and an MRI costs CHF 290.29 (cost for all pat. 111,162,000), the savings would be CHF 43,842,000.

The additional number of solid tumors in persons exposed to 10 mGy annually from 18 to 65 years of age is estimated to be 2600 (95% confidence interval (CI: 1250-5410) per 100,000 in men and 4030 per 100,000 in women (95% CI: 2070-7840) (Krämer et al, 2008, p. 598). Assuming these 382,500 residents would receive an average of 10.43 mSv (at low dose 4.45 mSv) of radiation during a CT scan. This would increase their risk of developing cancer by 0.053%.

Assuming these 382,500 residents would receive an average of 4.45 to 10.43 mSv (at low dose, 0.5 to 1.18 mSv) of radiation from the CT scan, this would increase the probability of developing cancer by 0.07%-0.16% (at low dose, 0.008%-0.15%), i.e., 273 to 624 individuals (at low dose 32 - 585) would develop cancer after a single CT-guided intervention (Table 18). The risk of developing cancer increases linearly after multiple interventions. According to data and publications of the Swiss Federal Statistical Office, the total direct costs due to cancer in Switzerland in 2014 amounted to CHF 5,018,000,000 and the total indirect costs to an estimated CHF 11,606 per patient per year for all cancer patients (all types of cancer) (Wieser et al., 2014, p. 5, Achtermann et al., 2016, p. 2).

With these data, a reliable calculation of the total costs of CT-induced cancer patients (specifically induced by CT-guided pain therapy) is possible. Total direct costs of 8'112'000 and total indirect costs of 7'488'000 CHF per year were calculated. This results in expected total costs of 15,600,000 CHF due to CT-guided pain therapies in the spine.

At a dose of 10.43 mSv, the radiation-induced cancer risk increases by 0.16%, i.e. 624 more people would develop cancer. These additional patients would again cause direct costs of

8'112'000 CHF and 7'488'000 CHF indirect costs. In total, these additional cancer patients would burden the economy by approximately 15,600,000 CHF per year. These costs would remain significantly lower with consistent use of MRI-guided interventions.

CHAPTER IV:

RESULTS

4.1 Research question

Even in Switzerland, one of the main impediments to high-quality healthcare is financial constraints. The rapid increase in health care expenses in the years after World War II has been one of the most important economic changes in the western world. There is a positive correlation between the growth of health insurance and new technology: the former raises demand for insurance, while the latter does the same for new technology. We will investigate the cost-effectiveness of this CT / MRI imaging paradigm for interventional spinal pain treatment with Ozone using model-based economic decision analysis. This study's main goal is to present a thorough evaluation of the literature and medical practices about the influence on the healthcare system, the efficacy and cost analysis of a particular modality. In particular, the following sub-objectives are part of the study:

- thorough analysis of the direct and indirect expenses associated with back discomfort;
- Overview of the impact of low back pain on the healthcare system generally (with emphasis on Switzerland);
- Different possibilities for treatment of disease, utilizing different approaches and innovative technologies from the financial perspective;
- Choice of imaging modality for minimal invasive treatment with ozone and its impact on the treatment costs;
- This decision's effects throughout the long and short terms healthcare system;

4.2 Summary of findings

When lumbal radicular pain syndrome and lumbal discomfort cannot be adequately treated conservatively, patients can benefit from the safe and efficient therapeutic approach of intradiscal nucleolysis utilizing ozone under CT, fluoroscopic, and MRI guidance [Maurer et al 2013]. It was also possible to establish therapy guidance by MRI in a clinical setting [Fritz et al 2009]. The technical success rate in our investigation was 100%. All patients in both groups received treatment with periradicular injectate dispersion in an appropriate manner.

