"Economics of Mammography in Norway"

A Descriptive study of costs of Mammography Screening from societal perspective.

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Table of contents

List of figures and tables-----------------------------4
Abstract-----------------------------------------------5
1. Introduction----------------------------------------6
2. Aim of thesis----------------------------------------6
3. Background-----------------------------------------7
   3.1 Anatomy of the breast-----------------------------------7
   3.2 Breast cancer’s Development-------------------------8
   3.3 Classification of Breast cancer---------------------9
   3.4 Risk factors-----------------------------------------10
   3.5 Available treatments of breast----------------------10
   3.6 Prevention from breast cancer-----------------------11
   3.7 Incidence, Mortality and Survival rate----------------12
4. Screening/Diagnosis---------------------------------15
   4.1 Screening by Mammography--------------------------18
   4.2 Quality indicators in Mammography-----------------19
   4.3 Sensitivity and Specificity of mammography test-----20
   4.4 Costs related to mammography screening-------------22
5. Material and methods-------------------------------23
6. Description of variables----------------------------24
   6.1 Direct expenses-----------------------------------24
   6.2 Indirect cost---------------------------------------26
7. Results---------------------------------------------29
   7.1 Analysis mammography and recall examination costs---28
   7.2 Analysing differences in travel costs between different regions---30
   7.3 Analysing productivity loss between different regions--31
   7.4 Municipalities with highest and lowest mammography costs-----31
8. Discussion------------------------------------------32
9. Conclusion-------------------------------------------34
List of Tables and Figures

Figure 3.1- Anatomy of the Breast ---------------------------------------------7
Figure 3.2: Developing of tumor-----------------------------------------------8
Figure 3.3- Steps of breast cancer development-----------------------------9
Figure 3.4- Breast appearance after surgery (Mastectomy) ------------------11
Figure 3.5- The five most common cancers among women worldwide---------13
Figure 3.6: Age adjusted incidence rate per 100 000 of three most brutal type of cancer in Norway ---------------------------------------------14
Figure 3.7: Breast cancer incidence and mortality among Norwegian women--15
Figure 3.8: Five-year relative survival in percent for breast cancer by period of diagnosis - 1953-2007------------------------------------------15
Figure 4.1- The idea behind mammography screening--------------------------16
Figure 4.2- WHO’s ten principles for screening for Disease------------------17
Figure 4.3- Detection of tumor by mammography----------------------------19
Figure 4.4- Process indicators in the Norwegian breast cancer screening-----20
Table 4.1- 2*2 table for true positive----------------------------------------21
Table 4.2- Different types of costs related to the Mammography screening----23
Figure 6.1- Costs related to the mammography busses-------------------------24
Table 7.1- Direct and indirect costs of Mammography-------------------------29
Table 7.2- Direct and indirect cost of 2nd time investigation/screening-----30
Table 7.3- Analyzing travel costs per women between different regions------30
Table 7.4- Analyzing productivity loss between different regions-----------31
Table 5.5- 5 Municipalities with highest mammography cost per woman-------32
Table 5.6- 5 Municipalities with lowest mammography cost per woman-------32
Abstract

My thesis is the part of an ongoing larger project “Economics of Mammography in Norway”. Mammography is an effective screening method to detect tumor in early stages of breast cancer, hence it saves lives and improves quality of life. I give an introduction to breast cancer, including biology, incidence and mortality and motivations for breast cancer screening.

In this thesis, I map all direct and indirect costs related to the mammography program in Norway. Direct costs of mammography screening include cost per mammography, cost per recall examination, maintenance of mammography buses, cost of invitations/results/reminders for mammography, recalling for recall examination, office space, personnel, whilst indirect costs consist of time cost, travelling cost and productivity loss.

Norway is a welfare state where state bares the all costs for mammography except women has to pay a little out of pocket payment of 210 kr. Societal costs are vital and are not covered by the state. Individuals have to bare these costs self.

To my knowledge this is the first through analysis of costs from societal perspective associated with mammography screening.

In this thesis we conclude that the travel cost and productivity losses account for 35,30 % of total costs related to mammography screening. I conclude that these costs are vital and should be taken into account when making economics’ decisions about mammography screening.
1- Introduction

Chronic diseases like cancer and cardiovascular disease are major causes of morbidity and mortality. In particular, cancer is one of the most common and deadly diseases worldwide. Breast cancer is the most common type of cancer among women and its incidence is increasing (Solbjør, 2008). The life time risk of developing breast cancer among women is approximately 1/8 in USA, 1/12 in Europe and 1/40 in Asia (WHO, 2008). According to the World Health Organization (WHO) breast cancer was responsible for 502,000 deaths in 2005 alone (Norgard, 2008). In Western countries breast cancer represents of 25% to 30% of the total incidence of cancers in women and is responsible for 15% to 18 % of mortality (Emaus, 2009). Worldwide, 1.301.867 of new cases of breast cancer is registered and deaths were 464.454 fallowed by other types of cancer (WHO, 2008). Health care authorities put a lot of efforts to overcome this merciless disease. One of these efforts is screening. By screening the breast cancer can be detected in early stages and thus the treatment can be more effective. It is possible to detect breast cancer by different kinds of screening methods such as mammography, ultrasound, CT and MR. Mammography is the most widely used screening method.

2-Aim of thesis

This thesis covers some aspects of related costs to mammography in Norway as health care costs are now one of the largest proportions of government expenditure. By World Health organization (WHO, 2009) Norway has a total health expenditure of 9.10 % of gross domestic product. In Norway the government pays the cost of most medical tests and treatments whereas patients have to pay a small co-payment. Travel cost and productivity loss costs associated with medical treatment are generally bared by the patients and employers respectively. My thesis is a part of ongoing project “The economics of mammography screening”. My contribution is to collect data about costs, related directly or indirectly to the Norwegian mammography screening program. I will then attempt to map the costs associated with societal perspective such as traveling cost and productivity loss. Data includes variables based on the travel distance to the nearest screening location, number of women aged 50-69 years, screening compliance, cancer incidence and proportion of women called in for a recall examination, and estimates of the costs of screening tests and screening buses.
This is the first study that will put the light on mammography costs and societal costs related to it in Norway. There has been a similar study done by Wang (2002) but she did not include travel cost, and productivity loss. She also only included the female population that resided in Oslo.

