

ERAS and length of stay

*An analysis of the effects of ERAS implementation
in liver resection*

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Abstract

Background: Enhanced Recovery after Surgery (ERAS) programs have been implemented for different types of gastrointestinal surgery and can be regarded as a safe and effective method to decrease length of stay (1). Studies show no effect or a positive effect on clinical outcomes (1). The gastro surgical ward at Rikshospitalet implemented an enhanced recovery after surgery program in March 2013 for open and laparoscopic liver resection.

Objective: To examine the effect of ERAS on hospital length of stay (LOS) and readmissions rate (RR), two years before and two years after the implementation.

Method: Electronic patient journal data using the procedure code JJB (liver surgery procedure code) was retrieved for this study to calculate average length of stay and rate of readmission. Patients were divided into two groups regarding type of surgery: open and laparoscopic surgery. I will test for significant differences in LOS and RR between the two groups before (2011-2012) and after (2014-2015) using propensity score matching for LOS and logistic regression for RR.

Results: For open liver resection group, the average LOS before ERAS (2011-2012) was 10.1 days and the average after ERAS (2014-2015) was 7.3 days. There was a statistically significant difference in length of stay with a reduction of 3.35 days (p -value=0.004). For the laparoscopic liver resection group, the average LOS before ERAS (2011-2012) was 4.3 days and the average LOS after ERAS (2014-2015) was 3.5 days. I found a non-significant reduction of 0.314 days (p =0.587) after ERAS.

The average readmissions rate before ERAS (2011-2012) was 12.1% and after ERAS (2014-2015) it was 12.9%. The rate of readmissions before ERAS (2011-2012) was 14.6% and after ERAS (2014-2015) was 14.9%. I found that ERAS does not affect the likelihood of a patient being readmitted before and after ERAS in the open liver resection group (p -value=0.988) and in the laparoscopic liver resection group (p -value=0.677)

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Abbreviations

ABF	Activity based funding
DRG	Diagnose related groups
ERAS	Enhanced recovery after surgery
HCC	Hepatocellular carcinoma
IV	Intravenous
LOS	Length of stay
OECD	Organization for Economic Cooperation and Development
OUS	Oslo University Hospital
POD	Postoperative day
PS	Propensity score
RCT	Randomized controlled trials
RR	Rate of readmission

1. Introduction

Healthcare systems around the world, with Norway being no exception, face budget pressures mainly due to two factors: an increase in the ageing population and the availability of new and expensive treatments (2–4). Policy makers and healthcare personnel are looking for ways to use resources more efficiently without risking health quality.

Politicians have implemented several health care policies the last twenty years with the intent to reduce costs and organize the different systems more efficiently (4–8).

On the healthcare delivery plan, clinical pathways have started being implemented on surgical wards around the world to increase efficiency and provide better care. The European Pathway Association defined clinical pathway as “*a methodology for the mutual decision making and organization of care for a well-defined group of patients during a well-defined period*”(9). Clinical pathways were originally developed as an efficiency tool, to reduce hospital length of stay (LOS) and use resources more wisely. Later on, they were also used as a quality tool (1). In 2013, the Gastro surgical ward at Rikshospitalet implemented a clinical pathway, called Enhanced Recovery after Surgery for patients undergoing open and laparoscopic liver resection. This study’s goal is to examine the effect of the enhanced recovery after surgery program for open and laparoscopic liver surgery in hospital length of stay and readmissions. The data is divided into two groups: after (case) and before (control) the implementation. I also separate the patients between those who underwent open liver resection and patients who underwent laparoscopic liver resection. Patients are matched according to age, gender and three diagnose groups (less severe, severe, very severe) and propensity score is used to match patients and test for differences in LOS. I will use logistic regression to calculate the effect of ERAS, age and gender on the rate of readmissions.

In the last twenty years, there has been a decrease in LOS both in Norway and in other Western countries. According to OECD, the average LOS for surgical disciplines in Norway is 6 days(2). There is a combination of factors that explains this decline. Health care reforms have provided financial incentives to promote efficiency, changed specialist care oversight and promoted better coordination between primary and specialist care to reduce costs and increase quality of care (5,10). The improvement and expansion of the primary health care system allows for an earlier transfer from the expensive specialist care to the community care, which potentially leads to shorter hospital stays (5). The improvement in medical

technology the last twenty years introduced new techniques and procedures that require less recovery time as well many types of treatment are offered in outpatient consultation and do not require hospitalization. This affects my calculation and inferences about LOS.

The goal of this case-control study is to answer the following questions:

- Is there a significant difference between 2011-2012 and 2014-2015(two years before and two years after implementation) in hospital length of stay for patients undergoing open and laparoscopic liver resection?
- Is there a significant difference between 2011-2012 and 2014-2015(two years before and two years after implementation) in 30-day hospital readmission (from surgery day) for patients undergoing open and laparoscopic liver resection?

This study's objective is finding whether there are statistically significant differences between the two groups before and after the implementation. Length of stay and rate of readmissions are common outcome measures when implementing a new procedure. I expect to find significant differences between the open liver resection group although it is unclear if I will find differences within the laparoscopic group, as laparoscopic surgery has already a lower length of stay when compared to open surgery(11–16). Regarding the readmissions rate I expect to find no statistical difference. While a literature review on this topic found no significant differences a second literature review did find significant differences. Since the first review included more studies, I expect to find no significant differences(9,11,13,15,16).

1.1. Standardization of care and ERAS

Standardization of care and the consequent creation of clinical pathways goal was to identify sources of variation and introduce measures that minimize the factors that prolong LOS. There is also a higher focus on the patient and what is expected of the individual for a speedy and better recovery (16–18).

As mentioned earlier, clinical pathways were originally developed to increase efficiency. Palmer and Torgersen defined efficiency in health care as the relation between resource inputs (costs, in the form of labor, capital or equipment) and either intermediate outputs (patients treated, waiting time) or final health outcomes (lives saved, life years gained, quality adjusted life years) with an ideal focus on final health outcomes (19). For a pathway

to be deemed efficient, there are several scenarios under this definition. If costs increase so should either health outcomes or number of patients treated also increase.

1.3. Data and methodology

1.3.1 Data

Data for this study was collected from DIPS and Metavision, using the procedure code JJB (liver surgery code). DIPS is an electronic patient journal system used by Oslo University Hospital where all patient contacts with hospital services are registered. Metavision is an electronic medical record system used in the intensive care units, postoperative units and operation rooms. DIPS provided information about age, gender, diagnose, surgical procedure code, different contacts with the three hospitals (Rikshospitalet, Ullevål Hospital and Radiumhospitalet) and several information about discharge. Metavision provided the date of when surgery started.

ERAS was implemented in March 2013 for patients undergoing open and laparoscopic liver resection. To analyze if ERAS as had an impact in LOS and rate of readmission (RR) I grouped patients from 2011-2012 and merged them into one group (the before group) and repeat the process for patients from 2014-2015 in to another group (after group).

1.3.2. Statistical software

I used Excel, MatLab, Stata and SPSS for my statistical analysis. I manually checked parts of the dataset to ensure its plausible accuracy since I have no way of checking on whether the register is correct.

1.3.3. Methods

I will use descriptive methods to characterize my study population, and all my statistics will be divided between open and laparoscopic surgery group from 2008 to 2015. For each surgical method, I will describe the most common diagnoses, LOS by age, gender and year and an overview of where patients were discharged and mortality. I will present readmissions information by gender and year.

To test my hypotheses, I will use different statistical tests for LOS and RR. I use propensity score matching to estimate the average effect of ERAS in LOS and logistic regression to ascertain the effects of ERAS on the likelihood of patients being readmitted. I chose propensity score matching as it is a method that mimics the characteristics of randomized

controlled trials (RTC) and can be applied in observational studies. I choose logistic regression because my dependent variable is categorical and my dataset does not follow the strict assumptions required to perform linear regression.

1.3. Thesis structure

In chapter two, I discuss standardization and ERAS. In chapter 3, I present the most important health policies implemented in the last twenty years that can have an impact of LOS. In chapter four I present my data and the methodology. Chapter five, I present the study's descriptive analysis followed by the results. The last two chapters include my discussion and conclusion.

2. Background

Enhanced recovery after surgery is a clinical pathway implemented in different wards around the world and to different abdominal surgeries offering a standard care to a group of patients. In this section, I will discuss how the process of standardization developed, the definition of a clinical pathway, the creation and spread of ERAS as well as present some of the research on this area. I will also examine the quality indicators used by several researchers to evaluate ERAS and lastly, I will present Rikshospitalet ERAS protocol.

The manufacturing industry has developed processes to minimize or even eliminate errors. One of the most famous processes is the lean methodology developed by Toyota. Their goal was to reduce waste, increase efficiency and to deliver the services the customer wants and not more. This methodology was very successful for Toyota and was copied by competitors and other industries that longed for similar results (20). The healthcare industry has also looked for this model for inspiration, as this is an area that can gain from error and variability reduction. While many non-clinical processes can be standardized in health care, the application to clinical setting has posed more challenges. Clinical care delivery has a tradition of being highly personalized and individually tailored for each patient. Although patient care cannot be compared to an industry's manufacturing line, there are clinical situations where variation can be reduced, which lead to the development and implementation of clinical pathways (13).

Several different terms have been used to describe clinical pathways. A literature review found 84 different terms that have been used synonymously to describe clinical pathways, such as, clinical guidelines, protocols, care pathways, care maps and critical pathways. A Cochrane review on the definition of clinical pathways found quite a variability in its definition, although it found some common traits among all definitions. There is a consensus that a clinical pathway is an intervention with five distinct characteristics. First, it is a structured multidisciplinary plan of care. Second, it is a tool that makes it easier to implement evidence-based practice into actual care. Thirdly, the intervention describes in detail the steps within the pathway and how the progression between occurs. Finally, its goal is to standardize care for a specific disease or population. (14).

Clinical pathways can be used to improve quality of health care. The primary goal in healthcare is to deliver care quality care, which can be described as providing care at the right time, which is safe, efficient and effective. So how do clinical pathways improve care? New

knowledge and research can take up to 17 years to be applied for general practice, pathways allow knowledge to be implemented to patients earlier since it is easier to incorporate new knowledge into a functioning protocol. Secondly, pathways improve in-hospital cooperation. Different professional groups are involved on a patient hospital stay. The pathway identifies not only the individual professional responsibility and area of expertise but also the expectations to each professional group. Issues of coordination and communication are more easily addressed. All these measures reduce variation, which in turn and can lead to efficiency(18).

Rotter et al. (16) published a systematic review, using Cochrane methodology about clinical pathways implemented from 1966 to 2006. The studies included addressed a variety of conditions and more than 4000 patients, with 13 randomized controlled trials (RCT) and four controlled clinical trials. The authors found that most clinical pathways showed a lower LOS with a stronger effect on invasive procedures. Four out of six trials also demonstrated cost reduction. There was no reported difference in readmissions and in-hospital complications rates between clinical pathways and standard care(16). The same group also published an update review in 2010, which included 27 studies and found a reduction in hospitals costs, length of stay, and in in-hospital complications(9). They also found an improvement in documentation and no differences in readmissions and mortality (16). Even though there are limited studies on the impact of clinical pathways on patients' experience, pain and functional status, it is considered not only to be a safe protocol but also as a quality-improvement tool (16).

Within the last years, standardization of care has been more frequent in hospitals around the world. For this analysis, I will present and discuss the enhanced recovery programs after surgery for liver resection.

2.1. ERAS creation

The last fifty years the world has seen enormous advances in medical knowledge and technology, despite that the average hospital stay in the 90s had stagnated between 10-15 days. A Danish surgeon named Kehlet started researching what were the factors that could explain the stagnation. In his research, he identified three major areas that prolonged hospital stay, the need for intravenous (IV) analgesia due to persistent pain, the need for IV fluid therapy and the lack of mobility caused by bed rest. To quicken recovery and reduce hospital

stay, Kehlet developed a clinical pathway to reduce loss of function and improve patient recovery after surgery. Kehlet's clinical pathway was further developed by the ERAS group, which published consensus guidelines for patients undergoing colorectal resection in 2005 (17). These guidelines were first introduced in colorectal surgery and later developed and adapted to several other abdominal and thoracic surgeries.

The introduction of clinical pathways led to a paradigm shift from a clinician-focused system to a patient-centered system. It provides a homogenous approach to perioperative and postoperative care for all patients submitted to an identical surgery, independent of the patient's care team. The goal of ERAS is adopting measures that are proven to be efficient in reducing the patient's stress response to the surgical procedure. The ERAS protocol defines what to expect from each member of the health care team as well as from the individual patient. (18). A meta-analysis, conducted by Cochrane, into randomized control trials of ERAS program has demonstrated a reduction in overall complications rates and length of hospital stay in patients undergoing colorectal surgery (18).

Due to its success for patients undergoing colorectal surgery, clinical pathways started to be developed for liver resection.

Liver cancer

The most common form of liver cancer in Norway is a result of metastases from colon cancer. Primary liver cancer is rare in Norway, in 2015 there were 175 men and 93 women who developed liver cancer (21). Five years after having been diagnosed, 16.7% of men and 19.6% of women are still alive (19). There were 2935 new colon cancer cases and 1300 rectum cancer cases registered in 2015 (20,22). Colorectal liver metastasis develops in more than one-third of patients with colorectal cancer. At the time of the diagnoses, around 15-25% of these patients have liver metastases but only one-third of the patients are suitable for curative resection. The prognosis in patients diagnosed with liver cancer and liver metastases varies according to the tumor stages. Patients with early stage tumor can be offered curative treatments such as surgery (liver resection or liver transplantation) and locoregional procedures.

Studies suggest that liver resection can be safely performed laparoscopically, with reduced blood loss, earlier recovery and similar oncological outcomes in comparison to laparotomy (21).

2.2. Quality indicators

In clinical research, when new procedures are implemented, there are two measures widely used to evaluate the quality and efficiency of a new procedure: LOS and RR (23–28). The research about ERAS is no exception, where most studies have used these measures to evaluate it(1,12–14,16,29–31). The first measure serves as proxy to measure efficiency while the second measures quality. In my study, I will also use this two measures and I will review the literature about the strengths and weakness of these measures. I will first review LOS and then RR.

2.2.1. Length-of-stay

LOS is an important metric used by several governmental and non-governmental actors. The Department of Health in England uses it a key performance indicator to monitor hospital quality and manage patient expectation (25). The OECD uses an indicator called average LOS to report on countries status and allow comparisons between countries. The average LOS for all hospital stays in Norway was 4.3 days, which one of the shortest and below OECD average (2). Many countries, including Norway, have seen a decrease in LOS for both medical and surgical specialists, as a result of new technology and pressures for cost containment (2,26).