The total cost of the MRI-guided and CT-guided pain regimens was calculated using three different cost types: material costs, labor expenses, and equipment use costs. The equipment usage expenses, as defined by German tax law, included purchase, depreciation, and maintenance charges, based on a seven-year use term and linear depreciation. To calculate the equipment usage costs per intervention for the open MRI system and the CT unit, the average usage duration of the particular modality was calculated as a percentage of the annual total usage duration, accounting for maintenance costs and energy costs per minute of use.
For each treatment approach, process models with all of the individual phases were constructed in order to calculate the human expenses for doctors and X-ray assistants. Each individual step listed the persons required to complete the intervention as well as their estimated time of involvement in minutes. The first scout image and the last image from either the CT fluoroscopy or the MRI sequence might be used to retrospectively assess the average intervention duration from the MRI or CT image series. An average value based on five MRI-guided and five CT-guided interventions could be used to prospectively determine the amount of time needed for activities prior to and following the intervention. The expenditures for personnel minutes were then computed using the specific involvement times of X-ray helpers and doctors, as well as their average monthly pay as determined by the civil service wage agreements, less absences for training, sick leave, and vacation. The total costs were increased by the costs of labor, equipment utilization, and disposables. The costs for sonographic treatment guidance were calculated in addition to the costs for CT and MRI guidance as an additional guiding option for periradicular treatments. Further cost types, including as room usage and cleaning expenses and building costs, were not taken into consideration for the purpose of simplification since they could not be consistently connected to individual therapies in our treated patient collective.

For MRI guided interventions, the mean intervention duration was 24.9 ± 6.3 minutes, with a range of 17 to 36 minutes. The average time for preinterventional patient preparation was 22 minutes, whereas the average time for postinterventional activities was 9 minutes. A CT guided intervention took an average of 19.7 ± 7.9 minutes (range: 5 – 54 minutes) after 20 minutes of preinterventional preparation and 9 minutes of postinterventional activity. An estimated average effective dose of 0.48 ± 0.51 mSv (range: 0.07 – 1.92 mSv) was obtained from CT-guided treatments. For improved nerve root localization and access planning, a brief CT spiral was required. The patient group's estimated average effective dosage, which ranged from 0.34 to 1.93 mSv, was 0.85 ± 0.48 mSv, which was considerably greater than the subgroup that did not have a planning scan (t-test, $p < 0.001$). The intervention duration, at 20.7 minutes on average, did not show a statistically significant increase over the patient group that did not receive the required planning scan. The average usable life of each modality, accounting for maintenance and energy costs per minute of usage, was computed as a percentage of the total yearly useful life to determine the equipment cost per operation for the MRI and CT machines. The acquisition cost of the MRI device is CHF 1,718,000, CHF 109,715 maintenance costs exclusive. The CT device costs CHF 812,000 excluding annual maintenance costs of CHF 96,880. The devices are used for a total of 540 minutes each day (140,400 minutes each year). The personnel expenses for an MRI-guided intervention were CHF 99.47, and for a CT-guided intervention, they were CHF 84.84, taking into account the involvement times for doctors and X-ray helpers in both intervention types (Table 2). For disposables, costs of CHF 61.95 for CT guidance and CHF 118.15 for MRI guidance were determined.

To calculate the costs of the overall process of a pain therapy (MRI- and CT-guided), 260 working days per year were assumed with a 48-hour working week for physicians and with a 42-hour working week for radiographer. Salary levels were calculated on the basis of collective agreements (cantonal hospitals) in the canton of Aargau at 99,840 CHF for an radiographer and 224,640 CHF for a physician (specialist competence). For personnel costs, the average times of CT-guided pain therapy and MRI-guided pain therapy are divided into different subgroupings with corresponding times and costs per unit. Here, higher costs of MR-guided pain therapy in the amount of 14.63 CHF can be derived, caused by longer lasting sequences with MRI than with CT.

4.3 Conclusion

It is vital to assess the expenses of two competing therapeutic techniques when they have remarkably comparable outcomes (Maurer, 2013). A reliable and secure therapy option for patients whose conservative treatment results are disappointing is periradicular nerve root infiltration guided by fluoroscopy and CT (Omidi, 2018). On the other hand, over 100% of clinically established nerve root infiltration procedures are technically successful when guided by magnetic resonance imaging (Fritz, 2009). This is supported by our findings: For each of the ninety patients, accurate injection needle placement and simple infiltration were made possible by MRI guidance.