3-Background

3.1- Anatomy of the breast:

The breasts are mammary glands that produce milk and are common in all mammals. Embryological tissues are responsible in both men and women to develop the breast, but in women the sex hormones, mainly estrogens, promote breast development and growth (Wikipedia, 2009). The mammary gland is one of the two half-moon-shaped glands on both sides of the adult female chest. The blood to the breast is supplied by the internal mammary and lateral thoracic arteries (Harris, 2004). The mammary gland is composed of fatty cells which store fat, and in adult lactating women, lobules produce milk. There are complex networks of branching ducts within the mammary gland. These ducts transport milk from the lobules out to the nipple. The size of a normal breast on average is 10-12 cm in diameter and in thickness 5-7 cm (Harris, 2004).

![Anatomy of the Breast](http://www.medicinenet.com/breast_cancer/article.htm)

*Figure 3.1: Anatomy of the Breast (resource: [http://www.medicinenet.com/breast_cancer/article.htm](http://www.medicinenet.com/breast_cancer/article.htm))*
3.2- Breast cancer’s development:

Cells in the body grow and divide in a controlled fashion and the cells die after several rounds of replication. New cells are formed from progenitor cells as needed. Breast cancer is a result of growth abnormality in the cells of breast resulting in change in consistency of the breast tissues. This abnormality develops usually in the inner lining of the milk ducts or lobules (Wikipedia, 2009). Breast cancer appears in the form of tumour when there is uncontrollable proliferation of breast cells.

![Diagram of tumor development](source: Nordgard, 2008)

The tumor is said to be malignant when the proliferating cells invade the neighbouring tissues and organs. These cells grow faster than surrounding cells. Without treatment, malignant breast cancer becomes an irreversible process. If the malignant tumor is not removed, the patient can die in early stages (Fekjær, 2007). These early stages of abnormal breast cell growth can be hard to detect by the patient and doctors alike. This is detected usually by a mammogram. The tumor growth varies considerably among individual patients and it grows faster among younger women Fekjær (2007, paper 4).

The steps of tumor development is summarised in the diagram below.
3.3- Classification of Breast cancer:

Breast cancer classification is based on growth, size and stage of the tumor. Tumors are of two types, benign or malignant. A benign tumor does not spread, but a malignant tumor is invasive and life threatening. Four different approaches are used for the classification of the breast cancer. The short description of these four approaches according to the Wikipedia is as follow,

1) Pathology: Tumors are classified by its microscopic anatomy i.e. what the tissue looks like in a microscope.

2) Grade of the tumor: The histological grade is determined under a microscope. There are three categories for the grade of tumor. a) A well-differentiated/low grade tumor resembles normal tissue. b) Poorly differentiated (high grade) tumor consists of disorganized cells and looks different from normal tissue. c) Moderately/intermediate tumors are somewhere in between.

3) Expression of proteins and genes: Expression of proteins and genes help us to assess the prognosis of breast cancer. Tumors are tested for expression of the estrogen receptor (ER), progestrogen receptor (PR) and HER2/neu proteins. These tests can help determine the best treatment.

4) Stage of the tumor: The stages of breast cancer that are most widely used are those stated in the NTM classification (Nontuberculous mycobacterium). These include a) the tumor itself, b) whether it has spread to lymph nodes and c) whether there is any further metastasis (Wikipedia, 2009).
3.4- Risk factors:

The two strongest risk factors for breast cancer are sex (gender) and age (Emaus, 2009). A recent study in USA and Denmark shows that risk of developing breast cancer increases by age (Roses, 2009). The extensive research on breast cancer has yielded much information about other risk factors which cause or contribute to developing breast cancer. Fekjær (2007) mentions high age at first birth, few children, early menarche, late menopause, family history of breast cancer (genetic predisposition), a previous benign breast disease, high oestrogen levels including the use of hormone replacement therapy, elevated body height, high post-menopausal or low pre-menopausal body mass index, high breast density and exposure to ionising radiation. Some probable risk factors which have yet to be verified include high alcohol consumption, low physical activity and short lactation period. American Cancer Society (2008) has issued a list of factors which are mostly the same as those described by Fekjær (2007) but it has listed some more potentially modifiable factors that contribute to breast cancer including being overweight, never having children or having child after the age of 30, and excessive consumption of alcohol. Smoking has been found to have little or no effect (Fekjær, 2007) but a Norwegian study found that women who start smoking at a young age and continue to smoke for at least 20 years increase their breast cancer risk (Hagen, 2009).

3.5- Available treatments for breast cancer:

The main objective of any cancer treatment is complete cure by clearing away malignant cells and leaving the remaining cellular structure as intact as possible, and if that is not possible then to prolong life and to improve quality of life for the patient. There are different types of treatments that are used separately or in combinations, such as surgery (removal of the cancer tissue), radiation therapy, and systemic treatments. Breast cancer is a heterogeneous disease and treatment methods depend on different clinical criteria e.g. age, type of cancer, size, stage of detection and metastasis. The mainstay of breast cancer treatment is surgery when the tumor is localized, with possible adjuvant hormonal therapy. By surgery the whole breast is removed (mastectomy) or some part (lumpectomy) of it, depending upon the tumor size, stage and location (Nordgard, 2008 p-14). Sometimes the surgery is done with the combination of radiation therapy and systematic treatments. Radiation therapy consists of high powered X-rays or gamma rays precisely targeting the affected area. By radiation therapy the microscopic cancer cells are
destroyed, but in the advanced cancer stage radiation therapy is not given. Systemic treatments are used alone or in combination in the advanced state. Systemic treatment consists of chemotherapy, immune therapy, and hormonal therapy. Neoadjuvant chemotherapy is a drug treatment given to the cancer patients before surgery in order to reduce the size of the cancer before surgery. Different kinds of chemotherapies are used in treating cancer depends upon the tumor size, lymph node status, health and age of the patient. Hormonal therapy is used usually in treating the patients with positive tumor after the completion of chemotherapy (Nordgard, 2008, pp.14-15).