In the USA and Europe LOS is used as a proxy for measuring efficiency and quality (27). The rationale behind it is, all other things equal, a shorter stay will reduce the cost per discharge (2). Although this might be true, there is the possibility that a shorter LOS can be more expensive as it can be more service intensive. Shorter LOS are not efficient if they have a negative impact on health outcomes or if this leads to a reduction in patient comfort and recovery and/or leads to a readmission. The good news is that this does not seem to be the case. A Dutch study published in 2012 investigating the correlation between hospital stay and patient satisfaction found no evidence that shorter stays had an impact on patient satisfaction in a positive or a negative way, except for one specialty, pulmonology (26). Research has also shown that reductions of LOS have no negative impact on health outcomes (27). From a health system perspective, shorter LOS might not be more efficient for the system. When shorter LOS are a result of rapider discharges to a patient's local hospital, it can be argued that the efficiency of the system is not improved as cost are shifted from one provider to the other. On the other hand, it may free resources at specialist hospitals to treat more patients.

The argument for using LOS as quality care measure is that fewer hospital days reduces the chance for complications such as nosocomial infections (28). This relationship between LOS and quality is multidimensional as LOS is determined by a complex interweaving network of multiple supply and demand elements. These elements range from organizational culture and hospital bed availability, to types of in-hospital services (such as availability of intermediary units) (27).

There is an agreement that LOS can be used as efficiency metric and a hospital planning tool, as the length of time patients spend in hospital beds is known to be a good representation of resource use. The Department of Health's NHS Choice publish these data on its website to help patients with hospital choice (25). There are more disagreements for LOS being used a proxy to evaluate quality of care. Clarke argues that the focus should be on delivering quality care through pathways and not reducing LOS (27). LOS can and is used as an efficiency tool although its use as quality tool should be used with more caution. In my analysis, I will not make any inferences about quality based on LOS.

2.2.2. Rate of Readmission

Rate of readmission is used not only as a common outcome in medical clinical trials but also as quality of care measure. Its use stems from the 1970's in the USA, where there was an interest in researching quality of care. In many health care systems, RR has been used as an indicator to monitor care as well as a financial tool to impose sanctions on hospitals with elevated rate of readmissions. The assumption behind its use is that it can be a result of substandard care delivery. (22) It is used as a quality indicator in various psychiatric, surgical and medical clinical specialists. There are several reasons why this is a popular and widespread indicator for both managers and researchers (23). Studies have found that about 25% of all readmissions are avoidable and/or preventable (24), which means there is potential for cost saving and improved patient outcomes. Data on readmissions tends to be easily available and allows researchers to investigate readmissions predictors which provide useful information for preventing these events. It can also provide information about outpatient and community care as some readmissions might occur due to a lack of appropriate care outside of a hospital setting (23).

On the negative side, despite being a common outcome measure in studies there is neither an agreed definition of what it means nor how it is calculated. A literature review found that 465 articles used it as an outcome measure although only 288 define what they meant by rate

of readmission (28). Another review found several problematic issues with the use of RR. First, as an indicator there is a lack of distinction between readmissions that are planned and unplanned. There is also a lack of distinction on whether the readmission is related to the last hospital discharge or not, which can lead to the inclusion of cases that are not directly related to quality of care and can result in an overestimation of the rate. There is also not a general accepted time frame to calculate readmissions. It is commonly used a 28-31-day time frame regardless of the research question (25). Some researchers argue that this approach does not make any distinction between diseases and conditions. While for some conditions 30 days might be sufficient and appropriate time frame, for others there is a risk of including a large percentage of unrelated readmissions (24).

There is also a discussion about the RR and confounding factors. Literature shows that disease progression, post-discharge care, readmission that happen at other facilities, demographic variables and clinical variables can distort the relationship between quality of care and RR. A patient's readmission can be explained by one or more of the previous elements and not be a result of poor care upon discharge (23). To avoid a third variable distorting the relationship, methodological and statistical techniques should be applied to minimize this risk.

Another issue with RR is its external validity and generalizability as different authors use different methods to calculate it which makes comparison and generalization challenging. Rumball-Smith & Hider suggest the following definition “*number of patients who experience unintended, acute readmission or death within 30-days of discharge from the index admission, divided by the total number of patients discharged alive within the reference period*” (23).

Due to the previous limitations of RR as a quality indicator, it should be used with caution to measure quality of care and as a tool for a pay for performance scheme (24). If the RR is used as a quality indicator, it should specify whether the readmission was avoidable. Secondly, the time frame for its calculation should fit the type of care being examined and the data used for calculating it should have undergone reliability analysis. Other cofounder's variables need also to be present, in order to adjust the RR for these variables (14).

Fischer et al., argues that at its current state it does not fulfill the methodological requirements of a reliable and valid indicator and should therefore not be used for external purposes (25).

Despite being a useful and easily available indicator, there should be exercised caution in extrapolating conclusions from this indicator.

2.2.3. Outcome indicators in ERAS

ERAS protocols have been implemented in abdominal surgery for more than a decade. Research shows they are safe, cost effective and minimize LOS without reducing quality of care (29). Many studies in clinical pathways use LOS as an efficiency indicator and RR as a quality indicator to evaluate the new procedure, despite the issues with these indicators discussed earlier. I calculate both indicators on my study, although I will refrain from making conclusions about quality of care based on them.

2.3. ERAS protocols at Rikshospitalet

There are two different protocols, one for open liver resection and another for laparoscopic liver resection. There will both be presented here.

2.3.1. ERAS protocol for open liver surgery

Perioperative care plan

Patients are admitted on the surgery day or the day before.

Anaesthetic management

On surgery day, patients can eat and drink until 2 am and at 6am they have had to drink a liquid protein drink, from 6 am they can only drink clear fluids.

For open liver resection, dexametason 8mg iv right before surgery start and Ondansetron 4mg iv right after surgery ends. The anaesthesia protocol consists of propofol and remifentanil and fentanyl 100-200 ug is given in the end of surgery before stopping remifentanil. By the end of surgery patients are given paracetamol 1g iv, Nexium 40 mg iv, ketorolac 30 mg iv and bupivacain is given along the surgical wounds edges, subcutaneous and in the retroperitoneal muscles. An epidural catheter is inserted in the level thoracic level 8-9 and the epidural infusion starts after the anaesthesia induction.

The goal during anaesthesia is to have a low central venous pressure, so there is fluid restriction. To reduce the risk of venous thrombose, patients are given blood thinners the day before surgery and compressions stockings on the surgery day

Surgical procedure

The surgeon registers in the operation journal the estimated blood loss, the amount of blood products transfused, the length and type of the incision.

Postoperative analgesia

Oksykodon 10mg is given when the patient awakes up in the recovery ward. On POD 1 (postoperative day) Oksykodon 10-20mg oral, twice a day and a reduction of the epidural infusion. POD 2, the epidural infusion is further reduced and can be removed. POD 3, if not done on the previous day, the epidural catheter is removed.

Accomplishment and adherence of ERAS protocol

The ERAS pathway aims for different goals in different POD. In POD0, patients should eat and drink and have a chewing gum 30 minutes after a meal. Urinary catheter can be removed and the activity goal for the patient is to be two hours out of the bed. POD 1: oral diet and chewing gum, removal of urinary catheter (if not previously removed) and all intravenous catheters. Patient activity goal is to be out of bed for at least 8 hours. The discharge starts being planned with the nurse and the doctor. POD 2 laxative medication if necessary and the same activity and dietary goals as POD 1. POD 3, same goals as POD 2.

After discharge patients are contacted the next working day, after one week and 4-8 weeks. They are also given a contact number they can use if they have questions.

The full protocol can be found in Appendix 1.

2.3.2. ERAS protocol for laparoscopic surgery

Perioperative care plan

Patients are admitted on the surgery day or the day before.

Anaesthetic management

On surgery day, patients can eat and drink until 2 am and at 6am they must drink a liquid protein drink. From 6 am they can only drink clear fluids.

For laparoscopic liver resection, dexametason 8mg iv is given right before surgery start and Ondansetron 4mg iv right after surgery ends. The anaesthesia protocol consists of propofol and remifentanil and fentanyl 100-200 ug is given in the end of surgery before stopping remifentanil. When surgery ends, patients are given paracetamol 1g iv, Nexium 40 mg iv,

ketorolac 30 mg iv and bupivacain is given along the surgical wounds edges, subcutaneous and in the retroperitoneal muscles.

The goal during anaesthesia is to have a low central venous pressure, so there is fluid restriction. To reduce the risk of venous thrombose, patients are given a blood thinners the day before surgery and compressions stockings on surgery day.

Surgical procedure

The surgeon registers in the operation journal the estimated blood loss, the amount of blood products transfused, the length and type of the incision.

Postoperative analgesia

Oksykodon 10mg is given when the patient awakes up in the recovery ward. Mandatory medication includes paracetamol, esomeprazole, ketorolac and oksykodon can be given if patients require extra analgesia.

Accomplishment and adherence of ERAS protocol

The dietary and activity goals are like open protocol.

The full protocol can be found in Appendix 1.

Discharge criteria

The discharge criteria for patients are independent of the type of surgery. For a patient to be discharged, there are activity, hygiene and pain management requirements. The patient needs to be able to use the bathroom and maintain personal hygiene without assistance, and should be able to walk at least from and to the bathroom. Pain is managed with oral painkillers or with no medication and the patient needs to accept that he/she is fit for discharge.

3. Norwegian Health Care System

Norway has a semi-decentralized, tax-financed universal health care system which is one of the key pillars of the Norwegian welfare system. The State provides an universal health care system which is based on the principles of universal access, decentralization and free choice of provider (7).

The overall responsibility for the provision of health care is the Ministry of Health and Care Services. Parliament and government are responsible for approval and/or repealing of laws, approving the yearly state budget and implementing reforms. The health services provision is organized on three levels: national, regional and local. Each level has different areas of supervision (32). The municipalities are responsible for the primary health care sector, which is funded by the state, municipalities and patients, while the central government through the regional health authorities is responsible for the specialized health care sector. (4).

According to Statistics Norway, the health expenditures as a percentage of GDP for mainland Norway in 2005 was 9%, while in 2015 it increased to 11.9%. (33). There are two trends that affect the Western world and Norway, the aging of the population and the increase of the number of people with chronic diseases(4,34). Many are concern that the combination of these trends can lead to an increase in the health care budget. To avoid this scenario, politicians have implemented different reforms the last twenty years.

The four reforms I will discuss have focused on cost containment and responsibility change for specialist care. The implementation in 1997 of activity based funding in order to control costs, the hospital reform of 2002 which changed the oversight of specialist care, the merger of the Oslo Hospitals and the Coordination reform of 2012.

3.1. Activity based financing

From the 1980 and onwards, hospital financing had two main sources: block grants given by the central government to the county council for the hospital financing and local taxes collected by the local councils (34).

In 1997, Norway implemented the Diagnostic-Related-Groups (DRG). This system was developed in the 60s by Yale University to compare care between hospitals and was later used by Medicare in the USA as reimbursement tool. DRGs classify cases according to the following variables: main and secondary diagnose, patient age and gender, the presence of

co-morbidities and complications, and procedures performed. Patients with the same DRG are seen as being medically and economically similar (35). The goal of this system was to increase transparency of what services the hospital was rendering and provide financial incentives for a more efficient resource use by hospitals (36). A study conducted in Norway to analyze the impact of ABF(activity base funding) in efficiency and patient satisfaction found that there is an increase in technical efficiency as a direct effect of the reform and a higher patient satisfaction as a result of lower waiting times (37).

3.2. Health Care Reforms of 2002

From 1969 to 2002, it was the 19 counties that were responsible for providing hospital services to its populations (32).

In 2002, the government implemented a comprehensive hospital reform to simplify the responsibility chain and allow hospital directors more autonomy in every day operations. The reform contained two major elements. The ownership and responsibility change for specialist care from the 19 counties to the central government. Secondly, the hospitals become organized in regional health authorities, which are independent legal entities with a board and no longer directly under state management(38). The four current regions are: North, Midland, West and South East and they are responsible for organizing hospital care.

3.3. Oslo Hospitals merger

In 2009, Ullevål Hospital, Rikshospitalet, Radiumhospitalet and Aker Hospital were merged into one organization, called the Oslo University Hospital. These four hospitals served as both local hospitals for the population of Oslo and as specialist hospitals for the Southern-Eastern Region and in some cases for the entire country. The reasons given for the merger was the overlapping of specialist care in two or more hospitals in Oslo, the same type of treatment being offered to similar patients and overlapping administrative functions. It was expected to be a cost reduction and a quality increase as a result of the merger since expertise would be gathered at the same place and overlapping administrative function would be reduced.

Before the reform, liver resection was performed both at Ullevål Hospital and Rikshospitalet, with the hospital merger the responsibility moved solely to Rikshospitalet.

3.4. Coordination Reform 2012

The Norwegian coordination reform was implemented in 2012. The main objective was to encourage the municipalities to increase its primary health care offer, and by doing so reducing the need for expensive specialist inpatient admission. The state not only expected the overall cost to shrink but also an increase in the coordination between primary and specialist care(5).

The two main components of this reform were: to have more patients being taken care of by the primary health care services and long-term care instead of being referred for hospital treatment. Secondly, to allow hospital discharge to happen sooner as the primary health care would provide appropriate out of hospital care. For this to happen, financial incentives were put into place. First, the municipalities would receive funds that previously were given to the hospital, to finance 20% of all hospital costs for their inhabitants. Secondly, municipalities would pay a fine per day when a patient who was ready for hospital discharge but was not discharged due to lack of appropriate care offer in the municipality. The municipalities would also need to create acute bed units to reduce the number of acute admissions to hospitals. The municipalities creation of all these out-of-hospital services would be financed by the cost saving of having patients treated in the communities instead of hospital (5).

A common trait in all these four reforms is cost containment and providing financial incentives for efficiency. This might have been achieved to some degree, as there has been a decrease in number of hospitals beds per 1000 inhabitants from 4.3 in 2000 to 3.3 in 2011. This can be due to a combination of several factors. There might have been a more efficient use of resources (11). Another interpretation is that as LOS has been decreasing and in combination with an increase in outpatient services lead to less demand of hospitalization. Another hypothesis can be the reduction in hospital beds is a conscious measure to reduce supply to control demand.

4. Data and Methodology

4.1. Study design

This study is a case control study at the Oslo University Hospital from January 2008 to December 2015. The data was retrieved from the patient journal DIPS using the procedure code JJB, which are the three initials that include liver surgery. I excluded the codes JJB06, JJB06D and JJB06K as they are liver biopsy codes. The data set contained data from January 2008 to March 2016, since there was only three months of data in 2016 I excluded the data from 2016.