In the event of anticipated additional price reductions for MRI-compatible injection cannulas and potential use of low-field scanners or conventional tunnel systems, MRI-guided nerve root infiltration appears to be a promising alternative to previously established CT fluoroscopic methods, given the lack of radiation exposure for patients and staff. However, ultrasound-guided therapy continues to be the least expensive method.

Our cost research showed that the MR-guided operations were still twice as costly as the same interventions performed with CT help. Currently, the cost of Interventional Spinal Nucleolysis utilizing ozone gas under MRI guidance is almost twice that of this therapy with CT fluoroscopy guidance per patient. The principal source of the increased total expenses was the much greater cost of equipment utilization in MR-guided interventions, since the purchase prices of open high-field MR systems running at 1.0 or 1.5 T are obviously more expensive. Despite the fact that our clinic's MR system is shared by several departments and that technological advancements in recent years have enhanced hardware and software to enable faster sequences and better workflow, these expenses resulted in comparatively higher equipment prices.

CHAPTER V:
DISCUSSION

5.1 Disscussion of results

A business employs a set of procedures known as cost control to keep tabs on its expenses. Over time, implementing this degree of control can significantly increase earnings. It is often known that throughout the previous ten years, the cost of medical technology has dramatically increased, driving up the overall cost of healthcare. The aim of this cost control analysis is to improve the overall performance efficiency of the spinal neuroradiology department, not to reduce the amount or quality of services offered to a patient. In order to control costs, cost analysis also aids in evaluating the efficacy and efficiency of each functional component in the manufacturing process (minimally invasive spinal procedures in this case) as well as the implications of those components' costs.

It's important to weigh the expenses of two alternative therapeutic approaches when they have extremely comparable results. Interventional imaging guided infiltration represents a safe and efficacious therapy option for individuals whose outcomes from conservative treatment are unsatisfactory (Omidi et al., 2018, p. 1516). MR-guided intervention has been clinically demonstrated as a substitute for CT imaging, with a reported technical success rate of over 100% (Fritz et al., 2009, p. 167) (Sequeiros et al., 2002, p. 1331, Ojala et al., 2000, p. 556). This is supported by our findings: For all patients, accurate injection needle placement and simple infiltration were made possible by MRI guidance.

The number of interventional pain therapies performed has been increased sharply in recent years (Konrad et al., 2011, p. 47), but no direct national or European statistics or database of pain therapies performed exists. But quantity data of outpatients and inpatients with back pain and back surgery exist. All data show a significant increase in the number of conservatively treated patients and back surgeries (Conrad et al., 2011, p. 47; Gerfin et al., 2011, p. 6; Statista, 2015, p. 2; SGS, 2016, p. 1; Kohlmann et al., 1995, p. 99; Von den Heuvel, 2008, p. 4; Duthey et al., 2013, p. 2; Parthan et al, 2005, p. 6; Healthcare, 2015, p. 1; Interpharma, 2011, p. 11; Wieser et al., 2014, p. 4; Achtermann et al., 2016, p. 2; BAG, 2018, p. 16). In addition, various studies report explosive growth in the number of CT scans performed. For our calculations, we were able to use U.S. data from one of the largest insurance companies in the U.S. as the only existing solid database. The number of back pain patients and the existing recommendations and "guide lines" for back pain therapies should not differ significantly in Western industrialized countries. European statistical guidance for interventional pain therapies, especially for back pain, would play a central role for accurate categorization and for meaningful cost-benefit studies. Only after such a survey and data analysis would an evidential and accurate statement be possible.

Equipment costs are CHF 72 per patient for an MRI-guided intervention and CHF 29 per patient for a CT-guided intervention. The average total cost per patient is 290.29 CHF for an MRI-guided intervention and 175.46 CHF for a CT-guided intervention.