![Breast appearance after surgery](source: Wikipedia, 2009)

**3.6- Prevention of breast cancer:**

Breast cancer is most likely triggered and/or promoted by multiple risk factors. Some of these risk factors are almost unavoidable for example age and being a woman. Governments have invested in a lot of awareness campaigns to introduce prevention methods for reducing and delaying breast cancer. New research shows that those women who give birth to a child in early age and feed their baby with their own milk reduce risk of exposing to breast cancer. Obesity and low physical activity also contribute in development of breast cancer (American cancer society, 2008). Researchers emphasize that the incidence rate of breast cancer in developed countries can significantly decrease if women give birth in the right age and feed their babies with breast milk in early stages after birth (American cancer society, 2008). According to the World Health organization (WHO) more than one-third of all cancer cases including breast cancer are
preventable. Prevention offers the most cost-effective long-term strategy for the control of cancer. WHO is trying hard to bring awareness among women worldwide. Information about diseases, right diet, and physical activity is provided in local language and free dispensaries for women in poor countries (WHO, 2009). One of the missions of WHO is to decrease the mortality among women worldwide that is caused by breast cancer. Medicines Tamoxifen and Raloxifen are also recommended to the women at high risk of having breast cancer (American Cancer Society, 2008, p-9). Norway put more efforts in preventing of breast cancer and women over age 50 are encouraged to take part in mammography screening program for early detection of breast cancer so that mortality can be reduced.

3.7- Incidence, Mortality and Survival rate:

Global facts and figures about the cancer reveals that breast cancer still the leading cause of deaths among women worldwide (American cancer society, 2008). P. Max (1999) cites in his article that by comparing incidence rate of breast cancer from 1975 to 1990, is increased by 37%. Incidence rates are increasing throughout the world and mortality has decreased over the past 25 years. In developed countries the women have early detection by mammography and good treatment facilities as compared to the women in poor countries (American Cancer Society, 2008).
Worldwide, in case of localized breast cancer where malignant cancer has not spread to lymph nodes or other areas outside the breast, the 5 year relative survival is 98%. If the cancer has spread, the 5 years survival rate is 84%. For the women with distant spread (metastases) the 5 year survival rate is 27%. The survival rate after the diagnoses of breast cancer continues to decline after 5 year. The survival rate at 10 years for all stages combined is 80% (American Cancer Society, 2008).

Norway is not exempt from this disease and breast cancer remains the most frequent type of cancer, accounting for 23, 12% of all cancers in Norwegian female population. The proportion of death from breast cancer is higher for women aged over 65 years (Fekjær, 2008). On average each year about 2500 women develop breast cancer. Data from the Norwegian Cancer Registry shows that incidence rate of breast cancer is higher than any other type of cancer.

Figure 3.5: The five most common cancers among women worldwide (Source: Fekjær, 2008).
In Norway the cumulative risk of developing breast cancer among women at the age of 75 by primary site from 2003-2007 was 8.2 % (Norwegian Cancer registry, 2009).

Norway has good records of breast cancer cases from 1953 and onward. The age-adjusted incidence of breast cancer is increasing steadily and has doubled over the last 45 years (Emaus, 2009, p-6). The number of new cases of breast cancer in women by primary site in 2007 was 2761 and 2673 in 2006. In 2007 breast cancer accounted for 23.12 % of all cancers in the Norwegian female population.

The incidence rate of breast cancer has increased in Norway because of early detection of tumor and mortality is gone down over the last two decades (Fekjær, 2007)
Figure 3.7: Age adjusted breast cancer incidence and mortality among Norwegian women
(Source: Fekjær, 2007)

Following diagram shows that survival rate has been increased over the last decades in Norway (Fekjær, 2007).

Figure 3.8: Five-year relative survival in percent for breast cancer by period of diagnosis - 1953-2007 in Norway (source: www.kreftregisteret.no)
4-Screening/Diagnosis

The survival rate for breast cancer depends, among other things, upon the time of detection of the tumor. Heightened awareness of breast cancer risk in the past decades has led to an increase in the detection methods which can be used to detect the breast cancer in the early stages. It can then be treated in an early phase and stopped from spreading further. The idea behind screening is to diagnose the tumor in an early stage and to perform the best treatment possible, as in very early stages the tumor is almost impossible to be detected by patients or doctors. The following figure shows the idea behind screening.

![Figure 4.1: The idea behind mammography screening (Source: Fekjaer, 2007).](image)

With advances in screening, diagnosis, and treatment, the death rate for breast cancer has declined considerably over the past decade. It is widely believed in the medical community that mortality can be reduced to 30% if all women of the correct age actively participate in mammography screening (Feiring, 2004). Researches are ongoing to develop even more effective screening methods to detect the breast cancer in the earliest stages possible to increase the survival rate and quality of life. Solbjør (2008) states, “One can say that screening is searching for a defined disease, using a specific tool, in a whole population free of symptoms”. It is based on the assumption that diagnosing a disease in an early stage improves its prognosis, and its main aim is to reduce morbidity and mortality among those who are screened”. The National Screening Committee in
the United Kingdom defined screening to be “a public health service in which members of a defined population, who do not necessarily perceive that they are at risk of, or already affected by, a disease or its complications are asked a question, or offered a test to identify those individuals who are more likely to be helped than harmed by further tests or treatments to reduce the risk of disease or its complications” (Solbjør, 2008). World health Organization’s definition is “Screening refers to the use of simple tests across a healthy population in order to identify individuals who have disease, but do not yet have symptoms” (WHO, 2009).