For my analyses, I have used only patients that were submitted to liver surgery at Rikshospitalet but included readmissions at Ullevål Hospital and Radiumhospitalet in addition to Rikshospitalet. I compare the LOS and RR before and after the ERAS protocol implementation in March 2013. The before group is patients submitted to liver resection in 2011-2012 and the after group the patients submitted to liver resection in 2014-2015.

4.2. Data and limitations

I will discuss in more detail my dataset as well as its limitations and what measures I adopted to ensure data quality.

The data set contains several variables that I will use for my analyses. It contains when patients are admitted and discharge, all the wards the patients have been in contact with through the years, the type of stay (hospital stay, outpatient clinic, day treatment), the main diagnose for the hospital contact as well as the secondary diagnoses, the surgical codes and the date for start and finish of surgery. Information about where the patient came from (home, another hospital, other) and where the patient was discharged to (home, another hospital, another ward, others). The data set also contains demographic information about the patient: age, gender and place of residence.

4.2.1. Study population

The study population is all patients submitted for liver resection at Rikshospitalet. I only considered patients over 18 that were admitted for inpatients stay (no outpatient contact) for liver resection and where there was a data of resection start time. The patients under 18 in my

dataset where admitted to the children’s ward and were not a part of ERAS. For the open surgery group, I used the codes: JJB10, JJB20, JJB30, JJB40, JJB50, JJB53, JJB60. For the laparoscopic surgery group, I used the codes: JJB01, JJB11, JJB21, JJB31, JJB41, JJB51, JJB54, JJB61 and JJB71.

The figure bellow illustrates my study population.

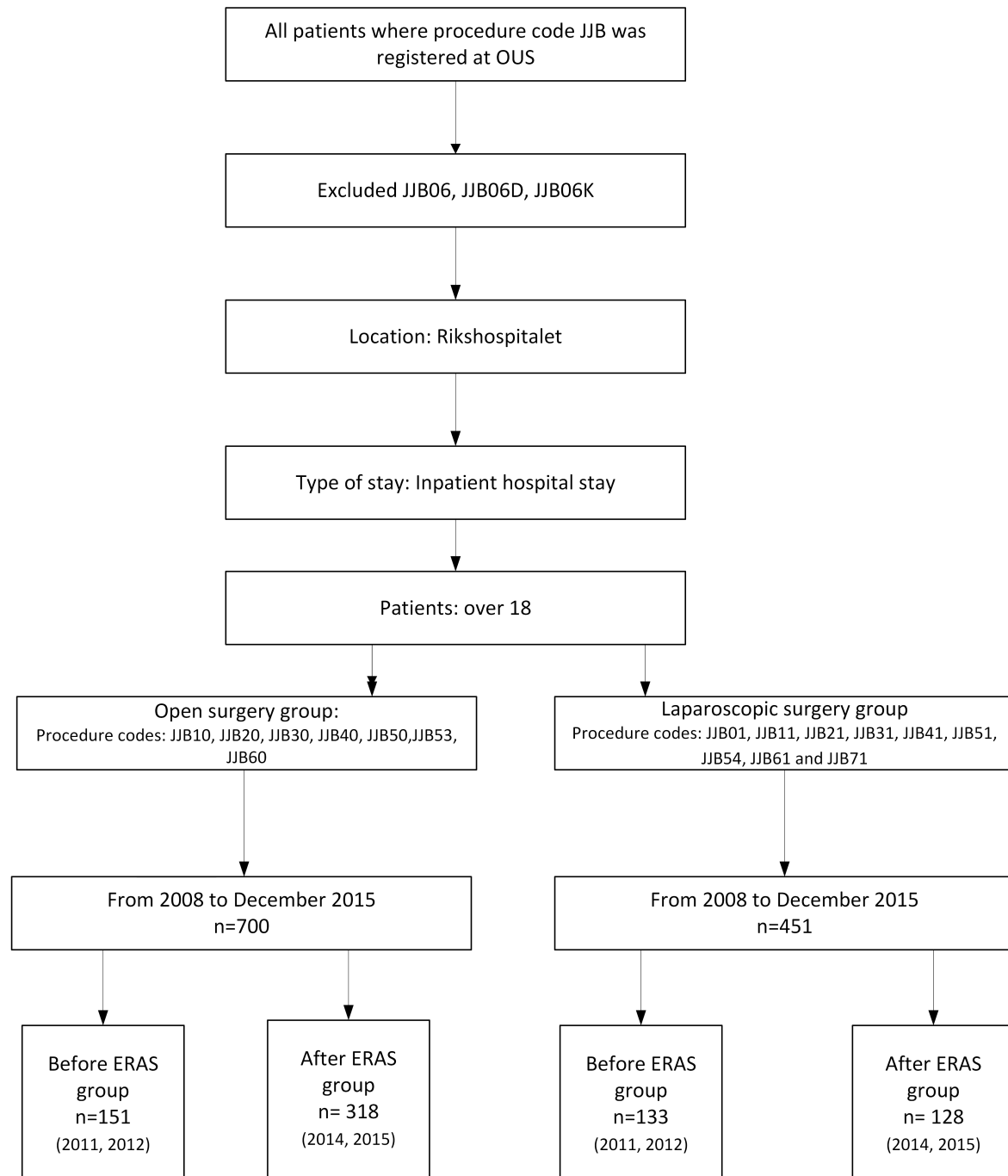


Figure 1 – Study population

4.2.2. Ensuring data quality

I took several measures to ensure data quality. Due to its size, it is likely to be some mistakes in its registry. The original file I received was an Excel file containing all the contacts of patients who underwent liver surgery at OUS. I used MatLab to filter for the patients I was interested in studying, as discussed earlier on the study population. Once I ran the MatLab scrip I visually checked in Excel between 10-20 random patients to make sure the script did what was intended to do. I found that some patients had very low length of stay, and manually checked for its accuracy and found that for some patients it was not correct, and corrected for it. The reason was that when patients are transferred between wards that belong to different departments, the system counts as a new stay and that was not being calculated. I included this calculation in the LOS. An example, a patient has a cancer diagnose that is not liver or colorectal metastases and liver resection is performed and the patient returns to the main diagnose ward, I counted this as one stay. This patient would not have been transferred home, as he/she was still in need of medical supervision. I also manually checked all the patients who had a stay lower two days and the 10% higher LOS for accuracy and found them to be correct. The stays of under 2 days reflect patients that either died or were transferred to other institutions. The higher stays were also manually checked and reflected one single stay.

To allow for consistency and accuracy in LOS calculation I used the start date of surgery.

4.3. Variables

My data set contained some variables but not all were included in the analyses.

Research on factors that prolong LOS found that age over 60, race, functional status, intraoperative blood transfusion, etc. negatively impact LOS. From these factors, the only I have data on is age (39).

4.3.1. Dependent variables

The main dependent variable (LOS) describes the length ofstay at Rikshospitalet from surgery start until the patient is discharged from Rikshospitalet. Some patients have several stays within the same time frame; this means that they have been transferred within different wards but still at Rikshospitalet. For the purposes of my analyses I consider it as one stay, although some patients have been transferred through several wards, most patients have been

admitted to the gastrointestinal surgical ward and were discharge from there either to another institution or home.

To calculate the RR, I use 30-days after surgery start date.

I have discussed earlier RR and researchers' recommendations to calculate it. I will define RR as a readmission within 30-days of surgery start, I will count all readmissions and divided by the number of patients that left the hospital alive after discharge. I do not know on whether a patient discharged has died within 30-days so this cannot be taken into the calculation. I did removed patients who died during their initial hospital stay. I only calculated the first readmission, if a patient has several readmissions within a 30-day time frame from surgery start it is not in my calculation.

$$RR = \frac{\text{Patients readmitted within 30-days from surgery start}}{(\text{All patients operated} - \text{patients that died in the initial hospital stay})}$$

4.3.2. Independent variables

For LOS calculation

I use propensity score matching to compare the most similar patients according to age, gender and diagnose groups.

Age

The data set only contained year of birth for patients, to calculate age I assumed all patients were born on the 1st January. Age was a continuous variable included as an independent variable for propensity score matching.

Gender

Gender was dichotomous variable and an independent variable for propensity score matching coded as a dummy variable, 1 for females and 0 for males.

Diagnose groups

I group the patients for both open and laparoscopic surgery in three diagnoses groups according to the degree of severity. Group 1 is less severe, group 2: severe and group 3: very severe. For group 1: diagnoses not coded with the letter C (not malign neoplasm) , group 2:C18, C19, C20, C787 (C18:malign colon neoplasm, C19: malign neoplasm in the transition between the sigmoid and the neoplasm, C20: malign rectum neoplasm, C787: secondary malignant neoplasm of liver and intrahepatic bile duct) and for group 3:C22 (malign neoplasm of liver and intrahepatic bile duct). I assume that a more severe diagnose can lead not only to a more invasive surgery but also require a higher time of recovery.

Treatment

The years 2011-2012 and 2014-2015 were coded as the dummy variable treatment. 2011-2012 was coded as 0 (before ERAS) and 2014-2015 was coded as 1 (After ERAS). This was used as a variable and in the propensity matching.

For RR calculation

I will also use age, gender has variables described for the LOS.

Treatment

The years 2011-2012 and 2014-2015 were coded as the dummy variable treatment. 2011-2012 was coded as 0 (before ERAS) and 2014-2015 was coded as 1 (After ERAS).

4.4. Other Variables

I will present descriptive information about hospital discharge and mortality.

Hospital discharge location can be an important factor to analyze when making inferences about LOS. There is a possibility that a lower LOS is due to patients being discharged to their local hospitals.

The data gives me information about the condition in which the patient left the hospital. I know whether the patient was discharged alive or dead from Rikshospitalet. I do not know whether or when they died after discharge.

4.5. Statistics

I will present descriptive analyses of the dataset from 2008 to 2015 but only test for statistically differences in the groups I have mentioned earlier.

I will use propensity score matching (PSM) to estimate the average treatment effect for the patients after ERAS. I choose PSM because it allows observational studies to mimic some of the characteristics of RCT. The RCT are considered the gold standard when studying the effects of treatment, interventions or outcomes because the way patients are randomized reduces confounding for both measured and unmeasured baseline characteristics (40). By doing so, it is possible to conclude to a certain degree, that the result arises from treatment and not from other sources. Rosebaum and Rubin demonstrated that all confounding can be controlled using PS methods, as patients with the same PS, treatment is unrelated to cofounders(40).

PSM is a tool that offers an alternative to regression. I used this method the following way. The first step is to perform a logistic regression. The dependent variable is ERAS (0=before ERAS, 1= after ERAS) and choose the other independent variables, age, gender and diagnose code. Running this logistic regression provides an propensity score, which is defined as the conditional probability of treatment given all cofounders (41). Once this is done, I have used 1:1 nearest neighbor matching with a caliber of 0.1 to avoid matching different patients. The software selects for each after ERAS patient a before ERAS patient with the closest propensity score to estimate the average treatment effect on the treated (40–43). Since I have used a 1:1 matching, there are patients that will not be matched.

I will also apply a t-test to test the differences in the groups before and after ERAS implementation to compare the results with the results for propensity score.

I will use logistic regression to calculate the likelihood of a readmission before and after ERAS. Linear regression techniques are not optimal when analyzing categorical variables due to the strict statistical assumptions of linearity, normality, and continuity for OLS regression(44,45). Logistic regression is better suited for describing and testing hypothesis about relationships between a categorical outcome variable and one or more categorical and/or continuous variable (45).

It is recommended that logistic regression is first performed on each individual variable to assess the effect it has on the dependent variable and according to the results include or not the independent variable in the final regression model. Since I only have three dependent variables, I will perform the individual analyses but include all three in the final model. To evaluate my logistic regression model, I use the Hosmer-Lemeshow test and Nagelkerke R^2 . The Hosmer-Lemeshow is a goodness-of-fit test to evaluate how the data fits the model. If the Hosmer-Lemeshow goodness-of-fit test statistic is greater than 0.05, we fail to reject the null hypotheses and there is no difference between observed and model predicted values, implying that the model's estimates fit the data at an acceptable level (44–46). In linear regression, R^2 tests are used to determine the proportion of the variation in the dependent variable than can be explained by the independent variables in the model. Researchers have tried to find a similar parameter for logistic regression. The Nagelkerke R^2 is a variation of the R^2 that does not possess the same predictive efficiency although it can be used as a supplement together with the other indices, as it indicates the degree of relationship between the independent and dependent variable.

Analyses were performed using Excel, MatLab, SPSS and STATA

4.6. Ethical approval

In Norway, the Norwegian Data Protection Authority has the oversight of personal data. To facilitate health care research this authority has created an exemption to OUS that means it does not need to notify this authority whenever personal information is released for research purposes. For research and quality assurance projects within OUS, a request must be sent to either the Regional Committee for medical and health care research or to the Privacy Ombudsman at OUS. My study did not require approval by the Ethical Committee only from the Privacy Ombudsman at OUS. The recommendation on how to handle the data by the Privacy Ombudsman is presented in Appendix 2. I have used the OUS guidelines and the recommendation I received for the treatment of health information. OUS guidelines recommend that data used for quality assurance projects and other research shall, as far as possible, be without identifiable characteristics. In practice, it means that the data is either anonymized or that it is not possible to identify the person in question. I first received an anonymized data set, which means it was not possible to identify the person in question. Later, it was made available to me gender and age, which means that despite not having name or personal number it provided more information about the patient and it could be possible to identify the patient. The general rule says that if the health information cannot be connected to a group of less than five people, then the data is anonymous. I find it difficult to know whether it could be connected to less than five people. This data with gender and age was stored on OUS computers in an area with restricted access. This area is a secure area provided by OUS for the handling of personal information. I did my analysis in a computer in a room only a few people have access to and that requires by personal login to the computer to access it, as required by OUS.

The most important element is to store and analyze the data in a responsible matter so that sensitive information is not lost or makes it possible to identify the person in question. It is very important that the public trusts the Institutions and researchers to handle their private information in an appropriate manner, as we do not want the public to mistrust researchers and Institutions. I have handled the data and will delete my dataset when this study is finished and communicate to the responsible entities when I am done with my project so that the data can be deleted.

5. Results

This chapter starts with an overview of the study population, followed by an account of the number of surgeries performed and the most common diagnoses. I will present LOS, hospital discharge, mortality and rate of readmissions. Secondly, I will present my results regarding differences in LOS and RR before and after ERAS.

5.1. Descriptive statistics

5.1.1. Study population

I start my descriptive statistics with an overview of the population in terms of age, gender by year. One of the main observation is that both groups are quite similar between them, in terms of gender and age distribution. It seems to be mostly 50% females and 50% males with an average age of 60 and these characteristics remain constant from 2008 to 2015 and in both the open and laparoscopic surgery group.