Despite these statistical limitations of the study, it is striking that CT-guided pain therapy is far more cost-effective than MR-guided intervention for the healthcare system. Even when radiation-induced cancer patients are factored in, CT-guided therapy remains more economically feasible. The largest cost difference comes from the clearly higher acquisition cost of an MRI machine compared to a CT machine. It should be assumed that in view of future technical developments and increasing competition in the medical-technical field, acquisition costs could decrease drastically. Also, that with an increase in MRI-guided interventions, material costs would decrease partly due to competition and partly due to volume sales. These possible factors could cause an incentive/shift toward MRI-guided interventions.

In the present study, only the material costs after cancer are calculated. Of course, a cancer diagnosis, especially in younger years, has a great psychological and social impact on the affected person and his/her immediate environment. Unfortunately, this non-material factor cannot be calculated in the cost-benefit comparison. A significant and detailed information of the patients about indirect complications, which can occur by irradiation, is necessary. Then it might make economic sense to ask for a financial contribution from the patients who decide to undergo MR-guided intervention. However, a cost comparison shows that the cost of MRI-guided infiltrations was on average 1.65 times higher than the cost of CT-guided infiltrations. Significantly higher device costs due to more expensive acquisition and maintenance costs are important factors contributing to this price difference, as an MRI device costs more than twice that of a CT device (1,718,000 CHF MRI device versus 812,000 CHF CT device). The MRI machines have much higher investment costs compared to CT machines (over 1.5 million CHF). The depreciation period for both devices is eight years. The annual maintenance costs amount to 5 % to 15 % of the purchase price.

In addition, there are higher costs for disposable material suitable for MRI, which are mainly due to marketing reasons. Since MRI-guided interventions are performed much less frequently worldwide than CT-guided interventions, the quantity sold is much lower and thus the price much higher. However, a significant price reduction has been perceived in recent years for MRI-guided injection cannulas. If MRI interventions are routinely performed, one can expect a significant competitive price reduction in this market. Furthermore, it must be assumed that the purchase of a "high end" MRI machine is not necessary for the performance of interventional pain therapy. Since these interventions do not require fine diagnostics, but only precise navigation of the puncture site, a less expensive MRI device (e.g., 1 Tesla) is completely sufficient. Correspondingly, the maintenance costs of the device then become considerably lower, since the maintenance costs are strongly dependent on procurement costs. The increased expenses of staff are another factor contributing to the higher overall costs of MRI-guided therapies. These are mainly due to a lack of experience of the medical staff (physicians and radiographers) with MRI-guided interventions and technically due to a slower acquisition of the MRI images. Fast MRI sequences have helped to decrease scan and intervention times since they were developed, continuously enhancing quality and dramatically lowering total costs. Different studies have reported average intervention times ranging from 24.9 to 42 minutes. Future further technical improvement of MRI sequences (both qualitative and quantitative) anticipates a significant price reduction due to a reduction in intervention time.

Ultimately, the experience and cohesiveness of the intervention team—which consists of the physician and radiographer—determines how long an intervention will last. One expects a "learning curve" and thus ever faster and shorter interventions and an optimization of the work flow.

In summary, CT-guided spinal pain therapy is significantly more cost-effective than MR-guided intervention. This is also considering the consecutive direct and indirect costs for additional necessary cancer treatments due to radiation exposures (in case of computed tomography). This cost difference results primarily from the enormous difference in acquisition and maintenance costs and extremely reduced radiation exposure with modern CT equipment. The dilemma for physicians and patients will continue to be that there is nonetheless a low cancer induction from CT-guided pain therapies. Whether MRI-guided pain therapies can economically qualify for young adults or younger patients and in serial therapy regimens using nonionizing radiation requires further detailed studies with meaningful statistical data.