By looking at these definitions screening can be said to be a method or process to identify a disease or symptoms of a disease in very early stages in a population who are identified as at high risk of having that particular disease by means of tests, examination or other procedures. The main purpose of screening is to reduce the mortality and morbidity by detecting the disease in the early stages i.e. early detection of disease greatly increases the chances for successful treatment. In 1968, the WHO established ten principles of early disease detection and these principles have subsequently been discussed and modified. Hofvind (2005) has discussed these principles in her PhD thesis.

1. The condition sought should be an important health problem
2. There should be an accepted treatment for patients with recognized disease
3. Facilities for diagnosis and treatment should be available
4. There should be a recognizable latent or early symptomatic stage
5. There should be a suitable test or examination
6. The test should be acceptable in the population
7. The natural history of the condition, including development from latent to declared disease, should be adequately understood
8. There should be an agreed policy on whom to treat as patients
9. The cost of case-findings (including diagnosis and treatment of patients diagnosed) should be economically balanced in relation to possible expenditure on medical care as a whole
10. Case finding should be a continuing process and not a “once and for all” project

*Figure 4.2: WHO’s ten principles for screening for Disease (source: Hofvind, 2005, p-3)*
4.1- Screening by Mammography:

Mammography is the most common screening method to detect breast tumors in an early stage. It is a black and white image of the breast. This image is interpreted by radiologists who look for any breast abnormality that may cause cancer. Mammography aims at improving the prognosis and including survival (Solbjør, 2008). Control trails by WHO affirms that invitation of women 50-69 years of age to screening with mammography reduces mortality by 25% or more but mammography program must be of high quality (Hofvind et al, 2004).

Mammography screening was initiated in USA during 1960’s, and this screening method was then followed by other countries including Canada, Sweden and thereafter almost all developed countries (Solbjør. 2008).

In Norway, all women aged 50-69 who reside in the country are invited for mammography screening. The mammography program was started as a four-year pilot project in four counties of Norway during 1995-1996 and it expanded gradually. In February 2004 it was made nationwide (Hofvind et al, 2004). From 1996 to 2004 1,1 million women had been called in for mammography among whom 77% were attended (Feiring, 2004). Women aged 50-69 are invited for mammography every second year. Approximately 80 % of the target population participated during the first round. Recently there has been a decline in participation rates (Feiring, 2004).

The reason for the decline in participation may be that many women think one mammography is enough. Others claim that the travel distance for screening is too long. Many women have mammography at private institutions that are not paid for by the government, such examinations are not included in official statistics. The Cancer Registry is looking into the causes in order to encourage the women to participate in the screening program (Feiring. 2004).
4.2- Quality indicators in Mammography:

Mammography is a costly test and requires great care and expertise both to perform the imaging and to interpret the results. If quality indicators of mammography are not fulfilled, then this can result in economic cost, erroneous results and over-diagnosing (Hofvind, 2004). The European Commission has set guidelines for quality assurance in mammography screening. The purpose of these quality indicators are to maintain streamlined cost-effective service and minimize anxiety which arises because of unnecessary workup of lesions which show clearly benign features. These guidelines for quality assurance in mammography screening are available at (http://ec.europa.eu/health/ph_projects/2002/cancer/fp_cancer_2002_ext_guid_01.pdf).

The Norwegian breast cancer screening program follows the same manual for quality assurance in mammography issued by the European commission. These quality indicators are stated and evaluated regularly. The continuous emphasis of quality control is essential in order to reduce mortality from breast cancer as consequence of erroneous screening (Hofvind, 2004). The following table shows the result of process indicators, cumulative result and comparison from the desirable levels given in the European guidelines.
The table shows that some of the quality indicators in the process of mammography screening in Norway are lower and some are higher than the guidelines set by the EU. There is always room for improvements and Norwegian Cancer Registry undertakes continuous evaluations to improve the quality of mammography program.

### 4.3- Sensitivity and Specificity of mammography test:

Any diagnostic test usually has two outcomes, positive test (T+) and negative test (T-) to predict the presence of the target disease (D+) or its absence (D-). If the test is positive (T+) then it indicates that disease is present (D+) in the patient. One may then calculate the proportion that is called true positive ratio or sensitivity. If the test is negative (T-) it indicates that the target disease is absent. One may then calculate a corresponding true negative ratio or specificity. There is another possibility when the test is positive (T+) but the patient does not have the target disease (D-) called false-positive ratio or when the test is negative (T-) but the patient has the target disease (D+) called false-negative ratio. A test authenticity is based on a high true-positive ratio/sensitivity and a low false-negative ratio or high true-negative/specificity and low false-positive ratio. A test with high sensitivity and low false-negative ratio is very good at detecting...
patients with the target disease (sensitive to the presence of disease). A test with high specificity i.e. with a low false positive and high true-negative ratio is very good at screening out patients who do not have the disease (specific to the presence of disease). The ideal test has a true-positive ratio of 1.0 and therefore a false-negative ratio of 0.0 or true-negative ratio of 1.0 and false-positive ratio of 0.0 (Hunink et al, 2001). The test result and disease status can be presented in the 2*2 table below.