Table 1- Study population per year by gender and age

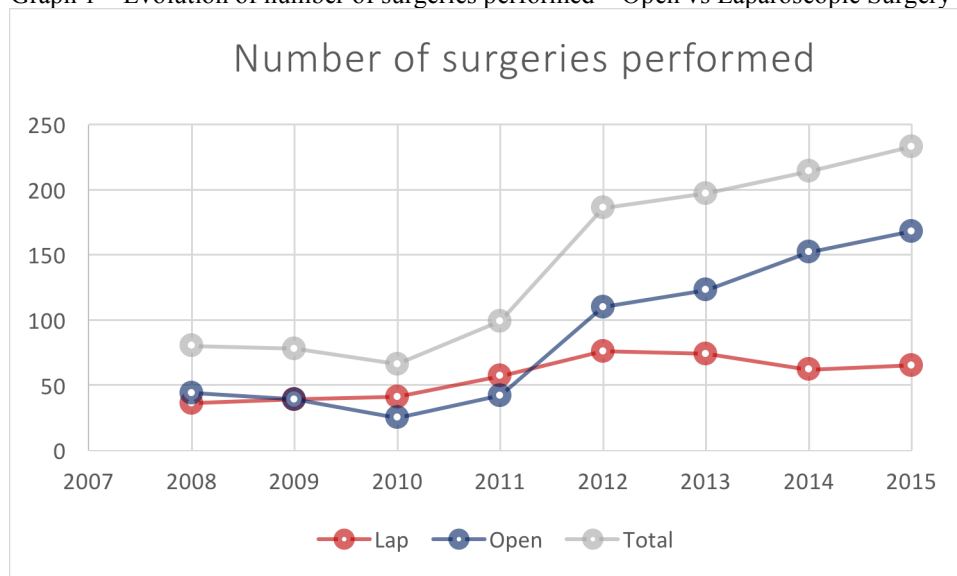
Year	Gender	n	Age	
			Mean	Min-Max
2008 n=44	Female	21(47%)	60	42-74
	Male	23(53%)	59	35-77
2009 n=39	Female	18(46%)	58	30-79
	Male	21(54%)	58	40-75
2010 n=25	Female	12(48%)	55	22-73
	Male	13(52%)	59	42-78
2011 n=41	Female	16(40%)	65	30-80
	Male	25(60%)	64	38-79
2012 n=110	Female	39(35%)	67	50-83
	Male	71(65%)	64	44-82
2013 n=123	Female	57(46%)	61	33-86
	Male	66(54%)	63	33-85
2014 n=152	Female	60(40%)	64	25-85
	Male	92(60%)	64	36-81
2015 n=166	Female	76(45%)	64	24-80
	Male	90(55%)	65	22-86

Year	Gender	n	Age	
			Mean	Min-Max
2008 n=36	Female	17(44%)	57	26-76
	Male	19(54%)	64	30-82
2009 n=39	Female	20(51%)	60	27-80
	Male	19(49%)	66	33-89
2010 n=41	Female	21(51%)	62	35-81
	Male	20(49%)	62	45-78
2011 n=57	Female	29(51%)	63	28-87
	Male	28(49%)	64	32-88
2012 n=76	Female	34(45%)	59	20-82
	Male	42(55%)	65	36-85
2013 n=74	Female	33(45%)	58	34-78
	Male	41(55%)	65	31-85
2014 n=62	Female	37(60%)	64	27-87
	Male	25(40%)	66	55-83
2015 N=66	Female	30(46%)	62	34-82
	Male	36(54%)	67	31-85

5.1.1. Number of surgeries performed

The data shows an increase in surgeries performed from 2008 to 2015. The most considerable increase happens within open liver surgery.

Graph 1 – Evolution of number of surgeries performed – Open vs Laparoscopic Surgery



From 2011 to 2012 there is a considerable increase from 43 to 111 in liver resection, due to the merger of the Oslo Hospitals, where liver resection started being performed almost exclusively at Rikshospitalet from 2012. In 2011, there were performed around 80 liver surgeries at Ullevål Hospital while in 2012 there were only 4. The increase from 2014 to 2015 is due to an increase in capacity.

5.1.2 Common diagnoses

The two tables below display the most main common diagnosis that lead to hospital admission for liver resection. For both types of surgery, the most common diagnosis is secondary metastases to the liver and intrahepatic duct, even though it has been declining from 2008 to 2015. It can be observed a change in 2013, diagnoses that were previously more frequent became less and diagnoses that were not so common earlier became more prevalent. These changes can be explained by a shift in diagnosis coding practice.

Table 2 - Most common diagnoses by year for open liver surgery

	2008	2009	2010	2011	2012	2013	2014	2015
C787 ¹	28(63.6%)	23(59%)	11(44%)	21(51%)	60(54.5%)	58(47.2%)	48(31.6%)	44(26.5%)
C221 ²	3(6.8%)	0	4(16%)	2(5%)	11(10%)	16(13%)	9(5.9%)	13(7.8%)
C20 ³	0	0	0	1(2.4%)	0	12(9.8%)	23(15.1%)	19(11.4%)
C187 ⁴	0	0	0	0	0	4(3.3%)	18(11.8%)	18(10.8%)
Others	13(29.5%)	16(41%)	10(40%)	17(41%)	39(35.5%)	33(26.8%)	54(35.5%)	72(43.3%)
Total	44	39	25	41	110	123	152	166

1- Secondary malignant neoplasm of liver and intrahepatic bile duct

2- Intrahepatic bile duct carcinoma

3- Malignant neoplasm of rectum

4- Malignant neoplasm of sigmoid colon

For patients submitted to laparoscopic surgery, one of the common diagnoses is benign neoplasm of rectum. This is the only not malign tumor present in this overview and it is almost only present in laparoscopic surgery.

Table 3 - Most common diagnoses by year for laparoscopic liver surgery

	2008	2009	2010	2011	2012	2013	2014	2015
C787 ¹	26(72.2%)	30(77%)	32(78%)	35(60%)	48(62%)	34(46%)	26(41.3%)	23(34.8%)
C220 ²	0	1(2.6%)	1(2.4%)	1(1.7%)	7(9.1%)	7(9.4%)	6(9.5%)	8(12.1%)
C20 ³	0	0	0	0	1(1.3%)	3(4.1%)	7(11.1%)	6(9.1%)
D134 ⁴	3(8.3%)	2(5,1%)	2(4.9%)	3(5.2%)	4(5.2%)	7(9.5%)	6(9.5%)	3(4.5%)
C187 ⁵	0	0	0	1(1.7%)	0	7(9.5%)	4(6.3%)	5(7.6%)
Other	7(19.4%)	6(15.4%)	6(14.6%)	18(31%)	17(22%)	16(21.6%)	14(22.2%)	21(31.8%)
Total	36	39	41	57	76	74	62	66

1- Secondary malignant neoplasm of liver and intrahepatic bile duct

2- Liver cell carcinoma

3- Malignant neoplasm of rectum

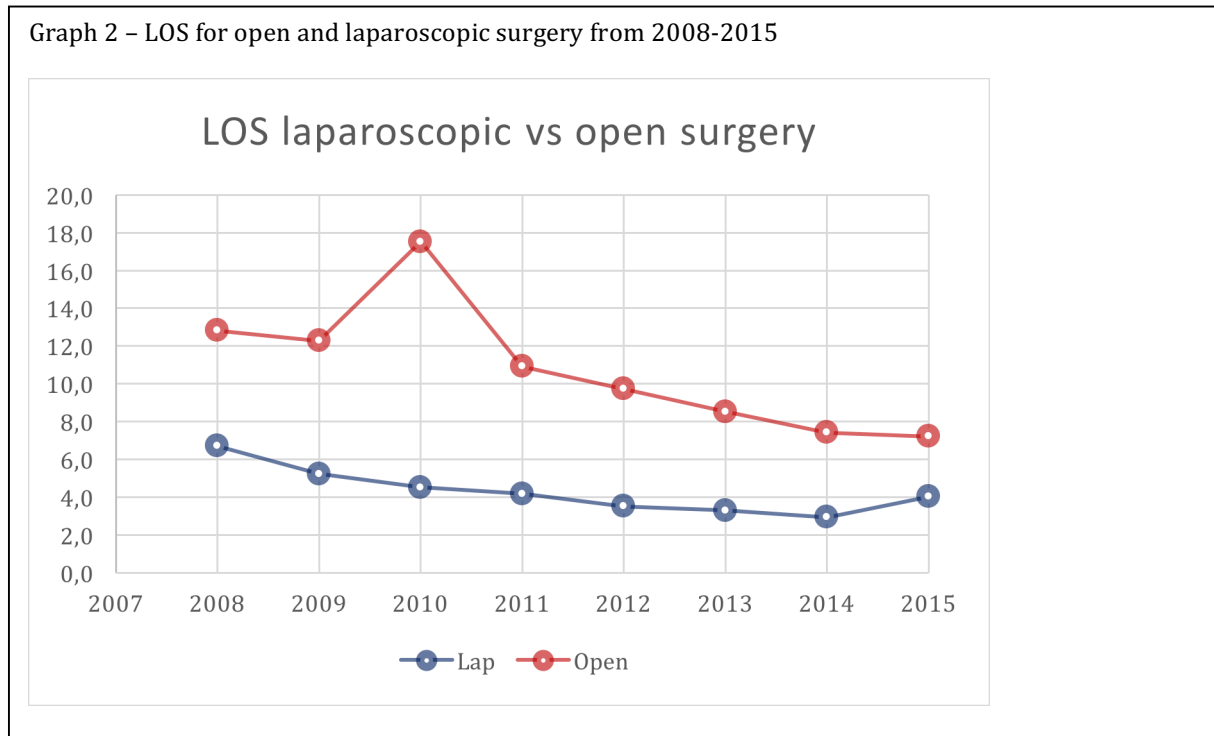
4- Benign neoplasm of liver

5- Malignant neoplasm of sigmoid colon

5.1.3. Hospital Length of stay

Decreasing hospital LOS is a trend that Norway and other developing countries have experienced in the last decades (13), this is also reflected in this data. The graph bellows show the LOS evolution from 2008 to 2015. There is a downward trend for both types of surgeries, despite a peak in open surgery in 2010 and a small peak in laparoscopic surgery in

2015. Open surgery LOS is higher than in laparoscopic surgery, which can be due to the more invasive nature of the procedure.



The next table contains the LOS average, mean, standard deviation, minimum and maximum per year for open surgery according to gender.

The general trend in open liver resection is the decrease in all measures for both genders. There is a decrease in mean and median. The maximum time patients have spent in the hospital have also decreased. In general, there is a positive trend in the reduction of days spent at hospital within the last years, at the same time as the number of surgeries has increased. When comparing between females and males, LOS is quite similar in most years although there are some differences in 2009, 2011 and 2014, where males have a higher LOS than females.

Table 4 – Hospital length-of-stay: mean, median, standard deviation, minimum and maximum for open liver resection

		Length-of-stay					
Year	Gender	N	Mean	Median	Std. Dev	Minimum	Maximum
2008 n=44	Female	21(47%)	12.7	8.2	13.0	4.8	63.1
	Male	23(53%)	13.0	12.1	7.5	1.4	31.0
2009 n=39	Female	18(46%)	11.1	9.6	5.7	6.1	31.0
	Male	21(54%)	13.3	10.1	9.4	3.4	49.1
2010 n=25	Female	12(48%)	17.9	11.6	15.9	1.1	60.1
	Male	13(52%)	17.2	11.1	15.5	.9	52.8
2011 n=41	Female	16(40%)	8.1	7.2	4.7	2.5	22.3
	Male	25(60%)	13.0	8.0	13.9	3.0	64.1
2012 n=110	Female	39(35%)	10.1	7.1	7.8	3.0	36.1
	Male	71(65%)	9.5	6.2	9.4	.4	56.1
2013 n=123	Female	57(46%)	8.7	7.1	7.7	2.5	45.0
	Male	66(54%)	8.3	6.6	7.2	1.1	37.9
2014 n=152	Female	60(40%)	6.5	6.2	3.6	1.9	21.5
	Male	92(60%)	8.1	5.3	8.3	.6	46.2
2015 n=166	Female	76(45%)	6.7	5.1	6.2	1.3	43.1
	Male	90(55%)	7.6	5.5	7.0	.5	40.6

The trend is the same as in open surgery, a general downward trend in average stay and median. The minimum and maximum stay has fluctuated, so there is no observable trend.

Table 5- Hospital length-of-stay: mean, median, standard deviation, minimum and maximum for laparoscopic liver resection

Length-of-stay							
Year	Gender	N	Mean	Median	Std. Dev	Minimum	Maximum
2008 n=36	Female	17(44%)	7.4	4.2	6.9	3.0	28.1
	Male	19(54%)	6.2	6.0	3.2	2.1	14.0
2009 n=39	Female	20(51%)	5.2	5.0	3.0	1.2	14.0
	Male	19(49%)	5.6	4.9	2.9	2.3	13.0
2010 n=41	Female	21(51%)	4.8	3.3	2.7	1.7	12.3
	Male	20(49%)	5.7	3.5	4.0	2	19.8
2011 n=57	Female	29(51%)	5.6	3.0	5.1	1.9	28
	Male	28(49%)	5.2	3.1	2.7	2.1	14.1
2012 n=66	Female	34(45%)	5.2	2.4	4.7	2.1	35.1
	Male	42(55%)	5.1	2.1	3.0	2.0	28.4
2013 n=74	Female	33(45%)	4.8	3.2	2.3	2.1	11.1
	Male	41(55%)	4.2	2.1	2.3	1.7	14.1
2014 n=62	Female	37(60%)	3.9	2.1	1.6	1.9	10.1
	Male	25(40%)	5.6	2.4	1.4	2.0	32.2
2015 n=66	Female	30(46%)	5.4	2.5	8.1	1.3	42.7
	Male	36(54%)	4.3	2.5	3.0	1.2	23.9

5.1.4. Hospital discharge

There has been an increase in patient discharge to their home and a decrease in discharge to other hospitals. This can indicate that LOS is not artificially lowered by transfer to other hospitals and can also indicate that either patients are fitter when they are discharge and/or their community health care is improved.