However, our cost study showed that the analogous CT-guided treatments were only somewhat less expensive than the MR-guided procedures (290.29 CHF vs. 175.46, roughly 1.65-fold). The main reason for the roughly 2.5-fold increase in overall expenditures was the much higher equipment usage cost in MR-guided interventions (CHF72 vs. 29), since it is evident that the purchase costs of open high-field MR systems operating at 1.0 or 1.5 T are substantially higher. Despite the fact that our clinic's MR system is shared by several departments and that technological advancements in recent years have enhanced hardware and software, these expenses resulted in comparatively higher equipment expenditures. As a result, carrying out more treatments could result in cheaper equipment costs per intervention. The cost of MR equipment increased just 1.82 times when using an open lowfield MR system at 0.23 T for bone biopsies (Alanen et al., 2004, p. 9). This was in comparison to CT-guided biopsies. An alternative sensitivity analysis (Table 22) shows that, assuming the use of a low-field scanner in our setting, this could significantly reduce equipment costs to €37 per MR-guided intervention, resulting in an overall cost that is 1.30 times higher (€121 vs. 88, Tables 22 and 23) and only 1.29 times higher equipment costs (€37 vs. 29) when compared to CT guidance. However, CT expenses might also be decreased. For CT-guided procedures, the most recent 64-slice multidetector CT scan is not required. Theoretically, each intervention's equipment costs for a standard 16-slice multidetector CT scan may be as low as €15 (Table 22). utilizing low-field MR technology for an MRguided intervention results in total expenditures that are 1.63 times higher (€121 vs. 75, Tables 22 and 23) than when utilizing a 16-slice multidetector CT scan. The somewhat longer operation time (MR 70.8 vs. CT 60.4 min) resulted in slightly higher human expenditures for MR guidance, which was one reason driving up the costs. Compared to Ojala et al.'s trial, our study's MR-guided therapies lasted noticeably longer. Since the time we calculate covers the entire procedure from patient preparation to creating a digital report by interventionalis, in 2000 (mean 32 min; range, 12–62 min), Ojala noted.

Table 5.22
*equipment use costs for each intervention, based on a seven-year depreciation period. utilized by several departments; the radiological department's utilization makes up just roughly one-third of all uses. The times provided are for procedure rooms (rounded to the nearest 16-row CT scanner *) and an open low-field magnetic resonance scanner (b).*

Types of costs for equipment (in €)	**CT Siemens Definition 64**	**Open MRI System (1,0 T, Panorama HFO)**	**CT Siemens Sensation 16“**	**Open MRI System (Outlook Proview, Picker (0,23T)b**
Purchase Costs	670,000	1,250.000	350,000	450,000
Annual Maintenance Costs	4,500	6,000	3,500	5,000
Annual Use in Minutes	90,000	24,000	90,000	24,000
Costs per Minute	1.11	2.73	0.59	1.10
Duration of Use (min) per Intervention	26	34	26	34
Costs of Equipment per Intervention (in Types of costs for equipment (in €)	28.86	92.83	15.34	37,40

Table 5.23
Total costs (in €) per intervention including costs of staff, equipment use, disposables and hospitalization for CT- and MR-guided nerve root infiltration. Alternative mean total costs per patient: €74 (Standard 16-row CT scanner) and €121.21 (open low-field MR scanner)

Types of Costs (in €)	**CT-Guided Intervention**	**MR-Guided Intervention**
Staff Costs	35.43	43.07
Use of Equipment	28.86	92.83
Disposables	23.81	40.74
Total Costs per Patient (in €)	**88.10**	**176.64**