<table>
<thead>
<tr>
<th>Test result</th>
<th>Disease status</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Disease</td>
<td>No disease</td>
<td></td>
</tr>
<tr>
<td>Positive</td>
<td>TP</td>
<td>FP</td>
<td>TP+FP</td>
</tr>
<tr>
<td>Negative</td>
<td>FN</td>
<td>TN</td>
<td>FN+TN</td>
</tr>
<tr>
<td></td>
<td>TP+FN</td>
<td>FP+TN</td>
<td>N</td>
</tr>
</tbody>
</table>

TP: True positive
FP: False positive
FN: False negative
TN: True negative
N: Total

Table 4.1: 2*2 table (Source: Hunink et al, 2001, p-132)

Due to the high cost of screening, quality indicators are implemented both to control costs and to reduce the number of invalid test results. False positive test results may result in extra cost of further examination, extra productivity losses and create anxiety. False negative results may be even worse. In Norway about 3,5% women are called in for a recall examination. This percentage involves women who actually have breast cancer, and those whose mammogram was equivocal (Hofvind, 2004). Hofvind (2004) conducted a study of women 50-51 years about the cumulative risk of a false-positive recall in the Norwegian breast cancer screening program and found that the cumulative risk for the participants in biennial screening was 20,8% for a false-positive recall during a screening period of 2 decades. However she conducted that the cumulative risk seemed to be acceptable in the Norwegian Breast cancer screening program.
4.5- Costs related to mammography:

Norway is a welfare state, and the costs of most health care including mammography screening are covered by the government. Additionally, the screening program incurs time, costs and productivity losses. Few studies have explored the cost of mammography screening in Norway, but no studies have included travel costs and productivity losses. Wang conducted a study on direct mammography costs in 2002. This study included females who lived in Oslo. She included travel costs but did not consider productivity losses in her study. Productivity losses, time costs and travel costs are societal costs, like other costs related to the mammography screening, and should also be taken into account. The direct screening costs are covered by the government, but time costs, travel costs and productivity losses are not covered by the government and are borne by the women themselves or their employers. The employer suffers productivity losses while their employee is away from job during screening, and the employer usually pays the full salary even when the employee is away from work.

In my thesis, I have mapped all the direct-indirect costs related to the mammography screening and included the cost of travel and productivity loss. Hopefully it will bring more awareness about the so called “hidden costs” behind the mammography screening which effect society in different ways. All the costs that are related directly or indirectly are shown in the table below.
### 5-Material and methods

The data for the thesis was collected from different sources such as the internet, the Norwegian Cancer Registry, professors and medical personnel etc. The data matrix on distance and time was provided by Tor Iversen who is professor at HELED. This data gives the distance and traveling time between all municipalities in Norway. The proportion of employed women in each municipality and average monthly salary for the screening age groups was taken from Statistics Norway (Data from 2008). The post number and code for each municipality as well as the population data about the women aged 50-69 years was also collected from the web site of Statistics Norway (Data from 2009). The data on places where the mammography facilities are available and the proportion of women who attended mammography per county were taken from the website of Norwegian Cancer Registry (2009). The data about the expenses of mobile buses for mammography were given by Aage Dolven Jacobsen who is chief engineer at Buskerud hospital (list was sent by email to my supervisor). The cost of the mammogram, ultrasound and biopsy were taken from the website of KITH (2008).

The screening program is run by the Norwegian Cancer Registry. Invitations and posting screening results to the women is administered by the National Institute of Public Health. All the expenses related to the mammography and cohort group is for the population of women aged 50-69 years in Norway. The SPSS program version 16.0 was used to analyse the data.

---

<table>
<thead>
<tr>
<th>Direct costs</th>
<th>Indirect costs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Screening costs</strong></td>
<td><strong>Recall examination costs</strong></td>
</tr>
<tr>
<td>-Personnel/Office space</td>
<td>-New mammogram</td>
</tr>
<tr>
<td>-Mammogram</td>
<td>-Biopsy</td>
</tr>
<tr>
<td>-Buses including maintenance</td>
<td>-Ultrasound</td>
</tr>
<tr>
<td>-invitations/reminder/result of mammogram by post</td>
<td>-Personnel</td>
</tr>
<tr>
<td></td>
<td>-Office space</td>
</tr>
<tr>
<td></td>
<td>-Result of Recall examination by post</td>
</tr>
<tr>
<td>-Travel costs</td>
<td>-Productivity losses</td>
</tr>
</tbody>
</table>

Table 4.2: Different types of cost related to the Mammography screening program.
6-Description of variables

6.1-Direct costs:

There are different costs related to the mammography program in Norway. It is a big project and all the expenses are bared by the Government except for a little out of pocket payment and travel cost is paid by the women.

The direct cost is the cost that is actually used to do screening and recall examinations, for example equipment cost. Norway is a large country where many municipalities do not have hospitals and the women have to travel to the nearest hospital in another municipality. To facilitate the women to meet up for mammography there are 4 buses that travel to some of the municipalities and stop there for some days before driving to the next. The buses are administered by Buskerud hospital. The budget for running these buses is 5.500.000 kr (2008) and this cost does not include the salary of the technicians who carry out the mammography screening. These buses are equipped with analogue equipments per today and the work is going on to convert these analogue equipments to digital by the end of 2010, but this will increase the cost. The following costs are included for the buses, see figure 6.1.

![Figure 6.1: Costs related to the mammography busses. (Source: Email from Jacobsen D.A)]
The cost of a mammogram per woman is 675 kr. This cost consists of a fixed out of pocket payment per woman of 210 kr and the fixed rate for public poly clinics of 201 kr which combined covers 40% of the total costs of resources used in the screening procedure. The 675 kr cost covers personnel, equipments, resources spend for mammography at bus/hospital. This is multiplied by the standard weight 0,294 for mammography set by the health care authorities. These costs for publicly funded polyclinics and standard weights for mammography can be downloaded from the web site of KITH (Kompetansesenter for IT i helse og sosialsektor AS). The calculation of the cost is as follows

\[
\text{Cost of Mammography} = \left( \text{Out of pocket payment} + \text{fixed unit price} \times \text{standard weight for mammography} \right) \times 100 / 40
\]

\[
\text{Cost of Mammography} = (210 \text{ kr} + 201 \text{ kr} \times 0,294) \times 100 / 40 = 675 \text{ kr}
\]

If a tumor appears on the mammogram or the result is inconclusive then these women are called in for a recall examination. In Norway 3,5% of women are called in for a recall examination at nearest hospital, as additional tests are required. All the women that are called in for a second time undergo additional clinical mammography as well as ultra sound, and 50% of them get biopsy. We set the price of clinical mammography equal to the price of mammography screening (concluded by my supervisor Tron Moger). Hence the direct cost of second time screening involves cost for ultrasound, mammogram and biopsy (Hofvind, 2009).