Table 7 – Discharge location for patients who underwent open liver resection

Discharge to	2008 (n=44)	2009 (n=39)	2010 (n=25)	2011 (n=41)	2012 (n=110)	2013 (n=123)	2014 (n=152)	2015 (n=166)
Home	13(29.5%)	10(25.6%)	7 (28%)	14(34.1%)	48(43.6%)	60(48.8%)	78(51.3%)	75(45.2%)
Another Hospital	30(68.2%)	29(74.4%)	16(64%)	23(56.1%)	57(51.8%)	58(47.2%)	67(44.1%)	69(41.6%)
Others	1(2.3%)	0	1(4%)	4(9.7%)	5 (4.5%)	5 (4%)	4(2.6%)	22(13.2%)

Analyzing the data for laparoscopic surgery, the home discharge has always been higher than open liver resection. This can be due to the less invasive nature of the procedure. Most patients have been discharged home, with a top of 93.5% of all patients being discharged home in 2014, 2015 there was a decrease in home discharge with an increase in transfer to another hospital.

Table 8- Discharge location for patients who underwent laparoscopic liver resection

Discharged to	2008 (n=36)	2009 (n=39)	2010 (n=41)	2011 (n=57)	2012 (n=76)	2013 (n=74)	2014 (n=62)	2015 (n=66)
Home	20(55.6%)	19(48.7%)	29(70.7%)	51(89.5%)	60(78.9%)	67(90.5%)	58(93.5%)	50(75.8%)
Another Hospital	16(44%)	19(48.7%)	12(29.3%)	6(10.5%)	15(19.7%)	7(9.5%)	4(6.5%)	14(21.2)
Others	0	1(2.6%)	0	0	1(1.3%)	0	0	2(3%)

5.1.5. Mortality

According to my date for open surgery there was a female that died in 2011, two male who died in 2012. A female and a male died in 2013 and one male both in 2014 and 2015. For patients who underwent laparoscopic surgery there is only one registered death in 2015.

5.1.6. Readmissions

The rate of readmission has fluctuated in both open and laparoscopic surgery and there is not a downward or upward trend. Both groups experienced a reduction from 2009 to 2010 followed by a peak in 2011 and a reduction from 2011 to 2012.

Graph 3 – Hospital readmissions, 30-days after surgery

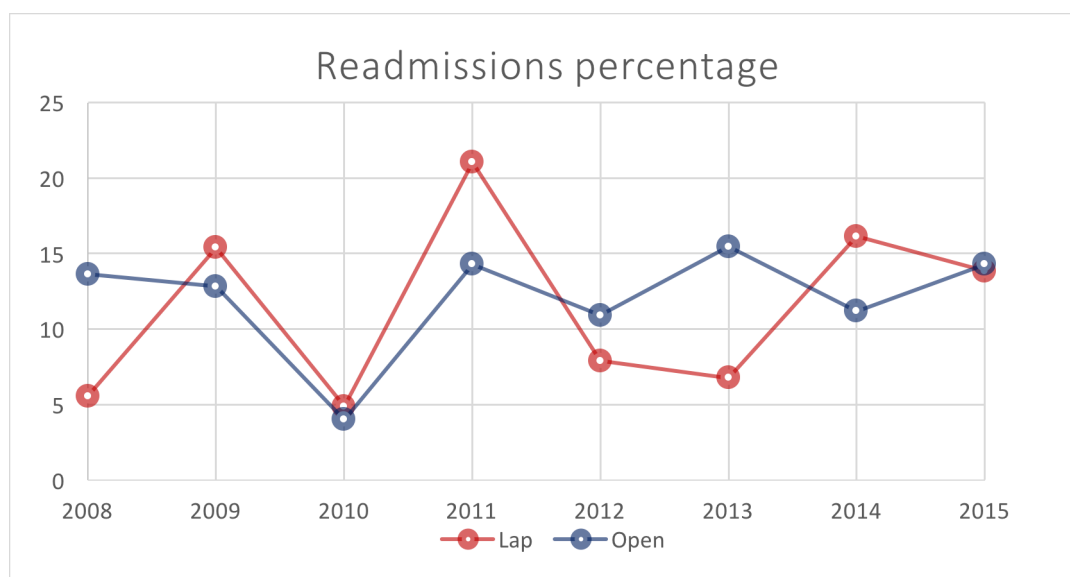


Table 6 – Hospital readmissions, 30-day after surgery

Year	Open Surgery (n= 672)		Total readmissions	Laparoscopic surgery (n=450)		Total readmissions
	Females	Males		Female	Males	
2008	4.5%	9.1%	6 (n=44)	5.6%	0	2 (n=36)
2009	10.3%	2.5%	5 (n=39)	10.2%	5.1%	6 (n=39)
2010	4%	0%	1 (n=25)	0	4.9%	2 (n=41)
2011	7.5%	7.5%	6 (n=40)	10.5%	10.5%	12 (n=57)
2012	4.6%	6.5%	12 (n=108)	3.9%	3.9%	6 (n=66)
2013	4.9%	10.7%	19 (n=121)	4.1%	2.7%	5 (n=74)
2014	4%	7.3%	17 (n=151)	9.7%	6.5%	10 (n=62)
2015	6.7%	7.9%	24 (n=165)	3%	10.7%	9 (n=65)

5.2. Results

In this section I will present the results from the differences in LOS and RR before and after ERAS implementation

5.2.1. ERAS effect on LOS

For the open surgery group, there was nearly no unbalances in the covariates after matching, the largest one was for the diagnose group 2 before matching. More information about checking for balances in the covariates can be found in Appendix 3.

The average treatment effect for the treated in the open surgery group is a reduction of 3.35 days (p-value= 0.004, 95% CI -5.65, -1.05) in hospital LOS. There was a significant reduction in LOS for the patients undergoing open liver resection in 2014-2015 compared to the patient in 2011-2012.

For the laparoscopic surgery group, there was nearly no unbalances in the covariates after matching. More information about checking for balances in the covariates can be found in Appendix 4.

The average treatment effect for the treated in the laparoscopic group is a reduction in LOS of -0.314 days (p-value= 0.587, 95% CI -1.48, 0.85). There was a non-significant reduction in LOS for patients undergoing laparoscopic liver resection in 2014-2015 compared to 2011-2012.

If I had use a t-test (assuming equal variances) to compare the average LOS before and after ERAS, the results would be similar although using propensity score matching the effect is higher in the open surgery group. The average LOS before ERAS is 10.2 days and 7.4 after. There is a significant difference of 2.8 days (p-value=0.000, 95% CI=1.3,4.3). In the laparoscopic group, the average LOS before ERAS is 3.8 days and 3.5 days after. There is a non-significant difference of 0.318 days (p-value= 0.539, 95% CI= -0.7,1.3).

The tables below show both groups according to gender, age and diagnose groups and it seems both groups are quite similar in these characteristics.

Table 9 – Groups description without propensity score matching for open liver resection

	Gender	Age		Diagnose Groups
		Average	Min-Max	
Before ERAS (n= 151)	Female :36.4% Males :53.2%	66 64	30-83 38-82	Group 1: 41% Group 2: 55% Group 3: 5%
After ERAS (n= 318)	Females: 42.8% Males: 57.2%	64 65	24-85 22-86	Group 1: 50% Group 2: 44% Group 3: 6%

Table 10 – Groups description without propensity score matching for laparoscopic liver resection

	Gender	Age		Diagnostic Group
		Average	Min-Max	
Before ERAS (n= 133)	Female: 47.4% Males :52.6%	61 65	20-87 32-88	Group 1: 28% Group 2: 64% Group 3: 8%
After ERAS (n= 128)	Females: 52.4% Males: 47.6%	63 67	27-87 31-85	Group 1: 34% Group 2: 52% Group 3: 14%

5.2.2. ERAS effect on rate of readmissions

I present the results for each individual independent variable and present the full model for the three variables. In Appendix 5 it is possible to find the output tables from the individual analyses in the open surgery group and in Appendix 6 for the laparoscopic surgery group.

5.2.2.1. Readmissions in open surgery

I present ERAS, age and gender analyzed individually and finalize with including all three variables in the logistic regression model, with readmissions as the dependent variable. The average readmissions rate before ERAS (2011-2012) was 12.1% and after ERAS (2014-2015) it was 12.9%.

ERAS

ERAS has no effect on the likelihood of being readmitted (p-value= 0.872). The Nagelkerke's R^2 of 0 indicates no relationship between ERAS implementation and readmission. The model was not statistically significant $X^2=0.018$ (p-value=0.894).

Age

The likelihood of being readmitted decreases by 0.973 by one year age increase (p-value =0.001). The Nagelkerke's R^2 of 2.1% indicates a low relationship between age and readmission. The model was statistically significant $X^2=8.38$ (p-value=0.004).

Gender

Gender has no impact on the likelihood of a patient being readmitted (p-value= 0.942). The Nagelkerke's R^2 of 0 indicates no relationship between gender and readmission. The model was statistically not significant $X^2=0.005$ (p-value=0.942).

Logistic regression model for open surgery group

I used all the three independent variables in the logistic regression model, even though only age was significant when I analyzed the variables independently. Despite this, I choose to present the logistic regression model with all the three variables.

Table 11 – The observed and the predicted frequencies for the null model and the full regression model

Observed	Predicted		
	Readmission		Percentage
	Correct		
Readmissions	0	1	
0	464	0	100
1	59	0	0
Overall percentage			87.2

The overall percentage gives me the percent of cases for which the dependent variable was predicted in the null model. The values of the overall percentage after regression give me the cases that are correctly predicted by the model. There has been no change in the percentages between the null and the full regression model, the percentage remained 87.2%.

Table 12- Logistic regression model with ERAS, age, gender

Predictor	Beta	Standard Error	Wald	df ¹	p-value	Exp(B)	95% CI for Exp(B)
Constant	0.648	0.8	0.66	1	0.418	1.949	
ERAS (Before=0, After=1)	0.005	0.307	0	1	0.988	1.014	0.556-1.847
Age	-0.042	0.012	11.9	1	0.001	0.958	0.936-0.981
Gender (Male=0, Female=1)	0.069	0.287	0.057	1	0.811	1.075	0.613-1.886

1-Degrees of freedom

Table 12.1. Hosmer and Lemeshow test and Nagelkerke R²

Chi-Square	Degrees of freedom	P-value	Nagelkerke R ²
3.89	8	0.867	0.048

Table 12.2. Omnibus Tests of Model Coefficients

		Chi-square	df	P-value
Step 1	Step	12.273	3	0.007
	Block	12.273	3	0.007
	Model	12.273	3	0.007

A logistic regression was conducted to predicted hospital readmissions using ERAS implementation, age and gender as predictors. The model was statistically significant $X^2 = 12.273$ (p-value<0.001).

Nagelkerke's R² of 4.8% indicates a low relationship between prediction and readmissions. Prediction success remained unchanged before and after regression with 87.9%. Age was the only significant predictor, a increase in age was associated with a significant decrease of 0.958 (p-value= 0.001) for the likelihood of being readmitted.

5.2.2.1. Readmissions in laparoscopic surgery

I present ERAS, age and gender analyzed individually and finalized with including all three variables in the logistic regression model, with readmissions as the dependent variable. The rate of readmissions before ERAS (2011-2012) was 14.6% and after ERAS (2014-2015) was 14.9%.

ERAS

ERAS has no effect on the likelihood of being readmitted (p-value= 0.763). The Nagelkerke's R^2 of 0 indicates no relationship between ERAS implementation and readmission. The model was statistically non-significant $X^2=0.091$ (p-value=0.763).

Age

Age has no effect on the likelihood of being readmitted (p-value= 0.27). The Nagelkerke's R^2 of 0 indicates no relationship between age and readmission. The model was statistically non-significant $X^2=0.365$ (p-value=0.546).

Gender

Gender has no impact on the likelihood of a patient being readmitted (p-value= 0.612). The Nagelkerke's R^2 of 0 indicates no relationship between gender and readmission. The model was statistically not significant $X^2=0.032$ (p-value=0.859).

Logistic regression model for laparoscopic surgery group

Table 13- The observed and the predicted frequencies for the null model and the full regression model

	Predicted		
	Readmission	Percentage Correct	
Readmissions	0	1	
0	247	0	100
1	37	0	0
Overall percentage			85

The overall percentage gives me the percent of cases for which the dependent variable was predicted in the null model. The values of the overall percentage after regression give me the cases that are correctly predicted by the regression model. There has been no change in the percentages between the null and the full regression model, the percentage remained 85.9%.

Table 14- Logistic regression model with ERAS, age, gender

Predictor	Beta	Standard Error	Wald	Df	p-value	Exp(B)	95% CI for Exp(B)
Constant	-0.732	0.896	0.667	1	0.414	0.772	
ERAS (Before=0, After=1)	0.149	0.358	0.173	1	0.677	1.160	0-576-2.340
Age	-0.016	0.013	1.495	1	0.222	0.984	0.959-1.010
Gender (Male=0, Female=1)	-0.259	0.364	0.506	1	0.477	0.772	0.379-1.574

Table 14.1. Hosmer and Lemeshow Test

Chi-Square	Degrees of freedom	P-value	Nagelkerke R ²
8.709	8	0.367	0.012

Table 14.2. Omnibus Tests of Model Coefficients

		Chi-square	df	P-value
Step 1	Step	1.833	3	0.608
	Block	1.833	3	0.608
	Model	1.833	3	0.608

A logistic regression was conducted to predicted hospital readmissions using ERAS implementation, age and gender as predictors. The model was statistically non-significant $X^2 = 1.833$ (p-value=0.608). Nagelkerke's R² of 1.2% indicates almost no relationship between prediction and grouping. Prediction success remained unchanged before and after regression at 85.9%

6. Discussion

In my discussion, I will first present my study's objective, followed by the main findings. Thirdly, I will discuss my results and its limitations and end with my thoughts about possible future research on this topic.

6.1. Study objective

The goal of this study was to determine whether ERAS implementation had an impact in LOS and RR and if so what kind of impact.

6.2. Main findings

I found that there is a significant reduction of days 3.35 days (p-value=0.004) in LOS from the patients who underwent open liver resection in 2011-2012 compared with patients who underwent surgery in 2014-2015. In addition, the percentage of patients who have been discharged home in 2014-2015 is higher than in 2011-2012, as well as the percentage of patients who have been discharged to other hospital has decrease. That can indicate that the LOS is not artificially low by discharging patients to other health care institutions.

In the case of laparoscopic surgery, I found no significant differences between the two groups. There is a reduction of 0.314 days (p-value=0.587) from 2011-2012 to 2014-2015. The discharge location in this group has not experienced differences. The percentage of patients who were discharged to their home and to other hospitals is very similar in 2011-2012 and 2014-2015.

The average readmissions rate before ERAS in the open surgery group was 12.1% and after ERAS it was 12.9%, so a slight increase. There has also been a slight increase in the laparoscopic group from 14.6% before ERAS to 14.9% after ERAS.

I found that ERAS implementation does not affect the likelihood of a patient being readmitted before and after ERAS in the open liver resection group (p-value=0.988). Age was the only variable to have a significant impact on the likelihood of readmission, as an increase in age leads to a decrease of 0.958 (p-value=0.001) of being readmitted.