only the scan tim. Sequeiros et al. reported a mean overall intervention time of 33 min (range, 9–84 min) and a mean puncture time of 12 min, whereas Fritz et al. stated an overall mean table time of 42 min (range, 23–75 min) and Streitparth et al. 27 min (range, 19–67 min) for selective nerve root injections. These differences in procedure times may be attributable to a learning curve of the interventionalist and differences in calculation process as mentioned before. Ojala et al. found the interventions to become shorter as the interventionalist's experience increased from a mean intervention time of 34 min for the first five and of 23 min for the last five interventions. MR-guided treatment in our study was performed by two interventionalists who were already very experienced in the technique, and this is reflected in similar mean intervention times for the first ten patients (21.1 min. pure intervention time) and the last ten treatments (22.4 min.). The absence of a learning curve may possibly explain the shorter MR invention times in our department. As the CT procedures were performed by two experienced interventionalists, there was also no significant learning curve for CT-guided treatments (mean overall scan time of 11.5 min for the first 10 and 12.4 min for the last 10 treatments). By comparison, the mean intervention time for CT guidance in our patient group was markedly longer than in a study by Wagner et al. (mean 7 min; range, 5–16 min). Compared with the literature, these longer mean intervention times may be due to time expenses for a pre-interventional CT acquisition for localisation the patients with severe spinal degeneration.

In our study, material costs were 1.9-fold higher for MRI guidance than for CT guidance (CHF 118.55 vs. 61.95). MRcompatible disposables are still more expensive, which is another factor contributing to the higher costs of MR-guided nerve root infiltration. However, prices have already markedly decreased in recent years and we expect a further decrease within the next years. This price difference for disposables is already much smaller than that reported in 2004 by Alanen et al., who analysed MR- and CT-guided biopsies and found the costs of MR-compatible disposables to be 5.57 times higher than those of CT-guided biopsies. Another important issue besides costs is radiation exposure, which may have a hazardous effect on both patients and medical staff. Radiation exposure is of particular concern in this field because many patients require repeated interventions to achieve an optimal outcome. The low-dose CT protocol used in our study resulted in a mean doselength product of 38.2 mGy*cm. Hoang et al. and Schmid et al. used a phantom model to investigate exact effective doses of CT fluoroscopy-guided lumbar nerve root infiltrations and found a mean effective dose of 0.45 mSV and between 0.22 and 0.43 mSv, respectively. Although it was not the aim of our study to investigate exact values for effective doses and we did not use a phantom, we were at least able to calculate an approximate mean effective dose of 0.73 mSv in the group with CT-guided interventions. A low-dose CT protocol alone, however, is not sufficient to reduce radiation exposure.

The pre-interventional acquisition required in some patients significantly contributes to the overall exposure. Hoang et al. reported an average increase in the effective dose of 2.90 mSv when pre-imaging was necessary. In our study, the patients who required a pre-interventional short-spiral CT scan to improve orientation in the presence of severe degenerative changes had a significant increase in mean dose-length product of 125.7 mGy*cm (approximate increase of 2.36 mSV; t test, $P < 0.001$).

MRI guidance interventional pain therapy involves no radiation exposure of patients or medical staff. Therefore, when choosing the method of treatment those patients with a high probability of severe degenerative changes should get a treatment with MR guidance to avoid the additional radiation of the scan needed for planning. When performing the procedure in an open MRI system, the interventionalist has good access to the patient and the option of interactive control of the procedure. Owing to multiplanar navigation capabilities, needle positioning is facilitated, improving the workflow, accuracy and speed of the intervention. A further technical advantage of MR guidance is the high soft tissue contrast, allowing injection control to be performed without contrast medium, which is used by some proceduralists for CT guidance. Hence, MRI guidance completely avoids the risk of a reaction to contrast agents.

5.2 Discussion of research question

Our study has limitations: The cost analysis for both CT and MR guidance was performed in Switzerlsnd. Costs of materials, personnel and equipment may differ widely among European countries. Although there may be differences in absolute costs, we nevertheless expect that relative cost differences are much smaller. As we pointed before, even for countries with the same levels of national income, health expenditure on cancer varied widely—eg, the gross domestic product per head of Germany and the UK were similar in 2009, but Germany's expenditure on cancer-specific health care was twice that for the UK on a per-person basis. Although this study represents a small population of the world and a single country's experience, it can probably be extrapolated to other parts of the world too. Administrators in the healthcare sector are looking for newer tools to control costs without affecting the quality of patient care. The knowledge of unit cost is required to assist planning for recurrent budget as an indicator of efficiency and to enforce pricing of services. With advancing technology, the imaging equipment is very complex now thaever and the available choices is extensive. The modern imaging technology CT scan and MRI scan are costly investigations and an important component of patient care, hence attention should be focused on cost control and quality of these investigations.