The cost of ultra sound is calculated in the same way as cost of a mammogram. The fixed cost biopsy is 106 kr and the standard weight of ultra sound is 0,197 (Kompetansesenter for IT i helse og sosialsektor AS). The calculation can be written as follows

\[
\text{Cost of recall examination} = (\text{Cost of mammography} + \text{cost of ultrasound} + \text{cost of biopsy})
\]

\[
\text{Cost of recall examination} = (675 + ((0,197 \times 201 \text{ kr} + 210 \text{ kr}) \times 100 / 40) + (0,5 \times 106))
\]

\[
\text{Cost of recall examination} = 1353 \text{ kr}
\]

There are other costs that contribute directly to the cost of mammography. The women aged 50-69 years are invited to mammography and the invitations are sent by letter. The cost of per letter is 6 kr (Hofvind 2009, personal communication at meeting about the cost of mammography screening). The cost of sending a letter does not involve the administration cost. Not all the
women show up for the screening program and then a reminder is sent by letter to them. Women that show up for mammography are sent a result of their mammogram per post and if anyone of them are advised for further examination at their nearest hospital then the invitation is included in that letter. The women that are called in for a recall examination get the result per post. These costs are also included in the calculations.

2- Indirect costs:

Most women live a distance from the mammography places and they need to use their own or public transport. There is a fixed cost per kilometer taken from the State travelling regulator of 3.50 kr for all municipalities (Consis, 2009). Women travel within their own municipality or to the nearest municipality where the mammography screening is conducted. In my data file the distance was equal to 0.0 km if the mammography was conducted in the same municipality as the women reside. My supervisor Tron Moger suggested to replace the distance from 0 km to 10.0 km as women has to travel within their own municipality to the screening place. The cost of travelling is estimated by multiplying 3.50 kr with turn-return distance to the mammography place. The total cost of travelling for different municipalities varies depending on how far women have to travel to the nearest screening place. In some cases the women have to travel very far and it is more convenient for them to go by plane than to use other ground travelling sources. This particularly applies to the recall examinations. On the advice of my supervisor I have set maximum travelling cost to 1000 kr. If women are called in for recall examinations then they have to travel to the nearest hospital as detailed investigation is not possible in mammography buses e.g. a woman in Finmark then have to travel to Trømso. The travelling cost can be summarized as follows

\[
\text{Travelling cost} = (\text{distance to the nearest screening site/hospital+return distance}) \times 3.50 \\
\text{Travelling cost} = (\text{distance to the nearest screening site/hospital} \times 2) \times 3.50
\]

One important cost that plays a very important role in increasing the costs related to the mammography is the productivity losses i.e. the loss of working hours because of screening, as women travel to the mammography site and has to take leave for those hours. This cost is bared by the employers of these women. The employers suffer by not only have to pay for these hours but also the vacuum creates at working place in the absent of the employee. The proportion of
employed women 50-69 years of age in each municipality is taken from Statistics Norway (2008). As standard there are 22 working days and 7,5 working hours per day in a month and half hour lunch break is not included in the working hours. The average monthly salary of a working women aged 50-69 years is 32000 kr. Per hour salary can be calculated as the average monthly salary divided by the working days and working hours. The calculation for per hour salary can be written as

\[
\text{Per hour salary} = \frac{\text{average monthly salary}}{\text{working hours} \times \text{working days}} \\
\text{Per hour salary} = \frac{32000}{7,5 \times 22} \\
\text{Per hour salary} = 195 \text{ kr}
\]

The productivity loss given by the time spent on travelling turn-return to the mammography site and the screening time multiplied by the weighted hourly salary gives the productivity loss per woman that attend mammography. In the data file the travelling time within a municipality is set to 0,0 hr. Tron Moger (my supervisor) advised me to adjust travelling time turn-return within municipalities from 0,0 hr to 1,0 hr and if the travelling time turn-return to other municipalities is greater than 7,5 hours, it is adjusted to 7,5 hours because these women will not get paid for more than 7,5 hrs. The time for standard mammography is standardized as 0,50 hr including waiting time (Hofvind, personal communication in meeting at Cancer Registry.

In order to calculate the productivity loss, the per hour salary is weighted down according to the proportion of the women employed in each municipality in the screening age groups, taken from Statistics Norway (2008).

\[
\text{Productivity loss} = (\text{Proportion of employed women}) \times \left(\frac{\text{travelling time to and from the mammography site/hospital}}{\text{(Mammography time)}}\right) \times (\text{per hour salary}) \\
\text{Productivity loss} = ((\text{Proportion of employed women}) \times \text{travelling time to and from mammography site/hospital}) + (0,50) \times 195 \text{ kr}
\]

Finally, when calculating the total costs of screening, all costs are weighted according to the proportion of women attending the screening program in each county (Kreftregisteret, 2008, Total invited and attendance). Data at municipality level was not available.
7-Results

7.1-Analysis of mammography and recall examination costs

Table 7.1 shows the different costs of mammography. Total cost of mammography in Norway is estimated to be 448,974,556 kr and the average cost per municipality is 1,044,127 kr with a standard error of 105,320 kr. The average costs per woman attending mammography in Norway is 1,307,81 kr with a standard error 18,51 kr.