I found that in the laparoscopic liver resection group, ERAS implementation did not impact the likelihood of being readmitted (p-value=0.677).

My findings corroborate the research on clinical pathways for liver resection. Many studies found a significant reduction in LOS when ERAS was implemented with a higher effect on more invasive surgery(1,11–13,15,16). My study found a significant effect on open surgery and non-significant effect on laparoscopic surgery.

Regarding readmissions, studies have found mixed effects after ERAS implementation, while some studies found a significant affect others did not. (11,12,14,16). My study found no significant difference in both groups.

The comparison between mine and other studies needs to be made with caution as ERAS protocols, LOS calculations and readmission calculation differ from study to study.

6.3. Limitations

My study as some limitations, like any other study and its findings should be interpreted with this is mind.

The first is the data accuracy and the potential for the existence of wrong entries that I have no opportunity to check without accessing patient's journal. This would require not only permission to do so but also a very high workload. I took the steps possible to ensure the data I analyzed was as accurate as possible.

Length of stay

While I have found significant differences in LOS in the open surgery group, I cannot be certain that this reduction is solely due to ERAS, as LOS has been decreasing the last years. Despite this, I believe that most of this reduction can be imputed to the ERAS implementation. I have discussed in this study three major factors that can impact LOS for patients undergoing liver surgery such as new technology, healthcare reform and ERAS implementation. As far as I know, no new technology has been implemented during this time that might have reduced LOS. As for health reforms the last years, the coordination reform of 2012 might impact LOS as more patients in 2014 and 2015 could be transferred home earlier due to an improvement in the primary care offer. There is an increase to home discharge from 2012, which is before the reform was implemented and continued after. The last eight years, my data shows an increase in home discharge and a decrease in discharge to other health institutions in the open liver resection group. I have also used a relative short time frame to calculate LOS, as ERAS was implemented in 2013, I have used two years

before and two after to make my calculation. Had I used a longer time frame, more factors that affect LOS could play a role, since the time frame is smaller the main event during these years was the ERAS implementation.

I choose propensity score matching to test the differences in LOS and my choice of method has downsides. My goal with this choice of method was to replicate in my statistical method the characteristics of a RCT so that I am comparing as similar patients as possible and reduce confounding. This method would have been even more relevant the more variables I had to match patients. I choose a 1:1 matching, which matched patients with a similar patient propensity score between the before and after ERAS group. A 1:1 matching means once a patient is matched it will not be selected again, so some patients in my after sample have not been matched to a patient in the before sample. Since the after group is larger in size than the control group, the overall power of this analysis is not reduced as much as if it was the opposite. I have used 1:1 matching, with a caliber of 0.1 to make sure the patients matched are as similar as possible. There was balance in the covariates in both groups which makes my results more reliable.

To check my results, I also performed a t-test for differences in means. The results were similar, a significant difference in the open surgery group and non-significant difference in the laparoscopic surgery group. The difference in LOS was higher using propensity score matching than a t-test. This result confirms my original findings.

My goal was to divide the patients in different groups by type of surgery, open and laparoscopic and whether they were submitted to major or minor surgeries. My assumption was that major surgery requires more recovery time than minor surgeries, and patients who require major surgeries might also require more recovery time. It would be interesting to examine on whether ERAS has an impact and if this impact was stronger in minor or major surgeries. Unfortunately, this was not possible due to changes in the surgical procedures codes.

I have discussed LOS differences between before and after ERAS implementation. In the ERAS protocol patients are invited for an outpatient consultation where the pathway is explained and what patients can expect from hospital admission and their role in recovery. The patients are also invited for outpatient consultation later and have the possibility of telephoning a dedicated nurse after discharge. My initial intention was to control for outpatient contact before and after the ERAS implementation, whether there was a difference

in outpatient contact before and after ERAS implementation. The data did not allow me to distinguish whether it was a consultation that as a part of the protocol or not.

From my analyses, ERAS can be considered an efficiency tool to reduce LOS in open liver resection. Costs have been incurred to implement the protocol and widen the outpatient consultation offer that follows from ERAS. I did not conduct a cost-efficiency analyses, so I do not know whether it is cost-effective. In one hand, there is a 3 day LOS reduction, which frees resources, on the other hand, there was an initial investment in implementing as well as the follow-up costs in outpatient contacts. In general, inpatient care is more costly than outpatient care, so it is likely that ERAS is cost-efficient.

Rate of Readmissions

I found no significant change in patients being readmitted before and after ERAS implementation. It was a result I expected, as many studies have found contradicting results about the impact of clinical pathways in readmissions.

There are some limitations to the results of this study. One of the challenges of making inferences with these data is that Rikshospitalet does not function as a local hospital, so it does not capture patients that have been readmitted in their local hospitals. This data captures patients from Oslo, since Ullevål Hospital functions as the local hospital for specialist care within gastrointestinal surgery. This may lead to a false lower rate of readmissions, as patients can be admitted to their local hospitals with complications. On the other hand, this effect is likely not to have changed by the ERAS implementation as Rikshospitalet functions as a specialist hospital. I had also intended to examine on whether readmission was due to a surgical complication or not. Since many patients have a severe diagnose and just by looking at the diagnose codes it was difficult for me to determine on whether it was a result of a surgical complication. Most patients had the same cancer diagnose code as when they were admitted for surgery, so my challenge was to determine on whether it was due to a complication or to the natural evolution of the disease. It can be expected that patients with cancer diagnoses might be readmitted in a period of 30-days that is not a result of surgical complications. For this reason and since I have no access to patients' journal to check the readmission reason, I present the general RR.

I used logistic regression to predict the outcome of being readmitted from a set of independent variables. According to my model, ERAS implementation, gender had no

predictive power, age had predictive power in the open surgery group. The regression model with the three variables was also considered significant. In the laparoscopic surgery group, the three variables had no predictive power in readmissions and the regression model has statistically non-significant. This might be that the factors that lead to readmission are not related to age and gender but other aspects I did not study.

6.4. Further Studies/Research

This study evaluated the effect of ERAS implementation in LOS and rate of readmissions at Rikshospitalet.

I have read many articles about the implementation of clinical pathways in different types of abdominal surgeries. One of the goals of pathways is to make clear what is expected of every healthcare professional and patients and at different points in time. Information and knowledge are more easily available today than in any other point in time. Patients are better informed, more demanding and aware of the type of care they are being provided. I would like to see more research in how patients respond and react to this explicit expectation of their role in their own recovery. I personally believe that patients need to take an active role in their recovery and treatment and clearly communicating how recovery can be shortened makes it easier for patients to actively participate. I would also like to see more research on how ERAS affects health outcomes (such as health related quality of life, or other similar measures).

Study in cost-effectiveness of ERAS can be a further field of research.

7. Conclusion

This study analyzed the effect of ERAS implementation in open and laparoscopic liver resection at Rikshospitalet.

ERAS implementation has a significant effect in reducing LOS for patients undergoing open liver resection, without increasing the rate of complications. The clinical pathways ERAS can be an efficient tool to reduce LOS in open liver surgery with no significant change in readmissions. ERAS implementation had a non-significant reduction in LOS in patients undergoing laparoscopic liver resection with no significant change in readmissions

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Appendix 1- ERAS protocol

ERAS LEVER DAG-FOR-DAG-PLAN

Innleggelsesdagen	PERSONLIG PLAN (egne notater)
<p>Mottas av sykepleier ved ankomst sengepost. Ta nye blodprøver. Drikke karbohydratdrikk (ProvideXtra®) 2 x 200 ml Dusje Barbering ved behov etter informasjon fra sykepleier Du vil få en blodfortynnende sprøyte Faste: ikke spise etter kl.02, men kan drikke klare væsker inntil kl.06 Ikke røyke/snuse</p>	
Operasjonsdagen morgen	
<p>Du blir vekket av sykepleier på morgenen Drikke karbohydratdrikk (ProvideXtra®) 1 x 200 ml innen kl. 06.00 Medisiner blir utlevert av sykepleier. Du skal gå på toalettet, pusse tenner og ta på støttestrømper.</p>	
Operasjonsdagen ettermiddag	
<p>Etter operasjon kommer du til en oppvåkningsavdeling. Her skal du ligge til du er klar for å komme tilbake til sengeposten. Noen overnatter her og kommer tilbake på sengeposten neste morgen. Du skal drikke og spise, og vi forsøker å avslutte intravenøs behandling. Tyggegummi 30 minutter etter måltid for å stimulere tarmfunksjonen. Blærekateter fjernes også hos noen. Du får hjelp til å være ute av sengen i til sammen to timer. Du får utlevert smertestillende tabletter, og veiledning bruk av smertepumpen hvis du har dette.</p>	
1. dag etter operasjon	Aktivitetslogg- noter hvor aktiv du er
<p>Du kan gjerne dusje. Egne klær tas på. Du skal være oppe av sengen i min. 8 timer og gå tur i korridoren min. 3 ganger. Du skal spise til alle hovedmåltider på dagligstuen. Du skal drikke min 1,5 liter/døgn, og føre drikkeliste selv. Tyggegummi tygges i 30 minutter etter hvert måltid. Du får en dosett med medisiner. Hvis du har smertepumpe skal denne reduseres eller fjernes. ERAS-sykepleier besøker deg for en samtale og dere planlegger veien videre. Hjemreisedato planlegges. Det er legevisitt ca kl.10-12. Du vil få informasjon om operasjonen. Noter evt. spørsmål på forhånd. Det blir tatt blodprøver av deg. Intravenøse tilganger og blærekateter fjernes.</p>	

2.dag etter operasjon Følger forløp som 1.dag. Operasjonsbandasjer skal skiftes. Du får avføringsmiddel hvis du ikke har hatt avføring ennå.	Aktivitetslogg- noter hvor aktiv du er
3.dag etter operasjon og evt videre Du skal fortsette å følge planene ifht aktivitet, ernæring og smertestillende som foregående dager.	Aktivitetslogg- noter hvor aktiv du er
Utreisedagen	
Operasjonsbandasjen skiftes. Du får med deg smertestillende tabletter utfra ditt behov. Samtale med lege under visitt. Trenger du sykmelding, transport/ bekreftelse på opphold e.l.? Har du kontaktet fastlege? Utreisesamtale med ERAS-sykepleier.	
1.hverdag etter utskrivelse	
ERAS-sykepleier ringer deg for å høre hvordan du har det.	
Ca en uke etter opr.	
ERAS-sykepleier ringer for å høre hvordan du har det, og bekrefter at du har time hos fastlege.	
12-14.dager etter operasjon	
Time hos fastlege. Leverer informasjonsskrivet, fjerner sting/stifter og tar blodprøver. Fastlegen følger opp svar.	
Ca 4-8 uker etter operasjon	
Du får prøvesvar i forbindelse med operasjonen enten på en time ved poliklinikken eller per telefon. Hva som vil gjelde for deg, får du informasjon om før hjemreise.	

**Du kan ta kontakt med ERAS-sykepleier dersom du har spørsmål utover dette.
Se visittkort/brosjyre for kontaktinformasjon.**

ERAS-lever

Trening før operasjonen

Fram mot operasjon er det viktig å være i daglig aktivitet. Oppretthold dagens aktivitetsnivå, gjerne også å øke nivået litt. Hvis du ikke er vant til å trene bør du som et minimum mosjonere en halvtime daglig, i form av å gå turer, svømme eller lignende. Aktivitet som øker styrke og virker respirasjonsfremmende er bl.a. hurtig gange i motbakke.

Etter operasjon

Du kommer først til en oppvåkingsavdeling. Allerede der skal du begynne å bevege på deg, men i denne fasen er det pusten som er i fokus. God pust vil hjelpe å løsne eventuelt slim og gi bedre hostekraft.

Begynn med dyp pusting; legg hendene på magen og kjenn at du klarer å trekke pusten godt inn og rolig ut. Hvis dette er smertefullt bes du si fra til sykepleieren, slik at du får smertestillende.

De fleste får noe slimdannelse i luftveiene under narkose, og for å unngå lungebetennelse er det viktig at eventuelt slim fjernes. Det gjøres ved å hoste, noe mange er redde for etter operasjon i magen. Dette gjør ingen skade for operasjonssåret, men er nødvendig. Det kan være litt ubehagelig, men skal ikke gjøre veldig vondt. Du kan be om å få en hostepute som du kan støtte mot såret mens du hoster. Du skal ikke hoste bare for å hoste, men prøv en gang for å sjekke om det er slimproduksjon. For og lettest mulig få opp slimet kan du gjøre noen øvelser før selve hostingen:

- bevege armene opp og ned for å utvide plassen lungene har å bevege seg på
- gjøre "støtende" pusteøvelser: lat som om du skal lage dogg på et spill

Det er også viktig å stimulere blodsirkulasjonen. Bevegelse av armer og bein kan lett gjøres i seng. Løft armen mens du puster inn og senk den mens du puster ut. Du kan også forsøke rumpeløft i sengen, ved at du trekker beina til deg langs madrassen og plasserer "hæl under knær" og løfter baken rett opp. Å løfte et og et ben opp og ned fra madrassen er også effektivt. Du skal ikke bue ryggen, men holde den strak.

Ved å gjøre øvelser i seng før du skal opp forbereder du kroppen på aktivitet. Slik har du også sjekket at kraften i beina er "på plass". Når du skal opp første gangen bør du få assistanse.

Aktivitet etter operasjonen

Du skal ikke overbelaste magemuskulatur de første seks ukene etter operasjonen og det er derfor viktig at du lærer deg teknikken for å komme ut av sengen på egenhånd (se bilder på baksiden).

Det er forventet at du er ute av sengen minst to timer allerede operasjonsdagen og åtte timer per døgn de neste dagene, med daglige turer ut av rommet. Du skal veksle mellom å sitte og gå og bruke sengen minst mulig! Hvil

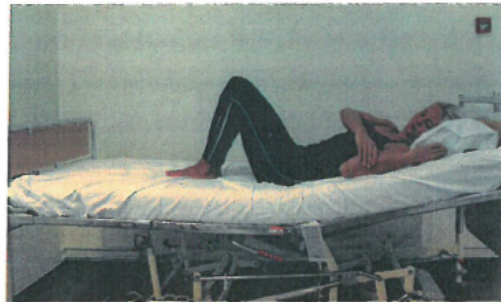
deg i stolen innimellom, du får slappet like godt av, mens pusten blir lettere og blodsirkulasjonen bedre når du sitter oppe..

I dagene etter operasjonen er det viktig å vedlikeholde og øke muskelkraften slik at kreftene er på vei oppover før du forlater sykehuset. Dette vil være med på å lette daglige gjøremål når du kommer hjem, gi økt overskudd og bedre søvn.