As the reimbursement policy is already complex in a single European country such as Switzerland and depends on the patient's health insurance, we did not take reimbursement into account in our study. We are aware that many institutions still perform fluoroscopy-guided interventions. We did not take the costs of fluoroscopic guidance into account as these procedures are performed in the orthopaedic department of our hospital and data on process time were not available.

Despite these acknowledged and important data limitations, this study is the first to quantify the economic burden of CT produced cancer in Switzerland. We believe that this study will be of particular interest to European policy makers. In addition to providing adequate evidence about new technologies, there are other aspects of value demonstration in diagnostic and interventional imaging that are germane to the future of neuroradiology. Although it is not possible to address them in detail in this study, briefly discuss several of these important considerations because they are complementary to clinical decision making. First, it is critical to ensure the appropriate use of imaging studies. The American College of Radiology's Appropriateness Criteria can serve as a starting point for interventional neuroradiologists and clinicians and can be adapted to fit institutional, local, or regional needs and consensus. In addition, the use of clinical decision support to provide appropriate feedback to physicians ordering imaging studies has been shown to yield significant gains in efforts to reduce the overuse of outpatient imaging modalities (CT or MRI) and has been shown to impact which studies are ordered in the emergency department.

The limited availability of open MRI devices is still an obstacle to the wider use of MR-guided interventions. However, as open high-field systems such as Siemens' 1.5-T Magnetom Espree (Siemens Medical Solutions, Erlangen, Germany) and the 1.0-T Philips Panorama show promising results with an improved workflow [Fritz et al, 2009) and a high level of patient acceptance (Bangard et al, 2007, p. 491), we expect interventional MRI to become more widely available in the future. In conclusion, lumbosacral nerve root infiltration under MRI guidance involves no radiation exposure for patients and personnel but is at this stage not a cost-effective alternative. It is still about twice as expensive per procedure as CT guidance, which is mainly attributable to higher costs of equipment and materials. Only with further decreases in prices for MRI devices and for MRcompatible disposables will MR-guided therapeutic nerve root infiltration perhaps become a promising alternative to the CT-guided procedure. Imaging choices for clinicians are largely based upon the imaging techniques they have at their reach. The evaluation of the appropriateness of imaging referrals is not always straightforward. The recommendations do not cover all potential diseases or situations, which means that physicians can make different decisions in such cases. Because financial considerations are key drivers of health care decisions, physicians must understand and participate to assure that they are robust.

CHAPTER VI:
SUMMARY, IMPLICATIONS, AND RECOMMENDATIONS

6.1 Summary and implications

Back pain is cost-intensive, as it is often the reason for sick leave and causes high direct and indirect costs. Direct costs refer to outpatient or inpatient medical care, which are charged to health insurance companies. Indirect costs are costs incurred due to absences from work because of pain, e.g. in the form of sick pay or continued payment of wages. There are no comprehensive and meaningful studies that perform a cost-benefit analysis between MRI-guided and CT-guided O3 Nucleolysis from both a medical and economic perspective. Accurate statistics on the number of invasive pain therapies in Europe do not exist.

The study used a qualitative case method to provide insights into a problem and help develop hypotheses by calculation the real costs of MR-guided and CT-guided ozone Nucleolysis. This module must take into account all variable and constant variants (acquisition costs, personnel costs, maintenance costs, etc.).