The direct cost of mammography is 290,709,597 kr or 64,70% of the total cost of mammography in Norway. The average direct cost per municipality is 676,074 kr. This includes the out of pocket payment of 210 kr. The direct cost per woman attending screening is 739,06. As the proportion of women attending screening varies across municipalities, this affects the number of reminders sent to the women in each municipality. Hence, one gets a small variation in the mammography costs per woman. Rest of the total costs consist of indirect societal costs i.e. travel costs and productivity losses, covering 35,30% of the total cost. Travel cost contributes 15,70% to the total costs. In figure the total travelling cost is 70,427,123 kr, per municipality average cost is 163,784 kr and per woman attending mammography average travelling cost is 286,17 kr. The productivity losses cost is 19,60% of the total cost of mammography, and in figure total productivity losses becomes 87,837,835 kr, per municipality average cost is 204,274 kr and productivity loss per woman in Norway is 282,58 kr.
<table>
<thead>
<tr>
<th></th>
<th>Cost in Kr</th>
<th>Cost in %</th>
<th>Average per Municipality (S.E)</th>
<th>Average per women attending screening (S.E)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total costs</strong></td>
<td>448974556</td>
<td>100 %</td>
<td>1044127 (105320)</td>
<td>1307,81 (18,51)</td>
</tr>
<tr>
<td>Of mammography</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Direct mammography costs</strong></td>
<td>290709597</td>
<td>64,70%</td>
<td>676074 (77020)</td>
<td>739,06 (2,83)</td>
</tr>
<tr>
<td><strong>Travel cost for Mammography</strong></td>
<td>70427123</td>
<td>15,70%</td>
<td>163784 (10196)</td>
<td>286,17 (10,56)</td>
</tr>
<tr>
<td><strong>Productivity loss During mammography</strong></td>
<td>87837835</td>
<td>19,60 %</td>
<td>204274 (20727)</td>
<td>282,58 (8,03)</td>
</tr>
</tbody>
</table>

S:E : Standard Error

Costs in table are in Norwegian kr

*Table 7.1: Direct and indirect costs for Mammography*

Table 7.2 shows the cost of recall examinations. The recall examination involves more specific tests that make its cost higher than the mammography screening. The total cost of the recall examination is 27.934.922 kr. The average cost per municipality is 64.965 kr. Average total cost per woman who attends recall examination is 2349,44 kr. Direct cost for recall examination becomes 70,30% of the total cost i.e.19.637.209 kr. The average direct cost per municipality is 45.670 kr and the average direct cost per woman is 1359 kr.

Travel cost contributes 14,60% of the total costs i.e. 4.087.461 kr. The average cost of travelling per municipality is 9506 kr and average travel cost per woman is 523,89 kr. Productivity loss cost is 4.210.252 kr or 15,10% of the total costs. Average productivity loss per municipality is 9791 kr and per woman average productivity loss is 466,54 kr. Average travel costs per woman are higher for the recall examinations than mammography due to the fact that women have to travel to a hospital instead of to a screening bus.
Table 7.2: Direct and indirect costs of recall examination.

<table>
<thead>
<tr>
<th>Cost</th>
<th>Cost in Kr</th>
<th>Cost in %</th>
<th>Average per Municipality (S.E)</th>
<th>Average per woman attending recall examinations in Norway (S.E)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Cost of recall examination</td>
<td>27934722</td>
<td>100%</td>
<td>64965 (6268)</td>
<td>2349,44 (29,56)</td>
</tr>
<tr>
<td>Direct costs of recall examination</td>
<td>19637209</td>
<td>70,30%</td>
<td>45670 (5291)</td>
<td>1359,00 (0,00)</td>
</tr>
<tr>
<td>Travel cost</td>
<td>4087461</td>
<td>14,60%</td>
<td>9506 (530)</td>
<td>523,89 (16,32)</td>
</tr>
<tr>
<td>Productivity loss</td>
<td>4210252</td>
<td>15,10%</td>
<td>9791 (730)</td>
<td>466,54 (14,07)</td>
</tr>
</tbody>
</table>

S.E: Standard Error
Costs in table are in Norwegian kr

Table 7.2: Direct and indirect costs of recall examination.

7.2-Analyzing differences in travel costs between different regions:

By using one-way ANOVA, one may test whether the average travel costs per woman attending the screening program are significantly different in different regions of Norway excluding recall examinations. Norway is divided in four regions i.e. East region, West region, Middle/North region and South region. Table 7.3 shows that at 0,05 significance level, there are no significant differences in the travel costs between the four regions.

<table>
<thead>
<tr>
<th></th>
<th>Average difference</th>
<th>Confidential Interval</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low bound</td>
<td>Upper bound</td>
<td></td>
</tr>
<tr>
<td>East region VS South region</td>
<td>14,387</td>
<td>-101,54</td>
<td>130,31</td>
</tr>
<tr>
<td>East region VS West region</td>
<td>-56,077</td>
<td>-127,45</td>
<td>15,30</td>
</tr>
<tr>
<td>East region VS Middle/North Region</td>
<td>-59,960</td>
<td>-129,05</td>
<td>9,13</td>
</tr>
<tr>
<td>South region VS West region</td>
<td>-70,464</td>
<td>-188,13</td>
<td>47,20</td>
</tr>
<tr>
<td>South region VS Middle/North region</td>
<td>-74,347</td>
<td>-190,64</td>
<td>41,95</td>
</tr>
<tr>
<td>West region VS Middle/North region</td>
<td>-3,884</td>
<td>-75,86</td>
<td>68,09</td>
</tr>
</tbody>
</table>

Average differences in table are in Norwegian kr

Table 7.3: Analyzing travel costs per woman attending screening among different regions by One-Way ANOVA
7.3-Analysing productivity loss between different regions:

To compare the productivity loss between different regions we may also use one-way ANOVA. The results are shown in table 7.4. The East region is significantly different from the West region and the Middle/North region with p-values< 0.01. On average the West region has a 103,30 kr higher mean cost and the Middle/North region has a 135,94 kr higher mean cost than the East region. This is because in West and middle/North region women are away from job for a longer period than women in the East region. South region Vs North/middle region women are also away from job for a longer period than women in the East region. South region Vs North/middle region also has a significant difference with p-value 0.006 i.e. Middle/North region is 157,95 kr more expensive than the South region for the same reasons as above.