Opp av sengen via sideleie

Første gang du skal opp av sengen etter operasjonen skal du ha hjelp av personalet. Øv deg gjerne på teknikken flere ganger i forkant av operasjonen.

Snu deg rundt på siden i én bevegelse fra utgangsstillingen på bildet



Trekk knærne opp mot magen



Samtidig som bena føres utfor madrasskanten støtter du deg opp i sittende med hjelp av albue og hånd



Bruk den samme teknikken via sideleie når du skal tilbake i sengen





Anestesiprotokoll

ERAS (Enhanced Recovery After Surgery)- forløp for leverreseksjon
Seksjon for lever og pankreaskirurgi
Oslo Universitetssykehus

Smertebehandling Laparoskopi	POD 0 på ettermiddag/kveld: OxyContin® (oksykodon): 10 mg når pasienten våkner på oppvåkningen Paracetamol: 1 g x 4 po / iv Toradol® (ketorolac): 30 mg iv ved avslutning av kirurgi. Deretter 30 mg x 3 intravenøst i 2 døgn forutsatt det ikke foreligger kontraindikasjoner. Når Toradol seponeres, kan dette ved behov startes opp: <ol style="list-style-type: none">1. Voltaren® (diclofenac) inntil 50 mg x 3 po dersom det ikke foreligger kontraindikasjoner eller2. Nobligan® (tramadol) 50 mg x 4 po. Eventuelt: Rescue» medikasjon. OxyNorm® (oksykodon): 5 mg po ved behov
Smertebehandling Åpen reseksjon	Epidural med standard EDA-blanding i 72 timer. <i>Ved EDA-svikt; overgang til smerteregime som ved laparoskopi.</i> Paracetamol inntil 1 g x 4 po/iv etter individuell vurdering. <i>Ved store formelle reseksjoner brukes det ikke rutinemessig paracetamol.</i> POD 1 på morgenen startes: <ul style="list-style-type: none">• OxyContin® (oksykodon) 10-20 mg x 2 po EDA-infusjonen trappes ned med 2 ml/t utpå dagen og avventer videre nedtrapping til POD 2. POD 2 på morgenen startes videre nedtrapping, evt seponere * POD 3 *EDA-kateteret seponeres senest kl 14. Blodprøver tatt siste 24 timer skal da være innenfor angitt referanseområde: Trombocytter < 100 INR < 1,5 APTT innenfor normalt område



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Oslo Universitetssykehus

Peroperativt	
Operasjonsprosedyre	Kirurgen skal anmerke i operasjonsbeskrivelsen: <ul style="list-style-type: none">• Estimert peroperativ blødning• Transfusjonsbehov perioperativt; antall SAG /andre blodprodukter• Lengden på inngrepet• Type snitt
Væskebehandling	De hemodynamiske forhold vurderes fortløpende. På grunn av venøs blødningstendens under leverkirurgi bør man holde CVP så lav som mulig. Kommunikasjon med operatør.
Anestesi/medikamenter Laparoskopi leverreseksjon	Medikamenter: Fortecortin [®] (dexametason) 8 mg injiseres intravenøst rett før kirurgistart Zofran [®] (ondansetron) 4 mg iv ved avslutning av inngrepet Anestesi: TIVA (propofol og remifentanyl (Ultiva [®])) Ved avslutning av kirurgi (før man stopper TIVA infusjonen) gis det en enkelt dose fentanyl 100-200 mikrogram. Smertestillende Perfalgan [®] (paracetamol): 1 g iv ved avslutning av kirurgi. Videre 1 g x 4/døgn Nexium [®] (esomeprazol) 40 mg iv. ved avslutning kirurgi. Videre 40 mg daglig Toradol [®] (ketorolac): 30 mg iv ved avslutning av kirurgi 30 mg x 3 intravenøst i 2 døgn forutsatt det ikke foreligger kontraindikasjoner. Ved første dosering gis først 10mg. Dersom ingen bivirkninger innen 10 minutter (bronkospasme) gis resterende 20 mg. Sårinfiltasjon: Ved kirurg avslutning Marcaïn [®] (bupivacain) 2,5 mg/ml med adrenalin 5 µg/ml, inntil 30 ml langs sårkanten; subkutan og inn i retroperitoneal muskulatur.



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<p>Anestesi/medikamenter</p> <p>Åpen leverreseksjon</p>	<p>Medikamenter:</p> <p>Fortecortin® (dexametason) 8 mg injiseres intravenøst rett før kirurgistart.</p> <p>Zofran® (ondansetron) 4 mg iv ved avslutning av inngrepet</p> <p>Anestesi:</p> <p>TIVA (Propofol og Remifentanil (Ultiva®)). Evt. Desfluran og Remifentanil. Ved avslutning av kirurgi (før man stopper TIVA infusjonen) gis det en enkelt dose fentanyl 100-200 mikrogram.</p> <p>Perfalgan® (paracetamol): 1 g iv ved avslutning av kirurgi etter individuell vurdering. Videre 1 g x 4/døgn. <i>Ved store formelle reseksjoner brukes det ikke rutinemessig paracetamol.</i></p> <p>Nexium® (esomeprazol) 40 mg iv. ved avslutning kirurgi. Videre 40 mg daglig.</p> <p>Thorakal epidural (Th8/9), startdose: standard EDA- blanding 6-15 ml/t.</p> <p>EDA. Epiduralkateteret føres inn på nivå Th 8-9. Epiduralinfusjon (5-15 ml/t og inntil 2 bolusdoser på 5 ml pr time) med standard blanding Marcain® (bupivacain 1 mg/ml, fentanyl 2 µg /ml og adrenalin 2 µg/ml) startes peroperativt etter at testdose er vurdert, og pasienten har fått anesthesiinnledning.</p> <p>Sårinfiltrasjon: Ved kirurgjavslutning Marcain® (bupivacain) 2,5 mg/ml med adrenalin 5 µg/ml, inntil 30 ml langs sårkanten; subkutan og inn i retroperitoneal muskulatur.</p>
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Postoperativt POD 1→



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Seksjon for lever og pankreaskirurgi
Oslo Universitetssykehus

	<p>Epiduralgruppen skal ikke ha NSAIDs med tanke på faren for epiduralt hematom. Når EDA seponeres, kan dette ved behov startes opp:</p> <ol style="list-style-type: none">1. Voltaren[®] (diclofenac) inntil 50 mg x 3 po dersom det ikke foreligger kontraindikasjoner eller2. Nobligan[®] (tramadol) 50 mg x 4 po <p>Ved et stort opioidbehov de første postoperative dager kan pasienten legge til; OxyContin[®] (okykodon) 5- 10mg x 1-2 po begrenset til POD 5</p> <p>Eventuelt: OxyNorm[®] (oksykodon) 5 mg po ved behov</p>
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Appendix 2 – Letter from Ombudsman at OUS



Oslo universitetssykehus HF

Postadresse:
Trondheimsveien 235
0514 Oslo

Sentralbord:
02770

Org.nr:
NO 993 467 049 MVA

www.oslo-universitetssykehus.no

PERSONVERNOMBUDETS TILRÅDING

Til: Bjørn Atle Bjørnbeth/ Helene Tønset
Gastrokirurgisk og barnekrurgisk avdeling/
Gastrokirurgisk og urologisk sengepost

Kopi:

Fra: Personvernombudet ved Oslo
universitetssykehus
Saksbehandler: Tor Åsmund Martinsen

Dato: 03.08.16

Offentlighet: Ikke unntatt offentlighet

Sak: Personvernombudets tilråding til
innsamling og databehandling av
personopplysninger

Saksnummer/
ePhortenummer: 2016/11786

Personvernombudets tilråding til innsamling og behandling av personopplysninger for prosjektet:

«Enhanced Recover After Surgery (ERAS) for pasienter operert for levermetastase etter kolorektal kreft - en kvalitetssikring»

Formål:

Hovedmål: å utforske hvordan ERAS - som er innført som standard oppfølging for pasienter operert for levermetastase etter kolorektal kreft - fungerer på gastrokirurgisk sengepost ved Oslo universitetssykehus, Rikshospitalet. Vi ønsker å se på kostnadseffektiviteten av ERAS, ved å vurdere total liggetid (kostnad) og reinnleggelsesraten (effekten) for pasienter behandlet med leverreseksjon etter kolorektalkreft sammenlignet med "standard oppfølging".

Vi viser til innsendt melding om behandling av personopplysninger / helseopplysninger. Det følgende er personvernombudets tilråding av prosjektet.

Med hjemmel i personopplysningsforskriften § 7-12, jf. helseregisterloven § 5, har Datatilsynet ved oppnevning av personvernombud ved Oslo Universitetssykehus (OUS), fritatt sykehuset fra meldeplikten til Datatilsynet. Behandling og utlevering av person-/helseopplysninger meldes derfor til sykehusets personvernombud.

Databehandlingen tilfredsstillende forutsetningene for melding gitt i personopplysningsforskriften § 7-27 og er derfor unntatt konsesjon.

Personvernombudet tilrår at prosjektet gjennomføres under forutsetning av følgende:

1. Databehandlingsansvarlig er Oslo universitetssykehus HF ved adm. dir.
2. Avdelingsleder eller klinikkleder ved OUS har godkjent studien.
3. Behandling av personopplysningene / helseopplysninger i prosjektet skjer i samsvar med og innenfor det formål som er oppgitt i meldingen.
4. Data lagres som oppgitt i meldingen. Annen lagringsform forutsetter gjennomføring av en risikovurdering som må godkjennes av Personvernombudet.
5. Eventuelle fremtidige endringer som berører formålet, utvalget inkluderte eller databehandlingen må forevises personvernombudet før de tas i bruk.
6. Personvernombudet har vurdert prosjektets potensielle samfunnsnytte til å oppveie for den personvernmessige ulempen det medfører for den registrerte å ikke bli forespurt om deltagelse.
7. Kryssliste som kobler aidentifiserte data med personopplysninger lagres som angitt i meldingen og oppbevares separat på prosjektleders avlåste kontor.
8. Kontaktperson for prosjektet skal hvert tredje år sende personvernombudet ny melding som bekrefter at databehandlingen skjer i overensstemmelse med opprinnelig formål og helseregisterlovens regler.
9. Data slettes eller anonymiseres ved prosjektslutt 31.12.2020 ved at krysslisten slettes og eventuelle andre identifikasjonsmuligheter i databasen fjernes. Når formålet med registeret er oppfylt sendes melding om bekreftet sletting til personvernombudet.

Prosjektet er registrert i sykehusets offentlig tilgjengelig database over forsknings- og kvalitetsstudier.

Med hilsen

Tor Åsmund Martinsen
Personvernrådgiver

Oslo universitetssykehus HF
Stab pasientsikkerhet og kvalitet

Seksjon for personvern og informasjonssikkerhet

Epost: personvern@oslo-universitetssykehus.no

Appendix 3- Output from SPSS for open liver resection group

Figure 1 – Distribution of propensity scores before and after matching with overlaid kernel density estimate. Graph is an output from SPSS.

RGraph

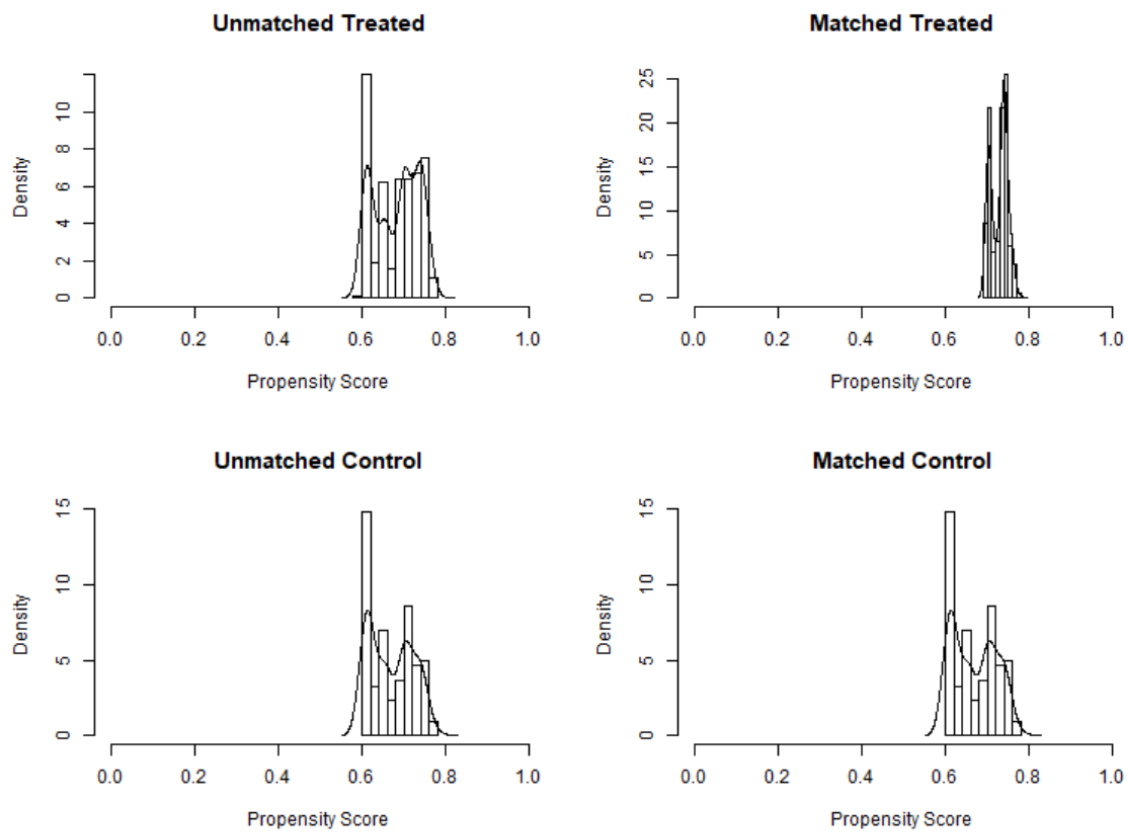


Figure 2- Dotplot of standardized mean differences for all covariates before and after matching