As an example, we take the walk-in medical practice Limmatfeld, a branch of the Cantonal Hospital Baden in the Canton of Zurich (Switzerland), which opened in 2015. The walk-in practice of the Limmatfeld Medical Center offers a wide range of general medical services. Also integrated are a radiology institute, physiotherapy, nutritional counseling, and surgical, rheumatological, and angiological specialty consultations. The Institute of Radiology at the Walk-in Practice Limmatfeld in Dietikon is equipped with a modern multi-slice spiral CT scanner (Siemens Somatom Definition 64 Slice Dual-Source), which is used for interventional pain therapy, and an MRI scanner (Siemens Magnetom Aera 1.5 Tesla).

In health care organizations, effective investment of precious resources is critical to assure that the organization delivers high-quality and sustainable patient care within a supportive environment for patients and health care providers. The average intervention time for MRI guided interventions was 24.9 ± 6.3 minutes (range: 17 – 36 minutes). Preinterventional patient preparation took an average of 22 minutes, while postinterventional activities took an average of 9 minutes. A CT guided intervention took an average of 19.7 ± 7.9 minutes (range: 5 – 54 minutes) with an average of 20 minutes of preinterventional preparation and 9 minutes of postinterventional activities. The approximated average effective dose for CT-guided interventions was 0.48 ± 0.51 mSv (range: 0.07 – 1.92 mSv).

Mean intervention time was 70.8 min (48–90 min) for MR-guided and 60.4 min (52–75 min) for CT-guided treatment. The average total costs per patient were CHF 290.29 for MR-guided and CHF 175.46 for CT-guided interventions. These consisted of (MR/CT guidance) CHF 72/29 for equipment use, CHF 99.47/84.84 for staff and CHF 118.55/61.95 for disposables. However, our cost analysis found that the MR-guided interventions were still almost twice as expensive as the same interventions performed with CT guidance (290.29 CHF vs. 175.46, almost 1.65- fold). The main source of the higher total costs was the markedly higher cost of equipment use in MR-guided interventions (CHF72 vs. 29, almost 2.5-fold) as open high-field MR systems operating at 1.0 or 1.5 T obviously have much higher purchase costs. With respect to possible long term costs because of radiation induced malignancies, the use of CT has been controversial even though there is apparently no major difference in medical effectiveness. It was assumed the use of CT leads to a huge number of radiation induced malignancies with higher sercondary cost of cancer therapy. However, in this study with the determined collective patients even with statistical risc calculation of secondary malignancy, showed no significant increase in general health costs. Interventional Spinal nucleolysis under CT fluoroscopy is still profitable comparing MRI guided intervention.

6.2 Recommendation for future research

Comparative effectiveness is likely to require a paradigm shift in thinking within the discipline. For new pain therapeutic applications to be accepted, we will need to show at least a significant change in treatment planning and at best meaningful change in patient outcomes. This shift will require a forward-thinking approach to robust evidence generation for new imaging modalities or indications and the inclusion of other modes of value demonstration such as clinical decision support and intelligent data mining.

The cost analysis for both CT and MRI was performed in Switzerland. Costs of materials, personnel and equipment may differ widely among European countries. Although there may be differences in absolute costs, we nevertheless expect that relative cost differences are much smaller. As we pointed before, even for countries with the same levels of national income, health expenditure on cancer varied widely—eg, the gross domestic product per head of Germany and the UK were similar in 2009, but Germany's expenditure on cancer-specific health care was twice that for the UK on a per-person basis. Although this study represents a small population of the world and a single country's experience, it can probably be extrapolated to other parts of the world too. The findings and issues raised by the current study indicate several possible avenues for future research. The first and most important priority is to develop and test a series of indicators for appropriate statistical registration for CT and MRI guided spine interventions. The current study used a combination of methods to extract the relevant demographic and technical data from patients and convert them into meaningful information, requiring considerable time, effort and skill. If an automated system could be integrated within clinical IT systems capable of summarisingspine intervention activity, this would facilitate regular self-monitoring, review and benchmarking of a crucial area of practice. It could also allow commissioners and health-care providers to access (and act upon) data in 'real time' without the need for separate research. Harnessed correctly, data held in clinical IT systems in hospital could also be used, either alone or in combination with other data sets, in epidemiological studies.

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