<table>
<thead>
<tr>
<th></th>
<th>Average difference</th>
<th>Confidential Interval</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>East region VS South region</td>
<td>22,005</td>
<td>-103,65 - 147,66</td>
<td>1,000</td>
</tr>
<tr>
<td>East region VS West region</td>
<td>-103,307</td>
<td>-180,68 - 25,94</td>
<td>0,003</td>
</tr>
<tr>
<td>East region VS Middle/North Region</td>
<td>-135,943</td>
<td>-210,83 - 61,05</td>
<td>0,000</td>
</tr>
<tr>
<td>South region VS West region</td>
<td>-125,312</td>
<td>-252,86 2,23</td>
<td>0,57</td>
</tr>
<tr>
<td>South region VS Middle/North Region</td>
<td>-157,948</td>
<td>-284,01 - 31,89</td>
<td>0,006</td>
</tr>
<tr>
<td>West region VS Middle/North region</td>
<td>-32,636</td>
<td>-110,65 45,38</td>
<td>1,000</td>
</tr>
</tbody>
</table>

Significance level= 0,05
Average differences in table are in Norwegian kr

*Table 7.4: Analyzing productivity loss among different regions by One-Way ANOVA*

7.4-Municipalities with highest and lowest mammography costs:

Table 7.5 and 7.6 shows the municipalities with the highest and lowest total mammography costs per woman in Norway respectively. These costs are given per woman in the screening age groups in the municipalities, regardless of whether they attend screening or not. Municipalities in table 7.5 have high costs because distance traveling and high productivity loss and most of them are situated in the North/Middle regions of Norway.
<table>
<thead>
<tr>
<th>Municipality</th>
<th>Cost per woman</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Rødøy</td>
<td>2235</td>
</tr>
<tr>
<td>2) Træne</td>
<td>2213</td>
</tr>
<tr>
<td>3) Røyrvik</td>
<td>2110</td>
</tr>
<tr>
<td>4) Selje</td>
<td>2091</td>
</tr>
<tr>
<td>5) Lierne</td>
<td>2038</td>
</tr>
</tbody>
</table>

Table 7.5: 5 municipalities with highest mammography cost per woman.

<table>
<thead>
<tr>
<th>Municipality</th>
<th>Cost per woman</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Rælingen</td>
<td>587</td>
</tr>
<tr>
<td>2) Asker</td>
<td>613</td>
</tr>
<tr>
<td>3) Lørenskog</td>
<td>614</td>
</tr>
<tr>
<td>4) Fet</td>
<td>620</td>
</tr>
<tr>
<td>5) Nøtterøy</td>
<td>628</td>
</tr>
</tbody>
</table>

Table 7.6: 5 municipalities with lowest mammography cost per woman

8-Discussion:

The thesis is based on a descriptive analysis of the costs related to mammography in Norway. The target group is clearly defined and information on the population in the target group is taken from reliable sources. The thesis puts light on the travel costs and production losses related to mammography screening.

The time costs are not discussed as there was no authenticated data available to measure the time costs in money of an individual consumed during screening. However there are some weak points in the data that should be taken into account. The thesis is based on data that are aggregated per municipality. Individual data would have given more precise results for travel costs and productivity loss. The travel distance, travel time and proportion of employed women gives variation in costs among different regions. However, the screening costs are fixed in all regions. One could imagine weighting screening costs according to different salary levels of medical personnel in different parts of Norway.
Women that have to travel far to reach the nearest mammography screening places or for recall examinations use car or may take a plane if it is more convenient. We calculate the societal cost per km as given by the State travelling regulator i.e. 3.5 kr. Godager (2009) used the same cost per km in his studies. But this will not be actual as it will give a much higher travel cost than the actual cost of travelling in some cases. For example, if a woman has to travel 800 km she might prefer to go by plane instead of by car. If we calculate the cost of travelling using the cost per km given by the State travelling regulator it becomes 2800 kr. I have set the maximum travel cost 1000 kr. This might also not justify the actual travel cost 2800 kr.

The travelling time is set to a maximum of 7.5 hours and the productivity loss is calculated on the basis of this value, but some women may travel for more than 7.5 hours. This might also affects the results, at least for the recall examinations. Invitations and results are sent by post, but the cost of 6 kr for sending a letter does not include administration costs, as the data were not available.

We have not included a direct comparison to Wang (2002), as the fixed cost of mammogram (675 kr in our study) has changed since 2002, and this was the only screening cost she included in her study.

This thesis focuses mainly on costs of mammography screening, and presenting the views of researchers who are positive to mammography screening. However, the effectiveness of the screening program has been heavily debated both in Norway and abroad. There are some researchers who claim that there is little or no evidence on improved survival, and that the negative consequences of the false positive mammograms outweigh any small positive effects of increased survival (e.g. Zahl & Mæhlen, 2004, Zahl et al., 2004 and 2008). Other researchers claim a significant improvement in survival since the introduction of mammography screening, and observe that the false positive rates declines with increasing rounds of screening (e.g. Nyström et al., 2002, Swedish Organized Service Screening Evaluation Group,2006, Perry et al., 2006 and Hofvind et al., 2006).
9- Conclusion:

The mammography screening can be an effective protection against mortality from breast cancer as early detection can improve survival.
My research shows that travel costs and productivity losses are vital and contribute with a large percent to the total costs for mammography. Results from table 7.1 show that combined travel costs and productivity losses make 35.30% of total costs of mammography which is significant and cannot be avoided.
Travel costs seem to be on average, evenly distributed among different regions of Norway. There are however differences in the productivity losses. At the municipality level, both travel costs and productivity loss contributes to a large difference in the total mammography costs per woman participating in the mammography program. The most expensive municipalities have more than three times higher costs per woman than the most inexpensive municipalities
There should be more studies for the cost-effectiveness analysis of screening by considering these costs as one of the crucial factors affecting the total costs related to the mammography screening.
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37