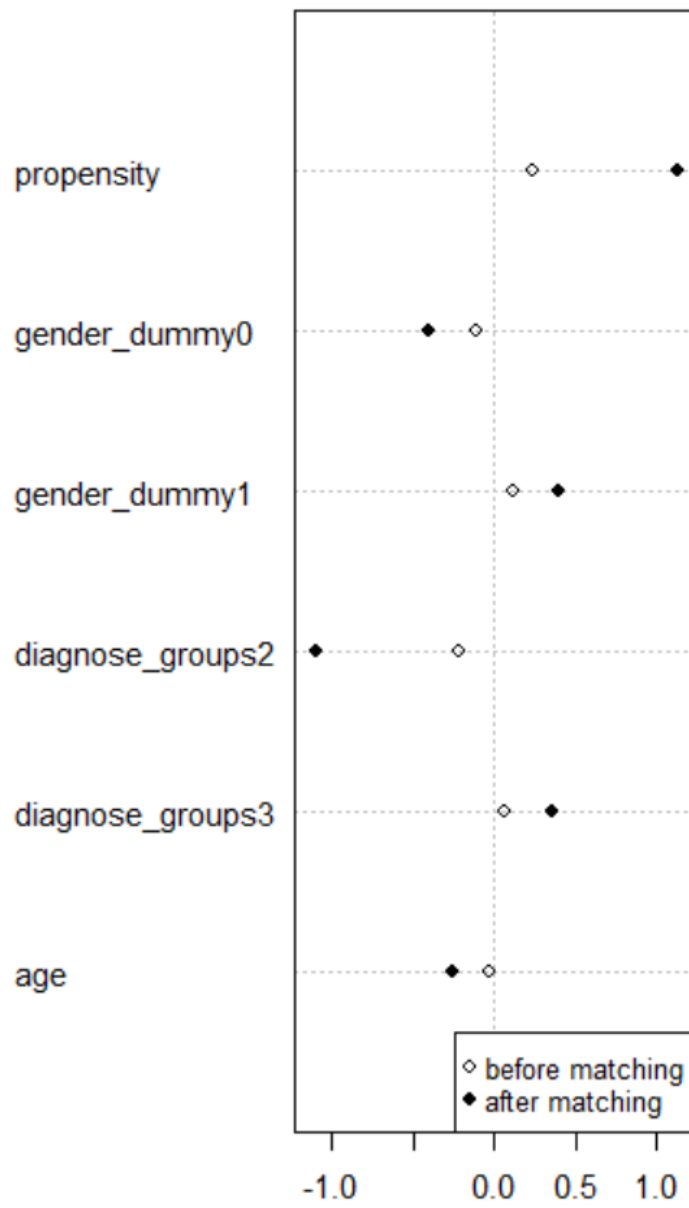
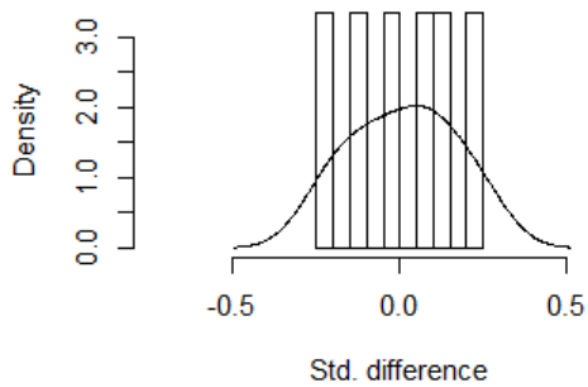


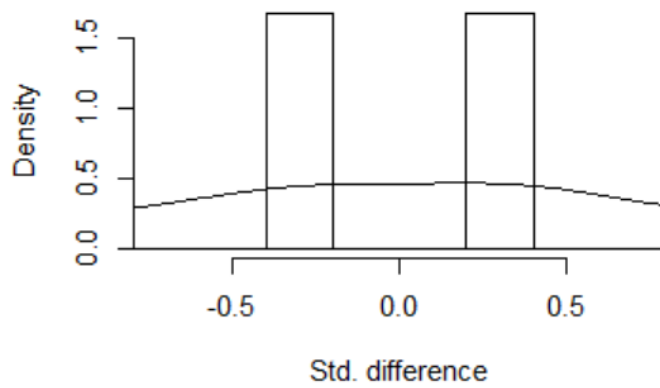
Figure 3- Histograms with overlaid kernel density estimates of standardized difference before and after matching.

RGraph

Standardized differences before matching



Standardized differences after matching



Appendix 4 - Output from SPSS for laparoscopic liver resection group

Figure 1 – Distribution of propensity scores before and after matching with overlaid kernel density estimate. Graph is an output from SPSS.

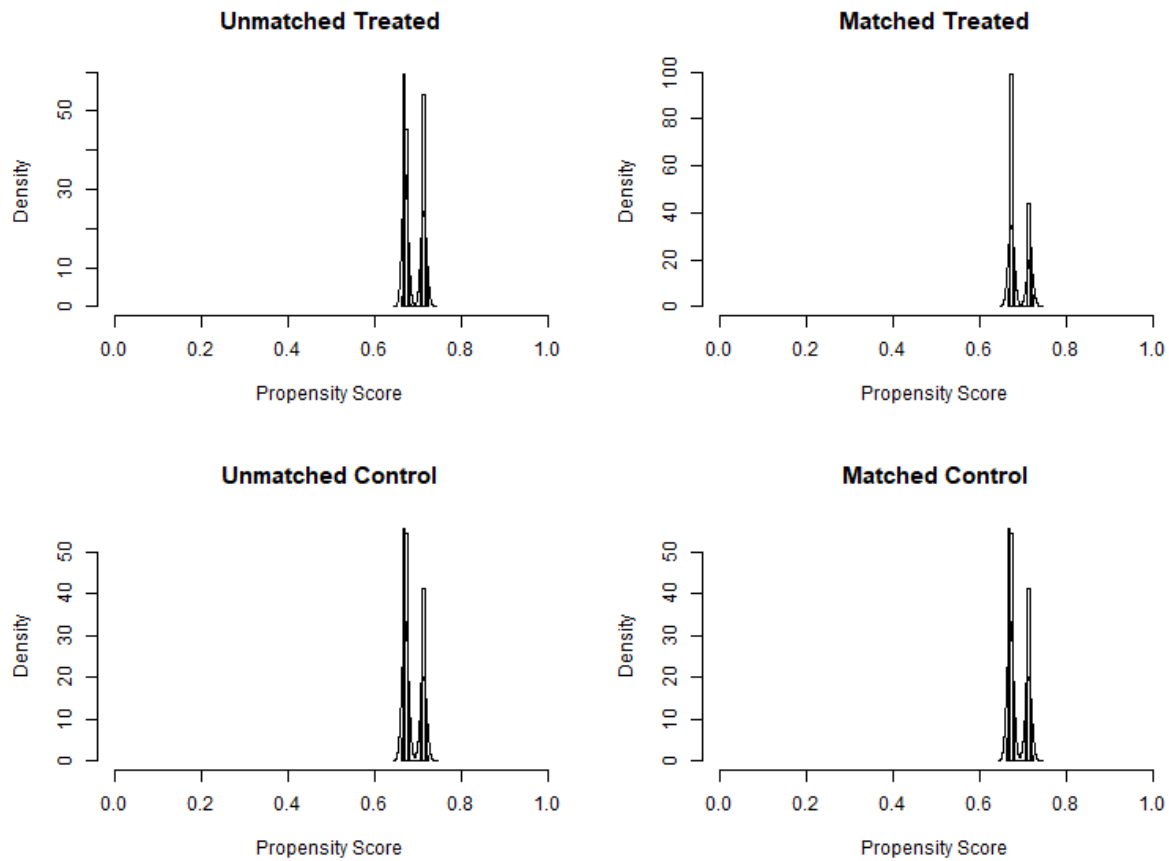
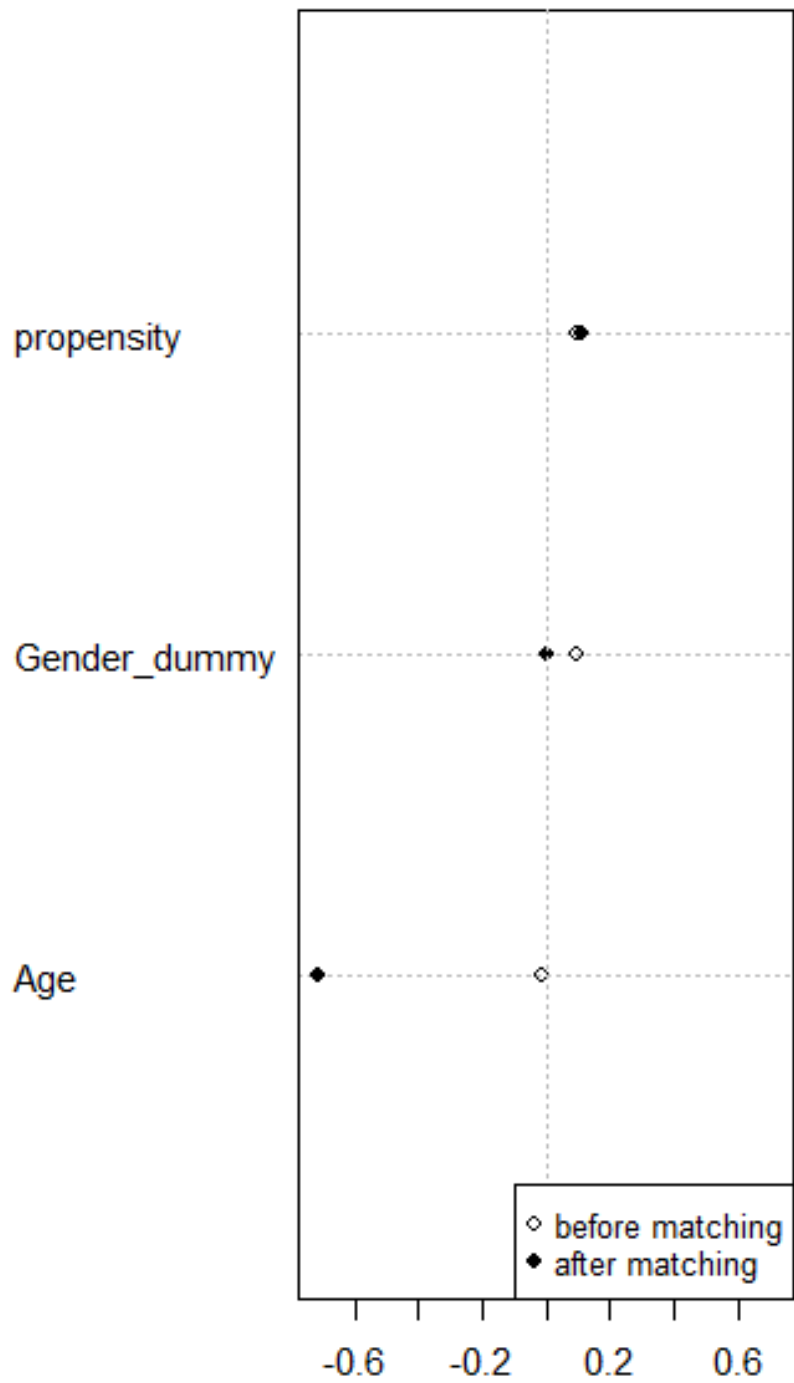


Figure 2- Dotplot of standardized mean differences for all covariates before and after matching



Appendix 5 – Logistic regression open liver resection group

ERAS implementation

Table 1 – Logistic regression using ERAS as the independent variable

Predictor	Beta	Standard Error	Wald	Degrees of freedom	p-value
Constant	-1.977	0.251	61.807	1	0.000
ERAS (Before=0, After=1)	0.049	0.302	0.026	1	0.872

Table 1.1. Omnibus Tests of Model Coefficients

		Chi-square	df	P-value
Step 1	Step	0.018	1	0.894
	Block	0.018	1	0.894
	Model	0.018	1	0.894

Table 1.2. Hosmer and Lemeshow Test

Chi-Square	Degrees of freedom	P-value	Nagelkerke R ²
0	0		0

Age

Table 2 – Logistic regression using age as the independent variable

Predictor	Beta	Standard Error	Wald	Degrees of freedom	p-value
Constant	0.686	0.750	0.838	1	0.36
Age	-0.042	0.012	12.069	1	0.001

Table 2.1. Omnibus Tests of Model Coefficients

		Chi-square	df	P-value
Step 1	Step	8.380	1	0.004
	Block	8.380	1	0.004
	Model	8.380	1	0.004

Table 2.2. Hosmer and Lemeshow Test

Chi-Square	Degrees of freedom	P-value	Nagelkerke R²
6.417	8	0.601	0.021

Gender

Table 3 – Logistic regression using gender as the independent variable

Predictor	Beta	Standard Error	Wald	Degrees of freedom	p-value
Constant	-1.979	0.183	116.99	1	0.000
Gender (Male=0, Female=1)	0.086	0.282	0.093	1	0.942

Table 3.1. Omnibus Tests of Model Coefficients

		Chi-square	df	P-value
Step 1	Step	0.005	1	0.942
	Block	0.005	1	0.942
	Model	0.005	1	0.942

Table 3.2. Hosmer and Lemeshow Test

Chi-Square	Degrees of freedom	P-value	Nagelkerke R²
0	0		0

Appendix 6 – Logistic regression for laparoscopic liver resection

ERAS implementation

Table 1 – Logistic regression using ERAS as the independent variable

Predictor	Beta	Standard Error	Wald	Degrees of freedom	p-value
Constant	-1.863	0.253	54.1	1	0
ERAS (Before=0, After=1)	0.107	0.344	0.091	1	0.763

Table 1.1. Omnibus Tests of Model Coefficients

		Chi-square	df	P-value
Step 1	Step	0.091	1	0.763
	Block	0.091	1	0.763
	Model	0.091	1	0.763

Table 1.2. Hosmer and Lemeshow Test

Chi-Square	Degrees of freedom	P-value	Nagelkerke R ²
0	0		0.001

Age

Table 2 – Logistic regression using age as the independent variable

Predictor	Beta	Standard Error	Wald	Degrees of freedom	p-value
Constant	-0.907	0.826	1.217	1	0.272
Age	-0.014	0.01	1.217	1	0.27

Table 2.1. Omnibus Tests of Model Coefficients

		Chi-square	df	P-value
Step 1	Step	0.365	1	0.546
	Block	0.365	1	0.546
	Model	0.365	1	0.546

Table 2.2. Hosmer and Lemeshow Test

Chi-Square	Degrees of freedom	P-value	Nagelkerke R ²
8.355	8	0.4	0.008

Gender

Table 3 – Logistic regression using gender as the independent variable

Predictor	Beta	Standard Error	Wald	Degrees of freedom	p-value
Constant	-1.723	0.243	50.4	1	0
Gender (Male=0, Female=1)	-0.18	0.36	0.26	1	0.612

Table 3.1. Omnibus Tests of Model Coefficients

		Chi-square	df	P-value
Step 1	Step	0.032	1	0.859
	Block	0.032	1	0.859
	Model	0.032	1	0.859

Table 3.2. Hosmer and Lemeshow Test

Chi-Square	Degrees of freedom	P-value	Nagelkerke R ²
0	0		0.002